2011-2012 Course Catalog

The University Of Montana

Department of Geosciences

- Special Degree Requirements
- Suggested Course of Study
- Courses
- Faculty

Johnnie Moore, Chairman

Human impact on Earth systems and reliance on Earth's resources will increase as human population and economic production grows. These impacts are creating "global grand challenges": complex, globally important problems that require an interdisciplinary approach. The most pressing grand challenges over the next decade will be resource scarcity/depletion (especially water and petroleum), adaption to and mitigation of climate change and natural hazards, and environmental stewardship of highly stressed physical and biological Earth systems. As University of Montana Geoscientists, we address these grand challenges in our research and teaching. We develop the knowledge to find and extract mineral and water resources, solve problems caused by using those resources and develop models of the past, present and future Earth. Faculty, staff, graduate students, and undergraduate students are part of this task: helping Montana and the World develop a sustainable future.

Our Vision:

We will build and teach a fundamental understanding of Earth processes to benefit humankind and sustain Earth systems.

Our Goals:

1. Conduct geoscience research, including obtaining extramural funding to perform essential and transformative research.

2. Disseminate research findings by publishing in peer-reviewed journals and presenting at national and international scientific conferences.

3. Teach students how to learn from known sources of information and create new knowledge from their own research.

4. Engage all graduate students and selected undergraduates in research and publication.

5. Produce graduates competent in their disciplines who can perform well in field, laboratory and computational settings, and who are prepared to serve as high-quality professionals in geoscience and related fields.

6. Provide opportunities for students to work and learn in other countries through international research and learning opportunities.

7. Educate the general student population about the nature of science and basic scientific principles through the study of Earth and its natural systems.

8. Engage the public with important geoscience issues through outreach and community education.

UM Geosciences in the National Context

There are about 300 Geoscience departments in the U.S. offering the B.S. degree and upwards of 120 offering the M.S. and Ph.D. With B.S., M.S. and Ph.D. degrees, UM Geosciences is one of 120 Ph.D. granting Geoscience departments. U.S. News & World Report ranks the UM Geosciences program with Universities like Florida State, Michigan Tech, University of Georgia, University of Pennsylvania, and University of South Carolina. We are ranked above schools like University of Idaho, University of Missouri, UNLV, and Notre Dame.

Employment

Geoscientists completing our program are employed by private industry, federal, state, and local governmental agencies, environmental consulting firms, non-profit organizations, and by schools needing Earth Science teachers. Jobs in geosciences are available at the B.S., M.S. and Ph.D. levels. The M.S. degree is considered the main working professional degree. The Ph.D. degree is required for positions at universities and with organizations specializing in research. However, there are ample opportunities for geoscience employment with the B.S. degree. Our graduates have a wide range of educational and employment opportunities. Over the last decade, 95% of our graduate program alumni are employed in Geosciences: 13% work for government, 23% for industry, 31% for consultancies and 2% for non-governmental organizations, 10% are teaching, and 17% went on for a Ph.D. UM Geosciences has exceptional placement rates compared to other universities in the country.

Undergraduate Degree Requirements

We offer four degree options/programs of study for the Bachelor of Science degree: Interdisciplinary Geosciences B.S., Geosciences B.S., International Field Geosciences Joint B.S. with University of Cork (Ireland), and International Field Geosciences Dual B.S. with Potsdam University (Germany).

We also offer an Option in Earth Science Education (*see electronic catalog for detailed curriculum and course descriptions for each of these options*)

Interdisciplinary Geosciences B.S.

This flexible option requires the following courses in Geosciences: GEO 101N (GEOS 100N), GEO 102N (GEOS 101N), GEO 211 (GEOS 200), GEO 226 (GEOS 226), GEO 228 (GEOS 228), and GEO 231 (GEOS 230). In addition, thirteen credits of Geoscience coursework must be taken, relevant to student interests, at the 200, 300, or 400 levels. A minimum of 27 credits from the Geosciences curriculum is required to earn this degree. In addition to 27 credits in Geosciences, at least 27 credits from recognized cognate science classes are required to earn this degree. Required classes include CHMY 121N (Chemistry 151N) or CHMY 141N (Chemistry 161N); M 151 (Math 121) or a more advanced math class; and three credits in Computer Science (modeling or programming), or GIS or Statistics. Additional cognate science courses completed to meet the minimum sume of 27 credits should be completed from the list below:

CHMY above 121N (CHEM 151N); MATH above M 151 (MATH 121); CSCI 135 (CS 131) or above; PHSX 205N (PHYS 111N) or above; BIOB 101N (BIOL 100N) or above; ENSC 245 (FOR 210N) Soils or abbove.

At the discretion of the academic advisor, other sciences courses may also be acceptable.

Geosciences B.S.

This option is designed for students who seek post-graduate employment as a professional geoscientist and has two major suggested courses of study; Earth History, Evolution and Earth Resources, and Water, Climate, and Environment. The following Geosciences courses are required to earn this degree: GEO 101N (GEOS 100N), GEO 102N (GEOS 101N), GEO 211 (GEOS 200), GEO 226 (GEOS 226), GEO 228 (GEOS 228), and GEO 231 (GEOS 230).

At least 32 credits of Geosciences courses must be completed, including at least 6 courses of which a minimum of 18 are upper-division (300-400 level) credits. Among the upper-division courses included in each of the two courses of study in this major are the following:

Earth History, Evolution, and Earth Resources

- GEO 305 (GEOS 306) Igneous and Metamorphic Petrology (4 cr.)
- GEO 309 (GEOS 309) Sedimentation and Stratigraphy (4 cr.)
- GEO 310 (GEOS 310) Invertebrate Paleontology (3 cr.)
- GEO 311 (GEOS 311) Paleobiology (3 cr.)
- GEO 315 (GEOS 330) Structural Geology (3 cr.)
- GEO 327 (GEOS 327) Geochemistry (4 cr.)
- GEO 429 (GEOS 429) Field Geology (6 cr.)
- GEO 433 (GEOS 430) Global Tectonics (3 cr.)
- GEO 442 (GEOS 432) Architecture of Sedimentary Deposits (4 cr.)
- GEO 443 (GEOS 433) Sedimentary Petrology (4 cr.)
- GEO 435 Applied Magnetics (3 cr.)
- GEO 436 Subsurface Imaging (3 cr.)
- GEO 460 (GEOS 460) Process Geomorphology (4 cr.)
- GEO 499 (GEOS 499) Senior Thesis (variable)

Water, Climate, and Environment

- GEO 309 (GEOS 309) Sedimentation and Stratigraphy (4 cr.)
- GEO 320 (GEOS 320) Global Water (4 cr.)
- GEO 327 (GEOS 327) Geochemistry (4 cr.)
- GEO 407 (GEOS 407) Global Biogeochemical Cycles (3 cr.)
- GEO 420 (GEOS 480) Hydrogeology (4 cr.)
- GEO 422 Hydrology (3 cr.)
- GEO 442 (GEOS 432) Architecture of Sedimentary Deposits (4 cr.)
- GEO 443 (GEO 433) Sedimentary Petrology (4 cr.)
- GEO 435 Applied Magnetics (3 cr.)
- GEO 436 Subsurface Imaging (3 cr.)
- GEO 460 (GEOS 460) Process Geomorphology (4 cr.)
- GEO 482 (GEOS 482) Global Change (3 cr.)
- GEO 499 (GEOS 499) Senior Thesis (variable)

In addition to completing the coursework in Geosciences, students must also complete a minimum of 30 credits in cognate sciences classes. Required are the following: PHSX 205N/206N-207N/208N or PHSX 215N/216N - 217N/218N (PHYS 111N/113N-112N/114N or PHYS 211N/213N-212N/214N); CHMY 121N/123N (CHEM 151N/152N) or CHMY 141N/143N (CHEM 161N/162N); M 162/274 (MATH 150/158) or M 171/172 (MATH 152/153); three credits in Computer Science (modeling or programming), or GIS, or Statistics.

Additional cognate science courses completed to meet the minimum sum of 30 credits may include additional courses in Chemistry, Computer Science, Math, and Physics above the listed minimum levels specified above. Biology 100N or above is also appropriate, but substitutions or other science courses must be approved by the student's advisor.

International Field Geosciences Joint B.S. Degree with University College of Cork (Ireland)

This option is designed specifically for students who seek to combine a rigorous education in the Geosciences with a year long international geosciences experience and an emphasis on field-based learning. It requires attending classes and living overseas. Students demonstrating a high level of performance at the University will be eligible for partial financial support as funds are available. Although most of the course work completed during the year abroad will take place at University College Cork (UCC) in Ireland, additional course work is required through Potsdam University in Germany. For students who satisfy all degree requirements, a joint B.S. degree in International Field Geosciences will be awarded by The University of Montana and the University College Cork.

The following UM Geoscience courses are required to earn this degree: GEO 101N (GEOS 100N); GEO 102N (GEOS 101N); GEO 211 (GEOS 200); GEO 226 (GEOS 226); GEO 228, GEO 231 (GEOS 230); GEO 315 (GEOS 330); GEO 442 or 443 (GEOS 432 or 433); and GEO 429 (GEOS 429). Also required are a minimum of 12 credits in upper division UM Geoscience courses selected from among the following: GEO 305, 310, 311, 320, 327, 420, 433, 442, 443, 460, 491 (GEOS 306, 310, 311, 320, 327, 430, 432, 433, 460, 480, 495) plus GRMN 101/102 (GERM 101/102) or ENIR 101/102.

In addition to Geosciences coursework completed at UM, students must complete one formal field course run by the Institute of Earth and Environmental Science at Potsdam University to sites in and around Europe (arranged in consultation with advisor) plus one formal field course module run by University College Cork, selected from GL 2016 (Easter Field Course - Dingle Peninsula), GL3019 (Easter Field Course - Western Scotland), ER3002 (Easter Field Course - North Clare) GL4008 (Easter Field Course - Central Greece) or another equivalent-level field course run by UCC that and approved a prior by their UCC and UM advisors. In addition, while in residence at Cork, students must complete any nine of the following courses in consultation with their UCC and UM advisors:

- GL2011 Sedimentological Processes and Petrology (3 cr.)
- GL2012 Igneous and Metamorphic Petrology (3 cr.)
- GL2018 Plate Tectonics and Global Geophysics (3 cr.)
- GL 2019 Marine Ecosystems Through Time (3 cr.)

- GL 3005 Geohazards (3 cr.)
- GL3010 Igneous Petrogenesis and Geochemistry (3 cr.)
- GL3011 Metamorphism and Geochronology (3 cr.)
- GL3012 Advanced Structural Geology (3 cr.)
- GL3013 Sedimentary Environments (3 cr.)
- GL3014 Stratigraphy and Geologic Maps (3 cr.)
- GL3017 Environmental Geology (3 cr.)
- GL3024 Terrestrial Ecosystems Through Time (3 cr.)
- GL4001 Micropaleontology and Palynology (3 cr.)
- GL4003 Petroleum Geology and Basin Analysis (3 cr.)
- GL4003 Applied Geophysics and Computer Applications (3 cr.)
- GL4004 Advanced Igneous Petrology and Geochemistry (3 cr.)
- GL4005 Hydrogeology (3 cr.)
- GL4007 Frontiers in Geology (3 cr.)
- GL4011 Geofluids and Ore Geology (3 cr.)

Students seeking this degree must also complete one additional formal upper-level Geosciences course at Potsdam University during their year abroad. Recommended are courses that focus on computer-based visualization of geoscience data, using GIS or other visualization platforms. Along with the formal Geoscience course work completed at UM and abroad, students earning this degree must complete a minimum of 27 credits in cognate sciences classes, including the following: PHSX 205N/206N-207N/208N or PHSX 215N/216N - 217N/218N (PHYS 111N/113N-112N/114N or PHYS 211N/213N-212N/214N); CHMY 121N/123N (CHEM 151N/153N) or CHMY 141N/143N (CHEM 161N/162N); M 162/274 OR M 171/172 (MATH 150/158 or MATH 152/153); three credits in Computer Science (modeling or programming), or GIS or Statistics. Also required is one year of college German, GRMN 101/102 (GERM 101/102) or one year of college-level Gaelic (ENIR/IRSH 101 and ENIR/IRSH 102) and completion of general education requirements relevant to German and Irish culture and history.

International Field Geosciences Dual Degree with Potsdam University (Germany)

This option is designed specifically for students who seek to combine a rigorous education in the Geosciences with a year-long international geosciences experience and an emphasis on field-based learning. It requires attending classes and living overseas. Students demonstrating a high level of performance at the University will be eligible for partial financial support as funds are available. Although most of the course work completed during the year abroad will take place at University Potsdam in Germany, additional course work is required at the University College Cork in Ireland. For students who satisfy all degree requirements, a B.S. degree in International Field Geosciences will be awarded by The University of Montana and a second B.S. degree in International Field Geosciences will be awarded by Potsdam University. The following UM Geoscience courses are required to earn this degree: GEO 101N (GEOS 100N); GEO 102N (GEOS 101N); GEO 211 (GEOS 200); GEO 226 (GEOS 226); GEO 228, GEO 231 (GEOS 230); GEO 326 (GEOS 302); and GEO 429 (GEOS 429). Also required are a minimum of 15 credits in upper division UM Geoscience courses selected from among the following: GEO 305, 310, 311, 315, 320, 327, 420, 433, 438, 443, 437, 442, 460, 491 (GEOS 306, 310, 311, 330, 320, 327, 480, 430, 438, 433, 437, 460, 495).

In addition to Geoscience coursework completed at UM, the following overseas field-based Geoscience courses are required: BP15 (Field course France, run by Potsdam) or BW01 (Field course-Norway, run by Potsdam) or BW02 (Field course-Alps, run by Potsdam); plus one of the following courses offered by University College Cork; GL 2016 (Easter Field Course-Dingle Peninsula), GL3019 (Easter Field Course-Western Scotland), ER3002 (Easter Field Course-North Clare), GL4008 (Easter Field Course-Central Greece) or another equivalent-level field course run by UCC that and approved a priori by their Potsdman and UM advisors. Students seeking this degree must also complete any four of the following courses offered by Potsdam University:

- BW04 Regional Geology (3 cr.)
- BW05 Paleoclimate and Quaternary Geology (3 cr.)
- BW06 Analysis of Geologic Maps (3 cr.)
- BW07 Analytic Geochemistry (3 cr.)
- BW16 Natural Hazards (3 cr.)
- BW15 Tectonophysics and Rheology (3 cr.)
- BW11 Seismology (3 cr.)
- BW12 Seismics (3 cr.)
- BW13 Geoelectrics (3 cr.)
- BWP05 Sedimentary Systems and Stratigraphy (3 cr.)
- BWP06 Geomorphology (3 cr.)
- BWP16 Tectonics and Geodynamics (3 cr.)

Along with the formal Geoscience course work, students earning this degree must complete a minimum of 27 credits in cognate sciences classes, including the following: PHSX 205N/206N-207N/208N or PHSX 215N/216N - 217N/218N (PHYS 111N/113N-112N/114N or PHYS 211N/213N-212N/214N); CHMY 121N/123N (CHEM 151N/152N) or CHMY 141N/143N (CHEM 161N/162N); M 162/274 (MATH 150/158) or M 171/172 (MATH 152/153); three credits in Computer Science (modeling or programming), or GIS or Statistics. While overseas, the students must complete two of the following cognate science courses at Potsdam University:

- BWP07 Basics in GIS (3 cr.)
- BWP08 Basics in Remote Sensing (3 cr.)
- BWP09 Numerical Methods (3 cr.)
- BWP10 Basic Data Analysis (3 cr.)
- BWP11 Basics in Visualization via Petrel (3 cr.)

Also required is one year of college German GRMN 101/102 (GERM 101/102) and completion of general education requirements relevant to German and Irish culture and history.

Option in Earth Science Education

Major Teaching Field of Earth Science: A student must complete GEO 101N, 102N, 105N, 231, 226, 211 or 228, 310, 315 (GEOS 100N, 101N, 105N, 230, 226, 301, 310, 330), 3 additional credits from any geosciences course numbered 100 or above and 12 credits from any geosciences courses numbered 300 or above. Also required are ERTH 303N (GEOG 322N), ASTR 131N-132N, M 151, STAT 341 (MATH 121, 341), CSCI

100 (CS 101), CHMY 485 (CHEM 485), and EDU 497 (C&I 426). One of BIOE 172N (BIOL121N-122N) or CHMY 121N/123N (CHEM 151N-152N) or PHSX 205N/206N, 207N/208N (PHYS 111N/113N, PHYS 112N/114N); must be completed.

For endorsement to teach earth science, a student also must gain admission to Teacher Education Program and meet the requirements for teaching licensure (see the College of Education section of this catalog). The demand in most Montana high schools for teaching in this field may be limited, and students must complete the requirements for the required second teaching endorsement (major or minor).

Suggested Course of Study

For questions concerning your specific course of study, special interests or preparation, see a Geosciences Department advisor; the following is provided only as a planning guideline to our degree options.

Interdisciplinary Geosciences B.S.

First Year	A	S
CHMY 121N (CHEM 151N) Intro to General Chemistry or CHMY 141N (CHEM 161N) College Chemistry I	3(5)	–
CHMY 123N (CHEM 152N) Intro to Organic & Biochem or CHMY 143N (CHEM 162N) College Chemistry II	–	3
WRIT 101 (ENEX 101) College Writing I	3	–
Approved Writing Course	-	3
GEO 101N/102N (GEOS 100N/101N) Intro to Physical Geology	4	–
GEO 231 (GEOS 230) Geosciences Field Methods	–	2
M 151 (MATH 121) Precalculus (if needed)	–	4
General Education	5(3)	3
Total	15	15
Second Year	**A**	**S**
M 162 (MATH 150) Applied Calculus or M 171 (MATH 152) Calculus I	4	–

GEO 211 (GEOS 200) Earth History and Evolution	2		–	
GEO 226 (GEOS 226) Rocks, Minerals & Resources	–		4	
GEO 228 Earth Surface Processes	–		2	
Electives and General Education	9		9	
Total	15		15	
Third Year		A		S
PHSX 205N/206N (PHYS 111N/113N) College Physics I & Lab or PHSX 215N/216N (PHYS211N/213N)	5		–	
PHSX 207N/208N (PHYS 112N/114N) College Physics II and Lab or PHSX 217N/218N (PHYS 212N/214N) Fundamentals of Physics with Calc II & Lab	–		5	
GIS/Computer Science/Statistics	–		3	
Additional cognate science*	–		3	
GEO (GEOS) any 200 and above	3		4	
Electives and General Education	7		–	
Total	15		15	
Fourth Year		A		S
GEO (GEOS) any 300 and above	3		4	
Upper Division Writing Course or Senior Thesis	3		–	
Additional cognate science*	3		3	
Electives and General Education	6		8	
Total	15		15	

*Suggested, a total of 30 additional science credits are required. See special degree requirements.

Geosciences B.S.

First Year		A		S
CHMY 121N (CHEM 151N) Intro to General Chemistry or CHMY 141N (CHEM 161N) College Chemistry I	3		–	
CHMY 123N (CHEM 152N) Intro to Organic & Biochem or CHMY 143N (CHEM 162N) College Chemistry II	–		5	
WRIT 101 (ENEX 101) College Writing I	3		–	
Approved Writing Course	–		3	
GEO 101N/102N (GEOS 100N/101N) Intro to Physical Geology	4		–	
GEO 231 (GEOS 230) Geosciences Field Methods	–		2	
M 151 (MATH 121) Precalculus (if needed)	–		4	
General Education	5(3)		1	
Total	15		15	
Second Year		**A**		**S**
M 162 (MATH 150) Applied Calculus or M 171 (MATH 152) Calculus	4		–	
M 274 (MATH 158) Differential Equations or M 172 (MATH 153) Calculus II	–		3(4)	
GEO 211 (GEOS 200) Earth History and Evolution	2		–	
GEO 226 (GEOS 226) Rocks, Minerals, and Resources	–		4	
GEO 228 (GEOS 228) Earth Surface Processes	–		2	
Electives and General Education	9		6(5)	
Total	15		15	
Third Year		**A**		**S**

PHSX 205N/206N (PHYS 111N/113N) College Physics I and Lab or PHSX 215N/216N (PHYS211N/213N) Fundamentals of Physics with Calc I & Lab	5	–
PHSX 207N/208N (PHYS 112N/114N) College Physics II and Lab or PHSX 217N/218N (PHYS 212N/214N) Fundamentals of Physics with Calc II & Lab II	–	5
GEO at 300 level or above	6	6
GIS/Computer Science/Statistics	–	3
Electives and General Education	4	1
Total	15	15

Fourth Year	A	S
GEO at 300 level or above	6	6
Upper Division Writing Course or Senior Thesis	3	–
Additional cognate science*	3	3
Electives and General Education	3	6
Total	15	15

*Suggested, a total of 30 additional science credits are required. See special degree requirements.

International Field Geosciences Joint B.S. Degree with University College Cork (Ireland)

First Year	A	S
CHMY 121N (CHEM 151N) Intro to General Chemistry or CHMY 141N (CHEM 161N) College Chemistry I	3(5)	–
CHMY 123N (CHEM 152N) Intro to Organic & Biochem or CHMY 143N (CHEM 162N) College Chemistry II	–	5

WRIT 101 (ENEX 101) College Writing I	3			–	
Approved Writing Course	–			3	
GEO 101N (GEOS 100N)–102N Intro to Physical Geology and Lab	4			–	
GEO 231 (GEOS 230) Geosciences Field Methods	–			2	
M 151 (MATH 121) Precalculus (if needed)	–			4(0)	
General Education	5(3)			1(5)	
Total	15			15	
Second Year		A			S
M 171 (MATH 152) Calculus I or M 162 (MATH 150) Applied Calculus	4			–	
M 172 (MATH 153) Calculus II or M 274 (MATH 158) Intro to Differential Equation	–			4(3)	
GEO 211 (GEOS 200) Earth History and Evolution	2			–	
GEO 226 (GEOS 226) Rocks, Minerals and Resources	–			4	
GEO 228 (GEOS 228) Earth Surface Processes	–			2	
GRMN 101 (GERM 101) Elementary German I or IRSH 101 Elementary Irish/Gaelic	5(3)			–	
GRMN 102 (GERM 102) Elementary German II or IRSH 102 Elementary Irish II	–			5(3)	
Electives and general Education	4(6)			0(4)	
Total	15			15	
Summer (in Montana and Potsdam)					
GEO 429 (GEOS 429) Field Geology (UM)	6				
BP15 Field Course-France	3				

BWPO7 Intro to GIS	3		
BWP11 Intro to Visualization via Petrel	3		
Third Year (in Cork)		A	S
Field Modules (two field trips)	–	6	
Metamorphism and Geochronology	-	3	
Geohazards	3	3	
Stratigraphy and Geological Maps	3	-	
Advanced Structural Geology	3	-	
Terrestrial Ecosystems Through Time	3	-	
Advanced Igneous Petrology and Geochemistry	3	-	
Geofluids and Ore Geology	-	3	
Petroleum Geology and Basin Analysis	-	3	
Hydrogeology	-	3	
Sedimentary Environments	-	3	
Total	15	24	
Fourth Year		A	S
PHSX 205N/206N (PHYS 111N/113N) College Physics I and Lab or PHSX 215N/216N (PHYS 211N/213N) Fundamentals of Physics with Calc I & Lab	5	–	
PHSX 207N/208N (PHYS 112N/114N) College Physics II and Lab or PHSX 217N/218N (PHYS 212N/214N) Fundamentals of Physics with Calc II & Lab	–	5	
GEO at 300 level or above	6	6	
Electives and General Education	4	4	
Total	15	15	

International Field Geosciences Dual Degree with Potsdam University (Germany)

First Year	A	S
CHMY 121N (CHEM 151N) Intro to General Chemistry or CHMY 141N (CHEM 161N) College Chemistry I	3(5)	–
CHMY 123N (CHEM 152N) Intro to Organic & Biochem or CHMY 143N (CHEM 162N) College Chemistry II	–	5
WRIT 101 (ENEX 101) College Writing I	3	–
Approved Writing Course	–	3
GEO 101N (GEOS 100N)–102N Intro to Physical Geology and Lab	4	–
GEO 231 (GEOS 230) Geosciences Field Methods	–	2
M 151 (MATH 121) Precalculus (if needed)	–	4(0)
General Education	5(3)	1(5)
Total	15	15

Second Year	A	S
M 171 (MATH 152) Calculus I or M 162 (MATH 150) Applied Calculus	4	–
M 172 (MATH 153) Calculus II or M 274 (MATH 158) Intro to Differential Equation	–	4(3)
GEO 226 (GEOS 226) /Rocks, Minerals and Resources	4	–
GEO 211 (GEOS 200) Earth History and Evolution	2	–
GEO 228 (GEOS 228) Earth Surface Processes	–	2
GRMN 101 (GERM 101) Elementary German I	5	–
GRMN 102 (GERM 102) Elementary German II	–	5

Electives and General Education	4		0(1)	
Total	15		15	
Summer in Montana and the EU				
GEO 429 (GEOS 429) Field Geology (UM)	6			
BP15 Field Course-France	3			
BWP07 Intro to GIS	3			
BWP11 Intro to Visualization via Petrel	3			
Third Year (in Potsdam)		A		S
BW16 Natural Hazards	3		-	
BW15 Tectonophysics and Rheology	3		-	
BWP16 Tectonics and Geodynamics	3		-	
BWP05 Sedimentary Systems and Stratigraphy	-		3	
BW05 Paleoclimate and Quaternary Geology	-		3	
BWP08 Basics in Remote Sensing	-		3	
BWP10 Basic Data Analysis	3		3	
German Language	3		3	
Total	15		15	
Easter Break (in Cork)	-		2.5	
Fourth Year				
PHSX 205N/206N (PHYS 111N/113N) College Physics I & Lab or PHSX 215N/216N (PHYS 211N/213N) Fundamentals of Physics with Calc I & Lab	5		–	
PHSX 207N/208N (PHYS 112N/114N) College Physics II & Lab or PHSX 217N/218N (PHYS212N/214N) Fundamentals of Physics with Calc II & Lab	–		5	
GEO at 300 level or above	6		6	

Electives and General Education	4		4
Total	15		15

Earth Science Education Option

First Year	A	S
CSCI 172 (CS 172) Introduction to Computer Modeling or Equivalent	–	3
WRIT 101 (ENEX 101) College Writing I	3	–
GEO 101N (GEOS 100N)–102N Intro to Physical Geology and Laboratory	4	–
GEO 105 (GEOS 105) Oceanography	–	3
GEO 231 (GEOS 230) Geosciences Field Methods	–	2
M 151 (MATH 121) Precalculus	4	–
PSYX 100S (PSYC 100S) Introduction to Psychology	4	–
*Electives and General Education	3	6
Total	18	14
Second Year	**A**	**S**
ASTR 131N–132N Elementary Astronomy I, II	3	3
CHMY 121N (CHEM 151N) General and Inorganic Chemistry	3	–
GEO 226 (GEOS 226) Rocks, Minerals and Resources	–	4
GEO 211 (GEOS 200) Earth History and Evolution or GEO 228 (GEOS 228) Earth Surface Processes	2	–
GEO any 100	–	3
*Electives and General Education	7	6
Total	15	16

Need to formally gain admission to the Teacher Education Program. See requirement in the School of Education, Department of Curriculum and Instruction. Deadlines: March 1 and October 1.

Third Year	A	S
CHMY 485 (CHEM 485) Laboratory Safety	–	1
C&I 200 Exploring Teaching Through Field Experience	2	–
C&I 303 Educational Psychology & Measurements	–	4
C&I Other	3	6
ERTH 303N (GEOG 322N) Weather and Climate	3	–
GEO 310 (GEOS 310) Invertebrate Paleontology	3	–
GEO 315 (GEOS 330) Structural Geology	3	–
GEO any 300 or above	3	6
Total	17	17
Fourth Year	**A**	**S**
C&I 426 Teaching Science in Middle and Secondary Schools	3	–
C&I Other	–	6
GEO any 300 or above	3	–
*Electives and General Education	9	12
Total	15	18

*C&I recommends a minor teaching field. A fifth year may be required to obtain a minor field endorsement.

Requirements for a Minor

To earn a minor in Geosciences the student must complete GEO 101N, 102N, 226, 231 (GEOS 100N, 101N, 226, 230) plus at least 12 credits in other geoscience courses numbered 300 or above. All courses must be taken for a traditional letter grade.

Courses

U = for undergraduate credit only, UG = for undergraduate or graduate credit, G = for graduate credit. R after the credit indicates the course may be repeated for credit to the maximum indicated after the R. Credits beyond this maximum do not count toward a degree.

Geosciences (GEO)

U 101N (GEOS 100N) Intro to Physical Geology 3 cr. Offered autumn and spring. General geology including the work of wind, flowing water, glacial ice, gravity, earthquakes, volcanoes and plate tectonics in shaping the earth.

U 102N (GEOS 101N) Intro to Physical Geology Laboratory 1 cr. Offered autumn and spring. Prereq. or coreq., any geoscience courses below GEO 130. A series of laboratory and field experiences designed around basic geologic processes and materials. Familiarization with common minerals, rocks, land forms, and structures. Intended to provide laboratory experience with any geoscience course below GEO 130.

U 105N (GEOS 105N) Oceanography 3 cr. Offered spring. Origin of sea–water and ocean basins; currents, tides, and coastal processes; use and misuse of the oceans by humans.

U 106N (GEOS 106N) History of Life 3 cr. Offered spring. The evolution of plants, invertebrates and vertebrate animals, highlighting major events in the evolution of life on Earth. Includes laboratory experience with fossils.

U 107N (GEOS 103N) Natural Hazards 3 cr. Offered spring. Examination of volcanism, earthquakes, landslides, floods, coastal erosion, hurricanes, and asteroid impacts. Emphasis on processes, recognition and consequences of catastrophic events, and how to minimize their societal impacts.

U 108N (GEOS 108N) Climate Change 3 cr. Offered autumn. The geoscience perspective on the earth's climate system. Climate processes and feedbacks, climate history from early earth to the ice ages, present and future changes due to natural processes and human activities.

U 151 (GEOS 151) Introduction to Fossil Fuels 3 cr. Offered autumn. A broad introduction to the basic principles and concepts related to the exploration for, the composition of, and the utilization of fossil fuels (coal, coal bed methane, natural gas, and oil). Environmental issues related to fossil fuel development and utilization are also addressed.

U 191 (GEOS 195) Special Topics Variable cr. (R–6) Offered intermittently. Experimental offerings of visiting professors, experimental offerings of new courses, or one–time offerings of current topics.

U 211 (GEOS 200) Earth History and Evolution 2 cr. Offered autumn. Traces the history of the earth since its inception 4.5 billion years ago. Presents scientific theories for the origin of the earth and the nature of important earth shaping events of the past, including the development of the oceans, atmosphere and climate.

U 226 (GEOS 226) Rocks, Minerals and Resources 4 cr. Offered spring. Prereq., any geoscience 100 level lecture course, GEO 102N (GEOS 101N), CHMY 121N or 141N (CHEM 151N or CHEM 161N). Study of minerals and rocks utilizing an Earth Systems approach; mineral identification and paragenesis; survey of the distribution of minerals from the interior to the surfaces of planets and the processes that led to their formation.

U 228 Earth Surface Processes 2 cr. Spring semester. Prereq. GEO101N-102N Introduction to the physical processes that affect the surface of the Earth, including global-scale energy distribution and balance, the hydrologic cycle, climate, weathering, transport mechanisms, and geomorphic processes.

U 231 (GEOS 230) Geosciences Field Methods 2 cr. Offered autumn and spring. Prereq. GEO 101N-102N (GEOS 100N-101N). This course introduces students to a variety of field methodologies routinely used in the collection, processing, and interpretation of geoscientific field data.

U 291 (GEOS 295) Special Topics Variable cr. (R–6) Offered intermittently. Experimental offerings of visiting professors, experimental offerings of new courses, or one–time offerings of current topics.

U 304E (GEOS 304E) Science and Society 3 cr. Offered autumn. Role of scientific knowledge in human societies from the pre–Classical to the present. Discussion of tools for integrating science into ethical, political, and social decisions, including analyses of modern case studies from physical sciences.

U 305 (GEOS 306) Igneous and Metamorphic Petrology 4 cr. Offered spring. Prereq., GEO 226 (GEOS 226), CHMY 143N (CHEM 162N). Igneous rock associations, igneous processes and origins; metamorphic minerals and phase relationships, metamorphic zones, facies, and conditions; metamorphic environments, metallic minerals and mineral deposits.

U 309 (GEOS 309) Sedimentation and Stratigraphy 4 cr. Offered spring. Prereq. GEO 101N-102 (GEOS 100N-101N) or 211 (GEOS 200), 226 (GEOS 226). Origins of sediments and sedimentary rocks; climate, weathering, and weathering products; transport, deposition, and depositional environments of sediments; concepts and methods of stratigraphy including correlation of sedimentary rocks and an introduction to basin analysis.

U 311 (GEOS 311) Paleobiology 3 cr. Offered autumn. Prereq. GEO 101N (GEOS 100N) or equiv. level Biology. Survey of the major groups of organisms in the geologic record and hands-on study of fossils; application of geologic and biologic data and principles to solve problems in geoscience and bioscience.

U 315 (GEOS 330) Structural Geology 3 cr. Offered autumn. Prereq., GEO 226 (GEOS 226). Structures of deformed rocks; mechanical principles; graphical interpretation of structural problems, tectonic principles.

U 317 (GEOS 309) Planetary Science 3 cr. Offered autumn even-numbered years. Prereq., PHSX 205N/206N or PHSX 215N/216N (PHYS 111N/113N or 211N/213N) and M 162, 171 (MATH 150, 152). Same as ASTR 351. Physical and geological characteristics of planets, satellites, asteroids, comets, and meteoroids with an emphasis on comparative planetology.

U 320 (GEOS 320) Global Water 4 cr. Offered spring. Prereq., one semester of college chemistry, WRIT 101 (ENEX 101) or equiv., and completion of one writing course. Students are encouraged to take the UDWPA prior to taking this course. Study of the chemistry of water as it moves through the hydrological cycles; discussion of how water chemistry evolves through atmospheric water, precipitation, ground water, and surface water.

U 326 (GEOS 302) Sedimentary Geology Field Trip 2 cr. Offered spring. Prereq., GEO 101N (GEOS 100N). Examination of modern and ancient sedimentary depositional systems in the field through a 9-day spring break field trip. Possible areas of focus include the Permian Reef Complex of West Texas, the California convergent margin, Oregon coastal processes, geology of the Basin and Range, Death Valley Region, Colorado Plateau, and Oklahoma Aulacogen.

U 327 (GEOS 327) Geochemistry 4 cr. Offered alternate years. Prereq., one year of college chemistry, one semester of calculus, and one semester of physical geology, or consent of instructor. One semester of mineralogy recommended. Chemical principles applied to geologic processes. Origin and chemical composition of earth, atmosphere, and hydrosphere. Methods of radiometric dating and isotope applications.

U 391 (GEOS 395) Special Topics Variable cr. (R–9) Offered intermittently. Experimental offerings of visiting professors, experimental offerings of new courses, or one–time offerings of current topics.

U 392 (GEOS 396) Independent Study Variable cr. (R–6) Offered every term. Specific topics of particular interest to individual students.

U 398 (GEOS 398) Internship Variable cr. Offered every term. Prereq., 12 credits in geosciences. Extended classroom experience which provides practical application of classroom learning during placements off campus. Prior approval must be obtained from the faculty supervisor and the Internship Services office. No more than 3 credits of GEO 398 (GEOS 398) may be applied to the geosciences minor. A maximum of 6 credits of Internship (198, 298, 398, 498) may count toward graduation.

UG 407 (GEOS 407) Global Biogeochemical Cycles 3 cr. Offered spring odd numbered years. Same as FOR 408, BIOL/CCS 407. Exploration of how variations in the availability or utilization of critical Earth elements influences the atmosphere, the oceans, and the terrestrial biosphere including the natural and agricultural ecosystems on which we depend.

UG 420 (GEOS 480) Hydrogeology 4 cr. Offered autumn. Prereq., GEO 101N (GEOS 100N)-102N; PHSX 205N/206N or PHSX 215N/216N (PHYS 111N/113N or 211N/213N) ; M 162 or 171 (MATH 150 or 152) strongly recommended. Occurrence, movement, quality, and methods of quantification of groundwater. Geological framework and physics of groundwater flow. Supply, contamination, and management problems.

UG 421 Hydrology 3 cr. Offered autumn semester. Prereq. one semester college calculus and physics or consent of instructor. Introduction to the physical mechanisms that drive the water cycle at different scales. The course covers heat, momentum and mass transfer and storage mechanisms in turbulent systems and their role in the global and local climates. At the local scale, the equations that govern surface and subsurface water flows are studied. Along with the overarching goals, students will improve their quantitative skills, will gain experience accessing and reading the professional literature and will improve their capabilities to acquire knowledge independently.

UG 426 (GEOS 402) Sedimentary Geology Field Trip 2 cr. Examination of sedimentary depositional systems through a nine–day spring break field trip off campus.

U 429 (GEOS 429) Field Geology 6 cr. Offered summer. Prereq., GEO 315 (GEOS 330) and consent of instr. Geologic mapping on aerial photos and topographic base maps. Field interpretation in a variety of rock types and structures. Taught every summer near Dillon, Montana. Extra fees. Pre–registration in early spring.

UG 433 (GEOS 430) Global Tectonics 3 cr. Offered spring. Prereq., GEO 315 (GEOS 330), M 162 (MATH 150), and 2.25 or better overall GPA in geosciences courses. Geodynamics and tectonics of the Earth and other planets. Course material includes methods of observing tectonic processes and tectonic phenomena, both at the surface and in the deep earth, over a wide range of time scales.

UG 436 Subsurface Imaging in Archaeology 3 cr. Offered Spring. Prereq., successful completion of UM general education requirements for math and natural science. Applied and theoretical aspects of radar, magnetics, gravity, and electrical methods related to the detection of buried archaeological features. The focus is on the development of experimental design, data acquisition, processing, and interpretation. Course content is also applicable to shallow environmental sources and problems.

UG 439 Applied Magnetics 3 cr. Offered Spring. Prereq. or coreq., M 172 or M 274 (MATH 153 or 158), GEO 101N-102N (GEOS 100N-101N), PHSX 205N/206N (PHYS 111N/113N). Theory and applications of magnetic exploration and paleomagnetism directed at: plate trajectories, continental deformation, Precambrian Euler poles, and the delineation of buried sources ranging in scale from environmental targets to continental sutures. Includes 2D frequency-domain signal processing of potential fields and the pitfalls of forward and inverse modeling.

UG 442 (GEOS 432) Architecture of Sedimentary Deposits 4 cr. Offered autumn alternate years. Study of the architectural elements and composition of sedimentary deposits in the context of their tectonic environments and their influence on petroleum and hydrogeologic systems.

UG 443 (GEOS 433) Sedimentary Petrology 4 cr. Offered autumn alternate years. Prereq., graduate standing or GEO 442 (GEOS 432). Field, hand specimen and thin section petrology of siliciclastic and carbonate rocks, emphasis on tectonic and diagenetic interpretation of siliciclastic rock and environments of deposition and diagenesis of carbonate rocks.

UG 451 (GEOS 451) Petroleum Geology 3 cr. Offered spring. Prereq. or coreq., GEO 317, 315 (GEOS 309, 330) M 171 (MATH 152), CHMY 123N (CHEM 152N), PHSX 205N/206N (PHYS 111N/PHYS 113N). Origin, migration, and entrapment of hydrocarbons in sedimentary basins. Course integrates several areas of geology with geophysics, geochemistry and engineering.

UG 460 (GEOS 460) Process Geomorphology 4 cr. Offered autumn, alternate years. Coreq., one year college calculus and physics. Quantitative examination of landforms, runoff generation, weathering, mechanics of soil erosion by water and wind, mass wasting, glacial and periglacial processes and hillslope evolution.

UG 469 (GEOS 465) Computer Modeling in the Physical Sciences with Matlab 3 cr. Offered spring alternate years. Coreq., one year college calculus and physics. Introduction to Matlab and writing and using computer models to address typical problems faced by physical scientists. Topics include heat diffusion, carbon storage, and landscape evolution. No previous computer experience required.

UG 482 (GEOS 382) Global Change 3 cr. Offered Spring. Prereq., upper division/higher standing in Geosciences or consent of instructor. Lectures, readings, discussions and practicum on the complexity of global climate. Emphasizes the physical, geochemical and geologic processes affecting climate change over geologic and recent time scales.

UG 488 (GEOS 488) Snow, Ice and Climate 3 cr. Offered spring. Prereq., M 121 (MATH 100). Study of basic physical processes occurring in snow and ice, and how these processes govern the interaction between frozen water and the climate system. The first half of the course focuses in snow, with special attention to snow formation in the atmosphere, snow metamorphism, water flow through snow, and basic avalanche mechanics. The second half of the course focuses on ice and includes glacier and ice sheet flow dynamics, glacier hydrology, and ice age theory. Graduate students will

be required to complete additional problem sets requiring higher level math; perform additional reading assignments; perform at a higher level on assignments and exams where students are asked to outline and describe various physical processes; submit a well researched and reference research proposal that is able to synthesize previous research and provide a sophisticated research plan.

UG 491 (GEOS 495) Special Topics 1-8 cr. (R-8) Offered intermittently. Experimental offerings of visiting professors, experimental offerings of new courses or one-time offerings of current topics.

UG 492 (GEOS 496) Independent Study Variable cr. (R-6) Offered every term. Specific topics of particular interest to individual students.

U 493 (GEOS 493) Omnibus Variable cr. (R–10) Offered intermittently. Independent work under the University omnibus option. See index.

UG 494 (GEOS 494) Senior Geology Seminar 1–10 cr. (R–10) Offered intermittently. Prereq., upper–division standing in geosciences or consent of instr. Independent study of various topics under the direction of a faculty member.

U 499 (GEOS 499) Senior Thesis/Capstone 3–10 cr. (R–10) Offered every term. Prereq., 18 credits in geosciences. Independent research project in any geosciences topic supervised by faculty member, and leading to completion of baccalaureate degree.

G 502 (GEOS 502) Thesis/Dissertation Proposal 1 cr. Offered spring. Work with advisors to choose a research project and write a proposal.

G 508 (GEOS 508) Fundamentals of Academic Research 3 cr. Offered autumn. Prereq., graduate standing. An introduction to research methods and tools in the academic setting intended for first semester graduate students in geosciences. Topics include proposal writing, presenting research results in oral and written formats, using computer tools for research in the geosciences, and ongoing research of department faculty.

G 522 (GEOS 522) Metamorphic Terrain Analysis 3 cr. Offered autumn. Introduction to techniques used to analyze burial and uplift histories of metamorphic terrains. Topics include: geochronology, including closure temperature theory and the use of geochronologic systems as thermochronometers; geothermometry and geobarometry; quantitative thermodynamic modeling of P–T paths; heat flow and the thermal structure of orogenic belts.

G 528 (GEOS 528) Sedimentary Basin Analysis 4 cr. Offered autumn. Influence of allocyclic processes (tectonism, climate, eustacy, etc.,) in shaping the evolution of sedimentary basins. Emphasis on integration and synthesis of tools of sedimentary basins analysis, including the study of depositional systems, provenance, paleocurrents, subsidence, sequence stratigraphy, and well logs.

G 531 (GEOS 531) Environmental Geochemistry of Metal Contamination 4 cr. Offered autumn. Prereq., GEO 570, 579 (GEOS 570, 579); CHMY 442 (CHEM 442); FOR 511 or consent of instr. Integration of major processes and cycles transporting, fixing, and transforming inorganic contaminants in aquatic systems, soils, sediments and subsurface environments. Concentration on research to solve complex environmental problems.

G 548 (GEOS 548) Topics in the Cryosphere 3 cr. (R–6 M.S., R–12 Ph.D.) Offered spring. Prereq., graduate standing or consent of instructor. Readings, discussions, lectures, and field experiments on various topics related to snow, ice, and climate

processes. Recent topics: meltwater infiltration in snow, glacier hydrology, climate cycles, ice, and sea level rise.

G 560 (GEOS 560) Fluvial Geomorphology 3 cr. Offered intermittently. Prereq., graduate standing or consent of instructor. Application of fluid mechanics to sediment transport and development of river morphology. Form and process in river meanders, the pool–riffle sequence, aggradation, grade, and baselevel.

G 570 (GEOS 570) Aqueous Geochemistry 4 cr. Offered alternate years. Prereq., one year college chemistry and one year of calculus, or consent of instructor. Chemistry of aqueous systems including aqueous kinetics, aqueous thermodynamics, acid/base chemistry, carbonate systematics, oxidation/deduction reactions, mineral solubility, and complexation. Includes an introduction to the use of geochemical models. Concepts applied to natural systems.

G 572 (GEOS 572) Advanced Hydrogeology 3 cr. Offered spring. Prereq., GEO 420 (GEOS 480) or consent of instr. Advanced concepts used in groundwater investigations, including flow systems analysis, hydrogeologic monitoring and sampling, resource evaluation, exploration, development and monitoring, and contaminant transport. Special problem areas in groundwater exploration and management.

G 573 (GEOS 573) Applied Groundwater Modeling 3 cr. Offered autumn. Prereq., GEO 420 (GEOS 480) and consent of instr. Development of numerical modeling techniques, finite difference and finite element modeling of groundwater flow systems. Application of standard 2D and 3D models to field problems.

G 579 (GEOS 579) Geochemistry of Hot Springs 3 cr. Offered alternate years. Prereq., one year of college of chemistry or consent of instr. Chemistry and geology of hydrothermal systems including solute/gas geothermometry, acid/base reactions, oxidation/reduction reactions, mineral equilibrium, and microbial ecology as applied to terrestrial and submarine hydrothermal systems. Includes an introduction to the use of geochemical models.

G 580 (GEOS 580) Topics in Mineralogy and Petrology Variable cr. (R–6 for M.S., R–12 for Ph.D.) Prereq., consent of instr. Offerings on request of graduate students by arrangement with appropriate faculty. Recent topics: tectonics and petrology; alkaline igneous rocks.

G 582 (GEOS 582) Topics in Structure and Geophysics Variable cr. (R–6 for M.S., R–12 for Ph.D.) Prereq., consent of instr. Offerings on request of graduate students by arrangement with appropriate faculty. Recent topics: structural analysis, Precambrian crustal evolution, field trips on Rocky Mountain structure.

G 583 (GEOS 583) Topics in Stratigraphy, Sedimentation and Paleontology Variable cr. (R–6 for M.S., R–12 for Ph.D.) Prereq., consent of instr. Offerings on request of graduate students by arrangement with appropriate faculty. Recent topics: evolution of life; Proterozoic stratigraphy; reefs through time.

G 585 (GEOS 585) Topics in Hydrogeology and Low–Temperature Geochemistry Variable cr. (R–6 for M.S., R–12 for Ph.D.) Prereq., consent of instr. Offerings on request of graduate students by arrangement with appropriate faculty. Recent topics: field methods, well design, contaminant transport, geochemical modeling.

G 587 (GEOS 587) Topics in Geomorphology Seminar Variable cr. (R–6 for M.S., R–12 for Ph.D.) Offered spring. Prereq., consent of instr. Reading and discussion of relevant papers. Offerings on request of graduate students by arrangement with

appropriate faculty. Recent topics: landscape evolution; weathering processes; tectonic geomorphology.

G 590 (GEOS 590) Supervised Internship 1–12 cr. Offered intermittently.

G 595 (GEOS 595) Special Topics Variable cr. (R–8) Offered intermittently. Prereq., consent of instr. Experimental offerings of visiting professors, experimental offerings of new courses, or one–time offerings of current topics.

G 597 (GEOS 597) Advanced Problems Variable cr. (R–10) Offered intermittently. Prereq., consent of instr. Investigations of geological problems exclusive of thesis or dissertation research.

G 599 (GEOS 599) Thesis Research Variable cr. (R–6) Offered every term. Prereq., thesis proposal approval. Directed research to serve as thesis for the master degree. Credit assigned upon submittal of final copy of approved and bound thesis.

G 699 (GEOS 699) Dissertation Research Variable cr. (R–12) Offered every term. Prereq., dissertation proposal approval. Directed research to serve as dissertation for the Ph.D. degree. Credit assigned upon submittal of final copy of approved and bound dissertation.

Faculty

Professors

Marc S. Hendrix, Ph.D., Stanford University, 1992

Nancy W. Hinman, Ph.D., University of California (San Diego), 1987

Johnnie N. Moore, Ph.D., University of California (Los Angeles), 1976 (Chair)

James W. Sears, Pd.D., Queen's University, 1979

Steven D. Sheriff, Ph.D., University of Wyoming, l981

George D. Stanley, Ph.D., University of Kansas, 1977

James R. Staub, Ph.D., University of South Carolina, 1985

William W. Woessner, Ph.D., University of Wisconsin (Madison), 1978

Associate Professors

Rebecca O. Bendick, Ph.D., University of Colorado, Boulder, 2000

Joel T. Harper, Ph.D., University of Wyoming, 1997

Assistant Professors

Julia A. Baldwin, Ph.D., Massachusetts Institute of Technology, 2003

Marco P. Maneta, Ph.D., University of Extremadura (Spain), 2006

Andrew C. Wilcox, Ph.D., Colorado State University, 2005

Emeritus Professors

David Alt, Ph.D., University of Texas, 1961

Donald W. Hyndman, Ph.D., University of California (Berkeley), 1964
Ian M. Lange, Ph.D., University of Washington, 1968
Raymond C. Murray, Ph.D., University of Wisconsin, 1955
Graham R. Thompson, Ph.D., Case Western Reserve, 1971
John P. Wehrenberg, Ph.D., University of Illinois, 1956
Robert M. Weidman, Ph.D., University of California (Berkeley), 1959
Donald Winston, Ph.D., University of Texas, 1963