

Trinity Earth Sciences



Undergraduate Course Handbook 2011-12

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1. Welcome to Earth Sciences at Trinity College Dublin

Welcome from the Course Director



In a world that is changing at an ever increasing rate there has never been a more important time to focus on the science of our natural environment. Earth Scientists play a central role in the race to understand how dynamic Earth systems are changing and what we might be able to do about such change. Earth Scientists also play a crucial role in our search for sustainable use and management of natural resources.

The Earth Sciences degree focuses on Planet Earth, and in particular the composition and structure of the Earth's surface layers, atmosphere and oceans, the dynamic processes that influence and shape our world, and the formation and distribution of resources that we depend upon. Notable areas of study will include climate change, geomorphic hazards (earthquakes, landslides, volcanism, flooding), pollution and the availability and exploitation of resources. The degree aims to produce articulate and informed graduates with a broad knowledge of Planet Earth by providing students with a firm grounding in those sciences that relate directly to the surface of the Earth and to surface-forming, atmospheric and oceanic processes. Particular emphasis will be placed on the development of critical thinking, a scientific approach to understanding, and training in relevant, transferable skills, including laboratory- and field-based analytical techniques.

We hope you will find your time at Trinity challenging, rewarding and enjoyable in equal measure.

Dr Robin Edwards, Course Director.

LEARNING OUTCOMES

On successful completion of your Earth Sciences degree, you will be able to:

- (a) Discuss the major theories, concepts, methods and processes associated with the Earth Sciences
- (b) Demonstrate a detailed knowledge of one or more specialised areas in Earth Science by, for example, being able to identify, analyse and resolve problems. Some of this knowledge will be at the current boundaries of research.
- (c) Apply this knowledge and comprehension in a manner that indicates a thorough and informed approach to your work, and have competences typically demonstrated through devising and sustaining arguments, and formulating and solving problems;
- (d) Use a number of specialised skills and tools, such as spatial data analysis and statistical techniques, which you can use selectively to address complex problems, or to conduct closely guided research.
- (e) Devise data gathering experiments, and to gather and interpret relevant data to inform independent judgements which include reflection on relevant social, scientific or ethical issues;
- (f) Communicate information, ideas, problems and solutions to both specialist and non-specialist audiences;
- (g) To undertake further study with a high degree of autonomy.

IMPORTANT NOTE: The details contained in this booklet are subject to change. In the event of any conflict or inconsistency between the General Regulations published in the University Calendar and information contained in this course handbook, the provisions of the General Regulations will prevail.



2. Course Structure



The Earth Sciences programme at Trinity has a modular structure that combines compulsory and optional elements, thereby giving you increasing levels of choice as you progress with your studies. Every element of the teaching programme at is associated with a credit value based upon the **European Credit Transfer and Accumulation System (ECTS)**. This is a student-centred system that is based upon the workload required to achieve the programme objectives. One year of study comprises work totalling **60 ECTS**.

One ECTS is equivalent to approximately 25 hours of student input

*Note: Student input **does not** correlate with the number of contact hours (ie how long you will spend in lectures, seminars and practical sessions). Instead it measures YOUR input and includes not only your attendance at lectures etc, but also the time taken for completing assessment tasks, individual study including assigned reading, revision and examinations. Working outside of class is a vital element of your studies at Trinity, and to meet the ECTS requirements it will sometimes be necessary to work outside of term time or the regular (5-day) working week.*

The first year (Junior Freshman) comprises six compulsory foundation modules that span the Earth and Physical Sciences and provide a broad background of knowledge that is built upon in the subsequent years.

During the second year (Senior Freshman), students take a further nine compulsory modules including a residential field course. In addition, students take one 5 ECTS module from outside the Physical and Earth Sciences as part of the *Broad Curriculum* programme.

The third year (Junior Sophister) is a programme of twelve modules that are aimed at broadening and deepening knowledge of Earth Science. The year culminates in the development of a research project proposal that will be implemented in the final year of study.

The fourth and final year of the course (Senior Sophister) comprises a mixture of compulsory and optional modules drawn from the Geography and Geology programmes. These are generally more specialist in focus, allowing students to further deepen their knowledge of specific areas of Earth Science, whilst providing opportunities to study new topics that have not been covered in detail in earlier years. In addition, students will undertake a substantial individual research project (20 ECTS).

FURTHER INFORMATION

Some modules will have online material including notes, reading lists and assessment details.

General enquiries regarding the course which are not dealt within this booklet or on the website should be directed to the course director (Dr Edwards).

3. Freshman Module Outlines

JUNIOR FRESHMAN (YEAR 1)

PY1FO1 Foundation Physics for Life and Earth Sciences

10 ECTS

Module Co-ordinator: Prof Eithne McCabe (emccabe@tcd.ie)

Type: Compulsory

Outline: This is a foundation course of lectures, practical work and tutorials that covers: the physics of motion and biomechanics; the physics of hearing and seeing; electricity and magnetism and bioelectricity; radioactivity, nuclear physics and related medical applications; heat; pressure and fluids and their biological, geological and medical applications.

Learning Outcomes: On successful completion of this module students will be able to discuss the physical concepts underlying, and solve problems in relation to, topics which include the following:



- Forces exerted by muscles, jumping, motion through air, motion on rivers; speed, velocity, acceleration, gravity, falling bodies, forces, Newton's laws of motion, statics, torque and rotational motion.
- Biological effects of ionising radiation, radiation diagnostics and therapy, radon gas; introduction to modern physics, atomic physics, radioactivity and nuclear physics
- Geological application of physics
- Efficiency and human activity, work, energy and power
- Heat and the human body, diagnostic and therapeutic uses of heat and cold, volcanoes; temperature and heat
- Biological and medical applications of pressures and fluids to include the cardiovascular system, flow regulation in the circulatory system and the Physics of respiration, ventilators and respirators; pressure and fluids
- Ultrasound for medical diagnostics, the hearing mechanism; elasticity and waves, frequency and intensity
- Image formation in the eye and correction of common eye defect; reflection and refraction of light, lenses, mirrors and optical instruments
- Physiological effects of electrical shock, bioelectricity; electricity and magnetism, simple electric circuits

Assessment: Examination (60%) laboratory practical mark (30%), project mark (10%)

GL1101 Junior Freshman Geology

10 ECTS

Module Co-ordinator: Dr Nicholas (nicholyj@tcd.ie)

Type: Compulsory

Outline: This course is a beginner's guide to our planet, Earth, and the fascinating science of geology. From the vastness of space, to the microscopic crystal structure of minerals; from events which take billions of years like galaxy formation, to volcanic eruptions which may last seconds. Geology, or Earth Science, sets out to investigate the origin and development of the planet, the natural principles that govern it, the processes that act in it, on it, and around it, and

finally the life that has evolved with it. Many sciences are conducted in the laboratory, but to a geologist the Earth itself is the laboratory.

This module follows two main consecutive themes over the course of the Semester. Firstly, 'Earth in Space', investigates the origin of the Universe and our solar system, how the Earth first formed and what makes it 'tick' over millions and billions of years. We will look at how dynamic events occurring below the surface of the Earth constantly change the landscape upon which we live, whether it be building mountains or rifting continents apart. In the second half of the semester, 'Earth and Life' explores how life originated and evolved hand-in-hand with our changing planet. We will look at how Earth has changed the course of evolution, sometimes causing 'mass extinction' events, and conversely, how life has changed the physical properties of the planet itself, such as the composition of our atmosphere. Finally, the module closes with a brief focus on the human impact of living on a dynamic planet; how to understand geological hazards such as volcanic eruptions and earthquakes.



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Learning Outcomes: On successful completion of this module students will be able to:

- Provide a basic explanation of the origin of planet Earth;
- Outline the fundamental physical processes that drive the planet
- Outline the major phases of the evolution of life on Earth
- Review the relationship between Earth resources, geological processes and human activities

Assessment: Examination (60%); In-course multiple choice tests (10%); Tutorial work (30%).

GG1021 Introduction to Geography I: Physical	10 ECTS
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Module Co-ordinator: Mr Quigley (mquigley@tcd.ie)

Type: Compulsory

Outline: This module aims to provide a basic introduction to the large-scale controls and processes that have influenced the physical landscape of the earth as a whole and that have provided the conditions for the evolution of a variety of life forms, species, habitats and ecological systems including those that led to and subsequently influenced human existence. While drawing on many principles within physics, chemistry, geology and biology this module has a distinctly geographical focus with an emphasis on the global scale.

The module will be taught in five sections:

1. Global geotectonic setting;
2. Global atmospheric & oceanic processes;
3. Climate change;
4. Surface processes of landscape development;
5. Global geocology: soils and vegetation.

Learning Outcomes: On successful completion of this module students will be able to:

- Demonstrate the importance of plate tectonics to the Earth sciences, and be able to explain how the distribution of continents and oceans has varied through time;
- Outline the physical evolution of Ireland and be able to place the geography of rock types in Ireland within their geotectonic setting;
- Describe the geography and character of major categories of rock types, and of volcanic and seismic events;
- Illustrate the structure and composition of the earth's atmosphere and oceans;
- Explain the heat budget of the earth and the ways in which heat imbalances are addressed;
- Describe the main atmospheric and oceanic circulation systems and linkages between the atmosphere and oceans;
- Discuss the role of atmosphere and oceans in weather and climate;
- Describe geographic variations in rock weathering regimes;
- Explain the processes that have created the various major types of landforms and the controls on landform evolution;
- Identify the different categories of soil, their properties and processes of formation;
- Describe the characteristics and extent of the major biogeographical units;

Assessment: 3 hour examination (80%); course work (20%)

GG1022 Introduction to Geography II: Human - Environment	10 ECTS
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Module Co-ordinator: Prof Davies (daviesa@tcd.ie)

Type: Compulsory

Outline: This module will introduce key concepts relating nature, society and the environment as well as introducing interactions between humans and their environment, using case studies from the fields of resource exploitation, environmental degradation and environmental hazards.

This module aims to:

- Introduce students to foundational concepts and issues relating to the human-environment interface;
- Expose students to a range of sources and materials for analysing human-environment relations;
- Describe and analyse issues of environmental degradation;
- Identify and evaluate environmental hazards.



Learning Outcomes: On successful completion of this module students will be able to:

- Define environmental geography and describe key areas of concern for environmental geographers;
- Explain the meaning of environmental resources and outline examples of resource exploitation;
- Critically examine environmental management approaches;
- Explain select cases of environmental degradation derived from human-environment interactions;
- Identify and evaluate human-environmental relations within select cases of environmental hazards.

Assessment: 2 hour examination (40%); course work (60%).

CH1101 Introduction to Physical Chemistry**10 ECTS**

Module Co-ordinator: Dr Scully (pnscurly@tcd.ie)

Type: Compulsory

For details of this module please go to the Chemistry website:
<http://www.tcd.ie/Chemistry/teaching/chemistry/if/>

MA1M01 Mathematical Methods**10 ECTS**

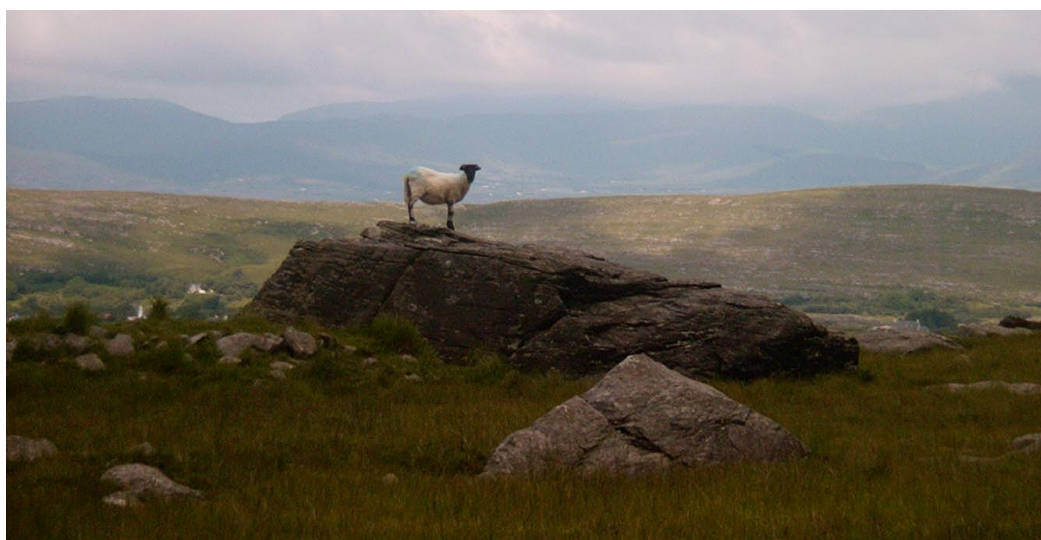
Module Co-ordinator: Dr Levene (levene@maths.tcd.ie), Dr Ryan (ryan@maths.tcd.ie)

Type: Compulsory

Outline: This module is divided into two parts. Part one (Calculus for Life Scientists) covers functions and graphs, differentiation, graphical interpretation of derivatives, exponential and log functions, integration (definite and indefinite). Part two (Discrete Mathematics for Life Scientists) covers linear algebra, working with spreadsheets (e.g. MS excel), properties of data, and probability.

Learning Outcomes: Contact module co-ordinators for learning outcomes

Assessment: 3 hour examination (75%); course work (25%)



SENIOR FRESHMAN (YEAR 2)**GG2021 Changing Worlds****10 ECTS****Module Co-ordinator:** Mr Quigley (mquigley@tcd.ie)**Type:** Compulsory**Outline:** This module integrates human and physical geography and is linked to GG2202: *Collection and Analysis of Geographical Data*.**Physical Geography**

Geomorphology: Fluvial processes and geomorphology including mass-movements and hill-slope processes drainage basins, sediment transport, channel morphology and landscape evolution.

Hydrology and water resources: The global hydrological cycle and the basin hydrological system with particular reference to conditions in Ireland. The importance of water to humans, water as a hazard (floods) and the globalisation of water (water footprints).

Biogeography and Conservation: Building on the material of the JF Geoecology sub-module which examined the geographical distribution of living organisms as a response both to various limiting environmental conditions and to the in-built tolerance of species to environmental gradients, this section of the SF Changing Worlds course will focus first on the geographical significance of various positive and negative interspecific relationships within ecosystems including competition, predation, mutualism etc. It will then examine, on various spatial and temporal scales, the historical dimensions of the dynamics of species distribution by exploring the effects of evolution, migration and extinction of species as a response to environmental change.

Human Geography

The world system is currently in a period of rapid spatial change, commonly known as globalization. The human geographical component of the course examines the rise and restructuring of the current world system from a geographic perspective. The first section introduces the processes and geographical patterns of European overseas expansion, c.1400 - c.1700. The Portuguese, Spanish and Dutch overseas empires are examined from a comparative perspective. China's experience of overseas expansion in the early fifteenth century is also considered.



The next two sections examine issues relating to globalisation and economic and political geography. Particular attention is given to developments in Asia and Africa.

The final section of the Changing Worlds module addresses how human geography is approaching the relationship between humans and their environment in an increasingly globalised world.

Learning Outcomes: On successful completion of this module students will be able to:

- Identify important topics and themes in contemporary physical and human geography;
- Appraise some of the major current debates in Geography.

Assessment: 3 hour examination (80%); course work (20%)

GG2022 Collection & Analysis of Geographical Data**10 ECTS****Module Co-ordinator:** Dr Raleigh (raleighc@tcd.ie)**Type:** Compulsory

Outline: Divided into three components, dealing with techniques used in the acquisition and analysis of quantitative, qualitative and digital spatial data, the module aims to introduce students to a variety of methods in geographical study, analysis and research; enable students to select appropriate methods to study diverse geographical issues; and develop student's geographical skills of numeracy, data management, manipulation, analysis, display, interpretation and explanation.

Lectures will cover: Research design; tools and data collection; quantitative and qualitative data analysis, and GIS and remote sensing. Practical sessions will cover: formulating research questions and problem solving; formulating interviews and questionnaires, use of Excel for data handling and data presentation; application of statistical techniques; application of GIS in human and physical Geography; introduction to remote sensing and image processing; and fieldwork.

Learning Outcomes: On successful completion of the module students will be able to:

- Outline and contrast a range of methodological approaches adopted in geographical analysis and research;
- Formulate basic research questions and proposals in both human and physical Geography contexts;
- Design simple research projects using a diversity of approaches and techniques;
- Select appropriate software packages and methods to undertake analysis;
- Interpret the results of basic analysis and present these findings on an individual and group basis.

Assessment: Course work (100%)

GL2299 Earth Sciences Field Course**5 ECTS****Module Co-ordinator:** Dr Wyse Jackson (wysicknp@tcd.ie)**Type:** Compulsory

Outline: This module is based on an extended residential field course. Geological rock types and structures are examined which illustrate topics covered in other freshman geology modules. Quaternary sediments and geomorphological features covered in freshman geography modules are also examined. Emphasis is placed on practical aspects of the earth sciences, especially interpreting outcrops and recording data in a systematic way.

Learning Outcomes: On successful completion of the module students will be able to:

- Identify common sedimentary, igneous and metamorphic rocks in the field;
- Identify and record basic geological features;
- Describe and record a range of Quaternary sediments and landforms;
- Conduct a basic surveying exercise.

Assessment: Course work (100%)

**GG2299 Geochemistry for Earth Scientists****5 ECTS****Module Co-ordinator:** Dr Rocha (rochac@tcd.ie)**Type:** Compulsory

Outline: This introductory module will focus mainly on the chemistry of earth processes, including the chemical evolution of the planet as whole through geological time. The material to be imparted will have a strong foundation on Earth System Science, thereby discussing the chemical processes underpinning interactions between the lithosphere, the hydrosphere and the atmosphere, including practical and theoretical aspects of planetary formation, the evolution of the atmosphere (including recent changes) and ocean compositional changes through time. This material will be brought together to understand the natural and anthropogenic drivers of life on earth, including the close chemical relationships between the compositional nature of living organisms, sediments and soils, water and the atmospheric gases.

Learning Outcomes: On successful completion of the module students will be able to:

- Illustrate the role chemistry plays in understanding the Earth system
- Identify specific clusters of elements and describe their role in natural geochemical processes.
- Illustrate how living systems control and/or are influenced by the geology and chemistry of the Earth
- Examine natural geochemical processes through a combination of field and laboratory-based exercises;
- Evaluate, interpret and summarize fundamental principles to explain natural phenomena arising from complex interactions between the biosphere, the lithosphere, the atmosphere and the hydrosphere.

Assessment: Course work (100%)

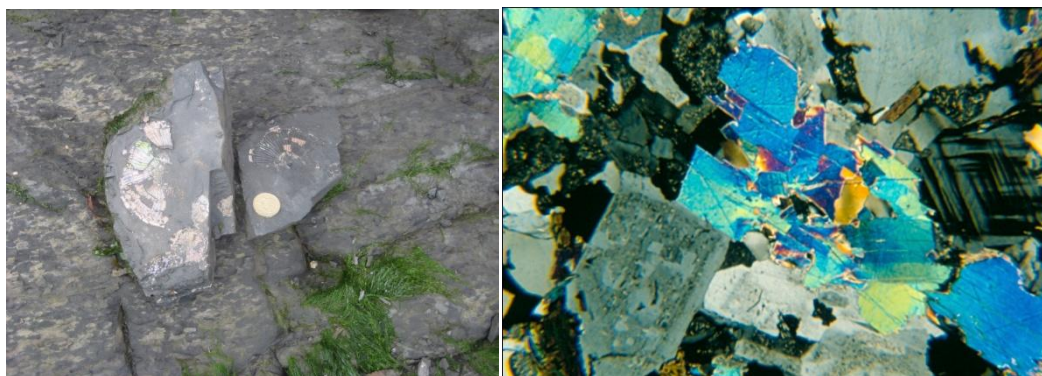
GL2201 Mineralogy**5 ECTS****Module Co-ordinator:** Dr Sanders (isanders@tcd.ie)**Type:** Compulsory

Outline: The aims of this module are to introduce the study of minerals - the solid chemical compounds from which rocks are made. It includes the appearance of minerals in hand specimens, the essentials of crystallography to explain their shapes and other properties, the practical use and the underlying principles of polarised light microscopy to look at minerals in transparent slices of rock called thin sections, and a systematic review of the main groups of minerals covering where they are found, what they look like, what elements they contain, and their physical stability. The module includes a half-day field trip to Dalkey Quarry and Killiney.

Learning Outcomes: On successful completion of this module students will be able to:

- Operate a polarised light microscope to describe minerals in thin sections of rock
- Outline the relationship between the atomic structure of minerals and their appearance in hand sample and thin section of rock

Assessment: Theory examination (60%); Practical examination (20%); In course exercises (15%); Field Trip (5%)

**GL2202 Palaeontology & Stratigraphy****5 ECTS****Module Co-ordinator:** Prof Clayton (gclayton@tcd.ie)**Type:** Compulsory

Outline: This module aims are to provide: (1) the means to identify a broad range of invertebrate and vertebrate fossils; (2) an understanding of form and function in fossil organisms and their links to living floras and faunas; (3) an overall appreciation of the evolutionary record of life on Earth; (4) an introduction to the geological evolution of Ireland.

Learning Outcomes: On successful completion of this module students will be able to:

- Outline and illustrate the diversity and palaeobiology of organisms found in the fossil record;
- Explain the concepts of fossilization, evolutionary sequences and lineages
- Describe the application of fossils in palaeobiological, palaeogeographical and evolutionary studies
- Describe the basic principles underlying taxonomic procedures
- Provide a sketch overview of the geological history of Ireland

Assessment: Theory examination (50%), Practical examination (20%), In course laboratory assessment (30%)

GL2203 Petrology**5 ECTS****Module Co-ordinator:** Dr Graham (jrgraham@tcd.ie)**Type:** Compulsory

Outline: This module aims to provide a basic understanding of igneous, sedimentary and metamorphic rocks. Techniques of describing and reaching first stage interpretations of rocks in hand sample and thin section will be covered. Rock associations will be placed in a global context. The module includes a half-day field trip to Howth.

Learning Outcomes: On successful completion of this module students will be able to:

- Identify common rock types in the field
- Conduct basic laboratory analysis to identify and classify common rock types in hand sample and thin section
- Describe the processes and environments responsible for the formation of these common rock types
- Outline the relationship between these common rock types and the major tectonic settings on earth.

Assessment: Theory examination (60%), Practical examination (20%), In course laboratory work (15%), and Field Trip (5%)

PY2P30 Physics for Earth Scientists**5 ECTS****Module Co-ordinator:** Prof Lunney (jlunney@tcd.ie)**Type:** Compulsory

Outline: The aim of this module is to provide an introduction to the application of physical principles in the study of earth science. The module will be taught through a combination of lectures, laboratory classes and tutorials.

Learning Outcomes: On successful completion of this module students will be able to:

- Apply Newtonian mechanics to the description of gravitational attraction, planetary motion and origin of tides and effect of Coriolis force in atmospheric circulation.
- Apply principles of statics to describe bodies in equilibrium, elasticity and fracture.
- Understand and calculate hydrostatic pressure, buoyancy and flow in fluid systems.
- Understand the mechanical analysis of seismic and water waves, including calculation of wave velocity, reflection and refraction.
- Understand the concepts of heat and temperature and elementary thermodynamics.
- Describe and calculate adiabatic processes in the Earth's atmosphere, including the effects due to water vapour.
- Describe and do calculations involving radiative transfer and energy balance in the Earth's atmosphere.
- Describe the various types of radioactive decay and do calculations involving radioactive dating.
- Make measurements on a physical system, analyse the results and prepare a report.

Assessment: Examination (65%), laboratory practical work (35%)

GL 2204 Structural Geology & Mapwork**5 ECTS****Module Co-ordinator:** Dr Chew (chewd@tcd.ie)**Type:** Compulsory

Outline: The structural geology part of the course examines the geometries, kinematics, mechanics and formation mechanisms of deformed rocks. The principles of rock deformation are covered including the classification of structures and the concepts of stress and strain. The lectures provide a global overview of active plate tectonic processes, including continental margin evolution, rifting, collisional processes from subduction zones to mountain building, and transform settings. The practicals aim to develop an understanding of map interpretation and the visualization of structures in three dimensions. Topics covered will include folds, faults, unconformities and three point problems, along with interpretation of published geological maps. The aim of the part of this course called Kitchen Physics is to hone quantitative skills by applying basic physics to solving geological problems relating to volume, density, gravity, pressure, seismic waves, heat and radioactivity.

Learning Outcomes: On successful completion of this module students will be able to:

- Discuss rock rheology, the concepts of stress and strain, and brittle and ductile deformation processes.
- Classify and summarise processes forming rock fabrics, faults, fractures and fault zone rocks and describe and classify folds.
- State the basic tectonic principles and structural features of rifted continental margin formation, from continental rifts through to passive margins
- Outline the basic geodynamic principles of plate tectonics.
- Read, interpret and create simple geologic maps.
- Create a crude structural cross section from a geologic map showing interpreted subsurface rocks and structures
- Manipulate simple mathematical formulae to assist solution of geological problems

Assessment: Theory exam: 70%; In-course practical work: 30%

**Broad Curriculum Module****5 ECTS**

Students select one the Broad Curriculum (Cross-Faculty) modules with the exception of: BCBOT (Living Sustainably) and BCGEOL (Planet Earth).

Details on the Broad Curriculum Programme can be found at:

https://www.tcd.ie/Broad_Curriculum/cfc/index.php

JUNIOR SOPHISTER (YEAR 3)**GG3035 Advanced Research Methods in Earth Science****5 ECTS****Module Co-ordinator:** Dr Edwards (robin.edwards@tcd.ie)**Type:** Compulsory

Outline: The objective of this module is to develop the research skills required to plan and execute an individual piece of guided research (the dissertation). Students will be provided with some basic training in research design, critical evaluation of academic literature, and presentation skills, before being introduced to a selection of topics that may form the basis of their final year dissertation. The module culminates in the production of a research proposal that will be implemented in the final year of study.

Learning Outcomes: On successful completion of the module students will be able to:

- Evaluate the strengths, weaknesses and appropriateness of a range of research methods employed in the Earth Sciences;
- Summarise and critique previous academic research published in peer-reviewed literature;
- Plan a significant piece of individual research and present this succinctly in the form of a research proposal.

Assessment: Course work including production of a final year dissertation research proposal (100%)

GG3020 Coastal Processes and Management 1**5 ECTS****Module Co-ordinator:** Mr Quigley (mquigley@tcd.ie)**Type:** Compulsory

Outline: This module views coasts as integrated spatial systems by analysing the interrelationships between physical and biological inputs, drawing on literature in the areas of coastal geomorphology and ecology. Coasts can be seen as highly complex systems that are very sensitive to changes in any input, be it physical, biological or human-induced. In the light of this, the module examines the morphodynamics of coasts on different temporal and spatial scales. It begins with an examination of the dynamics of inshore waters, including the origins and characteristics of waves, tides and currents before dealing with the sedimentological responses to these phenomena at the land/sea interface. The morphology and dynamics of various types of coastal features, especially those found in 'soft coast areas', will be considered in detail. The analysis of soft coasts as physico-biological systems, with a particular focus on the development of sand-dune, machair and salt-marshes will form a major part of this module.

Learning Outcomes: On successful completion of the module students will be able to:

- Explain the dynamics of waves, tides and currents that have a bearing on near-shore processes;
- Interpret the dynamics of sediment transfers in the near-shore zone;
- Describe the morphodynamics of soft coast systems;
- Discuss the importance of biological inputs into the physical landforms of the coast.

Assessment: 3 hr examination (100%)

GG3036 Earth Sciences - Tutorial**5 ECTS****Module Co-ordinator:** Dr Edwards (robin.edwards@tcd.ie)**Type:** Compulsory

Outline: These small group tutorials will focus on topical issues in the Earth Sciences and are aimed at developing critical engagement with current academic literature through set readings, individual study and group discussion. Emphasis will be placed on the societal relevance of Earth Science and the manner in which the wider scientific community engages with the public.

Learning Outcomes: On successful completion of the module students will be able to:

- Outline some key current debates in Earth Science;
- Discuss the societal relevance of selected topics in Earth Science;
- Evaluate the manner in which scientific knowledge is constructed and disseminated within and beyond the academic arena.

Assessment: Coursework (100%)

GL3315 Geological Fieldwork**5 ECTS****Module Co-ordinator:** Dr Graham (jrgraham@tcd.ie)**Type:** Compulsory

Outline: This module builds on GL2299 in terms of rock identification in the field. There is an emphasis on spatial and temporal relationships of different rock packages and the techniques with which these are recorded.

Learning Outcomes: On successful completion of the module students will be able to:

- use the basic techniques and applications at their disposal to describe and record information from rocks in the field;
- establish and interpret at a preliminary level, stratigraphic successions using base maps and measured vertical profiles.

Assessment: Coursework (100%)



GL3313 Geological Cartography**5 ECTS****Module Co-ordinator:** Dr Nicholas (nicholyj@tcd.ie)**Type:** Compulsory

Outline: The aim of this module is to investigate all the techniques needed for students to produce digital geological maps at a variety of scales and detail from their own field observations. The module will examine some basic background to maps, such as projection, coordinate systems and scale factors. It will also demonstrate how to use Global Positioning Systems (GPS) effectively in the field to record positions accurately on a base map. Different types of potential base map and their applications will also be investigated, including how to make your own high resolution satellite map, complete with coordinate grid, for any area in the world.

The module will focus mainly on its practical component, and will include students constructing their own scale sketch maps using just a blank sheet of paper and a GPS. Instruction will also be given on how to convert a hand-drawn field map into a scale, coloured digital version with software drawing packages, such as will be required in the summer mapping projects. Everyone will try their hand at digitising their own field maps from the Isle of Arran field module and learn how to orally present their maps and the information they contain to an audience using software such as Powerpoint.

Learning Outcomes: On successful completion of the module students will be able to:

- create a variety of base maps suitable for field mapping;
- use a handheld GPS to record field data accurately onto a map;
- digitise hand-drawn field maps;
- present orally and digitally maps and associated data to an audience.

Assessment: Coursework (100%)

GG3475 Glacial Geomorphology**5 ECTS****Module Co-ordinator:** Prof Coxon (pcoxon@tcd.ie)**Type:** Compulsory

Outline: The course is an introduction to the landforms and processes of glaciation. It covers past and recent work on glacial geomorphology and concentrates on landforms and sediments and their production by glaciers. The topics covered include: history of glacial studies, physical properties of ice, ice motion, glacier systems, thermal regime, erosional processes and landforms, glacial deposition, mineral exploration in glacial terrain, engineering geology in glaciated areas, moraines and drumlins, meltwater deposition and erosion (process and form). Examples are taken from Ireland where relevant and the course outlines the need for further work in many regions of the country.

Learning Outcomes: On successful completion of the module students will be able to:

- Have gained a basic knowledge of the main elements of glaciology
- Have gained a knowledge Ireland's glacial history
- Have gained a knowledge of modern glacial geomorphology
- Recognise the importance of the study of glacial geomorphology

Assessment: 3 hr examination (100%)

GL3304 Isotopes and analytical techniques**5 ECTS****Module Co-ordinator:** Dr Crowley (crpwleyg@tcd.ie)**Type:** Compulsory

Outline: This module consists of three components: (1) Radio-isotopes: This part of the module aims to provide a broad introduction to radioactive isotopes and the principles of geochronology (such as closure temperatures, isotope dilution and isochrons). It includes the theory and application of U-Pb, K-Ar, ^{40}Ar - ^{39}Ar , Rb-Sr, Sm-Nd, Re-Os and Lu-Hf isotopic systems. It also introduces, fission track dating and U-Th-He dating (low temperature thermochronology). (2) The Practical Stable Isotopes module introduces the use of stable isotopes of nitrogen, carbon and oxygen in studies related to the interaction of the biosphere. The theory and technology behind isotope ratio mass spectrometry is presented. (3) Analytical techniques introduces many of the currently used methods for quantitative chemical analysis of minerals and rocks (electron probe, X-ray fluorescence, atomic absorption, inductively coupled plasma mass spectrometry, thermal ionisation mass spectrometry); for mineral determination (X-ray diffraction); and for imaging rocks and minerals (scanning electron microscopy, transmission electron microscopy, cathodoluminescence, reflected light microscopy). Basic sample preparation techniques and site visits to various working laboratories are included.

Learning Outcomes: On successful completion of the module students will be able to:

- outline the principles of isotopic dating
- give examples of the application of the radioactive decay schemes used to date ancient geological evolution.
- outline the use of radiogenic isotopes as petrogenetic tracers, and of techniques for dating events during the Quaternary
- describe the sample preparation and analysis methods for stable isotopes studies of organic and carbonate materials
- outline the types of scientific questions that can be addressed using stable isotopes.
- explain the principles of some common analytical techniques
- perform simple calculations relating to processing analytical data.

Assessment: Theory examination (66%) coursework (34%)

GL3306 Palaeontology, Palaeoecology, & Evolution**5 ECTS****Module Co-ordinator:** Dr Wyse Jackson (wysjcknp@tcd.ie)**Type:** Compulsory

Outline: The aims are to provide (1) an understanding of evolutionary processes; (2) a link between modern and ancient ecosystems; (3) a synopsis of methodologies in taxonomy; and (4) guidelines on how to gather biological data from fossils in the field.

Learning Outcomes: On successful completion of the module students will be able to:

- describe the evolutionary steps displayed in the fossil record
- outline the modern ecological parameters that act on the biosphere and be able to apply this information to the fossil record
- summarise basic statistical and qualitative techniques used when investigating fossils in the field and in the laboratory
- discuss the basic principles of taxonomic procedures

Assessment: Theory examination (60%); in-course laboratory practical work and seminars (40%)

GL3311 Past Environments**5 ECTS****Module Co-ordinator:** Dr Graham (jrgraham@tcd.ie)**Type:** Compulsory

Outline: The module will examine the major depositional environments at the Earth's current surface and will relate information from these to the preserved successions of rocks. The aim is to develop strategies to then be able to work backwards from a preserved record to interpret palaeoenvironments.

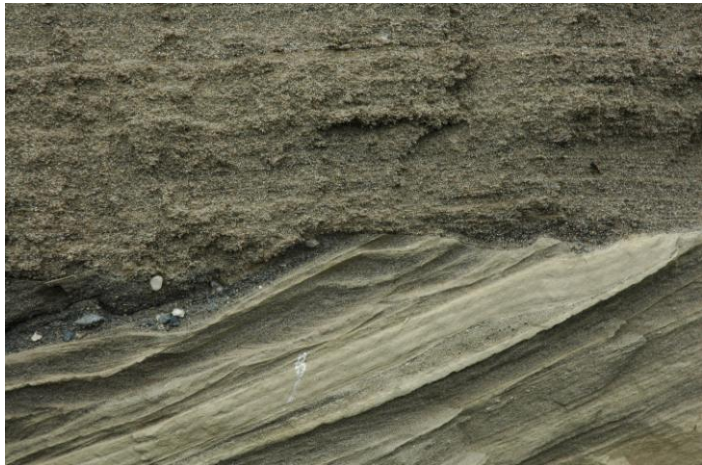
Learning Outcomes: On successful completion of the module students will be able to:

- outline the relationship between physical and biological processes and resultant sedimentary structures;
- describe how ancient environments can be deduced from the information preserved in the stratigraphic record;
- interpret depositional environment based both on field observations and on published data

Assessment: Theory examination 80%, coursework 20%

GG3034 Practical Physical Geography**5 ECTS****Module Co-ordinator:** Prof Coxon (pcoxon@tcd.ie)**Type:** Compulsory

Outline: This course is aimed at students who are considering a physical geography dissertation project. The student numbers will be limited. A white laboratory coat is required for this course. Sharp pencils, calculator, ruler (metric) and a protractor are also required. Basic mapwork using OS 1:50,000 series maps and GSI geological maps. Fluvial geomorphology from maps, simple drainage basin analysis, analysing geological and climatic controls on fluvial landscapes. Orientation and altitude of corrie basins. Basic field and laboratory methods including sediment descriptions, clast fabric, particle size analysis and loss of ignition measurements. Simple data handling using spreadsheets and graphics packages.



Learning Outcomes: On successful completion of the module students will be able to:

- Have gained practical experience in the use of OS maps
- Have gained a knowledge of simple surveying techniques
- Have gained a knowledge of laboratory methods in physical geography

Assessment: 100% coursework including a one day field exercise

GG3029 Quaternary Environmental Change & Climate**5 ECTS****Module Co-ordinator:** Dr Edwards (robin.edwards@tcd.ie)**Type:** Compulsory

Outline: This module contrasts 'glacial' and 'interglacial' worlds, examines the nature of the transitions between them, explores some potential causes of change, and illustrates their environmental impacts. In the process, a range of key environmental records are considered, along with the 'proxies' used to develop them.



Learning Outcomes: On successful completion of the module students will be able to:

- Describe what is meant by the terms 'glacial' and 'interglacial' and outline their key characteristics with particular reference to Europe and Africa;
- List the principal types of stratigraphic information used in Quaternary science and illustrate their application with reference to named examples;
- Explain the physical processes causing sea level change and outline their significance for plant and animal migration and colonisation;
- Describe how ice and sediment cores can provide information on past environments and illustrate their applications and limitations with reference to named examples;
- Outline atmospheric and oceanic circulation change and comment on their potential significance for abrupt climate transitions.

Assessment: 1.5 hr examination (50%), course work (50%)

GL3301 Sedimentary Petrology - from sediment to rock**5 ECTS****Module Co-ordinator:** Dr Graham (jrgraham@tcd.ie)**Type:** Compulsory

Outline: The aims are (1) To acquire a basic understanding of how sediment is produced at the Earth's surface and then becomes rock. (2) To be able to relate the information preserved in these sedimentary rocks to physical, chemical and biological processes that occurred during their formation.

Learning Outcomes: On successful completion of the module students will be able to:

- provide technical descriptions of common sedimentary rock types from hand samples and thin sections
- describe appropriate strategies for laboratory investigation of sedimentary rocks
- produce basic interpretations of petrological evidence.

Assessment: Theory examination (50%); practical examination (25%); in course laboratory practical work and seminars (25%)

4. EXAMINATIONS AND ASSESSMENT

Throughout your degree, your progress will be evaluated by examination and course work. Details concerning examination procedures are documented in the *College Calendar* and you are advised to familiarise yourselves with these at the earliest opportunity.

In all cases, the end-of-year mark is calculated according to the relative ECTS weightings of the modules taken.

In the case of supplemental examinations, any marks gained from continuous assessment are carried forward to the supplemental exam.

EXAMINATIONS

The regulations governing examinations are set out in the College Calendar.

Examination timetables are published in advance of the dates of examinations. See the examinations office website for more details (<http://www.tcd.ie/Examinations/Timetables/>). You must ensure that you are available for the duration of the examinations period as presented in the College Calendar (<http://www.tcd.ie/calendar/>).

NOTE: It is your responsibility to establish the dates, times and venues of examinations. No reminders will be sent to you.

The College employs anonymous marking where practically possible. Results will be published by student number. The marking criteria used when marking examination scripts are presented in the relevant section below.

AN IMPORTANT NOTE REGARDING PLAGIARISM

Plagiarism is interpreted by the University as the act of presenting the work of others as one's own work, without acknowledgement. Plagiarism is considered as academically fraudulent, and an offence against University discipline. The University considers plagiarism to be a major offence, and subject to the disciplinary procedures of the University.

Plagiarism can arise from deliberate actions and also through careless thinking and/or methodology. The offence lies not in the attitude or intention of the perpetrator, but in the action and in its consequences.

Plagiarism can arise from actions such as:

- (a) copying another student's work;
- (b) enlisting another person or persons to complete an assignment on the student's behalf;
- (c) quoting directly, without acknowledgement, from books, articles or other sources, either in printed, recorded or electronic format;
- (d) paraphrasing, without acknowledgement, the writings of other authors.

Examples (c) and (d) in particular can arise through careless thinking and/or methodology where students:

- (i) fail to distinguish between their own ideas and those of others;
- (ii) fail to take proper notes during preliminary research and therefore lose track of the sources from which the notes were drawn;
- (iii) fail to distinguish between information which needs no acknowledgement because it is firmly in the public domain, and information which might be widely known, but which nevertheless requires some sort of acknowledgement;
- (iv) come across a distinctive methodology or idea and fail to record its source.

All the above serve only as examples and are not exhaustive.

Students should submit work done in co-operation with other students only when it is done with the full knowledge and permission of the lecturer concerned. Without this, work submitted which is the product of collusion with other students may be considered to be plagiarism.

It is clearly understood that all members of the academic community use and build on the work of others. It is commonly accepted also, however, that we build on the work of others in an open and explicit manner, and with due acknowledgement. Many cases of plagiarism that arise could be avoided by following some simple guidelines:

- (i) Any material used in a piece of work, of any form, that is not the original thought of the author should be fully referenced in the work and attributed to its source. The material should either be quoted directly or paraphrased. Either way, an explicit citation of the work referred to should be provided, in the text, in a footnote, or both. Not to do so is to commit plagiarism.
- (ii) When taking notes from any source it is very important to record the precise words or ideas that are being used and their precise sources.
- (iii) While the Internet often offers a wide range of possibilities for researching particular themes, it also requires particular attention to be paid to the distinction between one's own work and the work of others. Particular care should be taken to keep track of the source of the electronic information obtained from the Internet or other electronic sources and ensure that it is explicitly and correctly acknowledged.

It is your responsibility to ensure you do not commit plagiarism. If in doubt, you should seek advice from a lecturer, tutor or supervisor on avoiding plagiarism. See Guidelines on Referencing below. NB: Assignments may be checked using anti-plagiarism software.

GUIDELINES ON REFERENCING

Earth Sciences employs the Harvard Referencing system and students must use this method in all written work (including presentations). Please note the following points:

1. You should insert a citation when referring to the work or ideas of others. This can be done when you are reviewing existing work, or using the work of others to support your own arguments.
2. You should cite all references within the text using the author's surname (no first names or initials) followed by the year of publication. For example, "Smith (2009) demonstrates that..." or "These results support previous work in this area (Smith, 2009)."
3. If there are two authors, include both in the citation within the text. For example, "Smith & Jones (2009) demonstrate that...". If there are three or more authors, insert "et al." after the first author. For example, if Smith & Jones write a paper with their colleague Blogs, this should be cited in the text as "Smith et al. (2009) demonstrate that...".
4. When citing multiple works, references must be arranged in chronological order within the text. For example, "These results support previous work in this area (Smith, 2001; Jones, 2004; Smith et al., 2009).
5. At the end of your assignment, you must compile a REFERENCE LIST that includes all of the material cited in your work. This differs from other forms of Bibliography that may list work that has not been cited (e.g. recommended reading).

6. Your reference list must be in alphabetical order by first author's surname, with material by individual authors ordered chronologically. For example, the papers above would be listed as:

Jones, A.B. (2004)

Smith, C.D. (2001)

Smith, C.D. (2009)

Smith, C.D., Jones, A.B. (2009)

Smith, C.D., Jones, A.B., Bloggs, E.F. (2009)

7. The precise format of the references varies with publication type. Common examples are:

Academic Journal papers:

Smith, C.D. (2001) Title of the paper. *Name of the Journal* **Vol No.**, pg X-Y.

Books:

Jones, A.B. (2004) *Title of Book*. Edition. Publisher:Location, No. of pages.

Website:

Author names (Year) *Title of webpage* (online), URL, [Date Accessed]

For more information see the guide on the Freeman Library Website:

https://www.tcd.ie/Geography/GeographyWebsite/Freeman/FAQ_referencing.php

5. Staff and Contacts

Specific enquiries relating to individual modules should be directed to the module co-ordinator or the member of teaching staff involved.

Administrative support for Earth Sciences is provided by the Geology Office.

Executive Officer: Dr Mags Duncan (earth@tcd.ie); Tel: (01) 896 1074

Course Director

Dr Robin Edwards B.Sc. (Southampton), Ph.D. (Dunelm)

Research Interests: Sea level change & climate; foraminifera; quantitative palaeoenvironmental reconstruction; oceanography; coastal change; environmental archaeology.

Contact: robin.edwards@tcd.ie

Module Co-ordinators

Dr Dave Chew

Research Interests: Applying geochronology and thermochronology to a variety of geological problems. These include the timing of orogenesis in ancient orogenic belts (The Caledonides and Andes), isotopic dating of sedimentation (particularly Neoproterozoic glacial sequences) and exhumation studies using low temperature thermochronology

Contact: chewd@tcd.ie

Dr Quentin Crowley, B.Sc. (NUIG), Ph.D. (NUIG)

Research Interests: Geochronology, Igneous and metamorphic petrology, Isotope geochemistry, structural geology, volcanology

Contact: crowleyq@tcd.ie

Prof Geoff Clayton

Research Interests: 1) PALYNOLOGY - the use of palynomorphs in Palaeozoic rocks to determine their age, depositional environment and palaeogeographic setting. 2) ORGANIC PETROLOGY – interpretation of thermal histories of rocks based on studies of microscopic plant debris and other organic particles

Contact: gclayton@tcd.ie

Prof Peter Coxon, B.Sc. (Sussex), Ph.D. (Cantab.), F.T.C.D.

Research Interests: Dating and analysis of landscape change using pollen analysis; biostratigraphy of late Tertiary and mid-late Pleistocene deposits; glacial geomorphology; bog flows; environmental archaeology of buried walls and Early Christian structures in western Ireland.

Contact: pcoxon@tcd.ie

Dr John Graham

Research Interests: Clastic sediments, Geology of Ireland particularly Carboniferous, Devonian and Ordovician, Provenance studies, Variscan fold belt.

Contact: jrgraham@tcd.ie

Dr. Rupert Levene

Research Interests: Operator Algebras and Operator Spaces

Contact: levene@maths.tcd.ie

Prof. James Lunney, B.Sc (Belfast), Ph.D. (Belfast)

Research Interests: laser ablation of solids; pulsed laser deposition of thin films and nanoparticles; electrical discharge plasma devices; applications of conical diffraction.

Contact: jlunney@tcd.ie

Dr Chris Nicholas, Ph.D. (Cantab.)

Research Interests: Clastic sediments, Stratigraphy, Sedimentary Processes, Ecological Evolution, Ecosystems Energy and Climate Change, Geochemistry, Hydrocarbons, exploration and production, Paleoclimatology, Paleoecology, Petroleum geology, Physical Oceanography, Volcanology.

Contact: nicholyj@tcd.ie

Mr Michael Quigley, B.A. (N.U.I.), M.A. (N.U.I.).

Research Interests: Biogeography; geomorphology, environmental issues, especially in Ireland; special interest in sand dunes.

Contact: mquigley@tcd.ie

Dr Clionadh Raleigh

Research Interests: African Governments, Political Geography, Local Impacts of Climate Change, African Civil Conflict Patterns, Human Security Spatial Analysis, Statistics and Geographic Information Systems (GIS).

Contact: raleighc@tcd.ie

Dr. Sinéad Ryan

Research Interests: High Energy Physics, Quantum Field Theory, Lattice QCD, Heavy Quark Physics.

Contact: ryan@maths.tcd.ie

Dr Carlos Rocha, B.Sc. (Lisbon). Ph.D. (Lisbon)

Research Interests: Marine and Environmental Biogeochemistry, Oceanography, Climate Change forcing on Carbon and Nitrogen Cycling, Benthic nutrient cycling, Estuarine nutrient dynamics.

Contact: rochac@tcd.ie

Dr Ian Sanders, BA (Cantab.), MA (Cantab.), Ph.D. (Cantab)

Research Interests: Building stone, Earth Science, Planets, Solar system

Contact: isanders@tcd.ie

Dr Patrick Wyse Jackson,

Research Interests: Palaeontology; Palaeozoic bryozoans; Recent bryozoans; History of Geology; History of Science in Ireland; Building Stones and materials.

Contact: wysicknp@tcd.ie

7. Facilities, Conduct and Safety

Please ensure that you read the regulations and safety information below. In addition, you should consult the general College regulations which are set out in the College Calendar (available from the Freeman and Berkeley Libraries or online at <http://www.tcd.ie/calendar/>).

Under the *Health and Safety at Work Act (1989)*, you are responsible for your own safety and that of your fellow students.

The person in charge must be informed immediately if any student falls ill during class, in a laboratory practical or on field work. If the student needs medical attention, inform the doctor of when and where the illness took place. In the case of accidents, however trivial, always inform the lecturer or laboratory supervisor.

Please make a mental note of the position of fire extinguishers and of the clearly marked emergency exits from lecture rooms. If the fire alarm sounds, please leave the building in an orderly fashion by one of the marked exits. Assemble on the forecourt of the Berkeley Library. When in the building, do not run or act in a foolish manner and avoid cluttering benches, floors and walkways with personal effects. Bicycles should not be brought into the building. Impeding exits jeopardises safety.

You are not permitted to smoke or bring food and drink into laboratories (including computing rooms), lecture and seminar rooms.

If you suffer from any health problem, such as colour blindness, epilepsy, asthma, fainting fits, haemophilia, general allergies, immunodeficiency, diabetes, balancing disorders, or any other health problem likely to affect your work, you must:

1. Inform your doctor of your intention to undertake laboratory and field work and seek relevant advice.
2. Notify your tutor.
3. Inform project / practical supervisors and field-course leaders.

Before embarking on any fieldwork, you must familiarise yourself with the Fieldwork Safety Manual, consult your supervisor and complete the relevant Fieldwork Safety and Risk Assessment forms.

IMPORTANT NOTE: Failure to complete the relevant forms may prevent you from undertaking fieldwork or participating in field trips, and can result in you forfeiting marks for associated work.

LABORATORIES

Never undertake experiments or use equipment or materials without first receiving instructions. White laboratory coats must be worn when undertaking experiments using chemicals. Students engaged in laboratory-based research must obtain prior approval from and discuss the precise nature of that activity with their supervisor. Particular care must be exercised when using equipment or chemicals. No students are allowed to work in laboratories unsupervised, or after 5 p.m. and on weekends/bank holidays.

FIELDWORK AND FIELDTRIP SAFETY

You must familiarise yourself with the Fieldwork Safety Manual and, where applicable, complete the relevant Health Questionnaire, Fieldwork Safety and Risk Assessment forms. In addition to following the instructions of fieldtrip leaders, please also pay particular attention to the following:

1. Always wear suitable clothing and, if in doubt, ask the leader prior to the trip.

2. Always leave an account of your movements and expected return time with a responsible person.
3. Check on the weather forecast prior to any trip.
4. Where necessary, use helmets and eye protection which will be made available for relevant trips.
5. Never enter caves alone or without an authorised leader and proper lighting.
6. Exercise particular caution around water.
7. Never visit pubs and clubs in unfamiliar places alone, and never leave drinks and valuables unattended.