GEOLGY AND GEOPHYSICS

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FACULTY OF THE DEPARTMENT OF GEOLGY AND GEOPHYSICS

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The Geology and Geophysics program prepares students for the application of scientific principles and methods to the understanding of Earth, the environment, and life on a regional and a planetary scale. Subjects range from the history of Earth and life to present-day environmental processes, integrating the study of Earth’s deep interior, tectonic plates, oceans, atmosphere, climate, land surface, natural resources, and biota. The emphasis of the curriculum is on employing basic principles from the core sciences (physics, chemistry, biology) to further an understanding of Earth’s past and present, and addressing issues relating to its future. Students gain a broad background in the natural sciences, and also select a specific track to focus their work on planetary or environmental phenomena of particular interest. The four B.S. tracks emphasize hands-on research experience in fieldwork, in laboratories, or in computer modeling. While some graduates continue on to research, consulting, or industrial careers in Earth, environmental, and planetary sciences, the major’s broad scientific training prepares students for a wide variety of other paths, including medicine, law, public policy, and teaching.

B.S. degree program  Majors in the B.S. program in Geology and Geophysics choose from four tracks: Atmosphere, Ocean, and Climate; Environmental and Energy Geoscience; Paleontology and Geobiology; and Solid Earth Science. The tracks are suggested pathways to professional careers and major areas of research in geology and geophysics. Students may change tracks during their course of study with guidance from the director of undergraduate studies.

1. The Atmosphere, Ocean, and Climate track provides a comprehensive understanding of the theory, observation, and prediction of the atmosphere-ocean-climate system. Topics range from past climate changes, including the ice ages, to present-day storms and weather, to forecasting climate change and global warming. The prerequisites are CHEM 167; PHYS 180, 181 and PHYS 205L, 206L; ENAS 130 or equivalent; and mathematics through differential equations (MATH 120 or ENAS 151, and ENAS 194). The major requirements consist of at least eleven term courses, for ten and one-half course credits, beyond the prerequisites, including either the senior essay or the senior thesis. To begin study of Earth processes, majors take an introductory course in G&G, with any accompanying laboratory, selected from G&G 100; 110 or 115, and 111L; or 125 and 126L. A higher-level course in G&G can be substituted with the permission of the director of undergraduate studies. Six core courses, totaling five and one-half course credits, introduce students to Earth’s climate system (G&G 140 and 141L), meteorology (G&G 322), physical oceanography (G&G 355), fluid mechanics (MENG 361), and statistics or linear algebra (STAT 230 or 238 or MATH 222). Three electives are chosen from topics in the environment and in processes that govern the atmosphere, ocean, and land surface; physics; and statistics. A list of suggested electives is available from the office of the director of undergraduate studies or on the departmental Web site (http://earth.yale.edu/academics/undergraduate-program). At least one elective must be from G&G.

2. The Environmental and Energy Geoscience track provides a scientific understanding of the natural and anthropogenic processes that shape the Earth-atmosphere-biosphere system, including energy and material flows among its components. It emphasizes comparative studies of past and current Earth processes to inform models of humankind’s role within the environment’s future. The prerequisites are broad and flexible and include CHEM 167 and mathematics through multivariate calculus (MATH 120 or ENAS 151). Depending on their area of focus, students may choose a prerequisite in physics (PHYS 170, 171; 180, 181; or 200, 201), or they may choose cellular biology (BIOL 101 and 102, or MCD 120) and evolutionary biology (BIOL 103 and 104, or E&EB 122, or G&G 125 and 126L). The major requirements consist of at least eleven term courses, for eleven course credits, beyond the prerequisites, including either the senior essay or the senior thesis. To begin study of the Earth system, majors take two introductory courses in G&G, with any accompanying laboratories, selected from G&G 100; 110 or 115, and 111L; or 140 and 141L (G&G 125 and 126L may count toward this requirement if not selected as the evolutionary biology prerequisite). Higher-level courses in G&G can be substituted with the permission of the director of undergraduate studies. Four core courses are chosen from topics in general resource use and sustainability (G&G 205), Earth’s surface processes (G&G 232), the microbiology of surface and near-surface environments (G&G 255), fossil fuels and energy transitions (G&G 274), renewable energies (G&G 275), geochemical principles (G&G 301), structural geology (G&G 312), meteorology (G&G 322), and satellite-based image analysis (G&G 362). Four electives chosen from Geology and Geophysics, Environmental Studies (http://catalog.yale.edu/archive/2016-2017/ycps/subjects-of-instruction/environmental-studies), Ecology and Evolutionary Biology (http://catalog.yale.edu/archive/2016-2017/ycps/subjects-of-instruction/ecology-evolutionary-biology), engineering, or related fields provide a broad approach to scientific study of the environment. A list of suggested electives is available from the office of the director of undergraduate studies or on the departmental Web site (http://
the office of the director of undergraduate studies. Permission of the instructor and of the directors of graduate and undergraduate studies. Descriptions of graduate courses are available at

Selection of courses

as an elective toward the major. A copy of each senior thesis or senior essay is made available on the departmental Web site

Senior requirement

Students in both degree programs must prepare either a senior essay based on one term of library, laboratory, or field research (G&G 492) or, with the consent of the faculty, a two-term senior thesis (G&G 490, 491), which involves innovative field, laboratory, or theoretical research. Students electing to do a senior thesis must first select a topic and obtain the consent of a faculty member to act as an adviser. They must then petition the faculty through the director of undergraduate studies for approval of the thesis proposal. The petition should be submitted by the end of the junior year. If the two-term senior thesis is elected, G&G 491 may count as an elective toward the major. A copy of each senior thesis or senior essay is made available on the departmental Web site (http://earth.yale.edu).

Selection of courses

Geology and Geophysics majors may not employ the Credit/D/Fail option for prerequisites or for courses in the major. With permission of the director of undergraduate studies, acceleration credits awarded at matriculation for high scores on national or international examinations (such as Advanced Placement subject tests) may be used to satisfy prerequisites, even if the student does not choose to accelerate. Higher-level courses may, with the permission of the director of undergraduate studies, be substituted for prerequisites and for specific required courses. Qualified juniors and seniors are encouraged to enroll in graduate courses, with permission of the instructor and of the directors of graduate and undergraduate studies. Descriptions of graduate courses are available at the office of the director of undergraduate studies.

3. The Paleontology and Geobiology track focuses on the fossil record of life and evolution, geochemical imprints of life, and interactions between life and Earth. Topics range from morphology, function, relationships, and biogeography of the fossils themselves, through the contexts of fossil finds in terms of stratigraphy, sediment geochemistry, paleoecology, paleoclimate, and geomorphology, to analysis of the larger causes of paleontological, geobiological, and evolutionary patterns. Integrative approaches are emphasized that link fossil evidence with the physical and chemical evolution of Earth. The prerequisites are college-level biology (BIOL 101–104; or MCDB 120 and E&EB 122); CHEM 167; and mathematics through multivariate calculus (MATH 120 or ENAS 151). The major requirements consist of at least thirteen term courses, for twelve course credits, beyond the prerequisites, including either the senior essay or the senior thesis. Students take G&G 100; G&G 110 or 115, and 111L, to gain geological and environmental context, and they are introduced to the fossil record and evolution in G&G 125 and 126L; higher-level courses in G&G can be substituted with the permission of the director of undergraduate studies. Four core courses give majors a comprehensive background in sedimentary rocks and rock correlation (G&G 332 or equivalent), the study of evolution (G&G 250 or equivalent), microbiology in past and present environments (G&G 255 or equivalent), Earth’s carbon cycle (G&G 308 or equivalent), and statistical data analysis as applied to the life sciences (STAT 101 or equivalent). Four electives selected from Geology and Geophysics, Ecology and Evolutionary Biology (http://catalog.yale.edu/archive/2016-2017/ycps/subjects-of-instruction/ecology-evolutionary-biology), Molecular, Cellular, and Developmental Biology (http://catalog.yale.edu/archive/2016-2017/ycps/subjects-of-instruction/molecular-cellular-developmental-biology), and related fields offer students flexibility in pursuing their specific interests. A list of suggested electives is available from the office of the director of undergraduate studies or on the departmental Web site (http://earth.yale.edu/academics/undergraduate-program). At least one elective must be from G&G.

4. The Solid Earth Science track emphasizes an integrated geological, geochemical, and geophysical approach to the study of processes operating within Earth and their manifestation on the surface. It includes the structure, dynamics, and kinetics of Earth’s interior and their impacts on our environment both in the long term (e.g., the evolution of the land surface) and in the short term (e.g., the causes for natural disasters such as earthquakes, tsunamis, and volcanic eruptions). Students acquire a fundamental understanding of the solid Earth system, both as it exists today and as it has evolved over geologic time scales. The prerequisites are CHEM 167; physics (PHYS 170, 171; 180, 181; or 200, 201); and mathematics through multivariate calculus (MATH 120 or ENAS 151). The major requirements consist of at least eleven courses, for eleven course credits, beyond the prerequisites, including either the senior essay or the senior thesis. To begin study of the Earth system, majors take two introductory courses in G&G, with any accompanying laboratories, selected from G&G 100; 110 or 115, and 111L; 125 and 126L; or 140 and 141L. Higher-level courses in G&G can be substituted with the permission of the director of undergraduate studies. The core of the track consists of four courses chosen from topics in mountain building and global tectonics (G&G 212), rocks and minerals (G&G 220), sedimentary rocks and processes (G&G 332 or equivalent), structural geology (G&G 312), and geochronological principles (G&G 301). Students also select four electives in geology, geochemistry, geophysics, or related topics. A list of suggested electives is available from the office of the director of undergraduate studies or on the departmental Web site (http://earth.yale.edu/academics/undergraduate-program). At least one elective must be from G&G.

B.A. degree program The B.A. degree in Geology and Natural Resources requires fewer upper-level courses than the B.S. degree. It may be more appropriate for students who wish to major in two separate Yale programs, who study geoscience in preparation for a career in law, business, government, or environmental fields, or who decide to pursue a science major only after the freshman year. The prerequisites include mathematics (MATH 115), biology (BIOL 101 and 102, or MCDB 120, or G&G 255), and a lecture course in chemistry. The major requirements consist of at least nine term courses beyond the prerequisites. These include two courses in G&G numbered 100–150, with any accompanying laboratories; courses in natural resources (G&G 205) and geochemical processes (G&G 220 or G&G 232 or 280 or G&G 301); and five additional courses at the 200 level or higher in Geology and Geophysics or related fields, approved by the director of undergraduate studies and including either the senior essay or the senior thesis. Course selections can be guided by any of the B.S. tracks described above.

Senior requirement Seniors in both degree programs must prepare either a senior essay based on one term of library, laboratory, or field research (G&G 492) or, with the consent of the faculty, a two-term senior thesis (G&G 490, 491), which involves innovative field, laboratory, or theoretical research. Students electing to do a senior thesis must first select a topic and obtain the consent of a faculty member to act as an adviser. They must then petition the faculty through the director of undergraduate studies for approval of the thesis proposal. The petition should be submitted by the end of the junior year. If the two-term senior thesis is elected, G&G 491 may count as an elective toward the major. A copy of each senior thesis or senior essay is made available on the departmental Web site (http://earth.yale.edu).

Selection of courses Geology and Geophysics majors may not employ the Credit/D/Fail option for prerequisites or for courses in the major. With permission of the director of undergraduate studies, acceleration credits awarded at matriculation for high scores on national or international examinations (such as Advanced Placement subject tests) may be used to satisfy prerequisites, even if the student does not choose to accelerate. Higher-level courses may, with the permission of the director of undergraduate studies, be substituted for prerequisites and for specific required courses. Qualified juniors and seniors are encouraged to enroll in graduate courses, with permission of the instructor and of the directors of graduate and undergraduate studies. Descriptions of graduate courses are available at the office of the director of undergraduate studies.
Practical experience  In addition to prerequisites and required courses in Geology and Geophysics, candidates for the B.A. and B.S. degrees are strongly encouraged to gain practical experience in the Earth sciences. This can be done in two ways: (1) by attending a summer field course at another academic institution, or (2) by participating in summer research opportunities offered by the Department of Geology and Geophysics, by other academic institutions, or by certain government agencies and private industries. Consult the director of undergraduate studies or see the departmental Web site (http://earth.yale.edu) for further information.

Physics and Geosciences major  The Department of Geology and Geophysics also offers a combined major with the Department of Physics. For more information, see under Physics and Geosciences (http://catalog.yale.edu/archive/2016–2017/ycps/subjects-of-instruction/physics-geosciences).

Combined B.S./M.S. degree program  Exceptionally able and well-prepared students may complete a course of study leading to the simultaneous award of the B.S. and M.S. degrees after eight terms of enrollment. See “Simultaneous Award of the Bachelor’s and Master’s Degrees” under section K, Special Arrangements (http://catalog.yale.edu/archive/2016–2017/ycps/academic-regulations/special-arrangements), in the Academic Regulations. Interested students should consult the director of undergraduate studies prior to the sixth term of enrollment for specific requirements in Geology and Geophysics.

REQUIREMENTS OF THE MAJOR

Prerequisites  B.A. – MATH 135; BIOL 101 and 102, or MCDB 120, or G&G 255; a lecture course in chem; B.S. – All tracks – CHEM 167; MATH 120 or ENAS 151; Atmosphere, Ocean, and Climate track – ENAS 130 or equivalent; ENAS 194; PHYS 180, 181, 205L, 206L; Environmental and Energy Geoscience track – physics (PHYS 170, 171, or 180, 181, or 200, 201) or biology (BIOL 101 and 102, or MCDB 120; and BIOL 103 and 104, or E&EB 122, or G&G 125 and 126L); Paleontology and Geobiology track – BIOL 101–104, or MCDB 120 and E&EB 122; Solid Earth Science track – PHYS 170, 171, or 180, 181, or 200, 201

Number of courses  B.A. – at least 9 courses beyond prereqs for letter grades (incl senior req); B.S. – Atmosphere, Ocean, and Climate track – at least 11 courses, for 10½ credits, beyond prereqs for letter grades (incl senior req); Environmental and Energy Geoscience and Solid Earth Science tracks – at least 11 courses beyond prereqs for letter grades (incl senior req); Paleontology and Geobiology track – at least 13 courses, for 12 credits, beyond prereqs for letter grades (incl senior req)

Specific courses required  B.A. – G&G 205; 1 from G&G 220, G&G 232, 280, G&G 301; B.S. – All tracks – G&G 100, 110 or 115; 111L; Atmosphere, Ocean, and Climate track – G&G 140, 141L, 322, 335; MENG 361; STAT 230 or 238 or MATH 222; Environmental and Energy Geoscience track – 4 from G&G 205, G&G 232, G&G 255, 274, G&G 275, G&G 301, 312, 322, 362; Paleontology and Geobiology track – G&G 125, 126L, 4 from G&G 232, G&G 250, G&G 255, G&G 308, STAT 101 or equivalents; Solid Earth Science track – 4 from G&G 212, 220, G&G 232 or equivalent, G&G 301, 312

Distribution of courses  B.A. – 2 intro courses in G&G, with labs, as specified; 5 addtl courses at 200 level or higher in G&G or related fields; B.S. – Atmosphere, Ocean, and Climate track – 1 intro course in G&G, with lab, as specified; 3 electives as specified; Environmental and Energy Geoscience and Solid Earth Science tracks – 2 intro courses in G&G, with labs, as specified; 4 electives as specified; Paleontology and Geobiology track – 4 electives as specified

Substitution permitted  All programs – with DUS permission, higher-level courses for prereqs or required courses

Senior requirement  All programs – senior essay (G&G 492) or, with permission of faculty, two-term senior thesis (G&G 490, 491)