GEOGRAPHY GEO

Department of Geography
College of Social Science

113 Introduction to Economic Geography
Fall, Spring. 3(3-0)
Spatial distribution of resources, population, enterprise, trade, consumption, and production. Interaction of those distributions at local to global scales.

151 Cultural Geography
Fall. 3(3-0)
Systematic approach to the spatial distribution of cultural features, processes, and relationships.

203 Introduction to Meteorology
Fall. 3(3-0)
Fundamentals of meteorology. Energy balance, adiabatic processes, horizontal motion, cyclogenesis, and severe weather.

204 World Regional Geography
Fall. 3(3-0)
In a time of increasing globalization of economic, political and technological processes, different societies on different continents are responding in various ways. This course explores the conditions that contribute to diversity in different world regions-including economic, social, political and environmental processes.

206 Physical Geography
Fall, Spring. 3(3-0)
Geographic and functional interrelationships within the physical environment: Earth-sun relationships, weather, climate, soils, vegetation and landforms (terrain characteristics).

206L Physical Geography Laboratory
Fall, Spring. 1(0-2) P:M: (GEO 206 or concurrently)
Geographic aspects of weather, climate, soil, vegetation, and terrain. Interpretation and application of maps and remotely sensed imagery.

208 Physical Geography of the National Parks
Fall of odd years. 2(2-0) Interdepartmental with Park, Recreation and Tourism Resources.
Physical features such as geology, landforms, biota, and waters of United States and Canadian national parks, forests, seashores and lakeshores. Emphasis on formation and distribution.

221 Introduction to Geographic Information
Fall, Spring. 3(2-2) SA: GEO 223, GEO 225
Principles and methods of spatial data collection, handling, analysis, and display. Introduction to remote sensing, geographic information systems, and cartography.

259 Geography of Recreation and Tourism
Fall of even years. 3(3-0)
Cultural, physical, and biotic factors affecting the distribution of recreation and tourism resources and participation. U.S. and international examples and case studies.

306 Environmental Geomorphology
Spring. 3(3-0) Interdepartmental with Geological Sciences. P:M: (CSS 210 or GEO 203 or GEO 206 or GEO 330 or GEO 333 or GEO 259 or GLG 201 or GLG 304 or ISP 203A or ISS 310 or RD 201 or ISP 203B) and completion of Tier I writing requirement.
Relationships of running water, weathering, gravity, ice, waves, wind, and biota (including humans) to terrain and soils. Evolution of landscapes. Classical and modern interpretations.

314 Methods for Investigation of Urban Systems
Spring. 4(3-2) Interdepartmental with Urban Planning. Administered by School of Planning, Design and Construction. P:M: (STT 201 and CSE 101) RB: (UP 201)
Models, approaches, and techniques for urban and regional problem analysis, research, program evaluation, and project management. Application of related computer software.

324 Remote Sensing of the Environment
Fall, Spring. 4(2-4) SA: GEO 224
Features and interpretation methods of remotely-sensed imagery, especially black-and-white and color infrared airphotos. Basic features of radar, thermal, and multispectral imagery. Interpretation for agriculture, archaeology, fisheries, forestry, geography, landscape architecture, planning, and wildlife management.

325 Geographic Information Systems
Fall. 3(2-2) P:M: (GEO 221)
Technical, and theoretical issues in the design, implementation, and use of geographic information systems for research and applications.

330 Geography of the United States and Canada
Fall, Spring, Summer. 3(3-0) SA: GEO 230
Regional analysis. Evolution and status of environmental, demographic, economic, and sociocultural patterns and processes.

333 Geography of Michigan and the Great Lakes Region
Fall of odd years. 3(3-0) SA: GEO 233
Michigan's physical, historical, and economic geography. Interrelationships between the physical environment (rocks, landforms, soils, climate, vegetation, hydrology) and historical and contemporary land uses. Demographic and agricultural patterns. Human history and settlement patterns contemporary recreational opportunities.

335 Geography of Latin America
Fall. 3(3-0) P:M: Completion of Tier I writing requirement. R: Not open to freshmen.
Physical and human geography of Latin America. Current development issues, especially people-environment interaction in urban and rural areas. Topics include migration, urbanization, and industrialization.

336 Geography of Europe
Fall of odd years. 3(3-0) P:M: Completion of Tier I writing requirement. R: Not open to freshmen.
Major regions and nations, including their physical resources, peoples, political structures, and economies.

337 Geography of East Asia
Spring. 3(3-0) P:M: Completion of Tier I writing requirement. R: Not open to freshmen.
Spatial patterns and processes of physical and human geography in China, Japan, Korea, and Taiwan. Emphasis on development problems, especially since 1950.

338 Geography of Africa
Fall. 3(3-0) P:M: Completion of Tier I writing requirement. R: Not open to freshmen.
Physical and human geography of Africa. Current development issues, especially people-environment interaction in urban and rural areas. Topics include drought, agricultural patterns, hunger, rural development, migration, and urbanization.

370 Introduction to Zoogeography
Fall. 3(3-0) Interdepartmental with Zoology; Fisheries and Wildlife. Administered by Department of Zoology. P:M: (ZOL 355)
Patterns of geographical distribution of animals and the ecological and historical processes leading to these patterns.

401 Geography of Plants of North America
Spring of even years. 3(3-0) R: Not open to freshmen or sophomores.
Geography of Plants in North America with emphasis on the East. Related ecological principles, soils, and post-cretaceous geologic history. Some field instruction.

402 Agricultural Climatology
Fall of even years. 3(3-0) Interdepartmental with Biosystems Engineering. P:M: (MTH 104 or MTH 110 or MTH 116) R: Not open to freshmen or sophomores. SA: AE 402
Relationships between climate and agriculture in resource assessment, water budget analysis, meteorological hazards, pests, crop-yield modeling, and impacts of global climate change.

405 Weather Analysis and Forecasting
Spring of odd years. 4(3-2) P:M: (GEO 203) and (MTH 110 or MTH 116)
Dynamic and thermodynamic principles of atmospheric science applied to the development and evolution of extratropical cyclones. Laboratory sessions include analysis of current observations and satellite imagery.

407 Regional Geomorphology of the United States
Fall of odd years. 3(3-0) P:M: (GEO 306 or GLG 201 or GLG 412 or ISP 203A or ISP 203B)
Geomorphic characteristics of physiographic regions of the United States.

408 Soil Geomorphology Field Study
Fall. 4(2-4) P:M: (CSS 210 or GEO 306 or GLG 201 or GLG 412 or ISP 203A or ISP 203B) R: Not open to freshmen or sophomores.
Common geographic relationships among soils, landforms, and vegetation in lower Michigan. Description, analysis, and genesis of soils and landscapes. Surficial processes. Field trips required.

409 Global Climate Change and Variability
Fall of odd years. 3(3-0) P:M: (GEO 206)
Analysis of climate change and variability at various time and space scales with emphasis on climate systems, paleoclimatology, global warming, climate models, and climate impact assessment.

412 Glacial Geology and the Record of Climate Change
Spring. 4(3-2) Interdepartmental with Geological Sciences. Administered by Department of Geological Sciences. RB: (GLG 201 or GEO 306 or GEO 408) R: Not open to freshmen or sophomores.
In-depth analysis of glacial geology and the record of climate change, with emphasis on North America and Europe. Laboratory focuses on glacial processes. One weekend field trip required.

413 Urban Geography
Fall. 3(3-0) Interdepartmental with Urban Planning. R: Not open to freshmen or sophomores.
Theories and models of urban spatial form. Underlying structures and processes. Socio-spatial dimensions of modern urbanism. Differentiation and locational conflict in residential, commercial, and industrial space.

414 Geography of Transportation
Fall of odd years. 3(3-0) Interdepartmental with Urban Planning. P:M: (GEO 113) R: Not open to freshmen.
Spatial principles of transportation. Theories of interaction, network structures, and location-allocation models. Role of transport and transport planning.

415 Location Theory and Land Use Analysis
Fall. 3(3-0) Interdepartmental with Urban Planning. P:M: (GEO 113 or UP 201) RB: One of the prerequisites or an introductory ECON course. R: Not open to freshmen or sophomores.
Classical and neoclassical, static and dynamic models of industrial location and spatial organization. Land rent theory. Central place theory. Multilocational organization. Growth transmission.

418 The Ghetto
Fall of odd years. 3(3-0) Interdepartmental with Urban Planning. R: Not open to freshmen or sophomores.
Analysis of the ghetto including its spatial organization and structure. Distribution of racial and ethnic populations. Emphasis on U.S. cities.

419 Applications of Geographic Information Systems to Natural Resources Management
Spring. 4(2-4) Interdepartmental with Fisheries and Wildlife; Forestry; Community, Agriculture, Recreation and Resource Studies; Biosystems Engineering. Administered by Department of Fisheries and Wildlife. RB: (GEO 221) Not open to students with credit in GEO 425.
Application of geographic information systems, remote sensing, and global positioning systems to integrated planning and management for fish, wildlife, and related resources.

423 Cartographic Design and Production
Fall. 4(2-4) P:M: (GEO 221)
Elements of map design including planning, layout, typography, color theory and selection, and user issues. Techniques of map production, for both printed and electronic display.

424 Advanced Remote Sensing
Fall. 4(3-2) RB: (GEO 324)
Interaction of solar radiation with the atmosphere, lithosphere, hydrosphere, and biosphere. Introductory digital image processing. Earth-resources satellite sensors, data products, and applications. Radar and thermal remote sensing.

425 Problems in Geographic Information Science (W)
Spring. 3(2-2) Interdepartmental with Urban Planning. P:M: (GEO 325) or (GEO 492)
Advanced theoretical and technical issues in geographic information science utilizing a problems oriented approach. Development and implementation of geographic information science solutions and formal documentation of work.

426 Thematic Cartography
Fall of even years. 4(3-2) P:M: (GEO 221) SA: GEO 326
Principles, techniques, and decision making in thematic mapping. Use of computer-mapping and geographic information systems (GIS) software to produce individual thematic maps and map series. Electronic delivery of thematic maps.

428 Digital Terrain Analysis
Fall of even years. 4(3-2) P:M: (GEO 221) R: Open only to juniors or seniors.
Theoretical and technical issues of collection, management, analysis, and display of terrain data. Application of photogrammetry, geographic information systems, and cartography.

432 Environmental Ethics (W)
Fall. 3(3-0) P:M: Completion of Tier I writing requirement. R: Open only to juniors or seniors.
Ethical dimensions of environmental and spatial issues and associated public policies

435 Geography of Health and Disease
Fall. 3(3-0) R: Not open to freshmen or sophomores.
Spatio-environmental concepts and techniques applied to health problems. Disease transmission cycles, community nutrition, and health-care planning.

453 Metropolitan Environments: Urban Forms and Land Uses
Spring. 3(2-2) P:M: (GEO 221)
Land use change, the physical fabric of the city, and the growth of regional centers in the American urban landscape. Issues associated with urban developments, practices and patterns in the 20th century and the resulting metropolitan form and function. Extensive use of geographic information software in spatial analysis.

454 Spatial Aspects of Regional Development
Spring of odd years. 3(3-0) P:M: (GEO 113 or GEO 151 or GEO 330 or GEO 333 or GEO 335 or GEO 336 or GEO 337 or GEO 338)
Spatial patterns and processes associated with regional development in selected world areas.

459 Tourism in Regional Development
Spring of odd years. 3(3-0) RB: (GEO 259 or PRR 213)
The role of tourism in regional development. Examples from Michigan, and the United States and other nations. Environmental considerations.

463 Introduction to Quantitative Methods for Geographers and Planners
Fall. 3(3-0) Interdepartmental with Urban Planning. RB: Completion of University mathematics requirement. R: Open only to majors in Geography, Urban and Regional Planning, and Landscape Architecture.
Quantitative techniques in the analysis and classification of spatial data.

478 Urban Transportation Planning
Spring. 3(3-0) Interdepartmental with Urban Planning. Administered by School of Planning, Design and Construction. R: Open only to juniors or seniors in Urban and Regional Planning or Geography or approval of department.
Principles of decision-making in urban transportation planning. Demand and supply analysis, social and environmental impacts, implementation programs. Use of computer models.

480 Senior Seminar (W)
Fall. 3(3-0) P:M: Completion of Tier I writing requirement. R: Open only to seniors in Geography.
History, philosophy, and methodology of the geographic discipline as it has evolved within academic and social contexts.

485 Senior Seminar in Geography Education
Spring of even years. 3(3-0) P:M: (GEO 113 or GEO 151) and (GEO 204 and GEO 206 and GEO 221 and GEO 330 or concurrently and GEO 333 or concurrently) R: Open only to Geography minors.
Geography educational standards will guide the development of knowledge and technical expertise of future K-12 teachers. Emphasis will be on continued learning of geography, integration of physical and human concepts, the role of representation (maps, etc.), and the use of current events, local observations, and technology to integrate geography into the K-12 curriculum.

490 Independent Study
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 12 credits in all enrollments for this course. R: Approval of department.
Supervised individual study in an area supplementary to regular courses.

492 Geographic Research Problems
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 12 credits in all enrollments for this course. R: Not open to freshmen or sophomores. Approval of department.
Supervised original research on selected aspects of geography.

494 Remote Sensing Field Techniques
Summer. 2(0-4) P:M: (GEO 424)
Collection and processing of field data to coordinate with remotely sensed imagery. Data correction and analysis. The use of global positioning systems (GPS) receivers and of sensors for determining chlorophyll levels and other biophysical properties. Hands-on experiences; considerable time outdoors. Field trips required.

495 Field Study
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 8 credits in all enrollments for this course.
Supervised field study in geography.

498 Internship in Geography
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 8 credits in all enrollments for this course.
Individual experience in geography in an approved organization.

801 Issues in Geographical Information Science
Fall. 3(3-0) P:M: (GEO 221)
Manipulation and display of geographic data. Interpreting and using geographic information in social and scientific contexts. Ethical issues associated with geographical information science.

813 Seminar in Urban and Economic Geography
Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. RB: Two of GEO 413, GEO 414, GEO 415, GEO 416, GEO 417, GEO 418.
Review of research on selected topics in urban and economic geography.

814 Applied Research Methods for Planning and Development
Spring. 3(2-2) Interdepartmental with Urban Planning. Administered by Department of Geography. RB: (UP 813) R: Open only to graduate students in Urban and Regional Planning, Public Administration, and Geography.
Techniques in urban and regional planning analysis. Forecasting models. Methods of urban project evaluation.

819 Spatial Epidemiology and Medical Geography
Summer of even years. 3(3-0) Interdepartmental with Epidemiology. Administered by Department of Epidemiology. RB: (EPI 810) R: Open only to master's students in the Epidemiology major or approval of department. SA: HM 819
Concepts, techniques, and utilization of spatio-epidemiologic analyses for human health.

824 Monitoring the Biosphere from Space
Spring of even years. 3(3-0) P:M: (GEO 424)
Remote sensing in support of global and other environmental change research. Observing patterns in satellite imagery and linking them with human processes. Monitoring Earth from space at variable spatial and temporal scales. Advanced digital image processing, information extraction, interpretation, and applications.

825 Geoprocessing
Fall of odd years. 4(4-0)
Integration of digital remote sensing data, geographic information systems, spatial analysis, and expert systems in solving research problems. Class research project.

826 Seminar in Cartography and Geoprocessing
Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course.
Review of research in cartography, geographic information systems, and remote sensing.

827 Digital Image Processing and Analysis
Fall. 4(2-4) P:M: (GEO 424)
Use of computer to classify and enhance satellite images and to extract information from them. Combining images from different sources. Accuracy assessment of resulting information.

832 Environmental and Natural Resource Law
Fall. 3(3-0) Interdepartmental with Resource Development; Agricultural Economics; Crop and Soil Sciences; Forestry. Administered by Department of Community, Agriculture, Recreation and Resource Studies. RB: (RD 430)
Origin and development of environmental law. Theories of power, jurisdication, sovereignty, property interests, pollution, and other bases for legal controls of natural resources. Common law and constitutional limitations on governmental power.

835 Biogeography
Spring of odd years. 3(3-0) Interdepartmental with Fisheries and Wildlife; Zoology; Plant Biology. Administered by Department of Fisheries and Wildlife. RB: Courses in evolution and ecology at undergraduate level.
Geographical distributions of plants and animals; biogeographic realms. Ecological and evolutionary mechanisms determining distributional patterns. Application of biogeography to conservation problems.

850 Seminar in Regional Geography
Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course.
Review of research on contemporary geographic issues in different world regions.

854 Economics of Planning and Development
Spring. 3(3-0) Interdepartmental with Urban Planning. Administered by Department of Geography. RB: (UP 801)
The physical urban environment and local economic development.

858 Gender, Justice and Environmental Change : Issues and Concepts
Spring of odd years. 3(3-0) Interdepartmental with Fisheries and Wildlife; Anthropology; Forestry; Resource Development; Sociology. Administered by Department of Fisheries and Wildlife. RB: Background in social science, environmental science, or natural resources.
Issues and concepts related to gender, ecology, and environmental studies. Key debates and theoretical approaches to addressing environmental issues from a gender and social justice perspective. Gender and environment issues and processes from a global perspective.

859 Gender, Justice, and Environmental Change: Methods and Application
Spring of even years. 3(3-0) Interdepartmental with Anthropology; Forestry; Fisheries and Wildlife; Resource Development; Sociology. Administered by Department of Anthropology. RB: Background in social science, environmental science, or natural resources.
Methods and case studies related to gender, ecology, and environmental studies. Methodological and fieldwork issues from a feminist perspective in international and intercultural contexts. Qualitative and quantitative methods for integrating social and environmental data.

865 Advanced Quantitative Methods in Geography
Spring. 4(4-0) RB: (GEO 465)
Statistical and mathematical approaches. Multiple regression, principal components and factor analysis, discriminant analysis. Related taxonomic methods.

866 Spatial Data Analysis
Spring. 4(3-2) Interdepartmental with Statistics and Probability. RB: (GEO 463 or STT 421 or STT 430) or equivalent quantitative methods courses SA: GEO 466
Theory and techniques for statistical analysis of point patterns, spatially continuous data, and data in spatial zones.

871 Seminar in Physical Geography
Fall. 3(3-0) RB: at least one course in physical geography
Research on topics in physical geography.

872 Seminar in Human Geography
Fall. 3(3-0) RB: at least one course in human geography
Research on topics in human geography.

873 Seminar in Human-Environment Geography
Spring. 3(3-0) RB: at least one course in human geography and one course in physical geography.
Research on topics in human-environment geography.

874 Seminar in Geographic Information Science
Spring. 3(3-0) RB: at least one course in geographic information science, cartography or remote sensing
Geographic information science (GIS) applications to social and environmental problems. Theory and related issues.

880 Seminar in Advanced Physical Geography
Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. SA: GEO 809
Advanced study of soils, geomorphology, climatology and/or plant geography.

886 Research Design in Geography
Spring. 3(3-0)
Research and writing in geography. Identification of geographic problems and their relative importance. Structuring and stating hypotheses. Data acquisition and tests for validity.

890 Advanced Readings in Geography
Fall, Spring, Summer. 1 to 8 credits. A student may earn a maximum of 12 credits in all enrollments for this course. R: Approval of department.
Advanced independent readings.

892 Advanced Research in Geography
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 12 credits in all enrollments for this course.
Advanced independent research.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 12 credits. A student may earn a maximum of 99 credits in all enrollments for this course. R: Open only to graduate students in Geography.
Master's thesis research.

986 Theory and Methods in Geography
Spring. 3(3-0) R: Open only to Ph.D. students in Geography.
Historical development of the discipline within social and intellectual contexts. Current methodological and philosophical approaches to geographic research.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 99 credits in all enrollments for this course.
Doctoral dissertation research.

GEOLOGICAL SCIENCES GLG

Department of Geological Sciences
College of Natural Science

201 The Dynamic Earth
Fall, Spring. 4(3-2) Not open to students with credit in GLG 301.
Physical and chemical processes related to the past, present and future behavior of the earth system, and the energy systems that drive these processes. A study of the earth's materials, the earth's surface and the earth's interior.

302 Geology of Michigan
Spring. 3(3-0) P:M: (GLG 201 or ISP 203)
Integration of the geological evolution of Michigan with its social and economic development.

303 Oceanography
Fall. 4(4-0) P:M: (CEM 141 or CEM 142 or CEM 151 or CEM 152 or CEM 181H or CEM 182H or LBS 171) and (PHY 183 or PHY 183B or PHY 193H or PHY 231 or PHY 231B or PHY 231C or LBS 271)
Physical, chemical, biological, and geological aspects of oceanography: ocean circulation, waves, tides, air-sea interactions, chemical properties of ocean water, ocean productivity, shoreline processes, and sediments.

304 Physical and Biological History of the Earth
Fall, Spring. 4(3-2) P:M: (GLG 201 or ISP 203) SA: GLG 202
Origin of the Earth. Differentiation of the Earth's core, mantle and crust. Lithospheric tectonics over geologic time. Origin and evolution of the Earth's hydrosphere, atmosphere and climate. Origin and evolutionary history of biological life. Interactions of life with the Earth's endogenic and exogenic systems.

306 Environmental Geomorphology
Spring. 3(3-0) Interdepartmental with Geography. Administered by Department of Geography. P:M: (CSS 210 or GEO 203 or GEO 206 or GEO 330 or GEO 333 or GEO 259 or GLG 201 or GLG 304 or ISP 203A or ISS 310 or RD 201 or ISP 203B) and completion of Tier I writing requirement.
Relationships of running water, weathering, gravity, ice, waves, wind, and biota (including humans) to terrain and soils. Evolution of landscapes. Classical and modern interpretations.

319 Introduction to Earth System Science
Fall. 3(3-0) Interdepartmental with Entomology; Plant Biology; Zoology; Sociology. Administered by Department of Entomology. RB: Completion of one course in biological or physical science.
Systems approach to Earth as an integration of geochemical, geophysical, biological and social components. Global dynamics at a variety of spatio-temporal scales. Sustainability of the Earth system.

321 Mineralogy and Geochemistry
Spring. 4(3-2) P:M: (GLG 201 or concurrently) and (CEM 142 or CEM 152 or CEM 182H or LBS 172) and (MTH 132 or LBS 118)
Geochemical properties and processes in the origin, modification, structure, dynamics and history of earth materials. Crystallography and crystal chemistry. Mineral classification and identification.

335 Plants Through Time
Spring of odd years. 3(3-0) Interdepartmental with Plant Biology. Administered by Department of Plant Biology. P:M: (BS 110 or PLB 105 or GLG 201 or LBS 144 or LBS 148H) R: Open only to juniors or seniors. SA: BOT 335
Evolutionary history of plants, development of ecosystems, and use of plant fossils in the reconstruction of ancient environments and climate.

351 Structural Geology
Fall. 4(3-2) P:M: (GLG 304 and GLG 361 or concurrently) and (MTH 114 or MTH 116 or LBS 117 or MTH 124 or MTH 126 or MTH 132 or MTH 133 or LBS 118 or LBS 119) RB: Introductory physics.
Mechanical behavior and kinematic history of the lithosphere. Stress and strain. Deformation features such as folds, faults and microstructure. Methods of analysis and interpretation. One weekend field trip required.

361 Petrology (W)
Fall. 4(3-2) P:M: (GLG 321) and completion of Tier I writing requirement. SA: GLG 461
Evolution, origin, occurrence and tectonic setting of igneous and metamorphic rocks. Phase relations of igneous and metamorphic systems. Studies of rocks in thin sections.

401 Plate Tectonics (W)
Spring. 4(3-2) P:M: (GLG 304) and (MTH 114 or MTH 116 or LBS 117 or MTH 124 or MTH 126 or MTH 132 or MTH 133 or LBS 118 or LBS 119) and (PHY 183 or PHY 183B or PHY 231 or PHY 231B or PHY 231C or LBS 271) and completion of Tier I writing requirement. R: Not open to graduate students in the Department of Geological Sciences. SA: GLG 371
Geophysical methods of studying the structure and dynamics of the earth and planets. Plate kinematics and global geodynamic processes, plate margin processes and evolution, marine geology.

411 Hydrogeology
Fall. 3(3-0) RB: (MTH 114 or MTH 116 or LBS 117 or MTH 124 or MTH 126 or MTH 132 or MTH 133 or LBS 118 or LBS 119) R: Not open to freshmen or sophomores.
Source, occurrence, and movement of groundwater emphasizing geologic factors and controls.

412 Glacial Geology and the Record of Climate Change
Spring. 4(3-2) Interdepartmental with Geography. RB: (GLG 201 or GEO 306 or GEO 408) R: Not open to freshmen or sophomores.
In-depth analysis of glacial geology and the record of climate change, with emphasis on North America and Europe. Laboratory focuses on glacial processes. One weekend field trip required.

419 Advanced Earth System Science
Spring. 3(2-2) Interdepartmental with Entomology; Plant Biology; Zoology; Sociology. Administered by Department of Entomology. P:M: (ENT 319)
Systems science theory applied to analysis of the biological, geological, physical, and social causes and consequences of global changes. Issues of sustaining the Earth system.

421 Environmental Geochemistry
Spring. 4(3-2) RB: (GLG 201) and (CEM 141 or CEM 151 or CEM 181H or LBS 171)
Natural and anthropogenic processes affecting environmental chemistry with emphasis on the water cycle. Chemical equilibria, kinetics, geochemical cycling, acid rain, carbon dioxide, heavy metals, toxic organics, global change and the greenhouse effect.

422 Aquatic and Marine Organic Geochemistry (W)
Fall. 3(3-0) P:M: (CEM 141 or CEM 142 or CEM 151 or CEM 152 or CEM 181H or CEM 182H or LBS 171) and completion of Tier I writing requirement. RB: (GLG 201 or GLG 304)
Organic geochemistry applied to global cycling of organic matter and diagenesis in aquatic and marine environments. Use of stable isotopes and molecular analyses to trace the fate of bulk organic matter and individual compounds in the environment.

426 Biogeochemistry
Summer. 3 credits. Summer: Given only at W.K. Kellogg Biological Station. Interdepartmental with Microbiology and Molecular Genetics; Crop and Soil Sciences; Zoology. Administered by Department of Microbiology and Molecular Genetics. RB: (BS 110 or LBS 144 or LBS 148H or BS 111 or LBS 145 or LBS 149H) and (CEM 143 or CEM 251) SA: MPH 426
Integration of the principles of ecology, microbiology, geochemistry, and environmental chemistry. Societal applications of research in aquatic and terrestrial habitats.

431 Sedimentology and Stratigraphy (W)
Spring. 4(3-2) P:M: (GLG 351) and completion of Tier I writing requirement.
Sediments, sedimentary rocks, sedimentary processes, and depositional environments through geologic time. Facies events correlation. Fossils as tools in stratigraphy and environmental analysis. Biostratigraphy, paleoecology and taphomony.

433 Vertebrate Paleontology
Fall of even years. 4(3-2) Interdepartmental with Zoology. P:M: (ZOL 328)
Fossil vertebrates with emphasis on evolution and interrelationships of major groups. Modern techniques of identification and interpretation of fossils.

434 Evolutionary Paleobiology
Fall. 4(3-2) Interdepartmental with Zoology. RB: (BS 110 or GLG 304 or LBS 144 or LBS 148H)
Patterns and processes of evolution known from the fossil record including speciation, phylogeny, extinction, heterochrony and biogeography.