

Trinity Earth Sciences



Undergraduate Course Handbook 2017-18

CONTENTS

1. Welcome to Earth Sciences at Trinity College Dublin	3
Learning Outcomes	4
2. Course Structure	4
Further Information.....	5
3. Freshman Module Outlines.....	6
Junior Freshman (Year 1).....	6
PY1FO1 Foundation Physics for Life and Earth Sciences 10 ECTS	6
CH1101 General & Physical Chemistry 10 ECTS	6
GG1024 Physical Geography & Earth System Science 10 ECTS	6
GG1025 Introduction to Geography II: Environmental Geography 10 ECTS.....	7
GL1101 Junior Freshman Geology 10 ECTS	8
MA1M01 Mathematical Methods 10 ECTS	8
Senior Freshman (Year 2)	9
GL2205 Dynamic Earth 1: Rocks & Evolution 10 ECTS.....	9
GL2206 Dynamic Earth 2: Structure & Microscopy 10 ECTS.....	9
GL2299 Earth Sciences Field Course 5 ECTS.....	10
GG2299 Geochemistry for Earth Scientists 5 ECTS	11
GG2025 Human Geography: Changing Worlds 10 ECTS.....	11
GG2024 Physical Geography: Changing Environments 10 ECTS	12
PY2P30 Physics for Earth Scientists 5 ECTS	13
Broad Curriculum Module 5 ECTS	14
Junior Sophister (Year 3).....	15
Compulsory Modules (40 credits).....	15
GG3035 Advanced Research Methods in Earth Science 5 ECTS.....	15
GL3325 Geological Field Skills 2 10 ECTS	15
GL3336 Microscopy & Crystalline Rocks 10 ECTS	16
GG3057 Practical Physical Geography for Earth Scientists 5 ECTS.....	16
GL3326 Sedimentology 10 ECTS	17
Optional Modules (Select 20 credits)	17
GG3025 Advanced Research Methods in Geography II 5 ECTS credits.....	17
GG3053 Deserts of Our Solar System 5 ECTS.....	18
GG3475 Glacial Geomorphology 10 ECTS	18
GG3477 Human Origins 10 ECTS	19
GL3420 Hydrology & Water Quality 5 ECTS.....	19
GG3478 Periglacial Geomorphology (Scheduled for 2018-19) 10 ECTS	20

GG3479 Quaternary Oceans and Climate (scheduled for 2018-19) 10 ECTS.....	21
GL3335 Stratigraphy & Geology of Ireland 5 ECTS	21
Senior Sophister (Year 4)	23
Compulsory Modules	23
GL4420 Earth Sciences Sophister Research Project 15 ECTS.....	23
GL4421 Earth Sciences Sophister Field Course 5 ECTS.....	23
GG4061 Understanding Environmental Change 10 ECTS.....	24
Optional Modules (Select 30 credits)	25
GL4422 Analysis in Geological, Earth & Environmental Research 5 ECTS.....	25
GG3475 Glacial Geomorphology 10 ECTS	25
GL4406 Global Igneous Petrology 5 ECTS	26
GG3477 Human Origins 10 ECTS	26
GL4424 Micropalaeontology & Evolution 5 ECTS	27
GG3478 Periglacial Geomorphology (Scheduled 2018-19) 10 ECTS	28
GL4416 Planet Formation & the Early Earth 5 ECTS.....	28
GG3479 Quaternary Oceans and Climate (Scheduled 2018-19) 10 ECTS	29
4. Examinations and Assessment.....	30
Examinations.....	30
Course Work	30
Submission of Assessed Work.....	31
Deadlines and Penalties for Late Submission	31
Progression and Mark Carry-Forward	31
Final Year Viva Voce Examination	31
An Important Note Regarding Plagiarism	31
Guidelines on Referencing	33
Marking Criteria.....	35
5. Staff, Contacts & Support	36
Course Director.....	36
Module Co-ordinators	36
Student 2 Student.....	38
6. Facilities, Conduct and Safety	38
Laboratories	39
Fieldwork and Fieldtrip Safety	39

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 include climate change, geomorphic hazards (earthquakes, landslides, volcanism, flooding), pollution and the availability and exploitation of resources. The degree programme 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 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. You have one study week per semester during which you are expected to undertake academic work (this is not a holiday 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 seven 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) comprises a mixture of compulsory and optional 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 (15 ECTS).

FURTHER INFORMATION

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

Specific enquiries about a particular module should be directed to the module co-ordinator. 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)

PY1F01 Foundation Physics for Life and Earth Sciences**10 ECTS****Lecturers:** Profs McCabe, Hegner, and Matthias**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.

For details of this module, lecture handouts and other information, please go to the Physics website: <https://www.tcd.ie/Physics/undergraduate/modules/jf/py1f01.php> or contact the lecturing staff involved.

CH1101 General & Physical Chemistry**10 ECTS****Module Co-ordinator:** Dr Scully**Type:** Compulsory

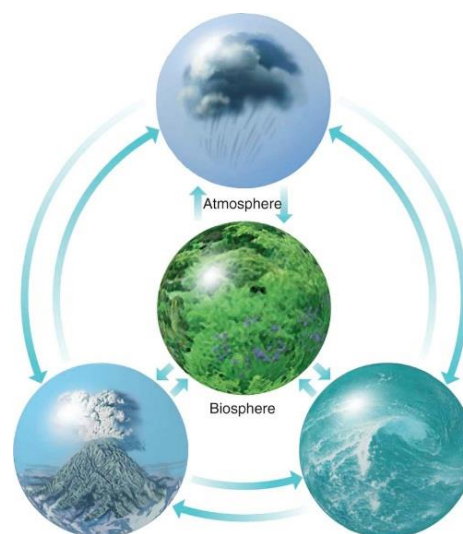
Outline: Chemistry is a fundamental science the influence of which is spread throughout other sciences, and is dominant in modern life. The interplay of chemical and physical ideas has produced the tools of the analytical chemist which are vital to the Earth and Environmental Scientist. This introductory module provides a general introduction to the fundamentals of general and physical chemistry.

For details of this module, lecture handouts and other information, please go to the Chemistry website: <http://www.tcd.ie/Chemistry/teaching/chemistry/jf/> or contact the lecturing staff involved.

GG1024 Physical Geography & Earth System Science**10 ECTS****Module Co-Ordinator:** Dr Edwards (robin.edwards@tcd.ie)**Type:** Compulsory

Outline: More than 7 billion people now inhabit the Earth and no corner of the planet is unaffected by human activity. The rise of our species has been fuelled by our ability to access planetary storehouses of energy and employ this to manipulate the environments around us. The global-scale of human impacts has led some to suggest we are entering a new era of Earth history - the Anthropocene. Dealing with the effects of environmental and climate change is one of the most significant challenge that our species faces in the 21st century.

This module provides a foundation for understanding global environmental issues by considering the Earth as an interconnected system in which matter and energy are exchanged between the Geosphere, Biosphere, Atmosphere, Hydrosphere and the Anthroposphere. It considers the life-support systems of 'spaceship Earth' and

*From Skinner & Murck, 2011*

aims to provide a theoretical basis for evaluating the role of humans as agents of climate and environmental change.

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

- Outline the fundamental concepts of Earth Systems Science with reference to its major subsystems: Geosphere, Biosphere, Atmosphere, Hydrosphere and Anthroposphere
- Illustrate how material and energy are cycled through the Earth system
- Apply an Earth Systems approach to describe the phenomena of environmental and climate change
- Identify how human activities modify Earth System function

Assessment:

Continuous Assessment [100%] comprising: two in-course assignments [25% each]; and two 1-hour on-line multiple choice tests [25% each].

Key Texts:

Holden, J. (2012) *An Introduction to Physical Geography and the Environment*. 3rd Edition. Pearson: Harlow, UK. 876 pages.

Skinner, B.J., Murck, B. (2011) *The Blue Planet: An Introduction to Earth System Science*. 3rd Edition. J. Wiley & Sons: Hoboken, USA. 656 pages.

GG1025 Introduction to Geography II: Environmental Geography	10 ECTS
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Module Co-ordinator: Dr Bresnihan (bresnip@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;
- Identify and evaluate human-environmental relations within select cases of environmental hazards.

Assessment: Examination (50%); course work (50%).

GL1101 Junior Freshman Geology**10 ECTS****Module Co-ordinator:** Dr Nicholas (nicholyj@tcd.ie)**Type:** Compulsory

Outline: The module gives an introduction to our dynamic Planet Earth, explains the natural principles and processes that govern how it works inside and out, and retraces its geological history over the past four and a half billion years.

From the vastness of the Universe to the microscopic structure of mineral crystals, from galaxy birth over billions of years to volcanic eruptions lasting only minutes; the science of geology sets out to investigate the origin and development of the planet, the natural principles that govern it, the processes that act in, on and around it, and the life that has evolved with it.



Many sciences are conducted in the laboratory, but to a geologist the Earth itself is the laboratory. In essence, this module provides a beginner's guide to Planet Earth. The module is divided into two main themes developed consecutively during the Semester. Firstly, 'Earth in Space' investigates the origin of the Universe and our Solar System, Earth's early formation, composition and structure, with a focus on how Earth's internal dynamism constantly changes the landscape upon which we live. The second theme, 'Earth and Life' explores how the planet and the organisms that have lived on it evolved together over billions of years. It investigates how evidence of past life can be preserved in rocks, how key fossil groups evolved, and the geological causes that drove some of them to extinction.

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

- explain the basic origin and evolution of planet Earth and outline its dynamics
- discuss the major evolutionary episodes in the fossil record and explain how the planet changed over time with life

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

MA1M01 Mathematical Methods**10 ECTS****Module Lecturers:** Prof. Samson Shatashvili & Prof Sinead Ryan**Type:** Compulsory

Outline: For all areas of science, knowledge of basic mathematics is a prerequisite. Experimental results are almost always numerical and thus their analysis is mathematical. Also the models which predict these results are quantitative and hence their theory is mathematical. The aim of the mathematical methods course is to ensure that everyone attains knowledge of the most basic mathematics that they are likely to meet in their chosen field of specialisation. This course is designed to help those who need help in mathematics: it is a refresher course and more. The first term will build on your present knowledge of mathematics, giving you a much better idea of what a function is, how to graph one, how to extract essential information such as its roots, its maxima and minima, and how to differentiate it. The second term will cover integration, including how to find areas and volumes, while the third term covers really new material such as differential equations and matrices. Throughout, the emphasis is always on the practical application of mathematics to real-life problems. During the second term there will also be an introduction to computing designed to further prepare you for a successful career in science.

For further details of this module go to:

<http://www.maths.tcd.ie/undergraduate/modules1415//MA1M01.php>

SENIOR FRESHMAN (YEAR 2)

Students take compulsory modules totalling 55 credits and select a further **5 credits** from the Broad Curriculum programme of cross-faculty modules.

GL2205 Dynamic Earth 1: Rocks & Evolution

10 ECTS

Module Co-ordinator: Prof Kamber (kambers@tcd.ie)

Type: Compulsory

Outline: The aims of this module are: (1) to promote the understanding of how material is cycled and recycled within the Earth and how rock types record different aspects of this cycling; (2) to provide (a) an understanding of form and function in fossil organisms and their links to living floras and faunas (b) an overall appreciation of the evolutionary record of life on Earth. The module initially approaches the solid materials that make up the outer parts of the Earth - the lithosphere - namely rocks and their basic building blocks, minerals. A pathway is taken through the rock cycle from initial formation from mantle material into igneous rocks, their subsequent breakdown at the Earth's surface and reconstitution into sedimentary rocks and, finally the alteration of these rocks through burial at elevated temperatures and pressures. Techniques of describing and reaching first stage interpretations of rocks and minerals in hand sample are covered.



Equipped with an appreciation of the dynamic natures of the solid Earth, the module then introduces the time dimension of life, which has existed on planet Earth for much of its history. Fossil organisms are the data that record the evolution of life on the planet.

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

- describe and identify common kinds of rock and the minerals they contain in hand sample
- describe and classify a broad range of organisms found in the fossil record, and explain the concepts of fossilisation, evolutionary sequences and lineages
- outline the uses of fossils in palaeobiological, palaeogeographic and evolutionary studies, and state the basic principles of taxonomic procedure

Assessment: Theory examination (60%); Practical examination (20%); In-course exercises (20%)

GL2206 Dynamic Earth 2: Structure & Microscopy

10 ECTS

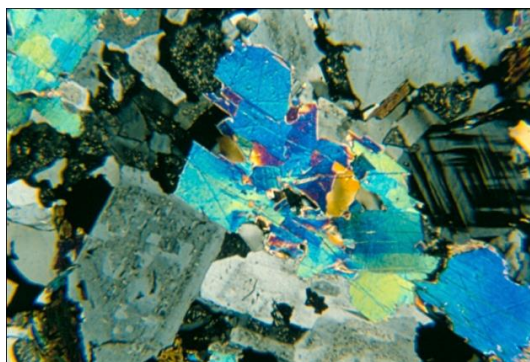
Module Co-ordinator: Dr Chew (chewd@tcd.ie)

Type: Compulsory

Outline: This module aims: (1) to investigate how, why and where rocks undergo deformation; (2) to be able to interpret two-dimensional representations of geological data (maps) in three dimensions; and (3) to understand the physical and chemical properties of minerals and how minerals can be investigated using the polarised light microscope.

This module investigates the structure of the Earth from the scale of plate tectonics through to investigation using the polarising microscope. The structural geology lectures cover the principles of rock deformation and the classification of structural features. The tectonics lectures

provide an overview of active plate tectonic processes and these various processes are exemplified by a brief overview of the geological history of Ireland. A series of practical exercises aim to develop an understanding of map interpretation and the visualisation of structures in three dimensions. Topics covered will include folds, faults and unconformities along with interpretation of published geological maps. The module also introduces the principals of crystallography and the theory and practice of using a polarised light microscope to look at minerals in thin sections of rock. The rock-forming minerals are examined in detail in terms of where they are found, what they look like through the microscope, what chemical elements they contain, and their physical stability.



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

- investigate and explain how, why and where rocks undergo deformation
- interpret two-dimensional representations of geological data (maps) in three dimensions
- describe the physical and chemical properties of minerals and describe how minerals can be investigated using the polarised light microscope.

Assessment: Theory examination (70%), Practical examination (15%), In-course laboratory assessment (15%)

GL2299 Earth Sciences Field Course

5 ECTS

Module Co-ordinator: Dr Wyse Jackson (wysjcknp@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%)

GG2025 Human Geography: Changing Worlds**10 ECTS****Module Co-ordinator:** Dr Philip Lawton (lawtonp@tcd.ie)**Type:** Compulsory

Outline: This module introduces students to a number of key issues within contemporary human geography and exposes them to a range of methodological approaches and research techniques. The overarching theme of the module is the way in which historical, cultural, environmental, political and economic geographies are changing under the force of globalisation. Specific areas covered include an examination of globalisation from a historical perspective; approaches, methods and sources in historical geography; emergence of global environmentalism in a changing world; the creation of 'third world' and the impact of globalisation on the developing world; and political and economic aspects of globalisation.

The module will cover:

Section 1 - Approaches and methods in historical geography: This section of the module introduces the diversity of approaches and methods employed in historical geography. Historical geography has traditionally been concerned with the evolution of landscapes and patterns of areal differentiation over time. Historical geography is concerned with how regions and places have come to acquire identity and character over time. It is therefore central to the wider study



of geography. Since the 1980s historical geography has been open to theoretical and methodological innovation. This section of the module will give an introduction to the more traditional and modern approaches to the use of historical methods in geographical studies.

Section 2 - Emerging Environmental Movements: Interactions between humans and the environment are of central concern for geographers. These interactions may create positive or negative outcomes (or in some cases both) across time and space and are often geopolitically motivated. This section of the Changing Worlds module will address how human geography is approaching the relationship between humans and their environment in an increasingly globalised world. Attention to the evolution of environmental organisations, including green political parties, will be considered.

Section 3 - Geographies of development: Most of humanity lives in the so-called “developing world”. This section of the module explores how the Third World was created historically and the mechanism through which it is reproduced. Attention will also be paid to the impact of “free” market policies in the developing world.

Section 4 - Economic geographies of globalisation: This section of the module will cover issues related to contemporary economic globalisation; governance of globalisation; multi-national corporations; global finance; global financial and economic crisis; geographies of transition economies; and policy challenges in the age of globalisation.

Section 5 - Collection & analysis of geographical data: Building on the above sections, this part of the module will specifically focus on methods in geographical research and a range of techniques used in acquisition and analysis of geographical data. In doing so, it will enable students to select appropriate methods to study diverse geographical issues and to develop students’ geographical skills of numeracy, data management, manipulation, analysis, display, interpretation and explanation.

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

- Identify important topics and themes in contemporary human geography;
- Appraise some of the major current debates in human geography;
- Outline and contrast a range of research methods in human geography..

Assessment: Examination (60%); course work (40%)

GG2024 Physical Geography: Changing Environments

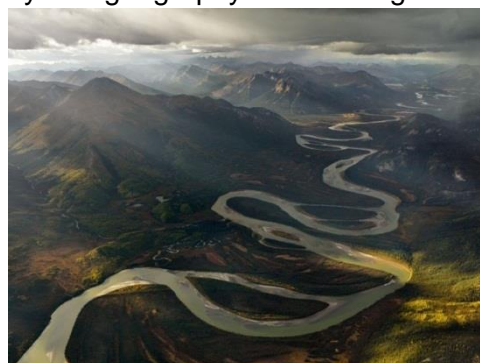
10 ECTS

Module Co-ordinator: Dr Bourke (bourkem@tcd.ie)

Type: Compulsory

Outline: This module represents a foundation in modern physical geography and is designed to explain and analyse environmental change during the last 2.6 million years (the Quaternary period). The module will take a number of key elements of contemporary environmental change and analyse modern process, past records and archives of environmental change. Elements of the course are designed to prepare students for Sophister physical geography modules.

Fluvial Geomorphology: Fluvial processes and landforms including fluvial hydraulics and sediment transport, bedforms, sediments, channel dynamics and long-profile, historic flood events and large-scale catastrophic floods, fluvial sedimentary archives.



Mass-movements: including landslides, slow downslope movement and peat failures. The importance of analysis of large-scale mass-movements is emphasised.

Drylands: The dynamics of geomorphic systems in global drylands will be examined. In particular, aeolian landforms, sediments, transport processes aeolian sedimentary archives.

Tropics: Environmental change across a range of temporal scales and environment types, particularly lacustrine systems and swamp basins. Attention will be paid to issues of landform scale.

Oceans: including submarine landslides; deep ocean sediments as archives of long-term environmental change; sea levels past present and future; and the evolving geography of our planet.

Biogeography and Conservation: This section of the 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.

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

- Identify important topics and themes in contemporary physical geography.
- Appraise some of the major current debates in physical geography.
- Illustrate how records of past change can be developed from a range of different environments.
- Explain how an understanding of modern processes is fundamental to our ability to reconstruct the past and predict the future.

Assessment: Continuous Assessment [100%] comprising: two in course assignments [15% each]; and two 1 -hour online multiple choice tests [15% each]. Two 1 -hour online short answer tests [20% each]

PY2P30 Physics for Earth Scientists	5 ECTS
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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 (60%), course work (40%)

Broad Curriculum Module**5 ECTS**

Students select one the Broad Curriculum (Cross-Faculty) modules with the exception of BCGEOL (Planet Earth).

Details on the Broad Curriculum Programme can be found at:

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

Note: You need to register for your module via the Broad Curriculum website. Please ensure that you do this before the start of the academic year.



JUNIOR SOPHISTER (YEAR 3)

Students take compulsory modules totalling 40 credits and select an additional **20 credits of optional modules**.

Compulsory Modules (40 credits)

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%)

GL3325 Geological Field Skills 2

10 ECTS

Module Co-ordinator: Dr Chew (chewd@tcd.ie)

Type: Compulsory

Outline: Undergraduate field courses provide vital experience in practising core subject skills. Much of this module will comprise a two week residential field course to a region of active tectonics. It will comprise a series of exercises in the techniques of geological fieldwork and mapping, and development of an understanding of how the geology of the field area is related to the tectonics of a region.



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

- accurately locate themselves in the field using topographic base maps, satellite imagery and / or GPS
- make essential field observations and measurements, including recognition of major rock types and geological structures
- use a compass-clinometer with familiarity to measure geological structures
- construct a geological map (field slips and interpretative map) and stratigraphic log and accurately record field observations in a notebook, as notes, sketches or tabulated data
- construct a geological cross-section on the basis of a geological map

- identify and interpret a range of sedimentary structures and their depositional environments
- identify diagnostic metamorphic assemblages in the field
- identify a range of volcanic rocks and their modes of deposition and be able to use this information to determine eruptive style
- evaluate the regional geology and tectonic setting in the context of an active orogenic belt

Assessment: Coursework (100%)

GL3336 Microscopy & Crystalline Rocks	10 ECTS
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Module Co-ordinator: Dr Tomlinson (tomlinse@tcd.ie)

Type: Compulsory

Outline: This module introduces the crystallographic and optical properties of minerals, discusses the formation and stability of minerals, and investigates the most important metamorphic and igneous rocks at a range of scales (tectonic setting, outcrop, hand specimen and thin section). The module aims to: provide an understanding of the mechanisms of formation of minerals and of mineral energetics and stability; broaden and deepen skills for identification and description of metamorphic and igneous rocks in hand specimen and thin section; provide an understanding of how metamorphic and igneous are classified; demonstrate how composition dictates the mineralogy of crystalline rocks; and develop an appreciation of how textural relationships amongst minerals can be used to infer the history of crystalline rocks

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

- Identify the most important mechanisms of mineral crystallisation and transformation.
- Describe the optical properties of major minerals and how they relate to crystal structure.
- Describe how the chemistry of a rock dictates its mineralogy.
- Correctly identify and classify major igneous and metamorphic minerals and rocks.
- Interpret mineral textures.
- Outline the various tectonic regimes in which crystalline rocks form.

Assessment: Examination (40%); Coursework (60%)

GG3057 Practical Physical Geography for Earth Scientists	5 ECTS
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Module Co-ordinator: Prof Coxon (pcoxon@tcd.ie)

Type: Compulsory

Outline: This module provides practical training in some basic field and laboratory methods to assist students in completing their individual research projects. 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

GL3326 Sedimentology**10 ECTS****Module Co-ordinator:** Stephen Coakley (coakleys@tcd.ie)**Type:** Compulsory

Outline: Sedimentary materials account for most of the Earth's crust, and much of our understanding of Earth history comes from their examination. This course provides an introduction to sedimentary processes and deposits that shape Earth's surface, including their description, formation and interpretation. In particular, the generation, transport, and preservation of sediment are studied as diagnostic tools to link surface processes with the geological records of Earth history and modern environmental change. The origin of a wide range of sedimentary rocks is investigated in theory and in the laboratory using field observations, stratigraphic sections, hand samples, and thin sections to decipher depositional environments and propose stratigraphic models.

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

- classify siliciclastic and carbonate sedimentary rocks;
- provide technical descriptions of common sedimentary rock types and textures from hand samples and thin sections;
- provide basic interpretations of depositional environments from outcrop observations, stratigraphic logs and petrological evidence;
- outline appropriate strategies for field and laboratory investigation of sedimentary rocks.

Assessment: Theory examination (30%); practical examination (20%); in-course assessment (50%)**Optional Modules (Select 20 credits)**

Note: Some modules run in alternate years. Those that are unavailable as Junior Sophister options for 2017-18 will be available as Senior Sophister options in 2018-19.

GG3025 Advanced Research Methods in Geography II**5 ECTS credits****Module Co-ordinator:** Professor Peter Coxon (pcoxon@tcd.ie)**Type:** Optional

Outline: This module comprises a residential field course held on Clare Island prior to the start of Fresher's week (10-16th September 2017). Students are required to complete a series of guided research tasks and to present the results of their work in evening seminars and as a field notebook. Students are required to work individually and in groups.

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

- Collect primary field data to address research questions as part of a guided research exercise;
- Conduct field research in a safe manner;

- Demonstrate technical proficiency in a range of primary data collection methods
- Distinguish between observations and interpretations, and compile a field notebook recording research activities and results;
- Work collectively to collate and analyse the results of fieldwork within strict time constraints;
- Interpret the results of fieldwork and present these findings in oral and written form.

Assessment: Course work (100%) comprising completion of fieldwork tasks and submission of field notebooks.

GG3053 Deserts of Our Solar System

5 ECTS

Module Co-ordinator: Dr Bourke (bourkem4@tcd.ie)

Type: Optional

Note: Places on this module are limited to 30. In the case of oversubscription, places will be allocated on the basis of student performance in GG2024.

Outline: Planetary geomorphology is *the* frontier field of Physical Geography. This module explores the desert landforms of our solar system. It focuses on the arid environments of Earth and Mars. Using the latest data from NASA and ESA we will explore how landforms and geomorphic processes vary under different atmospheric, gravity and temperature regimes. You will be introduced to geomorphic features that are not found on Earth. We will investigate how geomorphologists use landforms on Earth to understand those on other solar system bodies.



Learning outcomes: On successful completion of this module students will

- Have gained a basic knowledge of the desert geomorphology on Earth and Mars
- Understand how and why landforms vary across our solar system
- Know how field and experimental studies are used in Planetary Geomorphology
- Be competent in analysis of Planetary landforms using a GIS platform
- Be familiar with the latest findings from Lander and Orbiter missions

Assessment: 100% coursework.

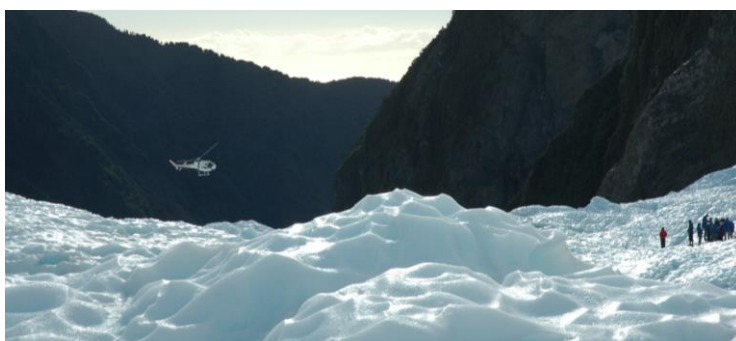
GG3475 Glacial Geomorphology

10 ECTS

Module Co-ordinator: Prof Coxon (pcoxon@tcd.ie)

Type: Optional [Unavailable 2018-19]

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.

The module includes a compulsory 3 day field course on Clare Island, Co. Mayo, sometime during the period September-November (this will be kept reasonably priced). There may be two groups so you need to keep all of this time slot free.

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: 2 hr Examination (50%). In-course assessment inc. attendance and successful completion of a weekend field course and laboratory reports (50%)

GG3477 Human Origins

10 ECTS

Module Co-ordinator: Dr Edwards (robin.edwards@tcd.ie)

Type: Optional [Unavailable 2018-19]

Outline: This module provides a general introduction to the field of palaeoanthropology with particular focus on the contributions made by Earth Scientists to the study of the origins of our species. The module will examine how diverse lines of evidence from subjects such as archaeology, anatomy and genetics, can be combined to examine the changing relationships between humans and their environment. It will introduce the world of our ancestors and evaluate the science behind stories of popular interest such as Neanderthals, "hobbits", and the rise and spread of our species, *Homo sapiens*.



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

- Outline human evolution during the Quaternary with reference to issues of speciation, extinction, and climate change;
- Illustrate how stratigraphy, geochronology and palaeoenvironmental reconstruction are applied in palaeoanthropological research;
- Discuss the potential role of environmental change in the evolving biogeography of humans, with particular reference to the timing and mechanisms of dispersal and colonisation;
- Employ a multidisciplinary approach that evaluates data of varying quality and quantity, synthesises contrasting types of information, and deals with differing levels of uncertainty.

Assessment: Examination (50%); Course Work (50%)

GL3420 Hydrology & Water Quality

5 ECTS

Module Co-ordinator: Dr C. Coxon (cecoxon@tcd.ie)

Type: Optional

Outline: This module provides students with an understanding of hydrological processes, following the different pathways of water through the terrestrial part of the hydrological cycle. It

also aims to familiarise students with the factors affecting groundwater quality, and to develop an understanding of groundwater quality issues in the context of integrated catchment management.

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

- evaluate the role of different hydrological pathways in a range of catchment settings
- carry out calculations relating to catchment water balance, river flow and groundwater movement
- analyse the factors controlling aquifer hydrochemistry and contaminant transport processes;
- assess groundwater quality problems in both rural and industrial settings;
- evaluate groundwater vulnerability to pollution;
- understand the role of groundwater protection schemes and of integrated catchment management

Assessment: Theory examination (70%); In-course assessment (30%)

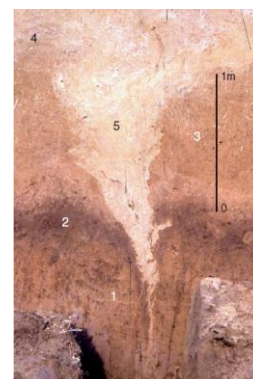
GG3478 Periglacial Geomorphology (Scheduled for 2018-19)

10 ECTS

Module Co-ordinator: Prof Coxon (pcoxon@tcd.ie)

Type: Scheduled as an option for 2018-19.

Outline: This module covers the regions of the world that experience at present (or have experienced in the past) permanently frozen ground or processes associated with frost action. The processes producing a variety of landforms of all scales are looked at in detail and a pervading theme in the course is the identification and significance of fossil periglacial features in the landscape. Topics covered include: climatic zones, freeze-thaw cycles, permafrost, ground-ice, frost action, patterned ground, hardware modelling of processes, ice-mounds, thermokarst, man and periglacial regions, slopes, fluvial processes, fossil periglacial features in Europe, USA, Britain and Ireland.



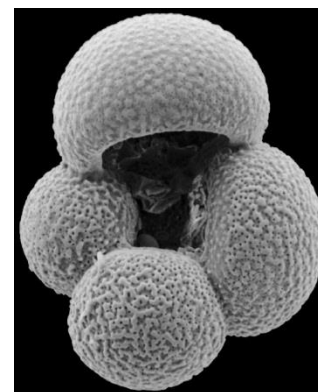
Learning Outcomes: On successful completion of the module students will be able to:

- Have gained a basic knowledge of cold climate regions and processes
- Have gained a knowledge of Ireland's periglacial history
- Have gained a knowledge of modern periglacial geomorphology
- Recognise the importance of the study of periglacial geomorphology

Assessment: 2 hr examination (100%)

GG3479 Quaternary Oceans and Climate (scheduled for 2018-19)**10 ECTS****Module Co-ordinator:** Dr Edwards (robin.edwards@tcd.ie)**Type:** Scheduled as an option for 2018-19.

Outline: The oceans play a pivotal role in the Earth's climate system, both as agents and archives of change. This module provides an overview of ocean – climate relationships with a focus on the Quaternary period (the last 2.6 million years of Earth history). It considers the drivers of glacial-interglacial climate change, ice sheet-ocean interactions, sea-level change and the use of foraminifera as environmental proxies. Teaching will comprise lectures and laboratory practical classes, providing students with both theoretical and hands-on experience working with foraminifera and quantitative palaeoenvironmental data.

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

- Outline the physical and chemical characteristics of the ocean and their significance for the Earth's climate system
- Illustrate how marine proxy data are used to infer past climates and environmental conditions
- Compare and contrast 'orbital' and 'sub-orbital' scale climate change during the Quaternary with reference to driving mechanisms and feedback systems
- Discuss the causes and effects of sea-level change
- Use foraminifera-based proxy data to investigate aspects of Quaternary environmental change

Assessment: 2 hr examination (50%), course work (50%)**GL3335 Stratigraphy & Geology of Ireland****5 ECTS****Module Co-ordinator:** Dr Wyse Jackson (wysjcknp@tcd.ie)**Type:** Optional

Outline: This module introduces the concept of stratigraphy detailing its various disciplines, and the regulations underpinning the modern stratigraphic framework. It will outline techniques in biostratigraphic recording and analysis of biological data from fossils in the field, their taxonomic description, and their biostratigraphic and palaeoecological use. The Geology of Ireland lectures focus on integrating the diverse geological processes that have acted during its geological evolution from the Precambrian to present.

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

- understand and discuss the basic principles of stratigraphy, biostratigraphy and taxonomic procedures
- select appropriate statistical and qualitative techniques when investigating fossils in the field and in the laboratory
- utilize fossils to determine the stratigraphic position of the units from where they were collected
- identify and describe modern ecological parameters that act on the biosphere and apply this information to the fossil record
- understand the geological history of Ireland, and the various processes that have been most influential on moulding its geological framework.

Assessment: Theory examination (40%); coursework (60%)



SENIOR SOPHISTER (YEAR 4)

Students take compulsory modules totalling 30 credits and select an additional **30 credits of optional modules**.

Compulsory Modules

GL4420 Earth Sciences Sophister Research Project	15 ECTS
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Module Co-ordinator: Dr Edwards (robin.edwards@tcd.ie)

Type: Compulsory

Outline: The Earth Sciences sophister research project develops detailed knowledge in selected, specialized areas of study, some of which will be at the current boundaries of the subject. It requires the mastery of specialized skills and tools which are applied to address particular research questions under the guidance of an academic member of staff. The research topic is developed as part of GG3035 – *Advanced Research Methods in Earth Science*. Data collection will normally comprise field work, laboratory analysis, novel work on museum collection material or pre-existing data sets, or some combination of these. The outcomes of the research are communicated in a precise and sustained manner by the production of a written report (dissertation).

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

- Complete a sustained piece of individual, academic research on a chosen topic within the field of Earth Science, under the guidance of a member of staff;
- Explain the methodological basis employed in their research;
- Critically evaluate existing research and its implications for the topic of study;
- Demonstrate technical proficiency in the application of the selected methods and techniques of data acquisition and analysis;
- Synthesise and discuss the results with reference to relevant academic literature;
- Present a succinct and precise written report of the research that is well presented, logically structured and accurately referenced.

Assessment: Dissertation (100%)

GL4421 Earth Sciences Sophister Field Course	5 ECTS
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Module Co-ordinator: Prof Kamber (kamberbs@tcd.ie)

Type: Compulsory

Outline: This module comprises a one week residential field course that is usually held overseas. It provides students with practical experience in conducting primary research across a range of Earth Science themes. Students are required to complete a series of guided research tasks and to present the results of their work in evening seminars, and in written form as a field notebook and report. The field course further develops practical fieldwork and problem solving skills. Emphasis is placed on the application of Earth Science techniques in real-world situations.



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

- Collect primary field data to address research questions as part of a guided research exercise;
- Conduct field research in a safe manner;
- Demonstrate technical proficiency in a range of primary data collection methods
- Distinguish between observations and interpretations, and compile a field notebook recording research activities and results;
- Work collectively to collate and analyse the results of fieldwork within strict time constraints;
- Interpret the results of fieldwork and present these findings in oral and written form.

Assessment: Field notebook and report (100%)

GG4061 Understanding Environmental Change
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10 ECTS

Module Co-ordinator: Dr Rocha (rochac@tcd.ie)

Type: Compulsory

Outline: The global environment, including climate, is changing. This change has major economic, social and policy implications and will thus underpin living conditions for the whole of humanity going forward. The course will introduce the functional aspects of this change using an Earth Systems Science approach by providing the basis to understand how major components of the Earth System are linked and how these links change over time. Conceptual developments in this understanding, as well as the basic modern concepts in Environmental Change (both human-induced and natural) will be discussed as a basis to comprehend the utility of forecast tools used as a basis for societal response.

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

- Demonstrate a solid understanding of the earth system
- Articulate the complexity of feedbacks driving current environmental change
- Quantitatively examine the factors shaping the environment, including climate
- Describe and distinguish between natural and human-induced drivers of environmental change
- Critically analyze conflicting arguments on the issues of environmental change
- Examine and evaluate public policy aimed at coping with environmental change

Assessment: 1.5 hour Examination (50%); Coursework (50%).

Optional Modules (Select 30 credits)**GL4422 Analysis in Geological, Earth & Environmental Research 5 ECTS****Module Co-ordinator:** Dr Goodhue (goodhue@tcd.ie)**Type:** Optional

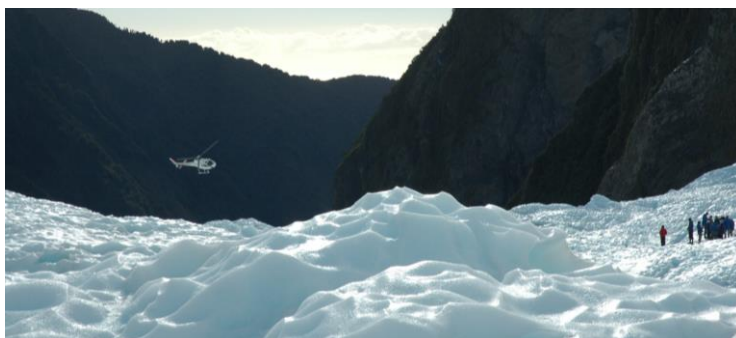
Outline: The module instructs students in geochemical and mineralogical analysis. It (1) introduces the key analytical instruments used for researching natural and man-made materials, before (2) providing a basic understanding of the operation of such instruments, and finally (3) developing the concepts of selecting the most appropriate techniques and limits of methodology. The module will follow a series of environmental and geological samples from their collection, to obtaining data, to data processing and final interpretation. Emphasis will be placed on how to select a suitable analytical technique, how the sample is prepared and how the instrument is operated and calibrated. Practical sessions will afford students the opportunity to remotely operate several of the analytical instruments housed in TCD Geochemistry and experience of processing some real and 'live' data. The techniques considered may include: CF-IRMS, ICP-OES, LA-ICP-MS, XRD, XRF.

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

- have an understanding of several key methods used in the modern analysis of samples;
- have learned how to approach analysis;
- have developed a clear appreciation of correct method selection, data analysis, sources of error and principles of sound interpretation.

Assessment: Theory examination (70%) coursework (30%)**GG3475 Glacial Geomorphology 10 ECTS****Module Co-ordinator:** Prof Coxon (pcoxon@tcd.ie)**Type:** Optional [Unavailable 2018-19]

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.

The module includes a compulsory 3 day field course on Clare Island, Co. Mayo, sometime during the period September-November (this will be kept reasonably priced). There may be two groups so you need to keep all of this time slot free.

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: 2 hr Examination (50%). In-course assessment inc. attendance and successful completion of a weekend field course and laboratory reports (50%)

GL4406 Global Igneous Petrology**5 ECTS**

Module Co-ordinator: Dr Tomlinson (tomlinse@tcd.ie)

Type: Optional

Outline: The module explores the key igneous rocks in the various tectonic settings and by use of petrology and geochemistry, investigates magma source evolution. The module will also study the anatomy of igneous centres and interrogate the history of large igneous provinces and their role in regulating long-term atmospheric composition. Finally, the module will focus on the opportunities that exist to use tephra for studying the relatively recent surface history of the Earth. Throughout the module, a combination of petrography, petrology, geochemistry, and radiogenic isotopes will be applied to extract the finer details from igneous rocks.



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

- use petrology, major and trace element chemistry and radiogenic isotope data from igneous rocks to interpret them in a plate-tectonic framework, describe in details the use of tephra in Earth surface studies

Assessment: Theory examination (70%), in-course assessments (30%)

GG3477 Human Origins**10 ECTS**

Module Co-ordinator: Dr Edwards (robin.edwards@tcd.ie)

Type: Optional [Unavailable 2018-19]

Outline: This module provides a general introduction to the field of palaeoanthropology with particular focus on the contributions made by Earth Scientists to the study of the origins of our species. The module will examine how diverse lines of evidence from subjects such as archaeology, anatomy and genetics, can be combined to examine the changing relationships between humans and their environment. It will introduce the world of our ancestors and evaluate the science behind stories of popular interest such as Neanderthals, "hobbits", and the rise and spread of our species, *Homo sapiens*.



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

- Outline human evolution during the Quaternary with reference to issues of speciation, extinction, and climate change;
- Illustrate how stratigraphy, geochronology and palaeoenvironmental reconstruction are applied in palaeoanthropological research;

- Discuss the potential role of environmental change in the evolving biogeography of humans, with particular reference to the timing and mechanisms of dispersal and colonisation;
- Employ a multidisciplinary approach that evaluates data of varying quality and quantity, synthesises contrasting types of information, and deals with differing levels of uncertainty.

Assessment: Examination (50%); Course Work (50%)

GL4424 Micropalaeontology & Evolution**5 ECTS**

Module Co-ordinator: Dr Patrick Wyse Jackson (wysicknp@tcd.ie)

Type: Optional

Outline: The aims of this module are: (1) to introduce the subject of micropalaeontology, its scope, methods (including scanning electron microscopy) and potential; (2) to introduce the main groups of microfossils – calcareous nannoplankton, foraminifers, radiolaria, ostracodes and conodonts; (3) to demonstrate the practical use of these fossils in biostratigraphy, palaeoenvironmental analysis, oceanography and thermal maturation studies; (4) to provide an understanding of evolutionary processes. This module will focus on two areas. Firstly it will cover techniques for description and identification of the main microfossil groups both in theory and in practice. Some practical examples of the uses in biostratigraphy, palaeoenvironmental analysis and oceanography will be covered. the evolution of life on our planet from earliest times, and the use of fossils as sources of palaeoenvironmental data. In the second area topics covered in lectures include the Cambrian explosion, evolution and classification, the evolution of flight, and the biodiversity in the past, present and future. Some of the content of this module will be student-led through presentations.



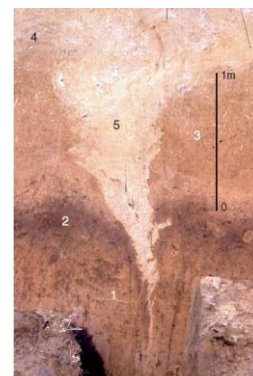
Learning Outcomes: On successful completion of the module students will be able to:

- describe and illustrate microfossils using the Scanning Electron Microscope
- identify individual microfossils to the level of group and use appropriate literature to identify them to the level of genus and species
- apply micropalaeontology to the solution of geological problems
- describe the evolutionary steps displayed in the fossil record

Assessment: Theory examination (50%), course work (50%)

GG3478 Periglacial Geomorphology (Scheduled 2018-19)**10 ECTS****Module Co-ordinator:** Prof Coxon (pcoxon@tcd.ie)**Type:** Scheduled as an option for 2018-19.

Outline: This module covers the regions of the world that experience at present (or have experienced in the past) permanently frozen ground or processes associated with frost action. The processes producing a variety of landforms of all scales are looked at in detail and a pervading theme in the course is the identification and significance of fossil periglacial features in the landscape. Topics covered include: climatic zones, freeze-thaw cycles, permafrost, ground-ice, frost action, patterned ground, hardware modelling of processes, ice-mounds, thermokarst, man and periglacial regions, slopes, fluvial processes, fossil periglacial features in Europe, USA, Britain and Ireland.



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

- Have gained a basic knowledge of cold climate regions and processes
- Have gained a knowledge of Ireland's periglacial history
- Have gained a knowledge of modern periglacial geomorphology
- Recognise the importance of the study of periglacial geomorphology

Assessment: 2 hr examination (100%)

GL4416 Planet Formation & the Early Earth**5 ECTS****Module Co-ordinator:** Prof Kamber (kamberbs@tcd.ie)**Type:** Optional.

Outline: This module first reviews evidence in meteorites and in the geochemistry of the Earth's mantle for the formation of solids and planetary embryos in the Solar System. Discussion of planet formation is followed by a chronological introduction to events that shaped the Earth until oxygenation of the atmosphere. The module will introduce students to rocks that are unique to the early Earth with a focus on the most important events that have shaped the planet from the billion of year perspective. It aims to: (1) familiarise students with meteorites and early Earth rocks; (2) develop an understanding of the steps from solid formation in the Solar System to the accretion of rocky planets; (3) appreciate the differences between early Earth geology and the more familiar Phanerozoic record; and (4) develop an understanding of how meteorites and early Earth rocks can be used to reconstruct the history of the Earth.

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

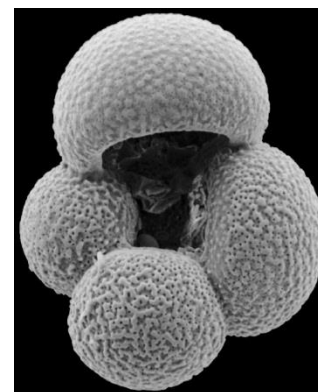
- summarise the difference between primitive and differentiated meteorites and to explain the significance of meteorites for reconstructing the steps towards planet formation
- recognise Archaean rocks and those aspects of Precambrian geology that are different from Phanerozoic geology
- integrate the evidence from the rock record to explain the major events in the physical, chemical and biological evolution of the early Earth



Assessment: Theory examination (50%), in-course assessments (50%)

GG3479 Quaternary Oceans and Climate (Scheduled 2018-19)**10 ECTS****Module Co-ordinator:** Dr Edwards (robin.edwards@tcd.ie)**Type:** Scheduled as an option for 2018-19.

Outline: The oceans play a pivotal role in the Earth's climate system, both as agents and archives of change. This module provides an overview of ocean – climate relationships with a focus on the Quaternary period (the last 2.6 million years of Earth history). It considers the drivers of glacial-interglacial climate change, ice sheet-ocean interactions, sea-level change and the use of foraminifera as environmental proxies. Teaching will comprise lectures and laboratory practical classes, providing students with both theoretical and hands-on experience working with foraminifera and quantitative palaeoenvironmental data.



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

- Outline the physical and chemical characteristics of the ocean and their significance for the Earth's climate system
- Illustrate how marine proxy data are used to infer past climates and environmental conditions
- Compare and contrast 'orbital' and 'sub-orbital' scale climate change during the Quaternary with reference to driving mechanisms and feedback systems
- Discuss the causes and effects of sea-level change
- Use foraminifera-based proxy data to investigate aspects of Quaternary environmental change

Assessment: 2 hr examination (50%), course work (50%)

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. Earth Sciences runs under the regulations of the Science course (TR071). In all cases, the end-of-year mark is calculated according to the relative ECTS weightings of the modules taken.

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.

COURSE WORK

The form of course work will vary between modules. Details concerning the assessment requirements, value, marking criteria, and deadline/process for submission will be circulated by the module co-ordinator or lecturer when the assessment task is set. Marks and feedback will also vary between modules and you should contact the module co-ordinator if you have any questions. Marks for Geography modules (those with a GG code) will normally be returned in the form of indicative grades as presented in the table below. Course work grades are provisional, being subject to moderation at the Examiners' Meeting.

Mark Range	Indicative Grade
90-100	A++
80-89	A+
70-79	A
65-69	B+
60-64	B
55-59	C+
50-54	C
45-49	D+
40-44	D
<40	F

Submission of Assessed Work

It is your responsibility to ensure that you accurately note the deadline and procedure for submission of assessed work.

When work is handed in, a register of its receipt is kept. The register includes the date of submission, the student's signature and the staff signature.

Many modules require work to be submitted electronically through the 'Turnitin' anti-plagiarism software. For other forms of electronic submission, you should obtain acknowledgement from the member of the academic staff responsible that the submission has been received. Unless otherwise stipulated, all written work must be word-processed.

You must keep a paper and electronic copy of all work submitted for assessment.

Deadlines and Penalties for Late Submission

You must ensure that you are available to submit course work by the deadline.

In the event of late submission of any course work, a penalty of -5% per day or part thereof will be applied to the mark for that piece of work up to a maximum of five days after which a zero mark will be given.

In cases where illness or other circumstances prevent the submission of work by a deadline, a certificate from a medical practitioner or a letter from the Tutor should be obtained setting out the circumstances. Certificates should insofar as is possible refer to the time period during which the illness or other condition prevailed.

Certificates seeking an extension of a deadline should be submitted as early as possible (and preferably before the deadline is reached) to the relevant member of staff who may then grant an extension.

If an extension is granted, the penalty for late submission will come into effect at the end of the extension period.

Progression and Mark Carry-Forward

In order to progress, students must pass each year and fulfil all requirements as outlined in the College calendar. The overall degree result comprises a weighted aggregate of the annual marks for Junior Sophister (20%) and Senior Sophister (80%) years.

Final Year Viva Voce Examination

All final year students will be interviewed by the external examiner at the end of the examination period and prior to the final board of examiners' meeting. Final year students must be available for interview and should not make plans to leave College prior to publication of the final results.

AN IMPORTANT NOTE REGARDING PLAGIARISM

All students (undergraduate and postgraduate, new entrants and existing students) must ensure that they have a clear understanding of what plagiarism is, how Trinity deals with cases of plagiarism, and how to avoid it.

We ask you to take the following steps:

(i) Visit the online resources to inform yourself about how Trinity deals with plagiarism and how you can avoid it at <http://tcd-ie.libguides.com/plagiarism>. You should also familiarize yourself with the 2015-16 Calendar entry on plagiarism and the sanctions which are applied.

(ii) Complete the 'Ready, Steady, Write' online tutorial on plagiarism at <http://tcd-ie.libguides.com/plagiarism/ready-steady-write>. Completing the tutorial is compulsory for all students.

(iii) Familiarise yourself with the declaration that you will be asked to sign when submitting course work at <http://tcd-ie.libguides.com/plagiarism/declaration>. (Download coursework/assignment submission forms [here](#).)

(iv) Contact your College Tutor, your Course Director, or your Lecturer if you are unsure about any aspect of 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 Bloggs, 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]

MARKING CRITERIA

The following guidelines outline the criteria used in awarding grades for Essays and Examination Answers in the Sophister Years.

Class	Mark Range	Criteria
I	90-100	EXCEPTIONAL ANSWER; This answer will show original thought and a sophisticated insight into the subject, and mastery of the available information on the subject. It should make compelling arguments for any case it is putting forward, and show a rounded view of all sides of the argument. In exam questions, important examples will be supported by attribution to relevant authors, and while not necessarily giving the exact date, should show an awareness of the approximate period. In essays, the referencing will be comprehensive and accurate.
	80-89	OUTSTANDING ANSWER; This answer will show frequent originality of thought and make new connections between pieces of evidence beyond those presented in lectures. There will be evidence of awareness of the background behind the subject area discussed, with evidence of deep understanding of more than one view on any debatable points. It will be written clearly in a style which is easy to follow. In exams, authors of important examples may be provided. In essays all important examples will be referenced accurately.
	70-79	INSIGHTFUL ANSWER; showing a grasp of the full relevance of all course material discussed, and will include one or two examples from wider reading to extend the arguments presented. It should show some original connections of concepts. There will be only minor errors in examples given. All arguments will be entirely logical, and well written. Referencing in exams will be sporadic but referencing should be present and accurate in essays.
II-1	65-69	VERY COMPREHENSIVE ANSWER; good understanding of concepts supported by broad knowledge of subject. Notable for synthesis of information rather than originality. Evidence of relevant reading outside lecture notes and coursework. Mostly accurate and logical with appropriate examples. Occasionally a lapse in detail.
	60-64	LESS COMPREHENSIVE ANSWER; mostly confined to good recall of coursework. Some synthesis of information or ideas. Accurate and logical within a limited scope. Some lapses in detail tolerated. Evidence of reading assigned course literature.
II-2	55-59	SOUND BUT INCOMPLETE ANSWER; based on coursework alone but suffers from a significant omission, error or misunderstanding. Usually lacks synthesis of information or ideas. Mainly logical and accurate within its limited scope and with lapses in detail.
	50-54	INCOMPLETE ANSWER; suffers from significant omissions, errors and misunderstandings, but still with understanding of main concepts and showing sound knowledge. Several lapses in detail.
III	45-49	WEAK ANSWER; limited understanding and knowledge of subject. Serious omissions, errors and misunderstandings, so that answer is no more than adequate.
	40-44	VERY WEAK ANSWER; a poor answer, lacking substance but giving some relevant information. Information given may not be in context or well explained, but will contain passages and words, which indicate a marginally adequate understanding.
Fail	35-39	MARGINAL FAIL; inadequate answer, with no substance or understanding, but with a vague knowledge relevant to the question.
	30-34	CLEAR FAILURE; some attempt made to write something relevant to the question. Errors serious but not absurd. Could also be a sound answer to the misinterpretation of a question.
	0-29	UTTER FAILURE; with little hint of knowledge. Errors serious and absurd. Could also be a trivial response to the misinterpretation of a question.

5. Staff, Contacts & Support

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

General administration (including examination results) for the Freshman Years is handled by the Science Course Office (see www.tcd.ie/Science)

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

Executive Officer: Ms Sarah Guerin (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 Mary Bourke, B.A., M.A. (UCD), Ph.D. (ANU)

Research Interests: Physical Geography: Geomorphology of Mars and Earth; fluvial, aeolian, mass wasting and rock breakdown, arid zone geomorphology.

Contact: bourkem4@tcd.ie

Dr Patrick Bresnihan

Research Interests: Political ecology and environmental infrastructures with a particular focus on water and energy.

Contact: pbresnih@tcd.ie

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

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 Catherine Coxon

Research Interests: Groundwater quality, nutrient transfers, wetland ecosystems, karst hydrogeology

Contact: cecoxon@tcd.ie

Dr Robbie Goodhue

Research Interests: Building materials; Geochemistry

Contact: goodhuer@tcd.ie

Prof. Balz Kamber

Research Interests: Global geochemical cycles; the early Earth

Contact: kamberbs@tcd.ie

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

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

Contact: nicholji@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 Emma Tomlinson

Research Interests: Evolution of silicic magmas, tephrostratigraphy and tephrochronology, mantle fluids & metasomatism.

Contact: tomlinse@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

STUDENT 2 STUDENT

From the moment you arrive in College right the way through to your end of year exams Student 2 Student (S2S) is here to make sure your first year is fun, engaging and a great foundation for the rest of your time in Trinity. You'll meet your two S2S mentors in Freshers' Week and they'll make sure you know other people in your course before your classes even start. They'll keep in regular touch with you throughout your first year and invite you to events on and off campus. They'll also give you useful information about your course and what to look out for. Mentors are students who have been through first year and know exactly what it feels like, so you never have to worry about asking them a question or talking to them about anything that's worrying you.

S2S also offers trained Peer Supporters if you want to talk confidentially to another student or just to meet a friendly face for a coffee and a chat.

S2S is supported by the Senior Tutor's Office and the Student Counselling Service.

<http://student2student.tcd.ie>, E-mail: student2student@tcd.ie, Phone: + 353 1 896 2438

6. 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 *Safety, Health and Welfare at Work Act (2005)*, 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.