



Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Science at Trinity

Faculty of Science, Technology, Engineering and Mathematics (STEM)

**TR062 Geography and Geoscience
Senior Fresh Programme 2024 - 2025**



Table of Contents

TR062: Geography and Geoscience introduction	3
TR062 Geography and Geoscience overview and module selection.....	4
Semester structure	5
Open Module Choice Forms	5
Moderatorships.....	5
The European Credit Transfer Accumulation System (ECTS).....	6
Change of Open modules.....	6
College registration.....	6
TR062 Geography and Geoscience - CORE MODULES	7
GSU22201: From Atoms to Rocks: Introduction to Geochemistry.....	7
GSU22202: Sedimentary Processes & Environments	8
GSU22003: Tectonics: Shaping Planet Earth.....	10
GSU22004: Senior Fresh Field Course.....	13
GGU22006: Physical Geography: Dynamic Earth.....	14
BYU22S01: Statistics and Computation	15
PIU22992: History, Philosophy and Ethics of Science.....	18
TR062 Geography and Geoscience – OPEN MODULES	19
BYU22201: From Molecules to Cells II.....	19
BYU22202: From Cells to Organisms	24
BYU22203: From Organisms to Ecosystems II	31
BYU22204: Sustainable Production: Food, Drink and Drugs	38
BYU22205: Influences on Animal Behaviour	40
BYU22206: Microbes, Immune Systems, and their Interaction.....	45
BYU22207: Genomes, Disease and Diversity	49
CHU22201: Chemistry 1.....	52
GGU22925: Human Geography: Changing Worlds.....	55
GGU22008: History & Philosophy of Geography	57
GGU22009: Spatial Data & GIS	58
GLU22007: The History and Evolution of Life on Earth	59
Graduate Attributes	60
Important information	61
Closing Dates for Course Transfer.....	61
Progression and Awards	61
Attendance.....	61
Assessment: procedures for the non-submission of coursework and absence from examinations	61
Guidelines on Marking for Junior and Senior Fresh Courses.....	62

Plagiarism.....	63
Absence from College – Medical and Absence Certificates.....	64
Student Services.....	65
Useful College Websites:	66
Academic Year Structure 2024-2025	67
Teaching Term Dates 2024-2025	67
TR062: Geography and Geosciences Contact details:	68
Appendix 1: General Information	69

TR062: Geography and Geoscience introduction

Welcome to Geography and Geoscience at Trinity. Geography and Geoscience is the study of our planet and the people that live on it. This multi-disciplinary programme is designed by leading research scientists in response to critical challenges facing the Earth system and humanity in the 21st century. It integrates knowledge from the physical, chemical, biological and social sciences to develop novel insights into Earth system function and human-environment interactions.

Our four-year programme, culminating in the degrees of Geography or Geoscience, combines classroom lectures, seminars, laboratory-based practical classes, and outdoor field work, to develop the theoretical understanding and technical expertise needed to address applied, real-world problems such as natural resource management and sea level rise.

In years 1 and 2 you will acquire a broad grounding in geography and geoscience with an emphasis on physical geography, geology and human-environment interactions. You will learn about topical issues such as climate change, natural hazards (e.g. volcanoes, earthquakes, landslides), energy, sustainability and natural resources. These foundation years cover a diverse range of material including: the origins and development of our planet; earth structure and composition; circulation in the atmosphere and oceans; the evolution of life on Earth; Earth surface processes and environments (e.g. glaciers, rivers and deserts). In addition to learning about the physical, chemical and biological processes responsible for creating and shaping the Earth, you will also consider the unique role that humans play in the Earth system, including our impacts on the land, air and water, and the grand challenges linked to environmental governance, policy and management.

In years 3 and 4, you will deepen your knowledge in specialist areas, while further developing a portfolio of practical and technical skills. The flexible programme structure provides for module choice while retaining coherent curriculum design, thereby ensuring you will be well prepared for entry to the constantly changing job market. Specialist options span the breadth of Geography and Geoscience, allowing you to tailor the course to suit your interests. In this way, you may focus on topics traditionally associated with geography (e.g. geomorphology, globalisation, sustainability) or geology (e.g. volcanology, palaeontology, natural resources), or you may choose to retain a broader, multi-disciplinary perspective that spans the critical interface between science and society.

An important part of your final year of study is the independent research project in which you will undertake an in-depth investigation of a specific topic. This project acts as a catalyst for you to reflect on your learning from the programme as a whole and to demonstrate your ability to think independently, communicate effectively, develop continuously and act responsibly as you transition to the world of work or to postgraduate studies.

My colleagues and I look forward to working with you and hope you will find your time at Trinity enjoyable, challenging and rewarding in equal measure.

Professor Sean McClenaghan

Director, TR062 Geography and Geoscience Course

TR062 Geography and Geoscience overview and module selection

The second year builds on the material covered in the first year and includes a residential field course in the study week of Semester 2. The Senior Fresh year is divided into Semester 1 (Michaelmas term) and Semester 2 (Hilary term) and you must select modules to the value of 60 credits for the year with no more than 30 credits from Semester 1 and 30 credits from Semester 2.

***** NOTE: Students will be required to pay an enrolment fee (approx. €400) for these mandatory field courses to cover field materials, transport, food and lodging. *****

Module Selection

Students must take 40 core/mandatory credit modules (20 in each Semester) as follows:

GSU22201:	From Atoms to Rocks: Introduction to Geochemistry	Semester 1	5
GSU22202:	Sedimentary Processes and Environments	Semester 1	5
GSU22003:	Tectonics: Shaping Planet Earth	Semester 2	5
GSU22004:	Senior Fresh Field Course	Semester 1	5
GGU22006:	Physical Geography: Dynamic Earth	Semester 2	10
BYU22S01:	Statistics and Computation	Semester 1	5
PIU22992:	History, Philosophy and Ethics of Science	Semester 2	5

Students will choose Open modules to the value of 20 credits (10 in Semester 1 & 10 in Semester 2)

BYU22201:	From Molecules to Cells	Semester 1	10
BYU22204:	Sustainable Production: Food, Drink and Drugs	Semester 1	5
BYU22205:	Influences on Animal Behaviour	Semester 1	5
CHU22201:	Chemistry	Semester 1	10
GGU22925:	Human Geography: Changing Worlds	Semester 1	10
GGU22008:	History and Philosophy of Geography	Semester 1	5
BYU22202:	From Cells to Organisms	Semester 2	10
BYU22203:	From Organisms to Ecosystems	Semester 2	10
GLU22007	The History and Evolution of Life on Earth	Semester 2	5
BYU22206:	Microbes, Immune Systems & their interaction	Semester 2	5
BYU22207:	Genomes, Disease & Diversity	Semester 2	5
GGU22009:	Spatial Data & GIS	Semester 2	5

Semester structure

***Teaching term dates may be subject to change.**

TR062: GEOGRAPHY AND GEOSCIENCE

CORE MODULES (mandatory) – (20 in Semester 1, and 20 in Semester 2) as follows:

SEMESTER 1 – Michaelmas Term 09 September 2024 – 29 November 2024	SEMESTER 2 – Hilary Term 20 January 2025 – 11 April 2025
GSU22201: From Atoms to Rocks: Introduction to Geochemistry (5 credits)	GSU22003: Tectonics: Shaping Planet Earth (5 credits)
GSU22202: Sedimentary Processes & Environments (5 credits)	GGU22006: Physical Geography: Dynamic Earth (10 credits)
BYU22S01: Statistics and Computation (5 credits)	PIU22992: History, Philosophy and Ethics of Science (5 Credits)
GSU22004: Senior Fresh Field Course (5 credits)	
OPEN MODULES (optional): Students will choose Open modules to the value of 20 credits (10 in each Semester)	
BYU22201: From Molecules to Cells (10 credits)	BYU22202: From Cells to Organisms (10 credits)
BYU22204: Sustainable production: Food, Drink and Drugs (5 credits)	BYU22203: From Organisms to Ecosystems (10 credits)
BYU22205: Influences on Animal Behaviour (5 credits)	BYU22206: Microbes, Immune Systems & their Interaction (5 credits)
CHU22201: Chemistry 1 (10 credits)	BYU22207: Genomes, Disease & Diversity (5 credits)
GGU22925: Human Geography: Changing Worlds (10 credits)	GGU22009: Spatial Data & GIS (5 credits)
GGU22008: History & Philosophy of Geography (5 credits)	GLU22007: The History and Evolution of Life on Earth (5 credits)

Open Module Choice Forms

Please submit module choice forms online by **4pm on Friday 19th April 2024**. Forms are available online via the following link: <https://forms.office.com/e/PVVaE0a5dz>

Moderatorships

In the Junior and Senior Fresh years TR062 students complete a course of study which will qualify them to compete for a place in one of the following Moderatorships after the Senior Fresh year:

Geography
Geoscience

The European Credit Transfer Accumulation System (ECTS)

The European Credit Transfer and Accumulation System (ECTS) is an academic credit system based on the estimated student workload required to achieve the objectives of a module or programme of study. It is designed to enable academic recognition for periods of study, to facilitate student mobility and credit accumulation and transfer. The ECTS is the recommended credit system for higher education in Ireland and across the European Higher Education Area.

The ECTS weighting for a module is a **measure of the student input or workload** required for that module, based on factors such as the number of contact hours, the number and length of written or verbally presented assessment exercises, class preparation and private study time, laboratory classes, examinations, clinical attendance, professional training placements, and so on as appropriate. There is no intrinsic relationship between the credit volume of a module and its level of difficulty.

The European **norm for full-time study over one academic year is 60 credits**. 1 credit represents 20-25 hours estimated student input, so a 10-credit module will be designed to require 200-250 hours of student input including class contact time, assessments, and examinations.

ECTS credits are awarded to a student only upon successful completion of the course year.

Progression from one year to the next is determined by the course regulations. Students who fail a year of their course will not obtain credit for that year even if they have passed certain component courses. Exceptions to this rule are one-year and part-year visiting students, who are awarded credit for individual modules successfully completed.

https://ec.europa.eu/education/resources-and-tools/european-credit-transfer-and-accumulation-system-ects_en

Change of Open modules

If, after a couple of weeks, a student feels that they have perhaps made the wrong choice of approved module combination, they should seek **advice immediately** from a Tutor, Course Director or the Science Course Office. It may be possible to change from one module to another within your course, subject to permission from the Associate Dean of Undergraduate Science Education. Once a decision has been made to change modules, it should be done **quickly** - it can be difficult to try to catch up with work in a new module when more than two or three weeks of lectures have been missed.

If you wish to change your mind before term begins in September 2023, you can resubmit the online form with a subject line of "change of module choice" and a note in the form specifying "change of module choice". Online forms can be found via the following link:

<https://forms.office.com/e/PVVaE0a5dz>. All change of module requests must be submitted via the online modules form by **Monday 30th September 2024**.

College registration

The Academic Registry issue an **'Invite to Register'** email to all continuing students eligible to register for the forthcoming academic year. This communication is issued via the my.tcd.ie portal and your institutional (TCD issued) email address. On receipt of the emailed invitation, you should log in to the my.tcd.ie to complete the registration steps. All information regarding College registration is available at the following links:

<https://www.tcd.ie/academicregistry/> and

<https://www.tcd.ie/academicregistry/student-registration/>

TR062 Geography and Geoscience - CORE MODULES

GSU22201: From Atoms to Rocks: Introduction to Geochemistry

Semester 1, 5 credits

Contact Hours

2 x 1-hour lectures / week for 10 weeks = 20 hours

1 x 3 hours laboratory / week for 10 weeks = 20 hours

Module Personnel

Dr. Michael Stock and Dr Juan Diego Rodriguez-Blanco

Module Outline

Geochemistry is a branch of Earth Sciences that uses chemical principles to study how the geosphere, hydrosphere, atmosphere and biosphere interact to process and distribute elements. This module will introduce fundamental chemical concepts, using geological examples to demonstrate their importance in Earth Science. The module provides an overview of high- and low-temperature geochemistry, outlining both how elements are processed in the Earth's crust/mantle, and providing an overview of the interaction between dissolved elements in natural waters and the rocks which they come in contact.

Module Learning Outcomes

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

- Illustrate the importance of geochemistry in Earth Sciences and the relationship between geochemistry and geology, environmental chemistry, oceanography, soil sciences and biology.
- Describe the electronic structure of atoms and ions, as well as the periodic table and the arrangement of atoms to form solids.
- Describe the main geochemical reservoirs Earth and the processes responsible for distributing elements within the crust and mantle.
- Outline the most relevant physicochemical phenomena occurring when minerals are dissolved in melts and aqueous solutions.
- Illustrate the most important processes occurring during the interaction of minerals/rocks with water and their relevance to environmental quality and therefore to humans.
- Define radiogenic and non-radiogenic isotope systematics and their importance in Earth Science.
- Relate the relevance of the carbon cycle and carbonate minerals with life, ocean evolution, climate and availability of elements.

Method of assessment

Theory examination (80%; 2 hrs) and in-course practical assessment (20%). For both assessment components is minimum threshold for passing.

Recommended reading lists

Ryan, P. (2014) Environmental and Low Temperature Geochemistry. Wiley-Blackwell.

White, W. M. (2013) Geochemistry. Wiley-Blackwell.

Contacts:

Module Coordinator: GSU22201: From Atoms to Rocks: Introduction to Geochemistry	
Dr Michael Stock	E-mail: MICHAEL.STOCK@tcd.ie
	Phone: 01 896 2957
Executive Officer:	E-mail: TR062Admin@tcd.ie
	Phone: 01 896 1074

GSU22202: Sedimentary Processes & Environments

Semester 1, 5 credits

Contact Hours

Lectures = 20 hrs

Lab Practical's = 8 hrs

Module Personnel

Dr Micha Ruhl, Prof. Gerald Dickens, Dr Robin Edwards

Module Aims

Sediments and sedimentary rocks hold a rich history of how physical, chemical, and biological processes have changed over space and time. This module is designed to give basic information, so that the evolution of Earth's surface can be understood. We will share how one can take sediments and sedimentary rocks and reconstruct the past and appreciate the processes that led to what we can see today. This module will provide the fundamentals of sediments and sedimentary rocks, and how to think about Earth evolution.

The module will develop understanding of:

- Geological time
- Basic sedimentary rock-analyses: from observation, to interpretation
- How sediments are generated transported, deposited & preserved
- Different sedimentary depositional environments across the Earth system (past & present; continental & marine)
- How sedimentary archives provide records of (changes in) the past Earth system and past environmental & climate change processes

Module Content

Earth's climate and environments have changed on multiple temporal and spatial scales throughout its history, which significantly impacted on physical, chemical and biological processes across Earth's surface. Information on past climates and environments, stored in sedimentary archives, informs our understanding on present-day conditions at Earth's surface and provides constraints on future changes. Sedimentary materials storing such information can be found across most of the Earth's crust, both on land and in the oceans, and much of our understanding of Earth history comes from their examination.

This Module will introduce key physical, chemical, biological and sedimentary processes, deposits and examples of contemporary sedimentary depositional environments. It will analyse and explain the generation, transport and preservation of sediments, as diagnostic tools to link surface processes with the geological records of Earth history, as well as modern environmental change.

To achieve the module learning aims, the module will introduce examples of environmental change, and their impact on the sedimentary depositional environment at that time, such as Snowball Earth, Oceanic Anoxic Events, Hyperthermals, the Messinian Salinity Crisis, and Quaternary Glacial-Interglacial Cycles.

The above described module will prepare the student for related modules in Stratigraphy, Climate Change, Oceanography, as well as fieldwork, in Junior and Senior Sophister.

Learning Outcomes

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

- Classify sediments and sedimentary rocks
- Provide technical descriptions of common sedimentary rock types and textures from hand samples and thin sections
- Explain the basic concept of "source-to-sink", and how this links weathering of mountains, and transport and deposition of sediments

- Describe changes in sedimentary archives from outcrop observations, stratigraphic logs and/or petrological evidence
- Describe (changes in) in sedimentary archives, and interpret these in regard to changes in physical, geochemical and biological Earth surface processes, and changing environments
- Distinguish and describe temporal and spatial variability in Earth surface processes and how this links to sediment deposition locally
- Illustrate how Global Change processes (physical/ geochemical/biological) (have) shape(d) Earth's surface, in the past, present, and future

Method of assessment

Laboratory practical's (50%); In-course problem solving exercises and tests (50%)

Module Coordinator: GSU22202: Sedimentary Processes & Environments	
Dr Micha Ruhl	E-mail: MICHA.RUHL@tcd.ie
	Phone: 01 896 1165
Executive Officer:	E-mail: TR062Admin@tcd.ie
	Phone: 01 896 1074

GSU22003: Tectonics: Shaping Planet Earth

Semester 2, 5 credits

Contact Hours

2 x 1 hour lectures / week for 10 weeks = 20 hours

1 x 2hr laboratory / week for 9 weeks = 18 hours

Module Personnel

Prof. David Chew

Module learning aim

To provide foundation-level knowledge of:

- The processes and products of plate tectonics
- Core concepts in structural geology
- Visualisation of geological structures through the use of geological maps and cross sections

To develop the following skills & graduate attributes

- Critical thinking
- Conceptual framework that will underpin subsequent specialism in Geography & Geoscience

Module Content

Lecture	Topic and Content
1	Topic 1. Introduction to plate tectonics Historical evolution of plate tectonic ideas; the theory of plate tectonics and the three main types of plate boundary
2	Topic 2. Plate movements Kinematic representation of plate tectonics on a sphere (Euler poles); measuring plate motion on human and geological time scales; reconstructing ancient plate configurations (palaeomagnetism).
3	Topic 3. Internal structure of the Earth Evidence for a layered Earth based on average density, seismic waves, meteorites and petrology (xenoliths, experimental). The major discontinuities – the Moho, the lithosphere – asthenosphere boundary; phase changes in the mantle, the mantle – core boundary, phase changes in the core.
4	Topic 4. Structure of the Oceanic and Continental crust Hypsometry of the Earth's surface; distinction between the oceanic and continental crust; Airy and Pratt isostasy. Deep structure of the oceanic lithosphere – the Moho and magma chambers.
5	Topic 5. Earthquakes and seismology Measuring the force of earthquakes; P, S, Rayleigh and Love waves; seismometers and measuring epicentres.
6	Topic 6. Tsunami: Process and Hazard (Robin Edwards) Origin of tsunamis; historical tsunamis; tsunami hazard.
7	Topic 7. Ocean-continent (Andes) Structure of the Andes; why are the Andes so high? Principal mechanisms for Andean orogeny.
8	Topic 8. Continent-continent collision (Himalayas) Introduction to foreland basins and flexural isostasy. Continent-continent collision – the Himalaya. Diffuse vs. plate-like deformation. Orogenic erosion. An ancient continent-continent collision – the Caledonides.

9	Topic 9. Continent-continent collision – the Alps and the Caledonides Tectonic history of the Alps. An ancient continent-continent collision – the Caledonides.
10	Topic 10. Sedimentary basins (part 1) Strike slip basins – structure and subsidence. Subsidence curves of foreland basins. Subduction basins – accretionary wedges, forearc basins and back-arc basins.
11	Topic 11. Rifting and extensional basins (part 2) Introduction to normal faults using the Aegean as a case study. The simple shear (Wernicke) and pure shear (McKenzie) models for lithospheric extension. Testing the McKenzie model using the North Sea - thinning of crust, extension on faults, sediment geometry, regional subsidence, heat flow.
12	Topic 12. Global tectonics and ore deposits (Sean McClenaghan) (part 1) Introduction to ore deposit geology: Importance of mineral deposits and the mining cycle; formation of mineral deposits, their source, transport and concentration in depositional environments.
13	Topic 13 Global tectonics and ore deposits (Sean McClenaghan) (part 2) An overview of mineral deposit styles and tectonic setting; tectonic controls on metal signatures in hydrothermal deposits, examples from the modern seafloor and ancient settings
14/15	Topics 14, 15. Tectonics, climate and the evolution of life Rare Earth hypothesis; the Great Oxygenation Event; Snowball Earth; the Cretaceous – Tertiary (K-T) extinction
	Structural Geology lectures
16	Topic 16: Introduction 1. What is structural geology? 2. Why is structural geology important? 3. Observing and describing deformation. 4. Describing stress in 2D and 3D. 5. Factors controlling rock deformation: pressure, temperature, competency, strain rate, fluids. 6. Interpreting structural histories.
17	Topic 17: Brittle Deformation 1. Observing and describing joints. 2. Observing and describing faults. 3. Relationship between faults and principal tectonic stresses. Observations from laboratory experiments. Anderson’s theory. 4. Examples of normal, thrust and strike-slip faults. 5. What happens at the ends of faults?
18	Topic 18: Ductile Deformation 1. Fold orientation: hinge lines, axial surfaces, plunge. 2. Fold shape: amplitude, wavelength, roundness, tightness, attitude, vergence, symmetry, harmony. 3. Folds in map and section view: antiforms, anticlines, synforms, synclines. 4. Folding mechanisms: buckling of single and multi layers, shear folds, flexural slip, folds related to faults.
19	Topic 19: Quantifying Strain 1. Components of strain: translation, rotation, distortion, dilation. 2. The strain ellipse and the strain ellipsoid. 3. Distribution of strain: pure shear and simple shear, homogeneous and inhomogeneous deformation, measuring strain from brittle and ductile deformation.
20	Topic 20: Fabrics 1. Primary and secondary fabrics. 2. Planar fabrics: cleavage, stylolites, schistosity, gneissic banding. 1. Linear fabrics: form lineations, mineral lineations, surface lineations. 2. Determining strain from fabrics. 5. Shear zones.
21	Topic 21: Minor Structures 1. Veins: sigmoidal tension gashes, conjugate vein arrays, difference between brittle and brittle-ductile deformation. 2. Grains: augen, pressure shadows, porphyroblasts. 3.

	Fibres: mineral fibres, slickensides. 4. Conclusion: kinematics and dynamics, strain and stress.
--	--

Learning Outcomes

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

- investigate and explain how, why and where rocks undergo deformation
- describe the different plate tectonic environments, and their evolution in time and space
- interpret two-dimensional representations of geological data (maps) in three dimensions

Method of assessment:

Theory examination (50%; 1.5hrs) and in-course practical assessment (50%)

Module coordinator - GSU22003: Tectonics: Shaping Planet Earth	
Professor David Chew	E-mail: chewd@tcd.ie
	Phone: 01 896 3481
Executive Officer	E-mail: TR062Admin@tcd.ie
	Phone: 01 896 1074

GSU22004: Senior Fresh Field Course

Semester 1, 5 credits

Contact Hours

1-week residential field course normally held during the study week. Anticipated cost: ~ €400

Module Co-ordinator

Prof. Gerald Dickens

Learning Aims

To provide foundation-level knowledge of:

- Core field skills of systematic observation and recording in a range of geoscience contexts.
- How theoretical geographical / geoscience concepts are applied in a practical, real-world setting.
- The geological history of a particular study area and its relationship to the wider history of the planet
- The modern processes operating in a particular study area and their relevance to contemporary landscape change.

To develop the following skills & graduate attributes

- Act responsibly at all times and conduct yourself in a manner consistent with the values of Trinity College Dublin
- Enhance teamwork skills, including collaborative work facilitated by effective oral and written communication.
- Independent, critical thinking and real-world problem solving in a time-limited setting.

Module Outline

Field work is an essential component of training in Geography and Geoscience. This module comprises a week-long residential field course during which time you will complete a series of practical tasks based around core geographical and geoscience topics covered elsewhere in the course. The tasks and problem-solving activities are designed to help you translate theoretical/textbook knowledge into practical/real-world understanding. This module forms the foundation for future field-based activities in your sophomore years.

Learning Outcomes

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

- Identify common sedimentary, igneous and metamorphic rocks in the field.
- Identify and record basic geomorphological / geological features and processes.
- Describe and record a range of Quaternary sediments and landforms.
- Produce an accurate summary of your work in the form a field notebook.
- Conduct basic field surveys in a safe and professional manner.

Assessment Details

Coursework based on field activities and notebook (100%)

Module coordinator - GSU22004 Senior Fresh Field Course	
Professor Gerald Dickens	E-mail: DICKENSG@tcd.ie
Executive Officer	E-mail: TR062Admin@tcd.ie
	Phone: 01 896 1074

GGU22006: Physical Geography: Dynamic Earth

Semester 2, 10 credits

Contact Hours

4 x 1 hr lectures / week for 10 weeks = 40 hrs

Module Personnel

Dr Pete Akers, Dr John Connolly, Dr Margaret Jackson, Prof Iris Möller, Dr. Mary Bourke

Module Content:

Physical geography is an exciting scientific discipline that examines the Earth and how it functions. Geographers have already contributed substantially to scientific efforts to understand the emergence of truly globally significant human– environmental linkages. Physical Geography has thus been fundamental to investigating and modelling long-term changes to Earth surface process and dynamics. This type of knowledge is critical in allowing humans to live sustainably on planet Earth. In this module you study a wide variety of environmental systems, ranging from climate and weather to soils, beaches and rivers, to name just a few. The focus is to understand the location and character of landscape features such as mountain ranges and river valleys, and to explain why they came to be and how and why they vary depending on their geographic context. An underlying theme is to examine how aspects of physical geography affect human lives and, in turn, how people impact the dynamics of the physical landscape. This module will give students an understanding of key physical geography concepts. You will build on key areas of Geography from the JF Spaceship Earth and Anthropocene modules. Elements of the module are designed to prepare students for Sophister geography modules.

Module learning outcomes:

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

- Critically evaluate the influence of climate, topography and humans on the variability of landforms.
- Explain the theories underlying how and why specific landforms vary over space and time.
- Draw on specific example of landforms and landscapes to demonstrate the influence of climate, topography, and humans.
- Evaluate the complex and reciprocal relationships between physical and human aspects of environments and landscapes.
- Assess the relative importance of infrequent/extreme versus frequent/moderate events in driving landform change.
- Discuss the potential application of geographical concepts, techniques and expertise as a means of addressing a range of issues facing the Earth and its people at a global and local scale.
- Explain the importance and relevance of physical systems and landforms to the future of human society.

Assessment Details:

In course tests and assessment (100%)

Module coordinator - GGU22006: Physical Geography: Dynamic Earth	
Dr Pete Akers	E-mail: pete.akers@tcd.ie
Executive Officer	E-mail: TR062Admin@tcd.ie
	Phone: 01 896 1074

BYU22S01: Statistics and Computation

Semester 1, 5 credits

Prerequisite: none

Module Coordinator: To be announced

Contact Hours: 20 hours Lectures; 5 x 3 hour practicals; 3 x 1 hour computational practise clinics. Attendance at practicals and computational practise clinics is mandatory & will be assessed.

Module Personnel: To be announced, Professor Dan Bradley, Professor Máire Ní Leathlobhair, Dr. Karsten Hokamp, Dr Jim Barnett

Learning Aims:

Through lectures (content delivery, explanation), practicals (learning how to problem-solve, program and design), computational practise sessions (reinforcement of practical learning), and formative assessment (problem solving) we will provide students with a broad overview of the kinds of statistical and computational approaches that are commonly used across the biosciences and geosciences. We will introduce the basics of programming techniques that are transferable across programming languages. This module will emphasise the importance of hypothesis generation and testing for different data types. We will introduce the basics of data driven modelling. We will enable students to work individually and in small groups to problem-solve and communicate the problem and solution in different formats.

Module content: Programme of lectures and practicals

Lecture Topic	Lecturer	Practical
Introduction to Statistics & Computation for Biologists, part of the scientific method		Computational practise 1 (M. Ní Leathlobhair)
Communicating quantitative biology		
Variables: types, sample distributions, summary statistics		Practical 1: R-Studio (M. Ní Leathlobhair)
Principles of probability		
Data visualisation, regression, correlation , precision & accuracy		Computational practise 2 M. Ní Leathlobhair)
Normal distribution z score, p values correlation		
Computation Control Structures: branching & loops	K. Hokamp	Practical 2: Hypotheses (M. Ní Leathlobhair)
Reusing code: functions and blocks	K. Hokamp	
Functional programming in R	K. Hokamp	
Programming in practice: document, debug, test & distribute	K. Hokamp	
Type I, type II errors	D. Bradley	Prac 3: Programming (K. Hokamp)
Sample error of the mean	D. Bradley	
Reading Week		
The t distribution and t tests	D. Bradley	MCQ test
The basics of Analysis of variance	D. Bradley	
Chi squared testing, contingency tables	D. Bradley	
Non-parametric tests	D. Bradley	
Simple linear regression & parameter estimation	J. Barnett	

Multiple linear regression & ANCOVA	J. Barnett	Computational practise 4 (J. Barnett)
Linear regression assumptions & generalised linear models	J. Barnett	Prac 4: Modelling 2 (J. Barnett)
Implementing an analysis workflow (support for final exam)		
		Prac 5: Modelling 2 (J. Barnett)

Description of Lecture Content:

- Introduction to module & resources, expectations around effort & activities. Where statistics & computation fit with the scientific method. How elements of the module fit together.
- Communicating quantitative biology – visualisation, writing comprehensible code, reporting on statistics. Workflows in quantitative biology, using R Studio, saving scripts, working with data, good housekeeping.
- Types of variables, sample distributions and families of summary statistics
- Basic rules of probability
- Data visualization, regression, correlation
- The normal distribution, the Z score and P values
- Type I, type II error
- Sample error of the mean
- The t distribution and t tests
- Analysis of variance (very basic introduction to concept)
- Regression & parameter estimation (intercept, slope)
- Multiple regression & ANCOVA
- Control Structures: branching and loops
- Reusing code: functions and blocks
- Functional programming in R
- Programming in practise: documentation, debugging, testing, distribution
- Chi squared testing, contingency tables
- Non-parametric test analogues of normal distribution-based tests
- Implementing an analysis workflow [to support the dataset analysis assessment]

Description of Practical Content:

- Computation in R & R-Studio, getting started with R, data import & visualisation
- Hypothesis generation and testing using 2D:4D finger length ratios
- Data collection in class, hypothesis generation, response and explanatory variables, data visualisation, using ratios, error assumptions, transformations, correlation & regression
- Statistical modelling to parameterise functional response curves
- Data collection in class – different densities of sweets with different handling times generate different parameter estimates for handling time & search rate by linearising the Hollings Disc Equation for functional curves (types 1, 2, and 3). Data input & collation (Google sheets). Workflow & pseudo-code.
- Using R to visualise the data, perform linear regressions, extract parameter estimates and plot functional responses on top of data. Draw conclusions and communicate results.
- Introduction to programming in Scratch. Create a graphical simulation of prey/predator or infection scenario. This will require understanding and application of control flow and will result in potential experimental data that can be captured for statistical analysis

- **Learning Outcomes:**

On completion of the module students will be able to:

- Design and use a work-flow and pseudocode for basic statistical and computational tasks
- Use R and R studio to import data, visualise data summaries and relationships, undertake basic statistical functions, models and tests, report summary statistics and draw conclusions
- Use different data types, understand what variables are and their types
- Generate and test hypotheses
- Parameterise biological functions using data
- Use control structures, functions and basics of good programming practise
- Generate and communicate well documented and tested code

Recommended Reading List:

Biocalculus: Calculus, Probability, and Statistics for Life Sciences. 1st Edition. J. Stewart and T. Day. Cengage. 2016

OpenIntro Statistics. 4th Edition. D. Diez, M. Cetinkaya-Rundel, C. Barr & OpenIntro. OpenIntro. 2019. <https://leanpub.com/openintro-statistics> (Available to download for a suggested price of \$15 or free).

Assessment Details:

Course work: 75% of the module, broken down as follows:

Practical assessments = 40% of module (best four of five practical marks used).

Computational practise submissions (three) = 5% of module

Mid term test based on lecture material in 1st half of semester = 25% of module

End of module examination: one hour exam = 25% of module

To pass the module a student must obtain an overall module mark of 40%.

Module Website

Blackboard site will be set up by Executive Officer and managed by module coordinator & other instructors.

Contacts:

Module Coordinator: To be announced

Biology Coordinator: Glynis Robinson, robinsog@tcd.ie, Phone: 01 8962895

Laboratory Manager: Audrey Carroll aucarrol@tcd.ie, Ph: 01 896 1620

Executive Officer: Daniel McCormick btcadmin@tcd.ie, Ph: 01 896 1117

Semester 2, 5 credits

Contact Hours:

22 hours of lectures + 10 hours of tutorials

Module Personnel: TBC

Module Content

In this module, we will consider foundational issues in the philosophy of science. Topics to be covered will include some selection of: the nature of scientific methodology, the variety of inference methods used in science (and their benefits and drawbacks), realism and anti-realism, and the role of values in science. By the module's end, students will be well situated to engage in further independent study of the topics in philosophy of science that interest them.

Learning Aims

Students will: 1) gain a grounding in foundational issues in philosophy of science; 2) learn how to critically assess theses in science and philosophy; 3) learn about how philosophy is relevant for, and can contribute to, the practise of science; and, 4) gain the knowledge and skills requisite for engaging in further work in the philosophy of science

Learning Outcomes

By the end of this course, students will possess an understanding of the core topics and ideas in the area of philosophy of science (see module content for more information), as well as how to critically engage with them. Consequently, they will be well-placed to: apply their knowledge in future scientific work; and, branch out and engage in their own independently guided research into the philosophy of science issues which interest them most.

Assessment

For 5 ECTS:

- 4x Written Responses of 750 words [25% each]

Module Website (See Blackboard)

Contacts:

Module Coordinator: TBC

Executive Officer: Tania Panero Garcia (philosophy@tcd.ie)

TR062 Geography and Geoscience – OPEN MODULES

BYU22201: From Molecules to Cells II

Semester 1, 10 credits

Prerequisite: BYU11101

Module coordinator: Prof Emma Creagh, ecreagh@tcd.ie Phone: 01 8962539

Contact Hours: 34 hours lectures, 21 hours practicals

Module Personnel: E. Creagh, K. Mok, A. Khan, J. Hayes, D. Nolan, E. Day, M. Ramaswami, S. Martin, M. Campbell, K. Roberts

Learning Aims:

This module aims to give students a detailed understanding of cellular structure, composition and function. The molecular composition of organelles, the processes carried out in each organelle, and how these processes are integrated in cellular function are presented in detail. Students are also introduced to enzyme kinetics; cellular metabolism; DNA structure and replication, transcription and translation; the regulation of gene expression; Mendelian inheritance and genetic disease. This module also introduces students to virology – how viruses replicate, mutate, enter cells and take over cellular processes during infection.

Module content:

Programme of lectures, practicals and an essay writing exercise: four lectures a week, Monday at 13:00, Wednesday at 17:00, Friday at 9:00 and 12:00, practicals Tuesday or Wednesday

Lecture Topic	Lecturer	Practical
Introduction to Module BYU22201 "From Molecules to Cells"	E. Creagh	Practical 1. Solutions & Dilutions
Cell structure & intracellular transport	E. Creagh	
Cell cytoskeleton I	E. Creagh	
Cell cytoskeleton II	E. Creagh	
Proteins & amino acids	K. Mok	Practical 2. Spectrophotometry & Chromatography
Protein folding and purification	K. Mok	
Oxygen binding proteins	K. Mok	
Enzymes, catalysis and assays	A. Khan	Practical 3. Enzyme Kinetics
Enzyme kinetics, inhibition & regulation	A. Khan	
Lipids - fatty acids & phospholipids	J. Hayes	
Lipids – beta-oxidation & fatty acid synthesis	J. Hayes	
Glycolysis and Gluconeogenesis	E. Day	
The TCA Cycle	E. Day	
Glycogen Metabolism	E. Day	

Powering Life: energy transduction & life	D. Nolan	
Bioenergetics 1: oxidative phosphorylation	D. Nolan	Practical 4. Oxidative Phosphorylation
Bioenergetics 2: the universality of chemiosmosis	D. Nolan	
Harvesting the light: photosynthesis	D. Nolan	
Summary & integration of metabolism	D. Nolan	
DNA – structure, replication, repair, recombination I	M. Ramaswami	
DNA – structure, replication, repair, recombination II	M. Ramaswami	
Reading Week -		
DNA – structure, replication, repair, recombination III	M. Ramaswami	Practical 5. Assessment of Genetic Variation through Computational Analysis
Transcription – RNA types, mRNA processing	M. Ramaswami	
Transcription – RNA types, mRNA processing	M. Ramaswami	
Regulation of gene expression: general principles	S. Martin	Practical 6. Differential Gene Expression I
Gene expression in prokaryotes and eukaryotes	S. Martin	
Chromatin and epigenetic effects on gene expression	S. Martin	
Alternative splicing and protein translation	S. Martin	
Mendelian inheritance	M. Campbell	Practical 7. Differential Gene Expression II
Mapping Mendelian traits	M. Campbell	
Quantitative traits and heritability	M. Campbell	
Genetics of common diseases	M. Campbell	
Virology (1)	K. Roberts	
Virology (2)	K. Roberts	
Revision Week		

Lecture Content:

- Introduction to the BYU22201 Module ‘from Molecules to Cells’
- Revision of Cell structure (Podcast), Membrane structure & Intracellular protein transport mechanisms. (Elements Flipped classroom)
- Cellular cytoskeleton I (Actin filaments, myosin motor protein) (combination of flipped classroom & traditional lectures material) - Principles of cellular movement & the process of muscle contraction.
- Cellular cytoskeleton II – Importance of Microtubules & Intermediate filaments for cellular function (combination of flipped classroom & traditional lectures material). Specialised microtubules involved in the motility of cilia/flagella will be discussed.
- What are proteins? The 20 amino acids and their structures and properties, acid-base equilibria, the isoelectric point. (Combined flipped classroom and traditional lectures) The polypeptide

chain and general properties of proteins. The hierarchy of protein structure (primary / secondary / tertiary / quaternary structures).

- Protein folding and protein misfolding diseases / neurodegenerative diseases. Protein purification and protein characterization techniques.
- Oxygen-binding proteins as an example of protein-ligand binding. Comparison of myoglobin and haemoglobin. Cooperativity. Bis-phosphoglycerate's role in oxygen affinity. Sick cell anaemia.
- Catalysis and the enzyme substrate relationship; Activation energy and the transition state. Michaelis-Menten kinetics; The active site- physicochemical properties; Enzyme assays.
- Principles of enzyme catalysis; Mechanisms of catalysis with examples; Reversible Inhibition; Allosteric regulation; Enzyme inhibitors as drugs Michaelis-Menten kinetics, limiting velocity, rate/enzyme correlation. Reversible inhibition and allosteric regulation.
- Lipids-Fatty Acids and phospholipids. What are lipids? Chemical and functional properties of diverse lipids such as steroid hormones, fat soluble vitamins and ketone bodies. Fatty acids, phospholipids and membranes.
- Lipids- β -oxidation and fatty acid synthesis. Energy production through the mobilisation of fatty acids from triacylglycerols and their oxidation in mitochondria. Energy storage through the synthesis of fatty acids and storage of triacylglycerols in adipocytes.
- Catabolism and anabolism. Sources of sugars in our diet. Glycolysis, its control and regulation. Catabolism of fructose and galactose. Fermentation.
- The necessity for gluconeogenesis. Its control and regulation. Substrate sources. Reciprocal control of gluconeogenesis and glycolysis in liver.
- Pyruvate dehydrogenase and control of regulation of oxidative catabolism of substrates via the tricarboxylic acid (TCA) cycle. The TCA cycle as a source of biogenic amines. The TCA cycle as a source of anabolic substrates. Anapleurotic reactions.
- What is glycogen? Breakdown of glycogen/glycogenolysis in liver and skeletal muscle. Its control and regulation. Flight or fight! The effect of starvation. Glycogen biosynthesis.
- Powering Life: Energy transduction & life. Introduction to basics: energy transduction in biological systems: concept of displacement from equilibrium, chemical potential, electrochemical potential and redox potentials. ATP and energy coupling: key concepts: Is ATP a high energy compound?
- Bioenergetics 1: Oxidative Phosphorylation. The machinery of oxidative phosphorylation: The electron transport chain and the universal turbine of life: the F_1F_0 -ATPase.
- Bioenergetics 2: The Chemiosmotic view of Life and the universality of the concept.
- Harvesting the light: Photosynthesis. The light reactions of photosynthesis: photophosphorylation, the Z scheme, PSI & II and C_1C_0 -ATPase. A comparison of oxidative and photo phosphorylation.
- Summary & Integration of Metabolism
- DNA – Structure, Replication, Repair, Recombination I. Discovery of DNA as the genetic material; structure, properties and conformation(s) of DNA; mechanism for DNA replication in prokaryotes and eukaryotes: DNA polymerases and the replisome.
- DNA - Structure, Replication, Repair, Recombination II. The role of telomeres in DNA replication in eukaryotes. Spontaneous and induced mutations; mutagens and the effects of mutations.
- DNA - Structure, Replication, Repair, Recombination III. DNA repair mechanisms; non-homologous end joining and homologous recombination.
- Transcription - RNA types and processing I. Discovery of RNA; properties and classes of RNAs; types of RNA polymerases; transcription in prokaryotes: initiation, elongation and termination.

- Transcription - RNA types and processing II. Types of RNA polymerases; transcription in eukaryotes: initiation, elongation and termination.
- Regulation of gene expression. The general principles of the regulation of gene expression in prokaryotes and eukaryotes.
- Gene expression in prokaryotes and eukaryotes. Mechanisms of the regulation of gene expression in prokaryotes and eukaryotes: promoters. Sigma factors, transcription factors, enhancers, silencers, insulators
- Chromatin and epigenetic effects on gene expression. Introduction to epigenetics; structure and composition of chromatin; histone and DNA modifications and their effects on chromatin and gene expression.
- Alternative splicing – protein translation. Mechanisms of alternative splicing. Initiation, elongation and termination of translation
- Mendelian Inheritance. Mendel's laws (revision of BYU11101) and molecular basis of inheritance patterns; pedigree analysis; gene interactions: dominance, co-dominance, incomplete dominance, recessivity, penetrance, expressivity, and epistasis.
- Mapping Mendelian traits: This lecture outlines the historical methods that were used to identify mutations in genes associated with Mendelian diseases. It highlights the methodology and underlying analysis with a focus on linkage and recombination.
- Quantitative traits and heritability: This lecture will focus on more complex traits, somatic mutations and heritability and how they pertain to human disease. The lecture uses examples of conditions such as breast cancer to describe the identification of genes that ascribe relative risk scores to disease.
- Genetics of common diseases: This lecture focuses on giving a wide range of examples of human disease that show Mendelian and non-mendelian modes of inheritance. It aims to give the student a broad understanding of the complexities of these diseases and the underlying genetic causes.
- Virology I: genetic diversity of viruses. The diversity of viral genomes and particle structures will be explored in this lecture. Introduction to viral replication - how different viruses enter cells and an example of viral strategies for producing mRNA.
- Virology II: Replication continued– we will explore how replication and assembly of new virions is dependent on location within the cell and also the cellular processes a virus needs to utilise during replication. In this lecture we will touch on viruses causing emerging infections and how their replication cycles have changed to adapt to new hosts/cell types.

Practical Content:

Practical 1 Solutions & dilutions - This numerical skills activity will prepare students for numerical calculations relevant for lab work (eg. calculating molarities, how to make up buffers, dilution factors, etc.).

Practical 2 Chromatography & spectrophotometry - During this practical students will perform (1) **ion exchange Chromatography** and (2) **a spectrophotometric enzyme assay**: increasing alcohol dehydrogenase (ADH) concentrations will be assayed - measuring the spectrophotometric production of NADH as the readout.

Practical 3 Enzyme Kinetics - Students perform a stopped enzyme assay, using increasing substrate and inhibitor concentrations. They calculate the final concentrations in the assay, calculate K_m and V_{max} for uninhibited series, use Lineweaver-Burk plots to demonstrate competitive inhibition, and determine the K_i .

Practical 4 Oxidative Phosphorylation

Practicals 5 and 6: Differential Gene Expression

Practical 7: Assessment of Genetic Variation through Computational Analysis

Introduction to Bioinformatics; accessing and retrieving DNA sequence information from *Genbank*; comparison of homologous gene sequences using *BLAST*; identification of polymorphisms.

Learning Outcomes:

- On completion of this module students should be able to demonstrate an understanding of fundamental concepts in the following cellular structures and processes: the structure and function of cells and organelles; structures and functions of nucleic acids, proteins, carbohydrates and lipids; the fundamental concepts and regulation of metabolism; the composition, structure, synthesis and function of DNA and RNA; regulation of gene expression in prokaryotes and eukaryotes; chromatin structure and epigenetic regulation of gene expression; the principles of genetic inheritance; genetic diseases and fundamental concepts in virology.
- Students should be able to demonstrate practical, numerical and analytical skills appropriate to modern biochemistry, genetics and microbiology.
- Students should be able to collate, synthesise and present information in written reports and essays.

Recommended Reading List:

The topics and concepts presented in this module will be found in many general textbooks on cell biology, biochemistry and genetics. The following are recommended for your guidance:

Essential Cell Biology. Alberts, Hopkin, Johnson, David Morgan, Raff, Roberts, Walter. (4th / 5th Editions). W. W. Norton & Company.

Biochemistry. Berg, Tymoczko, Gatto, Stryer (8th edition). Macmillan International.

Introduction to Genetic Analysis. Griffiths, Wessler, Carroll, Doebley (11th edition). W.H. Freeman and Co.

Assessment Details:

(A) End of semester written examination: 50% of module mark

The examination paper is divided into two sections, equally weighted.

- **Section 1: Essay** One essay from a choice of three.
- **Section 2** Ten short answer questions from across the module.

(B) Course Work: 50% of module mark

1. In course essay, 5% of module
2. Practical assignments 20% of module mark
3. End of Module practical exam, 15% of module
4. MCQ test of lecture material, 10% of module

To pass the module a student must obtain an overall module mark of 40%

Contacts:

Module Coordinator:	Emma Creagh, ecreagh@tcd.ie , Ph: 01 8962539
Biology Course Coordinator:	Glynis Robinson, robinsog@tcd.ie , Ph: 01 8962895
Laboratory Manager:	Audrey Carroll aucarrol@tcd.ie , Ph: 01 8961620
Executive Officer:	Daniel McCormick btcadmin@tcd.ie , Ph: 01 8961117

BYU22202: From Cells to Organisms

Semester 2, 10 credits

Prerequisite: BYU11101

Module coordinator: Prof Colm Cunningham, colm.cunningham@tcd.ie, Phone: 01 896 3964

Contact Hours: 37 hours lectures, 15 hours practicals.

Module Personnel: C. Cunningham, S. O'Brien, D. Zisterer, P. Murphy, Á. Kelly, T. Ryan, A. Witney, C Kröger

Learning Aims:

This module aims to bring the student from the functioning of prokaryotic unicellular organisms right up to the integrated functioning of perceiving, thinking, and acting multicellular organisms. The module will give the students an appreciation of the highly specialised and dynamic communication between cells and tissues that brings about the functioning organism.

Module content:

Programme of lectures, laboratory practical's and writing skills exercise. four lectures a week, Monday at 9:00, Tuesday at 9:00 and 13:00, Wednesday at 17:00, practicals on alternate Wednesdays.

Lecture Topic	Lecturer	Practical
Introduction to BYU22202 "From Cells to Organisms"	C. Cunningham	Practical 1. Adherence & the induction of bacterial gene expression Carsten Kröger
The bacterial world: diversity & unique extracellular structures	S. O'Brien	
Energy, transport and scavenging in bacteria	S. O'Brien	
Motility and chemotaxis in bacteria	S. O'Brien	
Cell: Cell communication & bacterial development	S. O'Brien	
Introduction to the bacterial cell envelope I	S. O'Brien	
Introduction to the bacterial cell envelope II	S. O'Brien	
Cell: Cell communication; autocrine, juxtacrine, paracrine & endocrine signalling	C. Cunningham	
Cargo packaging for export	C. Cunningham	
Calcium-dependent exocytosis for signal release (Neurotransmission I)	C. Cunningham	Practical 2. Resting membrane and action potential Colm Cunningham
Signalling via ligand-gated ion channels (Neurotransmission II)	C. Cunningham	
Intracellular signal-transduction: conserved mechanisms for responding to extracellular signals	D. Zisterer	
Signalling through G-protein coupled receptors	D. Zisterer	

Signalling through receptor tyrosine kinases and MAP kinases	D. Zisterer	
Conservation of signalling pathways between organisms	D. Zisterer	
Organising a body plan in multicellular organisms	P. Murphy	
Cell signalling/cell communication in the context of development	P. Murphy	Practical 3. Development Paula Murphy
Elaboration of positional information/progressive specification/cell lineage analysis	P. Murphy	
How a cell responds to positional information	P. Murphy	
Evolution/Development –body plan changes through evolution	P. Murphy	Practical 4. Writing skills Colm Cunningham
Organogenesis	P. Murphy	
Nervous control of physiological function	A. Kelly	
Pharmacology of autonomic nervous system	A. Kelly	
Reading Week		
Muscle physiology	A. Kelly	Practical 5. Cardiovascular physiology Áine Kelly
Endocrine regulation of physiological function	A. Kelly	
Fundamentals of cardiovascular & renal physiology I	A. Kelly	
Fundamentals of cardiovascular & renal physiology II	A. Kelly	
Pathophysiology and treatment of hypertension	A. Kelly	
The immune system and its influence on homeostasis	C. Cunningham	
Digestion & metabolism, metabolic syndrome, gut-brain axis	A. Kelly	
Integration of nervous, endocrine and immune regulation of physiology; Importance in pathophysiology.	A. Kelly	
Introduction to brain function, motor control	A. Witney	
Sensation and perception	A. Witney	
Pain, nociception and interoception	A. Witney	
Learning and memory	T. Ryan	
Emotion and motivation	T. Ryan	

Understanding brain function through pathology/disease	T. Ryan	
Summary - Revision/integration lecture	C. Cunningham	

There will be two in-course assessments of Lecture material (multiple choice format).
The first will be immediately after reading week, the second in the last week of semester.

Lecture Content:

Unicellular to multicellular life

- Examples of signalling molecules released by bacteria and their effects on individual cells and populations
- Quorum sensing as a method of communication between bacteria within a population
- Regulatory and physiological adaptations to stress in bacteria
- ATP synthesis and the generation of proton motive force in bacteria
- Nutrient uptake mechanisms and transporters in bacteria
- Motility and chemotaxis in bacteria
- Extracellular structures such as fimbriae, capsules and S-layers and their role in adaptation to the environment
- Mechanisms employed by bacteria to attach to and interact with eukaryotic cells

Cell-cell communication & Signal Transduction

- The basic mechanisms of cell-cell communication including juxtacrine, autocrine, paracrine & endocrine signaling. From gap junctions and plasmodesmata (metabolic or electrical coupling), to contact-dependent signaling, neurotransmitter release at short range to hormone release at long range
- Packaging of cargo for export: protein synthesis and export via the trans-golgi network and the secretory pathway versus vesicular transporter-mediated packaging of synaptic vesicles (with provision of online resources)
- Neurotransmission as a specialized form of calcium-dependent exocytosis. Resting membrane potential and depolarization, the action potential, voltage-dependent calcium channels (with provision of online resources).
- Signalling via ligand-gated ion channels: neurotransmitter binding and gating of ion channels. Acetylcholine and end plate potentials at the neuromuscular junction. Glutamate and GABA receptors, excitation and inhibition.
- Highly conserved components of intracellular signal-transduction pathways-G proteins used as on/off molecular switches; protein kinases/phosphatases employed in virtually all signalling pathways; second messengers carry and amplify signals from many receptors. Concept of crosstalk between signalling pathways. Signal termination.
- General elements of G protein coupled receptor systems. GPCRs that activate or inhibit adenylyl cyclase. GPCRs that activate phospholipase C. Mechanisms that downregulate signalling from GPCRs. Integrating responses of cells to environmental influences.
- Receptor tyrosine kinases (e.g. EGF). Activation of ras and MAPK pathways. The role of protein binding domains in the specific interactions between signalling molecules. Pathways that involve signal-induced protein cleavage (e.g. Notch/Delta signalling).
- Signalling networks that respond to changes in nutrient and energy status of cell (e.g. SnRK1 and TOR kinases in plants). Signalling pathway conservation between organisms. Defects in signalling pathways leading to disease with emphasis on cancer.

Development

- **Organising a body plan in multicellular organisms:** The concepts of multicellular life and how an organized body plan, composed of different cell types and tissues, is established. Examples of relatively simple (hydra) organisms to the most complex (examples of drosophila, mouse, human and others) will be used. Fundamental similarities and differences in the organisation of animals and plants will be covered. Molecular and biophysical mechanisms governing cellular behaviour will be discussed.
- **Cell signalling/cell communication in the context of development.** Cell communication is fundamental to building an organized body plan. The main developmental signalling pathways (Wnt, BMP, Hedgehog, FGF, YAP/hippo etc) will be introduced with examples of how they guide development. Pathway conservation and elaboration through evolution related to developmental complexity will be examined.
- **Elaboration of positional information over time.** Exploration of key concepts, moving from the “French flag model” to more sophisticated ways of thinking. The concept of gradients and graded influence across tissues. Progressive specification and how information builds over developmental time. Cell lineage analysis and tracing a cell through time. Stem cells and how stem cell niches are established during development.
- **How a cell responds to positional information.** Transcriptional and post-transcriptional regulation leading to cellular differentiation. The integration of different types of information at the cellular level determining how a cell responds. The importance of the cellular context and epigenetics. Hox genes and how they relate to positional information – the concept of a positional code. Mutations that change the body plan.
- **Evolution & Development:** How body plans can change through evolution. The concept of “the Toolkit” for building an organism and “tinkering with the toolkit” – genetic changes that can lead to major body plan shifts such as loss of limbs or acquisition of specialised structures such as a turtle shell.
- **Organogenesis:** Development of organ and organ systems; e.g. heart, kidney, lung etc. building on the concepts and mechanisms involved in building complex structures, current knowledge on how specific organs are established will be presented and explained.

Human physiology

- Nervous control of physiological function: sensory and autonomic nerves. CVS as model system.
- Muscle function and its nervous control. Disorders of skeletal muscle, cardiac hypertrophy (physiological via exercise & pregnancy; pathophysiological via hypertension)
- Neuropharmacology, with specific emphasis on pharmacology of the autonomic nervous system; effect of toxins on neuromuscular junction
- Endocrine regulation of physiological function, highlighting endocrine disorders.
- Fundamentals of cardiovascular and respiratory physiology and their interaction (homeostatic responses to altitude, exercise)
- Fundamentals of cardiovascular and renal physiology and their interaction (regulation of blood pressure and volume, acid-base balance)
- Pathophysiology and treatment of hypertension (pharmacology of ANS, role of exercise in prevention and treatment)
- Digestion and metabolism, metabolic syndrome, the gut-brain axis.
- Immune regulation of physiological function (innate vs adaptive, role of inflammation in infection and cancer. Regulation of tissue homeostasis and role in obesity, diabetes and brain injury/neurodegenerative disease.

- Pathophysiology of diseases of the nervous system (MS, AD, PD, encompassing nervous, endocrine and immune regulation of physiology).

Neuroscience and Behaviour

- Sensation and perception. Students will gain an understanding of how the brain makes sense of sensory input. They will be aware of and able to explain fundamental discoveries (e.g. Hubel & Wiesel). They will be able to describe neuronal circuitry that enables us to distinguish between sensory input from the external world and that which is internally generated (sensory cancellation and efference copy mechanisms).
- Pain, nociception, and interoception. Students will attain an understanding of the internal awareness of the animal body to states such as pain.
- Motor coordination and control. Students will learn how the complexity of an animal's movement is constrained by the underlying neural circuitry. Simple behaviours in simpler animals and their underlying neural control (e.g. CPGs) through to complex voluntary action and manipulative tasks.
- Emotion and motivation. Students will develop an understanding of how we empirically study animal behaviours that can be attributed to motivational drives and emotional states and will attain knowledge of how environment experience and genetic background can alter these behaviours.
- Learning and memory. Students will be able to describe the basic learning theory models in the context of Pavlovian and operant conditioning, and basic invertebrate and vertebrate experimental models of learning-induced brain plasticity and memory storage.
- Understanding brain function through pathology/disease. Students will gain an understanding of how clinical studies of humans with brain damage and disease, when combined with careful behavioural and psychiatric analysis, and give us new insights into brain function at a systems level. An introduction to the use of animal disease models and a few highlights of how animal models have been used to develop an understanding of disease processes.

Practical Content:

Practical 1: Bacterial Adherence to Eukaryotic Cells & the Induction of Bacterial Gene Expression during Infection

Examination of buccal epithelial cells to observe adherence of resident microbial flora to cells. Determination of the induction speed of the acid-responsive *asr* gene of *Salmonella enterica* in the human stomach using Green Fluorescent Protein as a biosensor.

Practical 2: Simulation of resting membrane potential and action potential using Metaneuron.

Students will use a downloadable application to simulate neuronal behaviour. This will be used to examine the contribution of sodium and potassium ions to the resting membrane potential; contribution of sodium flux and alteration of membrane potential in induction of the action potential; relationship between stimulus intensity and stimulus delay in the refractory period

Practical 3: 3D Imaging and database research of embryonic development

Students will use online 3D databases of developing embryos, to investigate and describe changes in anatomical features during the formation of a 3D body plan and begin to explore the molecular changes that underpin morphological change.

Practical 4: Writing Skills Activity: A topic from the lecture series will be selected and students given approximately two weeks to prepare a first draft essay. Students will bring their drafts to a supervised session where they will peer review the drafts in small groups (under supervision) and attend a masterclass on writing skills. Final essays will be submitted a few days later.

Practical 5: Cardiovascular and respiratory physiology. In this class, fundamental cardiovascular and respiratory physiology parameters will be measured. Students will be trained in the use of standard physiological equipment and will explore regulation of heart rate, blood pressure and blood flow, along with respiratory volumes and control of breathing.

Learning Outcomes:

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

- Describe the regulatory and physiological adaptations that bacteria undergo to acquire nutrients, respond to stress, and describe the structure, function and importance of bacterial extracellular structures and their roles in modulating cell-cell interactions. Utilise phenotypic tests and microscopy to characterise bacteria in the laboratory (Practical).
- Demonstrate an understanding of the role of signalling in bacterial communication in forming communities and the mechanisms used by bacteria to interact with eukaryotic cells.
- Describe the multiple ways in which cells communicate with each other over short and long distances.
- Demonstrate an understanding of how biological signals are prepared for export, are temporally and spatially controlled, are sent, received, transduced and amplified in the cellular context (signal transduction), and provide examples as to how this is achieved in cells.
- Utilise online tools and databases to explore fundamental concepts relating to neurotransmission and to answer specific questions related to embryonic development including an appreciation of the power of using shared data in research (Practical's).
- Articulate the concepts of how biological complexity is established as the body plan of multicellular organisms emerge and integrate these concepts in the context of how body plans have evolved.
- Describe the contribution of the nervous, endocrine and immune systems to regulation of whole-body physiological homeostasis in humans and detail cell, tissue and organ integration in the cardiovascular, respiratory, immune, renal and digestive systems.
- Describe how alterations in physiological variables as a result of exercise, changes in barometric pressure or pathophysiological processes impact on homeostasis in different organ systems
- Measure and understand fundamental cardiovascular and respiratory variables in human subjects (Practical).
- Articulate how the brain achieves basic functions for the animal using examples from invertebrate & vertebrate neurobiology.
- Provide explanatory accounts of movement and motor control; sensation and interoception; emotion and memory, and how brain injury in human patients can inform us about brain function.
- Describe, integratively, how the fundamental physiology of neural circuits can be used to explain behavioural function in both vertebrates and invertebrates.
- Demonstrate good practice in essay writing: including planning, drafting, responding to constructive review and timely submission of a final draft (Practical, graded for continuous assessment).

Recommended Reading List:

The topics and concepts presented in this module can be found in selected chapters of the following textbooks:

- Biology, A global Approach. Campbell *et al.* 12TH Edition. Pearson.

- Prescott's Microbiology 10th edition. McGraw Hill.
- Biochemistry. Berg, Tymoczko, Gatto, Stryer 8th edition. Macmillan International.
- Molecular Cell Biology. Lodish *et al.*, 8th edition. Macmillan International.
- Principles of Development. Wolpert, Tickle, Martinez-Arias. 5th Edition Oxford University Press.
- Developmental Biology. Gilbert, Barresi, 11th Edition. Sinauer, Oxford University Press
- Human Physiology from Cells to Systems. Sherwood. 9th Edition. Cengage Learning.
- Principles of Neurobiology. Liqun Luo. 1st edition. Garland Science.

Assessment Details:

Marks are allocated across two components, course work (50% of module mark) and end-of-module examination (50% of module mark). The end-of module examination will be two hours duration. Students must answer three out of five questions. **To pass the module a student must obtain an overall module mark of 40%.**

Contacts:

Biology Course Coordinator: Glynis Robinson, robinsog@tcd.ie, Phone: 01 896 2895

Module Coordinator: Colm Cunningham, colm.cunningham@tcd.ie, Phone: 01 896 3964

Laboratory Manager: Audrey Carroll aucarrol@tcd.ie, Ph: 01 896 1620

Executive Officer: Daniel McCormick btcadmin@tcd.ie, Ph: 01 896 111

BYU22203: From Organisms to Ecosystems II

Semester 2, 10 credits

Prerequisite: BYU11102

Module coordinator: Professor Nessa O'Connor, n.oconnor@tcd.ie Phone: 01 896 1640

Contact Hours: 38 hours lectures, 15 hours practicals.

Module Personnel: N. O'Connor, F. Mitchell, L. Cassidy, D. Bradley, N. Payne, & P. Luijckx

Learning Aims:

This module builds on the key concepts introduced in BYU11102 including evolution, biodiversity, animal and plant physiology and ecosystem biology. While further introducing core principles that underpin the study of genetics, botany, zoology and global change biology.

Module content:

Programme of lectures and practicals, four lectures a week, Thursday at 12:00 and 15:00, Friday at 11:00 and 13:00, practicals on alternate Wednesdays.

Lecture Topic & Lecturer	Lecturer	Practical
Introduction to BYU22203 Organisms to Ecosystems II	N. O'Connor	
Diversity of life: Conquering the land	F. Mitchell	
Diversity of life: fungi, lichens, algae, angiosperms	F. Mitchell	
Diversity of life: animals, phylogeny and early evolution	N. O'Connor	
Diversity of life: tetrapods and evolution of humans	N. O'Connor	
Diversity of life: animal feeding strategies	N. O'Connor	Molecular Genetics D. Bradley
Diversity of animal life: reproductive behaviour	N. O'Connor	
Diversity of plant life: plant reproductive strategies	F. Mitchell	
Darwin		
Natural selection		
Species and speciation		
Coevolution		
Evolution of sex and sexual selection		
Kin selection		Altruism
Evolution of reciprocity		

The molecular basis of Mendelian genetics	L. Cassidy	
Fitness and selection	L. Cassidy	
Genetic drift and neutral evolution	L. Cassidy	
Molecular phylogenetics	L. Cassidy	
Population genetics	L. Cassidy	
Human evolution in health and disease	L. Cassidy	
Animal metabolism	N. Payne	Animal Physiology N. Payne
Thermoregulation and water stress in plants		
Animal nutrition and digestion	N. Payne	
Plant nutrition and digestion		
Reading Week		
Circulation and gas exchange in animals	N. Payne	Plant Physiology
Circulation and gas exchange in plant		
Life in extreme environments: evolutionary adaptations	F. Mitchell	
Interactions between organisms including mutualisms	F. Mitchell	
Global climates and biomes	F. Mitchell	
Terrestrial ecosystems: forests and grassland ecosystems	F. Mitchell	
Ecological modelling	F. Mitchell	
Terrestrial ecosystems: desert, tundra and peatland	F. Mitchell	Ecological Modelling F. Mitchell
Freshwater ecosystems: Rivers and lakes	P. Luijckx	
Marine ecosystems: Estuaries	N. O'Connor	
Marine ecosystems: Coastal waters and Open Seas	N. O'Connor	
Impacts of global climate change	F. Mitchell	
Genes to ecosystems	P. Luijckx	

Lecture Content:

- **Module Introduction**

Learning outcomes, module aims, assessment details, recommended reading etc.

- **Diversity of life: Conquering the land**

This lecture explores the challenges that had to be overcome by organisms conquering the land in the geological past. The adaptations required will be addressed and how these adaptations are relevant to life on land today.

- **Diversity of life: fungi, lichens, algae, angiosperms**

This lecture will explore the evolution of diversity of plant life and how this diversity has facilitated the pivotal role that plants play in supporting all life on the planet.

- **Diversity of life: animals, phylogeny and early evolution**

This lecture introduces animal body plans, the early invertebrates and the significance of the Cambrian explosion. Students will learn to define an 'animal', radial symmetry, bilateral symmetry, ecdysis, lophotrochozoan and where these features fit on the phylogeny of animals. The lecture includes key characteristics of the major invertebrate phyla.

- **Diversity of life: tetrapods and evolution of humans**

This lecture describes the evolution of tetrapods from sea to land, including the major steps in the evolution of tetrapods, suggested reasons why tetrapods may have moved to land including when this may have occurred and how tetrapods are adapted to live on land. In addition, we explore how the many things that make humans "special" are not unique to humans. We will discuss how to tell if a fossil hominid was bipedal and how humans are still evolving with examples.

- **Diversity of life: animal feeding strategies**

The main feeding types of animals will be explored: suspension/filter feeders, substrate feeders, fluid feeders, bulk feeder's vs predators, herbivores, parasites, parasitoids. The great diversity of animals and how this relates to dietary adaptations will be discussed including examples of predators and their prey, herbivores and plants, and humans.

- **Diversity of life: animal reproductive behaviour**

Reproductive behaviour and evolution of mating systems, sexual selection *etc.*

- **Diversity of life: plant reproductive strategies**

This lecture will explore the diversity of reproduction strategies in plants, how they have evolved and how they can dictate the distribution of specific plant groups.

- **Darwin**

The main historical events leading to the evolutionary thinking under a Darwinian view will be discussed. This includes, but is not limited to, philosophy of organismal transformation, fixing forms, catastrophism and emergence of new life forms. This lecture also covers the stages by which Darwin came to his understanding of Natural Selection and ends with an overview of the natural selection process.

- **Natural selection**

The mechanism of natural selection as Darwin and Wallace conceived it, Mendel, the New Synthesis (NS), ways NS have been misunderstood, examples of NS in action, convergent and divergent processes with examples, directional, normalising and disruptive selection effects. Rates of change and fixation.

- **Species and speciation**

The species concept, and six approaches to defining what a species is will be explained and their various merits discussed. Examples from current work on speciation on islands in Indonesia being carried out by Prof Marples' group will be used to illustrate the use of genetic methods. The three mechanisms of speciation will be introduced including the concept of hybrid zones.

- **Coevolution**

We explore the concept of animals evolving in response to the evolution of other species using the case study of the warning coloration of insects co-evolving with their predators. This example is used

to illustrate the complexity co-evolutionary processes including positive and negative frequency dependence, differing selection pressures and three types of mimicry.

- **The evolution of sex and sexual selection**

This lecture covers the problem of why evolving sexual reproduction is difficult, the reasons why it is costly and the possible individual and population level advantages which may lead to its evolution and maintenance. We then address Darwin's concerns about sexual selection and the evolution of maladaptive sexual characteristics and discuss the two main theories explaining extreme male ornaments.

- **Kin selection**

Five reasons for co-operative behaviour are introduced. The concept of group selection, and why it is flawed as an explanation for co-operation is explained, encountering the concept of evolutionary stable strategies in the process. Forced co-operation is discussed with examples, then kin selection is explored in detail, along with the concept of inclusive fitness, and calculating the coefficient of relatedness. Examples demonstrating kin selection are given and eusociality is discussed both in haplodiploid insects and in mole rats.

- **Evolution of reciprocity**

The lecture covers the remaining three reasons for co-operative behaviour, starting with examples of mutualisms, both with immediate and with delayed payoffs. The concept of reciprocal altruism is introduced, the evolution of tit-for-tat systems and the importance of policing both using theoretical animals and real-life examples. Finally, human altruism and experimental results that demonstrate a strong inclination towards policing being present in humans. The altruism practical, which students undertake in their own time, is introduced and the ethical considerations of working with the public are explained.

- **The molecular basis of Mendelian genetics.**

This lecture reintroduces Mendel's laws in the context of molecular genetics. Foundational/refresher content will be provided on heredity, the structure of DNA, genetic variation, the transmission/segregation of alleles, and the relationship between genotype and phenotype. Historical perspective is given on the characterisation of the molecular mechanisms of inheritance and their centrality to evolutionary theory. This serves to introduce a core paradigm: that all evolution ultimately occurs at the genetic level.

- **The principles of population genetics**

In this lecture, the mathematical consequences of Mendelian inheritance are expanded upon. We will learn how to describe the genetic variation that exists within and between biological populations in terms of allele and genotype frequencies. The concept of the "idealised" population in Hardy-Weinberg Equilibrium is introduced, where allele and genotype frequencies do not change through the generations. We then explore the deviations from this expectation. Specifically, we will look at the consequences of non-random mating on genotype frequencies, and the four main modes of allele frequency change (*i.e.* the four main forces of evolution): mutation, genetic drift, selection and gene flow.

- **Fitness and selection**

The concept of natural selection is revisited in this lecture, but this time from the perspective of allele frequency change over evolutionary time. We introduce the concept that genotypes can have different fitnesses in a given environment and explore how the relative quantification of these fitnesses allows us to predict allele frequency change. Students will learn how natural selection can be classified in different ways, including by its effect on phenotype distributions, genotype frequencies and new alleles. Real-world examples of natural selection acting upon a single locus will be provided, including data from the Irish population.

- **Genetic drift and neutral evolution**

In this lecture, we turn our attention to neutral genetic variation that has no overall effect on fitness. We will chart several major milestones in molecular biology, which allowed genetic variation in

populations to be directly detected for the first time and led to the discovery that the vast majority of observed alleles are neutral. Students will learn how molecular sequencing techniques made cross-species comparisons possible and explore the consequences of genetic drift acting on neutral allele frequencies over long evolutionary timescales. This provides the conceptual framework for the molecular clock hypothesis, which revolutionised the way in which we infer species relationships.

- **Molecular phylogenetics**

Building from the theory laid down in the previous lecture, we will learn how molecular sequence data can be used to reconstruct evolutionary history in the form of a phylogenetic tree. We establish the major aims of the field of phylogenetics and introduce the terminology required to read a phylogenetic tree. Methods for the construction of phylogenetic trees from multiple sequence alignments are explored.

- **Applied evolutionary genetics**

This lecture applies key concepts in population genetics, molecular evolution and phylogenetics to the study of a single species, *Homo sapiens*. We use molecular phylogenetics to uncover the origin of our species and characterise our relationship with archaic humans. Students will learn that each loci in the genome has an independent evolutionary history and whole genomes are required to understand the whole story of human evolution. We also untangle the interplay between selection and genetic drift to explain the persistence and distribution of inherited human diseases today.

- **Animal metabolism**

This lecture will explore the process of metabolism in animals, from perspectives of biochemistry, physiology, and ecology. Different metabolic pathways (e.g. aerobic and anaerobic) are introduced, and we will explore key factors that cause metabolic rates to vary: body size, temperature, and activity level. We then focus on the variety of adaptations (both physiological and behavioural) animals exhibit for regulating metabolic rates, and their ecological significance.

- **Thermoregulation and water stress in plants**

Extreme habitats, growth forms, thermoregulation through evapotranspiration and mitochondrial respiration, heat and water loss, structural and metabolic solutions to water loss.

- **Animal nutrition and digestion**

Having been introduced to the feeding strategies and energy requirements of animals, this lecture links those concepts by focussing on nutrition. The different types of essential nutrients will be introduced, as will be the various stages of food processing (from ingestion to elimination). We will examine the range of digestive systems seen across taxa, and look in a little more detail at characteristics of the mammalian digestive system. Focussing on vertebrates, examples of digestive system adaptations to deal with specific diets will also be presented.

- **Plant nutrition and digestion**

Nutrient deficiency in plants, serpentine soils and heavy metal accumulation, insectivorous plants.

- **Circulation and gas exchange in animals**

This lecture explores the immense variation in form and function of circulatory and gas-exchange systems seen in animals. By taking a largely comparative approach, we will examine the different types of respiratory systems (e.g. trachea, gills and lungs), modes of ventilation, and circulatory systems (open and closed) seen across invertebrates, fish, birds and mammals. We will also consider how physical attributes of water present challenges to gas exchange for aquatic animals, and how these can be overcome in groups such as 'water-breathing' sharks and deep-diving whales.

- **Circulation and Gas exchange in plants**

Plants are high pressure systems, the three transport pathways, biophysical 'pumps' in plants, water potential, gas exchange: CO₂ and O₂.

- **Life in extreme environments: evolutionary adaptations**

Polar, deep sea, high altitudes, deserts *etc.* Evolutionary adaptations for survival in plants and animals.

- **Interactions between organisms including mutualisms**

This lecture will explore the range of interactions between plants and animals. This will include both positive and negative interactions and how these interactions are a vital aspect of ecology.

- **Global climates and biomes**

How the global climate system operates. The relevance of the biome concept and overview of ecosystem function. How organisms respond and adapt to their environment.

- **Terrestrial ecosystems: forests and grassland**

Functioning and adaptations in forest and grassland ecosystems at individual, biome and global scales.

- **Ecological modelling**

The practicalities of ecosystem modelling. Demonstration and instruction relevant to the practical exercise and the role of fire in forest ecosystems.

- **Terrestrial ecosystems: desert, tundra and peatland**

Functioning and adaptations in desert, tundra and peatland ecosystems at individual, biome and global scales.

- **Freshwater ecosystems: rivers and lakes**

An introduction to the formation, ecological importance and management of freshwater ecosystems. Current research into the impact of multiple stressors (sediment, pollution, agriculture, climate change, invasive species *etc.*) will be discussed.

- **Marine ecosystems: estuaries**

Classification, biological and environmental characteristics. Biological communities associated with estuaries. Estuarine ecosystem functioning and food webs, disturbance and biodiversity. Using Dublin Bay as an example.

- **Marine ecosystems: coastal waters and open seas**

Characteristic features of shelf seas, habitat characteristics, associated biota and functional roles, food webs and human interactions. Characteristic features of the deep sea and associated fauna, with examples.

- **Impacts of global climate change**

Review of climate change predictions. Examination of how biomes have reacted to climate change in the past and the likely consequences of predicted climate change on global biomes.

- **Genes to ecosystems**

This lecture will demonstrate that the genetic make-up of a population can have large consequences for ecological and evolutionary processes. How genetic diversity can play a role in ecosystem functioning, biodiversity and resilience. Genetic diversity in keystone species can have a large effect on biodiversity. What does that mean for conservation? Role of genetic diversity in invasions by non-native species. How a single genetic change can have large consequences for the entire ecosystem.

Practical Content:

Practical 1 – Molecular phylogenetics In this practical session students undertake their own genotyping experiments to infer the phylogeny of a set of *Mycobacterium tuberculosis* strains. Students perform gel electrophoresis of strain-informative DNA sequences amplified by polymerase chain reaction and construct a phylogeny of the various strains using techniques explored in preceding lectures. Students are assessed during the practical session via a pro-forma lab report consisting of a series of short answer questions (submitted at the end of the session).

Practical 2 Altruism This practical is carried out in the students' own time, in groups of 3 or 4. They read about altruistic behaviour in humans, then design and carry out their own experiment to test one of the supposed influences of humans on each other's behaviour. They are provided with a list of possible projects to get them thinking but are encouraged to design something new. They then fill in a template for their write-up, one for each group, report due 3 weeks later.

Practical 3 Animal physiology This practical will allow students to make measurements of the metabolic rates of living invertebrate animals, and to quantify the influence of body size or temperature on metabolism. Rates of change in the concentration of respiratory gasses will be measured, and data from different individuals will be combined to estimate metabolic scaling parameters.

Assessment: Completion and submission of results and questions relating to the practical.

Practical 4 Plant physiology Leaf photosynthesis of C3 and C4 plants using infra red gas analysis to monitor changes in concentration of CO₂ in air.

This practical involves students constructing a light saturation curve for maize (C4) and bean (C3) leaf photosynthesis. Students will use a simple gaseous CO₂ probe (an IRGA, Infra Red Gas Analyser) fitted to a programmable calculator to calculate steady state photosynthesis at differing light intensities in a closed chamber. Learning outcomes are associated with careful collection of laboratory data, quality control, calculation of suitable functional units to compare photosynthesis between leaves of varying shape and mass, understanding the three major gradients of the light saturation curve and how they relate to photosynthetic efficiencies.

Assessment: Completion and submission of results and questions relating to the practical.

Practical 5 Computer based ecological modelling This practical uses the interactive SimUText/Ecobeaker package that is loaded on the PAC room computers and accessible via My Trinity Apps. It is a self-directed practical which tests the Intermediate Disturbance Hypothesis by modelling forest succession and manipulating fire return time and intensity.

Assessment: Completion and submission of results and questions relating to the practical.

Learning Outcomes: On completion of this module students should understand some fundamental principles of evolution, genetics, animal and plant diversity, physiology and be able to describe characteristic features of selected ecosystems and their ecology.

Recommended Reading List: The topics and concepts presented in this module can be found in selected chapters of the following textbooks:

- **Biology, A global Approach.** Campbell *et al.* 12TH Edition. Pearson. Introduction to Genetic Analysis, chapter 18 (Griffiths *et al.*, 12th edition).
- **Introduction to Genetic Analysis.** Griffiths, Wessler, Carroll, Doebley (11th edition). W.H. Freeman and Co.
- **The Evolution of Plants.** 2nd Edition. K.J. Willis & J.C. McElwain. Oxford University Press.
- **Marine Ecology: processes, systems and impacts.** 3rd Edition. Kaiser *et al.*, Oxford University Press.

Assessment Details:

(A) **End of module written examination: 65% of module mark** Exam is comprised of 50 short answer/ multiple choice questions.

(B) **Practical assessments: 35% of module mark, five assignments equally weighted.**

To pass the module a student must obtain an overall module mark of 40%.

Contacts:

Module Coordinator: Nessa O'Connor, n.oconnor@tcd.ie Phone: 01 896 1640

Biology Course Coordinator: Glynis Robinson, robinsog@tcd.ie, Phone: 01 896 2895

Laboratory Managers: Audrey Carroll aucarrol@tcd.ie, Ph: 01 896 1620

Executive Officer: Daniel McCormick btcadmin@tcd.ie, Ph: 01 896 1117

BYU22204: Sustainable Production: Food, Drink and Drugs

Semester 1, 5 credits

Prerequisite: none

Module coordinator: to be announced

Contact Hours: 16 hours lectures, 12 hours practicals.

Module Personnel: to be announced

Learning Aims:

The aims of this module are to familiarise the student with concepts of sustainable development, ecological farming, green pharma, sustainable diets, novel food and drink products, and how environmental impacts of the food/drink and drug industry are assessed using Life Cycle Analysis. Practicals will focus on techniques relevant to the biotechnology industry, sustainability of food production and health indices of global diets.

Module content:

Programme of lectures and practicals, two lectures a week.

Lecture Topic	Practical
Introduction to the module: concepts of sustainability and sustainable indicators	The Mediterranean Adequacy Index as a measure of the “healthiness” of national diets.
Sustainable diets and health	
Life cycle assessment	
Sustainability of the drinks industry	
Environmental impacts of agriculture (GHG production)	
Environmental impacts of agriculture (reactive nitrogen pollution)	Hormonal control of seed germination
Nutrition and Life cycle Assessments	
Non-food crops; biofuels, fiber and packaging	
Plant biotechnology	The environmental footprint of the European diet.
Plant secondary metabolites I	
Reading week	
Plant secondary metabolites II	
Bioprospecting	
Sustainable Pharma	
Module Summary	

Learning Outcomes:

At completion of this module students should be better informed with regard to sustainable food, drink and drug production, be able to make informed decisions with respect to diet and food choice, be familiar with concepts and methodology of life cycle analysis of food production pathways, understand the practical aspects of tissue culture and how important such methodologies are in biotechnology.

Recommended Reading List:

1. UN Transforming our world: the 2030 Agenda for Sustainable Development - <https://sustainabledevelopment.un.org/post2015/transformingourworld>
2. Poore, J. and Nemecek, T. 2018. Reducing food's environmental impacts through producers and consumers. *Science*, 360 (6392), 987-992.
3. Willet et al., 2019. Food in the Anthropocene: the EAT–*Lancet* Commission on healthy diets from sustainable food systems. *The Lancet Commissions*, 393 (10170) 447 – 492.
4. Roschinger et al., 2017. A deeper shade of green: inspiring sustainable drug manufacturing. *Green Chem.*, 2017, 19, 281-285
5. Muralikrishna, I.V. and Manickam, V. 2017. Life Cycle Assessment. In: Muralikrishna, I.V. and Manickam, V (eds) *Environmental Management – Science and Engineering for Industry*, chapter 5, pp 57-75. Butterworth Heinemann publishers.
6. Thorpe T. (2012) History of Plant Tissue Culture. In: Loyola-Vargas V., Ochoa-Alejo N. (eds) *Plant Cell Culture Protocols. Methods in Molecular Biology (Methods and Protocols)*, vol 877. Humana Press, Totowa, NJ
<https://www.fooddrinkeurope.eu/publication/data-trends-of-the-european-food-and-drink-industry-2018/>

Assessment Details:

The course will be assessed both by examination (70% of the module mark) and continual assessment (30% of the module mark). The examination paper will consist of one essay question from a choice of three (60% of examination) and five compulsory short answer questions (40% of examination). Practical activities will be assessed by laboratory report and data analysis as appropriate.

Contacts:

Module Coordinator: to be announced.

Biology Coordinator: Glynis Robinson, robinsog@tcd.ie, Phone: 01 8962895

Laboratory Manager: Audrey Carroll, aucarrol@tcd.ie, Phone: 01 8961049

Executive Officer: Daniel McCormick, btcadmin@tcd.ie , Phone: 01 8961117

BYU22205: Influences on Animal Behaviour

Semester 1, 5 credits

Prerequisite: None

Module coordinator: To be announced

Contact Hours: Lectures and discussion sessions, 21 hours

Module Personnel: To be announced

Learning Aims:

The Influences on Animal Behaviour module comprises a series of lectures, discussions, on-line assessments, and practicals. The module is taught jointly by the School of Natural Sciences and the School of Psychology, and covers a wide range of topics, beginning with a brief history of behavioural research. The students are then introduced to various aspects of perception and learning, cultural transmission, cognition, play and intelligence in animals including humans.

Subsequent lectures explore the animal's behaviour in its environment and why all individuals of a species do not behave in the same way. The final lectures address the importance of an understanding of behaviour in relation to conservation in the wild and in zoos, and in relation to climate change. Lectures are supported by a series of discussion sessions in which there is ample opportunity for interaction and deeper exploration of the topics. The module includes student-led-learning leading to online assessment and fosters a responsible approach to learning by allowing students to complete most aspects of the assessments in their own time.

Module content:

Programme of lectures and practicals, two lectures a week. There are two self-directed practical activities, and one supervised practical activity.

Lecture Topic	Practical
1. Introduction and Historical overview	Practical 1: Dublin Zoo: Animal Behaviour Introduced in lecture 1 and completed within three weeks in student's own time
2. Learning	
3. Memory	
4. Human sensation and perception	Practical 2: Trials of Life Introduced in Lecture, completed by start of reading week
5. Human perception and attention	
6. Play in animals	
7. Play in humans	
8. Cultural transmission	
9. Imitation and teaching in animals	

10. Intentionality in animals	Practical 3: Collective Behaviour Assessment introduced in Lecture 13, completed by end of lecture series.
11. Intentionality & Agency in Infancy and Childhood	
12. Navigation	
13. Collective behaviour	
14. Modelling behavioural polymorphisms	
15. Animal Personalities	
16. Behaviour and climate change	
17. Behaviour and conservation	
18. Behaviour, zoos and reintroductions	

Lecture Content:

Introduction and Historical overview

Course over-view; historical context: Gilbert White, Pavlov, Lorenz, von Frisch, Tinbergen, four whys of Tinbergen, Skinner, Operant conditioning, Ethology vs behavioural ecology / ultimate vs proximate distinction, lab and field both needed, correlation does not prove causation

Learning

Innate vs learned, not complete distinction, uses of learning, uses of innate knowledge, types of learning: habituation, associative learning, Pavlov's experiment, unconditioned stimulus (US), conditioned stimulus (CS), conditioned response (CR), reinforcer, contingency, Instrumental learning, Thorndike's experiment, Skinner boxes, behaviour transfer, species differences in propensity to categorise, cognitive reasoning, theory of mind (mention); experimental design and Clever Hans; cost of learning and evidence for it, marsh wrens, hippocampal volume, vole spatial abilities, brain shrinkage without use.

Memory

Types of memory: Explicit/implicit; semantic, episodic, procedural, priming, learning through classical conditioning; examples and experiments relating to priming, sensory memory, eidetic imagery, echoic memory, short term and long-term memory, working memory, experiments on rehearsal, sleep and consolidation, events during training, interference during retention, primacy, recency, chunking, importance of forgetting.

Human Sensation and Perception

What are the basic sensory processes; How do we measure our perceptual abilities; how the brain perceives a constant world; perception and social psychology; how perception changes across the life course; individual differences.

Human Perception and Attention

What is the relationship between perception and attention; visual attention is selective and serial; attending to sounds; attending to multiple sensory stimulation; social attention and the role of eye gaze.

Play in Animals

Definitions, characteristics, Fagen, play signals, self-handicapping, costs of play, age effects. Object play: Hutt play vs exploration, ravens, hunting practice. Locomotor play: Byers and Walker, stamina improvement. Social play: hierarchies, coalition formation, social competence, play predicting personality in human children, sex differences in humans and animals. Play to use energy, produce heat, and improve cognitive skills. Reward stops play.

Play in Humans

Defining and recognising play in infancy and childhood; dimensions, functions, and development of play in humans (object play and tool use, locomotor play, non-social play, social pretend play, rough-and-tumble play), cultural variations in beliefs about play; meaning of play for childhood development.

Cultural Transmission

Definition, speed of propagation, Galef experiment, neophobia, predator identification by contagion, maladaptive cultural taboos, other maladaptive features. Prerequisites: brain size, demonstrator, live tutor, social bond. Demonstrators blocking learning, scroungers, vertical, horizontal, and oblique CT, 2 case studies on CT of bird song.

Imitation And Teaching In Animals

Imitation and what's mistaken for it: Instrumental learning, stimulus enhancement, social facilitation, contagion, emulation, with examples and experiments for each; true imitation examples. Teaching definition, examples. Dialects, traditions in ape societies, stoneplay, speciation by cultural song learning in cactus finch, memes and permanent storage.

Intentionality in Animals

Griffin's questions, detecting consciousness, possible uses, orders of intentionality. Evidence for theory of mind: Abstract ideas, evidence from Pepperberg and Alex; Self-awareness, Povinelli's tests with chimps, manipulation and deception in animals, Menzel and chimps, triangulation method, Kummer and macaques, gaze following, Povinelli test with chimps, knowledge attribution, two-box test, non-verbal form for animals, Povinelli's evidence chimps can't, test on students, return to use of 2nd order intentionality

Intentionality & Agency in Infancy and Childhood

Early signs of intentionality: self-directed activity, means-end-differentiation, and the cognitive revolution at 9 months of age; emerging understanding of intentional-states in others; (Meltzoff and the "like me" framework, Tomasello and the simulation account); perspective taking and intersubjectivity; language (personal pronouns) and reflective forms of agency; intentional self-regulation.

Navigation

Simple contortion of path, swarming of bacteria, dead reckoning, piloting by landmarks, Tinbergen's wasps, bees, mice, food storing birds, wind and current maps, auditory maps, olfactory maps, celestial cues of direction, clock shift experiments, shoreline orientation, sun compass, zugunruhe experiments, magnetic sense, Walcott experiment, combining cues, "true navigation", shearwaters, monarch butterflies

Collective Behaviour

Emergent behaviours of groups; simple rules leading to complex outcomes, flocking in starlings, analysis of the film made during the practical in which students move according to simple rules to demonstrate emergent behaviours.

Modelling Behavioural Polymorphisms

Why don't all individuals respond the same, (ref to hormones, neuro, diurnal cycles), playing different strategies, personalities. Game theory: hawk/dove game and ESSs, Bourgeois butterflies, Anti-bourgeois spiders, wars of attrition, dung flies. Side blotched lizards, rock-paper-scissors games, mention of green beards.

Animal Personalities

Personality: Multiple mating strategies examples, horned beetles, isopods, age deciders in guppies, male mimicry in damselflies, cuckoo eggs, polymorphism in sparrows, feeding behaviour polymorphisms in cactus finch, producers and scrounger pigeons, bold/shy fish, lab vs wild differences, predator inspection behaviour, predator inspection in fish, fast/slow great tits, foraging strategies, behavioural syndromes.

Behaviour And Climate Change

Brief evidence it's real, physiological responses to temperature change, effects of CO₂ on insects, phenological changes, examples of this, miss-timings, migration timing and route changes, limitations to adjustment by animals, range shifts, Hawaii as ecological disaster.

Behaviour and conservation

Conservation high priority, behavioural ecology can help: Counting populations: methods of counting, mark-recapture, call censusing methods, playback. Small populations: importance of breeding systems, monogamy and extinction, sexual selection, and extinction, Allee effect, clumping populations. Disturbance alleviation: sex-biased hunting, size biased hunting, light pollution, water turbidity, effects of sound pollution. Kakapo case study.

Behaviour, zoos and reintroductions

Behavioural ecology can help: imprinting problems, migration route learning, cross fostering, predator recognition, hunting skills, movement in the environment, stress, boredom, stereotypies, appetitive behaviours, natural behaviour management, contra-free loading, inbreeding, mate choice, selection for personality types.

Practical Content:

Practical 1: Zoo animal behaviour

Self-directed visit to Dublin Zoo and completion of worksheet on animal signalling. Ticket provided by Biology Teaching Centre. After the visit students complete an online quiz in Blackboard.

Practical 2: Trials of Life Videos

Students watch, in their own time, up to four videos from the BBC series "Trials of Life" by David Attenborough. For at least two of the videos' students must demonstrate understanding of the concepts explored in the videos by completing associated MCQ tests.

Practical 3: Collective Behaviour Self-directed computer based practical carried out in student's own time. Students use the free, open source software Netlogo and run a series of experiments to investigate how small changes to simple individual behaviours can manifest as large group-level changes to the overall behaviour of the group. Specifically the exercise will focus on models of bird flocks, fish shoals and ant colonies.

Learning Outcomes:

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

- Place the study of behaviour in context related to a historical perspective.
- Describe the range of factors which influence animal behaviour, linking the understanding of behaviour to evolution, psychology, and a number of other areas of biology.
- Outline the basics of learning, both through classical mechanisms and through cultural transmission.
- Discuss the concept of animal intelligence and our understanding of consciousness in non-humans.
- Outline the main reasons for variation in behaviour between individuals.
- Discuss how and why animals play, and how they navigate.
- Outline the importance of animal behaviour studies in the context of conservation.
- Appreciate the range of effects climate change is having on animal behaviour.

- Build from a sound basis of understanding of basic behavioural ecological concepts.
- Organise and complete assessed work independently of the module co-ordinator.
- **Recommended Reading List:**
- Alcock J. 2005 Animal Behaviour an evolutionary approach. 8th edition. Sinauer Associates Inc
(*Provided as a PDF file in Blackboard*)
- Dugatkin L.A. 2003 Principles of Animal Behaviour. Norton (*Provided as a PDF file in Blackboard*)
- Barnard C. 2004 Animal Behaviour: Mechanism, Development, Function and Evolution. Springer
(*Provided as a PDF file in Blackboard*)
- McFarland 1999 "Animal Behaviour: Psychobiology, Ethology and Evolution" 3rd ed. Longman
(*Provided as a PDF file in Blackboard*)
- Konrad Lorenz (1960) King Solomon's Ring. Methuen, London.
- Niko Tinbergen (1972) Curious Naturalists. Penguin Books, London
- Marian Stamp Dawkins "Through Our Eyes Only? The search for animal consciousness" 1998
Oxford University Press

Module Delivery: All assignments will be published through Blackboard and all course work will be submitted through Blackboard. The module will be managed through Blackboard.

Assessment Details:

The module grade is divided between the end of module written exam (70%) and the course work (30%). **To pass the module a student must obtain an overall module mark of 40%.**

Exam Format: 10 compulsory short answer questions

Course work components

- Practical 1 assessment: Worksheet from zoo marked pass/fail; online quiz marked electronically = 30% of course work;
- Practical 2 assessment: Trials of Life, four online MCQs of which a minimum of two are completed, the best two of four will be taken = 40% of course work.
- Practical 3 assessment: Online quiz for collective behaviour, marked electronically = 30% of course work

Contacts:

Module Coordinator: To be announced

Biology Coordinator: Glynis Robinson, robinsog@tcd.ie, Phone: 01 896 2895

Laboratory Manager: Audrey Carroll aucarrol@tcd.ie, Ph: 01 896 1620

Executive Officer: Daniel McCormick btcadmin@tcd.ie, Ph: 01 896 1117

BYU22206: Microbes, Immune Systems, and their Interaction

Semester 2, 5 credits

Prerequisite: BYU11101

Module coordinators: Carsten Kröger and Cliona O'Farrelly

Contact Hours: 17 hours lectures, 2 Tutorial/Discussion sessions, 10 hours practicals.

Module Personnel: Cliona O'Farrelly, Carsten Kroger, Kingston Mills, Marta Martins, Gareth Brady, Daniel Bradley, Rachel McLoughlin, Mary Canavan, Siobhan O'Brien

Learning Aims:

An extensive microbial world existed successfully on earth for 1.5 billion years before multicellular organisms began to appear. During that time, microbes evolved multiple defence mechanisms against potential competitors. Many of these mechanisms are conserved in multicellular organisms and used in defence against potential pathogens, together with many additional immune/defence mechanisms that provide survival advantage to all species. In this module, students will learn about the cells and molecules of defence systems and about the complex interactions between microbes and their hosts which can lead to significant disease, but which are also required for health. Students will learn about the molecular and cellular biology of key pathogens (viral, bacterial and parasitic) which currently threaten human populations. They will learn about immune systems and the diverse mechanisms used by immune molecules and cells to detect and respond to these microbes; they will be introduced to concepts of immune manipulation by vaccines and immunotherapies.

Module content:

Programme of face-to-face lectures and laboratory sessions: two lectures a week, Thursdays at 14:00, Fridays at 15:00, laboratory on Mondays

Lecture Topic	Lecturer	Practical / Discussion Session
Introduction: Microbes, Immune Systems and their Interaction	Prof O'Farrelly / Prof Kröger	Practical 1: Microbial Offence and Defence 1 (Siobhan O'Brien)
Microbial Offence Mechanisms	Prof Kröger	
Microbial Defence Mechanisms:	Prof Kröger	Practical 2: Cells and Organs of the Immune System (Mary Canavan)
Combatting Infectious Disease: antimicrobials and antimicrobial resistance	Prof Kröger	
Introduction to Vertebrate Immune Systems	Prof O'Farrelly	
Where and how immunology happens: Molecules, Cells & Organs of the Immune System.	Prof O'Farrelly	Practical 3: Antibody Specific Detection (Rachel McLoughlin)
Innate Immunity:	Prof O'Farrelly	
Adaptive Immunity 1: Immunisation	Prof O'Farrelly	

Bacterial Pathogens: Mycobacterium tuberculosis:	Prof Marta Martins	
Adaptive Immunity 2: Anti TB Immunity	Prof Kingston Mills	
Reading Week		
Adaptive Immunity 3: Anti- 'flu Immunity	Prof Kingston Mills	
Viruses	Prof Gareth Brady	
Parasitic Pathogens - Malaria	Prof Kröger	
Immune Responses to Malaria	Prof O'Farrelly	
Microbiomes and Health	Prof O'Farrelly	
Inflammation in Health and disease	Prof O'Farrelly	

Lecture Content:

Evolution of microbial and multicellular organisms

An introduction to how multicellular organisms evolved 'around' the microbial world and how the microbial world continues to exist successfully on the planet.

Microbial defence mechanisms

The microbial world existed successfully for 1.5 billion years before multicellular organisms began to evolve. During that time, microbes evolved multiple defence mechanisms against potential competitors e.g. bacteriocins, ways of blocking nutrient uptake, CRISPR cas9, restriction modification systems

Introduction to vertebrate anti-microbial defence

An overview of what vertebrate immunology is; how so much of microbial defence has been conserved; how competition for nutrient resources underpins immunometabolism immune activity and immune regulation; immune systems detect altered self as well as foreign and danger – anti-cancer immunity, virally infected cells, Natural Killer cells.

Where immunology happens and how: molecules, cells & organs of the immune system

Overview of the key immune organs, cells and molecules, their location structure and principle functions; introduction to haematopoiesis.

Microbiomes in health & disease

The human body is inhabited by communities of bacteria and other microbes on the skin, in the respiratory tract and oral cavity, the intestine and the genito-urinary tract. The composition of these communities differs significantly between different anatomical sites. The presence of a balanced microbial community is essential for appropriate immune system function and health and dysbiosis of the microbiota is associated with infection and with a variety of chronic disorders.

Innate immunity

Macrophages, epithelial cells and neutrophils - how they detect infection & danger; pathogen recognition receptors; how they signal.

Inflammation in health & disease

Inflammatory cytokines, chemokines, local inflammation systemic inflammation; chronic inflammatory disease, anti-inflammatory therapies.

Bacterial pathogens, mycobacterium.

Biology of the pathogen, intracellular life of *Mycobacterium tuberculosis* pathogenesis, epidemiology of the disease.

Adaptive immunity 1: immunisation:

Global effect of successful vaccines; structure and function of antibodies; primary and secondary responses, B lymphocytes, induction of an effective antibody response; infectious agents without vaccines.

Adaptive immunity 2 anti TB immunity:

How T lymphocytes are activated, DCs antigen processing and presentation; 4 populations of T cells; Mtb evasion of adaptive immunity; granuloma formation; role of TNF

Viral pathogens - influenza:

The influenza virus, pathogenesis of influenza virus infections, anti-virals.

Adaptive immunity 3: anti-flu immunity

The adaptive immune response against viruses; cytotoxic T cells; flu vaccine.

Parasite pathogens, malaria. Parasites are the giants of the pathogen world – they are responsible for major burden of disease across the globe. An introduction will be given to the major pathogenic parasites, with a focus on malaria.

Immune responses to malaria:

Innate and adaptive immune responses to natural malarial infection; malarial evasion of immunity; vaccine challenges

Combatting infectious disease – antimicrobials and antimicrobial resistance: How antibiotics (and other antimicrobials) revolutionised the treatment of infectious disease. How microbes become resistant to antimicrobial chemotherapy. The current global crisis of antimicrobial resistance.

Practical Content**PRACTICAL 1: Microbial offence and defence**

This practical will familiarise students with the strategies used by microbes to defend themselves against competing microbes and to cause damage to host cells.

Completion of this practical will enable students to:

- Demonstrate the growth inhibitory activity of antibiotics produced by fungi and bacteria on a culture of *Escherichia coli*.
- Isolate antibiotic resistant mutants of *Escherichia coli*
- Determine the sensitivity of *Escherichia coli* to antibiotics
- Enumerate bacterial viruses and animal viruses using a plaque assay

PRACTICAL 2: Cells and Organs of the Immune System

This practical will familiarise students with the anatomy of the immune system so that they recognize the appearance of key immune organs, structures and cells and have some insight into their immunological primary roles.

Completion of this practical will enable students to:

- identify the cells and tissues involved in the mammalian immune system
- demonstrate awareness of the relative dimensions of the organs of the immune system
- be familiar with the appearance of the neutrophil, macrophage, dendritic cell, and lymphocyte

PRACTICAL 3: Immunological Activity: Antibody-Specific Detection & Phagocytosis

This practical will familiarise students with some immunological functions in particular the specific recognition ability of antibodies and phagocytic potential of macrophage-like cells.

Completion of this practical will enable students to:

- carry out an ELISA (enzyme-linked immunosorbent assay)
- Perform blood-typing
- Carry out a phagocytosis assay

Learning Outcomes:

Completion of this module will enable students to:

1. Demonstrate an understanding of the microbial world.
2. Discuss the evolution of multicellular organisms.
3. Discuss the evolution of 'defence' amongst microbes and multicellular organisms.
4. Appreciate the components of and function of prokaryotic and mammalian immune systems.
5. Describe how key pathogens cause infection and the immune response to pathogens. infectious disease.

Recommended Reading List:

The topics and concepts presented in this module can be found in selected chapters of the following textbooks:

1. Campbell Biology 12th Edition Pearson (especially chapter on Immunology)
2. Prescott's Microbiology. 10th edition
3. Goldberg & Marraffini 2015. Resistance and tolerance of foreign genetic elements by prokaryotic immune systems — curating the genome.
Nat Rev Immunol. 15(11): 717–724. doi:10.1038/nri3910.

Assessment Details:

30% of module mark for assessment of practical activities

70% of module mark for end of semester examination, combination of single essay and short answer format questions. To pass the module students must achieve an overall module mark of 40%.

Contacts:

Module Coordinator: Carsten Kroger, krogerc@tcd.ie

Biology Coordinator: Glynis Robinson, robinsog@tcd.ie, Phone: 01 8962895

Laboratory Manager: Audrey Carroll, aucarrol@tcd.ie, Phone: 01 8961049

Executive Officer: Daniel McCormick, btcadmin@tcd.ie, Phone: 01 8961117

BYU22207: Genomes, Disease and Diversity

Semester 2, 5 credits

Prerequisite: BYU11101 or BYU11102

Module coordinator: Dr Lara Cassidy, cassidl1@tcd.ie, Phone: 01 896 3521

Contact Hours: 16 hours lectures, 9 hours practicals.

Module Personnel: Jane Farrar, Seamus Martin, Pepijn Luijckx, Linda Ongaro, Lara Cassidy, Máire Ní Leathlobhair

Learning Aims: Through lectures and practical exercises we will provide students with a broad overview of genomics and the impact of new approaches across the biosciences. We will introduce the basics of new technologies and show the application of these to the study of: a) inherited traits, including Mendelian and complex human diseases; b) the non-inherited somatic genome with particular focus on cancer; c) human kinship and origins; d) the microbiome; and e) the genomics of ecology.

Module content:

Programme of lectures and practicals, two lectures a week, Tuesday and Thursday, practicals on Mondays

Lecture Topic	Lecturer	Practical
1. The inherited genome: Introduction to the human genome	J. Farrar	
2. The inherited genome: Human disease and genomics	J. Farrar	
3. The inherited genome: Genome wide analysis of human traits	J. Farrar	
4. The non-inherited genome: Cancer, incidence, sources of mutagens, types of mutation	S. Martin	Practical 1. Human Disease Analysis
5. The non-inherited genome: Oncogenes and tumor suppressor genes	S. Martin	
6. The non-inherited genome: The process of cellular transformation	S. Martin	Practical 2. Microbial Analysis
7. The non-inherited genome: Cancer genomics, epigenomics and implications for treatment.	S. Martin	
8. The Social Genome: Modern human diversity	L. Cassidy	
9. The Social Genome: Our deep past	L. Cassidy	
10. The Social Genome: Our recent history	L. Cassidy	
Reading Week		

11. The Microbial Genome: The Human Microbiome	M. Ní Leathlobhair	Practical 3. Human Diversity analysis
12. The Microbial Genome: Microbial Fossils & Endogenous Viral Elements	M. Ní Leathlobhair	
13. The Microbial Genome: Disruption and Disease	M. Ní Leathlobhair	
14. The Ecological genome: Evolutionary genomics	P. Luijckx	
15. The Ecological genome: Ecological genomics	P. Luijckx	
16. The Ecological genome: De-extinction	P. Luijckx	

Lecture Content:

Lectures are grouped in five themes:

The inherited genome, with topics including:

- Introduction to the human genome
- From genes to genomics
- Human disease and genomics
- Non disease traits and genomics

The non-inherited genome, with topics including:

- Cancer, incidence, sources of mutagens, types of mutation
- Oncogenes and tumor suppressor genes
- The process of cellular transformation
- Cancer genomics, epigenomics and implications for treatment

The social genome, with topics including:

- Patterns of modern human diversity
- Archaic human genomics
- European and Irish archaeological genomics
- Genealogy and forensic genomics

The microbiome, with topics including:

- Microbiology without culture
- the human microbiome
- Environmental microbiomics

The ecological genome, with topics including

- Conversation genomics
- Biodiversity
- De-extinction

Practical Content:

Practical 1

Cancer Genomics: Single Cell RNA Sequencing. Students will be introduced to the use of single cell RNA sequencing of tumors to assess cellular and genetic heterogeneity of oncogenic tissue samples. Advanced clustering techniques such as t-SNE will be utilized to assess tumor cell diversity, and gene enrichment tests will be performed using Gene Ontology (GO) criteria.

Practical 2

Microbial Genomics: Phylogenies and outbreak genetics. In the first of three computer-based practicals leveraging R-based skills from Semester 1, students will be introduced to the phylogenetics, sequence evolution models, and evaluating different methods of evolutionary tree construction. These skills will then be applied to genomic data from the 2013-2016 Ebola outbreak in West Africa, and experience the potential role played by genome sequencing and phylogenetics in dissecting pathogenic outbreaks.

Practical 3

Population Genomics: Analysis of human population and archaic ancestry. Students will be presented with genome-wide data from a diverse range of both modern and ancient human populations and dissect how these relate to one another. This session will demonstrate the potential of allele frequency-based measures of genetic similarity, D statistics and test of introgression in adding to our understanding of recent and ancient human evolution, exploiting the availability of ancient genomic data.

Learning Outcomes:

On completion of the module students will be able to:

- Understand the core concepts in genomics.
- Understand the interaction of genomic investigation and human inherited traits, including complex disease.
- Understand the impact of genomics on the study and treatment of cancer.
- Understand genomic impact in the study of human evolution.
- Understand core concepts in microbial genomics.
- Appreciate genomic impacts in ecological research.
- Key analytical skills gained in the statistics and computation for biologists' module will be reinforced through application to genomic data.

Assessment Details:

30% of module mark for assessment of practical activities

70% of module mark for end of semester examination, combination of single essay and short answer format questions. Students must achieve an overall module mark of 40% to pass the module.

Contacts:

Module Coordinator: Lara Cassidy, cassidl1@tcd.ie, Phone: 01 896 3521

Biology Coordinator: Glynis Robinson, robinsog@tcd.ie, Phone: 01 8962895

Laboratory Manager: Audrey Carroll, aucarrol@tcd.ie, Phone: 01 8961049

Executive Officer: Daniel McCormick, btcadmin@tcd.ie, Phone: 01 8961117

CHU22201: Chemistry 1

Semester 1, 10 Credits

Contact Hours: 50 hours lectures and tutorials and 27 Labs hours.

Rationale and Aims: To provide core Inorganic and Organic Chemistry topics at an intermediate level, which further develop the material covered in the JF year and are the basis for further detailed studies in the Sophister years.

Content Layout

Teaching Week	Topic
1-4 (14 L)	<p>Introduction to Molecular Orbital Theory</p> <ul style="list-style-type: none">• Atomic orbitals (s,p,d) as wave functions; their representation as enclosed boundary surfaces and as radial distribution functions. The relationship of these ideas to the Bohr model for atomic hydrogen. Relative energies of these orbitals; orbital angular momentum in non-hydrogen-like atoms; penetration and shielding.• Hybridisation of atomic orbitals and the hybrids associated with various geometries; VSEPR treatment of molecular structures.• Bonding as the linear combination of atomic orbitals, including non-bonding and anti-bonding interactions. Labelling of molecular orbitals as sigma, pi (g or u), molecular orbital diagrams of homonuclear diatomic molecules of the first and second row of the Periodic Table. Mixing of molecular orbitals and its effect on the relative energies of the resulting molecular orbital diagram. Molecular orbital approach for simple molecules including H₂O, BeH₂ and BCl₃. Reactivity of CO in terms of the molecular orbital energy diagram for this molecule. Appreciation of the Molecular Orbital basis of the spectrochemical series. <p>Transition Metal Coordination Chemistry</p> <ul style="list-style-type: none">• Brief introduction - why study metal complexes?• What is a metal complex? Overview of concepts and definitions: Lewis Acid-base concept.• Formation and stability of metal complexes: Complex formation and dissociation; cumulative stability constants and trends; the 'chelate effect'; factors affecting stability.• Classification of common ligands: Donor atoms and functional groups. Multidentate and chelating ligands; stereochemistry and formation of chelate rings.• Stereochemistry of metal complexes. Coordination numbers 2-6 and geometry of metal complex; square planar, tetrahedral; trigonal bi-pyramid; square based pyramid; octahedral; distortion of geometries.• Electronic structure and properties of transition metal complexes: Ionic vs. covalent bonding models; crystal field theory; energy level diagrams in tetrahedral - octahedral fields.• Consequences and applications of orbital splitting: Electronic configurations of metal complexes; crystal field stabilization energies (CFSE); Factors effecting

	<p>Delta; spectrochemical series; HS and LS configurations; magnetic properties and the spin-only formula.</p> <ul style="list-style-type: none"> • Electronic spectra of metal complexes: UV-vis. Spectra; interpretation of data; Laporte and spin selection rules; extinction coefficients and wavelength; Jahn-Teller effect.
4-5 (5L)	<p>Molecular Spectroscopy</p> <ul style="list-style-type: none"> • This course will focus on the major techniques employed in the identification of chemical entities (although some are not spectroscopic techniques). • Why is spectroscopy important? • Nuclear Magnetic Resonance Spectroscopy (NMR): Nuclear spin, chemical shift, shielding and spin-spin coupling. Both ^1H and ^{13}C NMR are covered. A brief consideration of MRI is included. • Ultraviolet Spectroscopy: Effect of π-conjugation. • Infra-red Spectroscopy: Molecular vibrations, detection of characteristic functional groups • Mass spectrometry: Uses and application • X-Ray Diffraction: How X-ray diffraction can be employed to aid structural elucidation.
6-9 (12 L)	<p>Introduction to Organic Synthesis</p> <ul style="list-style-type: none"> • In-depth discussion of stereochemistry including definition of chemo-, region- and stereoselectivity. Identification of stereoisomers and assignment of absolute configuration. Resolution of racemic mixtures. Biological relevance of stereochemistry. • Conformational analysis, including Newman projections diagrams. Conformation of cyclohexane including chair, boat, twist-boat. Concept of allylic strain. • Introduction to carbohydrate chemistry and a discussion of common protecting groups in organic chemistry. • Applications of radical reactions in Organic synthesis. • In-depth discussion of aldol, carbonyl and beta-dicarbonyl chemistry for the formation of C-C bonds. • Aldol and carbonyl chemistry. • HSAB theory, the Michael addition reaction and Diels-Alder reaction.
Week 7 Study week	
10-12(9L)	<ul style="list-style-type: none"> • Aromatics • Why is aromatic chemistry important? An overview of important drugs, dyestuffs and polymers that are based on aromatic compounds. • Recap: An overview of JF Aromatic Chemistry I: The structure of benzene and a reminder of the mechanism of electrophilic aromatic substitution (EAS) reactions. • How and why substituents on an aromatic ring influence the regiochemical outcome of EAS reactions: How do electron donating groups and electron withdrawing groups cause the substitution patterns that they do? • Nucleophilic Aromatic Substitution: Introduction to NAS and the differences to EAS. The three different mechanisms of NAS and their use in synthesis.

	<ul style="list-style-type: none"> • Organometallic chemistry: Introduction to metallation reactions, directed metallation as a method of controlled synthesis, metal catalysed coupling reactions. • Synthetic considerations: How to plan successful synthetic strategies to prepare aromatic compounds. • Other important aromatic systems: A brief look at some of the less common compounds and their chemistry. • Aromatic chemistry in the body - a brief look at some important aspects including biosynthesis, hormones, drug metabolism and the production of toxic metabolites. • Tying it all together: An overview of the synthesis of an important aromatic compound.
13	Student Revision/Study week – tutorials only
14	Student Assessments

Reading list/ Indicative Resources

- Organic Chemistry, by Jonathan Clayden and Nick Greeves; Publisher: OUP Oxford; 2 ed.
- Inorganic Chemistry, by C. E. Housecroft and A. G. Sharpe, PrenticeHall, 1 ed, 2001

Methods of Assessment

In-course assessment: 25% of Final Grade

Written Examination: 75% of Final Grade

Lab Hours = 9 x 3 hours = 27 hours. Organic Chemistry (6 experiments), Inorganic (3 experiments)

Learning Outcomes

1. Discuss the trends in atomic orbitals and use these to explain trends in atomic properties.
2. Generate a set of molecular orbitals and an energy level diagram based on the principles of molecular orbital theory.
3. Classify ligands and explain transition metal complex geometries.
4. Predict and explain the d-orbital splitting in transition metal complexes and its effects on the geometry and electronic properties.
5. Identify and explain stereochemical features of organic molecules.
6. Describe strategies for controlled formation of stereochemical centres in organic synthesis.
7. Formulate reasonable retrosynthetic pathways for the design of simple organic molecules.
8. Explain the principles of standard organic spectroscopy techniques.
9. Determine information about the structure of unknown organic materials using spectroscopic data.
10. Categorise and explain the principle reactions of aromatic molecules.

Contacts

Coordinator Fresh Teaching

Dr Noelle Scully

E-mail: pnsully@tcd.ie

Phone: 01 896 1972

Administrative Officer

Ms AnneMarie Farrell

E-mail: farrea25@tcd.ie

Phone: 01 896 1726

GGU22925: Human Geography: Changing Worlds

Semester 1, 10 credits

Contact Hours

2 x 1 hour lectures / week for 10 weeks = 20 hours

1 x 2 hour practical / week for 10 weeks = 20 hours

Module Personnel

Prof. Mark Hennessy

Module 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 approaches the uneven and contested relationships that exist between humans and their environments in an increasingly globalised world. Attention will focus on the way environmental problems (climate change, overfishing, pollution) are experienced and understood by different actors.

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.

Module 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 Information

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

Module Coordinator: GGU22925 – Changing Worlds	
Prof. Mark Hennessy	E-mail: mark.hennessey@tcd.ie
Executive Officer:	E-mail: geog@tcd.ie
Helen O'Halloran	Phone: 01 896 1576

GGU22008: History & Philosophy of Geography

Semester 1, 5 credits

Contact Hours

11 x 1 hr lectures = 11 hours

Module Personnel

Dr Mark Hennessy

Module Content

A. The classical world. 1. Hecataeus, Eratosthenes and the early Greek geographers. 2. Ptolemy, Strabo, Pliny the Elder and other geographers from the period of the Roman empire.

B. Geography in the age of Enlightenment. Focus on Alexander von Humboldt.

C. Geography in the age of Victorian exploration. The relationship between empire and geography is a key theme in this section.

D. French Geography in the late nineteenth and early twentieth century. The contrasting ideological context of the Vidalian school and the work of Élisée Reclus is considered. The influence of German geographers such as Von Humboldt, Ritter and Ratzel on this tradition is also considered.

E. The “Quantitative Revolution”. Developments in geography in the late 1950s, ‘60s and ‘70s are examined and are contrasted with Hartshorne’s earlier outline of the scope and methods of geography.

F. Radical and Marxist Geography. The development of critical approaches in geography is traced with a particular focus on the works of William Bunge and David Harvey.

G. Feminism and Geography. The influence of Feminist perspectives on research and writing in geography is traced and set within the wider context of the introduction of radical and anti-systemic ideologies to the practice of geography.

H. Postmodernism and Geography. This section explores how the philosophical, methodological and ideological innovations associated with Postmodernism have influenced the practice of geography

Module Learning Outcomes

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

- Demonstrate a knowledge of how the discipline of Geography has changed from Classical times to the present
- Have a critical awareness of how intellectual and disciplinary change is related to broader patterns of historical change
- Evaluate debates regarding the scope and purpose of the discipline of Geography
- Compare different approaches to the study of the Geography

Assessment Information

1.5-hour written theory examination (50%); in-course assessment (50%)

Module Coordinator: GGU22008: History and Philosophy of Geography	
Dr Mark Hennessy	E-mail: Mark.Hennessey@tcd.ie
	Phone: 01 896 1881
Executive Officer:	E-mail: geog@tcd.ie
Helen O’Halloran	Phone: 01 896 1576

GGU22009: Spatial Data & GIS

Semester 2, 5 credits

Contact Hours

1 x 2 hour lecture / week for 10 weeks = 20 hours

Module Personnel

Dr John Connolly, Dr Mark Hennessy

Module Content

This module introduces the student to mapping and Geographical Information Systems (GIS). It explores how to identify, create and use geographic data and tools. The object is to teach students about how data can be constructed, used, found, and manipulated by geographic researchers. The module will enable students to: interpret maps; find and evaluate data; organise, manipulate and analyse data in a basic GIS; create projects and maps using that GIS system; identify how geographic data construction and analysis differs from typical quantitative approaches

Module learning outcomes:

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

- Appreciate different ways of representing geo-spatial/mapping information
- Understand the meaning and importance of spatial resolution and different types of spatial data (raster/vector, digital/manual)
- Assess the appropriateness of different geospatial data representations for different purposes
- Understand the concept of 'remote sensing' and the various ways in which it can be achieved in general terms
- Explain basic principles of GIS and have familiarity with Google Earth
- Critically reflect on, and assess, the use of GIS applications for a variety of purposes (in the human and physical environment)
- Confidently and critically deploy a number of basic, but key, geospatial data presentation methods

Assessment Information

In-course assessment (100%)

Module Coordinator: GGU22009: Spatial Data & GIS	
Dr John Connolly	E-mail: john.connolly@tcd.ie
Executive Officer:	E-mail: geog@tcd.ie
Helen O'Halloran	Phone: 01 896 1576

GLU22007: The History and Evolution of Life on Earth

Semester 2, 5 Credits

Contact Hours

2 x 1 hour lecture / week for 10 weeks = 20 hours

1 x 3 hour practical / week for 10 weeks = 30 hours

Module Personnel

Dr Patrick Wyse Jackson, Dr Una Farrell

Module Content

This module will provide a comprehensive foundation in the geological and palaeontological history of life on Earth as determined through study of diverse fossil groups, their geological ranges, palaeobiology, and their evolution through time. It will examine the complex processes of fossilisation, show how fossils are named and described, and detail how they can be used to infer evidence of palaeoenvironments and in particular Ireland's geological history.

Module Learning Outcomes

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

- recognize the diversity and major morphological characteristics of organisms found in the fossil record
- outline the concepts of fossilization, evolutionary sequences and lineages
- outline the concepts of evolution and with changes in evolutionary thought
- summarise key features of the evolutionary record of life on Earth.
- outline the uses of fossils in palaeobiological, palaeoecological, palaeogeographical and evolutionary studies
- use palaeontological information to further their understanding of Ireland's geological history

Assessment Details

Written theory examination (50%) and in-course assessments (50%)

Module Coordinator - GLU22007 The History and Evolution of Life on Earth	
Professor Patrick Wyse Jackson	E-mail: wysjcknp@tcd.ie
	Phone: 01 896 1477
Executive Officer	E-mail: TR062Admin@tcd.ie
	Phone: 01 896 1074

Graduate Attributes

The Trinity Graduate Attributes represent the qualities, skills and behaviours that you will have the opportunity to develop as a Trinity student over your entire university experience, in other words, not only in the classroom, but also through engagement in co- and extra-curricular activities (such as summer work placements, internships, or volunteering).

The four Trinity Graduate Attributes are:

- To Think Independently
- To Act Responsibly
- To Develop Continuously
- To Communicate Effectively



Why are the Graduate Attributes important?

The Trinity Graduate Attributes will enhance your personal, professional and intellectual development. They will also help to prepare you for lifelong learning and for the challenges of living and working in an increasingly complex and changing world.

The Graduate Attributes will enhance your employability. Whilst your degree remains fundamental, also being able to demonstrate these Graduate Attributes will help you to differentiate yourself as they encapsulate the kinds of transversal skills and abilities, which employers are looking for.

How will I develop these Graduate Attributes?

Many of the Graduate Attributes are 'slow learned', in other words, you will develop them over the four or five years of your programme of study.

They are embedded in the curriculum and in assessments, for example, through undertaking independent research for your final year project, giving presentations and engaging in group work.

You will also develop them through the co-curricular and extra-curricular activities. If you help to run a club or society you will be improving your leadership skills, or if you play a sport you are building your communication and team-work skills.

Important information

Closing Dates for Course Transfer

If you decide to transfer out of your course altogether, you must submit an application for **transfer of course** to the Academic Registry, following discussion with your tutor. Decisions are based on **a)** the availability of places, and **b)** the entry qualifications of the transfer applicant. It may not be possible to permit transfers to subjects which already have a full complement of students. Further details are available on the following link:

<http://www.tcd.ie/study/apply/making-an-application/undergraduate/index.php>

Students may not register or attend a course until their application to transfer has been formally approved by the Senior Lecturer

Progression and Awards

Information on progression and awards can be found via the following webpage:

<https://www.tcd.ie/teaching-learning/academic-affairs/ug-prog-award-regs/index.php>

Attendance

All students should enter into residence in or near Dublin and must begin attendance at the College not later than the first day of teaching term and may not go out of residence before the last day of teaching term, **unless they have previously obtained permission from the Senior Lecturer through their tutor.**

Students must attend College during the teaching term. They must take part fully in the academic work of their class throughout the period of their course. Lecture timetables are published through my.tcd.ie and on school or department notice-boards before the beginning of Michaelmas teaching term. The onus lies on students to inform themselves of the dates, times and venues of their lectures and other forms of teaching by consulting these timetables.

The requirements for attendance at lectures and tutorials vary between the different faculties, schools and departments. The school, department or course office, whichever is relevant, publishes its requirements for attendance at lectures and tutorials on notice-boards, and/or in handbooks and elsewhere, as appropriate.

Assessment: procedures for the non-submission of coursework and absence from examinations

All students must fulfil the course requirements of the school or department, as appropriate, with regard to attendance and course work. Where specific requirements are not stated, students may be deemed non-satisfactory if they miss more than a third of their course of study or fail to submit a third of the required course work in any term.

Full regulations on non-submission of coursework can be found via the following:

<https://www.tcd.ie/teaching-learning/academic-policies/assets/assess-nonsub-absence-sep2020.pdf>

Further details of procedures for reporting a student as non-satisfactory are given on the College website at <https://www.tcd.ie/academicregistry/student-cases/>

Guidelines on Marking for Junior and Senior Fresh Courses

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 necessary giving the exact date, should show an awareness of the approximate period. In essays the references 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 presented and accurate in essays.
II-1	65-69	VERY COMPREHENSIVE ANSWER: Good understanding of the concepts supported by broad knowledge of the 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. Occasional 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 the assigned course literature.
Class	Mark Range	Criteria

II-2	50-59	SOUND BUT INCOMPLETE ANSWER: Based on coursework alone but suffers from significant omission, error or misunderstanding. Usually lacks synthesis of information or ideas. Mainly logical and accurate within its limited scope with lapses in detail
	50-54	INCOMPLETE ANSWER: Suffers from significant omissions, errors and misunderstandings, but still 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 the 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.

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.

A general set of guidelines for students on avoiding plagiarism is available on:

<https://libguides.tcd.ie/friendly.php?s=plagiarism>. The Calendar entry outlines the process through which a suspected case of plagiarism should be dealt with

<https://www.tcd.ie/calendar/undergraduate-studies/general-regulations-and-information.pdf>

Absence from College – Medical and Absence Certificates

The online SCIENCE ABSENCE FORM must be completed for all types of absences.

You can specify what type of absence once you start completing the form. The form can be found here [Science - Online Absence Form](#)

***You must select from one of the three categories of absences in the online form...**

Medical Certificates (You MUST upload medical documentation ie; Certificate, Letter or Note, to section 14 of the Science Absence Form)

Where a student misses an assigned laboratory practical class through illness, they should do the following;

(a) Complete the online Science Absence form, and upload the medical documentation in section 14, **on the day of their return to College.**

and

(b) inform the laboratory practical supervisor of their absence at the next session.

Self-Certification (uncertified medical reasons)

For periods of illness of three days or less (**but no more than seven days in any year**) a student may 'self-certify' their illness via the Science absence form, on the day of their return to College.

Students taking BYU modules please note: a student may self-certify for no more than 1/3 of laboratory sessions in a module, and no more than 1/3 of course work in a module.

Sporting/ Other Absences (funerals etc)

Students who require to be absent from a laboratory practical classes or tutorials (with or without an associated assessment) for any other reason, such as a sporting event or other situation, should

(a) Complete the online Science Absence Form well in advance of the event (preferably a week beforehand), and upload the Sporting, Club/Societies letter in section 14 of the absence online form.

Please note that filling in this form is **not a guarantee** that you will be afforded any accommodations with regard to marks or assignment of an alternative lab or tutorial session. In such cases decisions on what action/accommodations will be given is purely at the discretion of the individual disciplines concerned. The Science Course Office do not have any jurisdiction in this situation.

Students who will not be in attendance for any extended duration during term time must have permission from Senior Lecturer via their tutor to be absent from College. Please refer to the absence regulations noted in the previous page.

Excuses for absence, presented after the event, **will not be entertained.** Students who anticipate that their sporting commitments may necessitate more than the occasional absence from College (e.g. Sport Scholars, etc.) should discuss their situation with their tutor and the Associate Dean of Undergraduate Science Education (ADUSE).

NOTE:

Please note that these regulations do not apply to absence from examinations. Students who are absent from examinations must contact their tutor as a matter of urgency and present any medical information/documentation to them.

Student Services

Trinity Tutorial Service

The Tutorial Service is unique, confidential and available to all undergraduate students offering student support in all aspects of College life. The Tutorial Service is supported and co-ordinated by the Senior Tutor's Office which is located on the ground floor in House 27.

Opening Hours

The Senior Tutors Office is open Monday - Friday from 9am - 5.30pm. Closed for lunch from 1-2pm.

Appointments

If you require specific advice or would like a confidential meeting with the Senior Tutor, you can make an appointment by telephoning +353 1 896 2551 or by emailing stosec@tcd.ie

What is a Tutor?

A Tutor is a member of the academic staff who is appointed to look after the general welfare and development of the students in his/her care. Whilst the Tutor may be one of your lecturers, this is not always the case as the role of the College Tutor is quite separate from the teaching role.

When should I go to see my Tutor?

Whenever you are worried or concerned about any aspect of College life or your personal life, in particular if it is affecting your academic work. Everything you say to your Tutor is in strict confidence. Unless you give him/her permission to do so, s/he will not give any information to anybody else, whether inside College or outside (to your parents/family for example). Your Tutor can only help you if s/he knows you are facing difficulties, so if you are worried about anything go and see your Tutor before things get out of hand.

Further information on the Senior Tutors Office and College Tutors may be found via the following webpage: **Senior Tutor's Office** - <https://www.tcd.ie/seniortutor/students/undergraduate/>

Disability Services

The Disability Service aims to provide appropriate advice, support and information to help students and staff with disabilities. The Disability Service has in place a range of supports to ensure that students with disabilities have full access to the same facilities for study and recreation as their peers. Most students registering with the Disability Service request access to a range of supports that help the student reach their full potential while studying. Most students' needs are accommodated through these supports. The student decides what level of support they require.

For contact information or to make an appointment please contact the Disability Services – contact details are available via the following webpage: <https://www.tcd.ie/disability/contact/>

Student Counselling

The Student Counselling Service is here to help you to manage any difficulties you are experiencing so you can enjoy and fully participate in your time here at College.

If you wish to make an appointment with the Student Counselling Service, please consider one of the options below. If you have any other queries you can call into reception on the 3rd floor of 7-9 South Leinster Street or contact us on:

Phone: (01) 8961407

Email: student-counselling@tcd.ie

For further information visit the following webpage:

https://www.tcd.ie/Student_Counselling/

Useful College Websites:

Student Life

Student life offers information on Supports and Services, Clubs and Societies, Student Unions etc.,

<https://www.tcd.ie/students/>

Academic Registry

The Academic Registry is responsible for services that support the complete student lifecycle of Trinity College Dublin – from application to graduation.

For information on Registration, Fees, Grants, ID Cards etc. visit the Academic Registry (AR) in the Watts Building, on the first floor, or the visit the AR website: <https://www.tcd.ie/academicregistry/>

Student Accommodation

The Accommodation Office is open Monday to Friday from 8.30am to 1pm and 2pm-5pm each day. Queries can be emailed to residences@tcd.ie, or you can telephone 8961177 during office hours.

After hours you can contact Front Gate at 8963978 in case of difficulties or key problems. In Goldsmith Hall attendants are on duty in the residential area at weekends and overnight and they will assist with local problems. In the event of a serious emergency, particularly where you require the attendance of ambulance, fire or police services please telephone College Security at 8961999 (internal 1999). To ensure a co-ordinated response please do not call these services directly. We recommend that you programme these numbers into your mobile phone using the prefix "01" before the number. <https://www.tcd.ie/accommodation/>

Academic Year Structure 2024-2025

Key Dates:

Semester 1 teaching term begins:	Monday 09 September 2024
Study/revision week Semester 1:	Monday 21 October - 25 October 2024
Semester 1 teaching term ends:	Friday 29 November 2024
Semester one examinations:	*Monday 09 December to Friday 13 December 2024
Semester 2 teaching term begins:	Monday 20 January 2025
Study/Revision week Semester 2	Monday 03 March to Friday 07 March 2025
Semester 2 teaching term ends:	Friday 11 April 2025
Revision week	*Monday 14 April to Friday 18 April 2025

* To be confirmed by Academic registry. All the information contained in this booklet is accurate at time of publication. However, the Science Course Office reserves the right to modify information, dates, and times as necessary. Students will be notified of any changes via e-mail and/ or the Science webpage <https://www.tcd.ie/courses/undergraduate/courses/science/>

Teaching Term Dates 2024-2025

Michaelmas Term (Semester 1) Monday 9 September - Friday 29 Nov 2024			Hilary Term (Semester 2) Monday 20 January 2025 - Friday 11 April 2025		
Teaching wk. 1	Week 03	09 Sept – 13 Sept	Teaching wk. 1	Week 22	20 Jan - 24 Jan
Teaching wk. 2	Week 04	16 Sept - 20 Sept	Teaching wk. 2	Week 23	27 Jan – 31 Jan
Teaching wk. 3	Week 05	23 Sept - 27 Sept	Teaching wk. 3	Week 24	*03 Feb - 07 Feb
Teaching wk. 4	Week 06	30 Sept – 04 Oct	Teaching wk. 4	Week 25	10 Feb - 14 Feb
Teaching wk. 5	Week 07	07 Oct - 11 Oct	Teaching wk. 5	Week 26	17 Feb - 21 Feb
Teaching wk. 6	Week 08	14 Oct – 18 Oct	Teaching wk. 6	Week 27	24 Feb – 28 Feb
Study week	Week 09	* 21 Oct - 25 Oct	Study week	Week 28	*03 Mar - 07 Mar
Teaching wk. 8	Week 10	*28 Oct - 01 Nov	Teaching wk. 8	Week 29	10 Mar - 14 Mar
Teaching wk. 9	Week 11	04 Nov - 08 Nov	Teaching wk. 9	Week 30	*17 Mar - 21 Mar
Teaching wk. 10	Week 12	11 Nov - 15 Nov	Teaching wk. 10	Week 31	24 Mar - 28 Mar
Teaching wk. 11	Week 13	18 Nov - 22 Nov	Teaching wk. 11	Week 32	*31 Mar - 04 Apr
Teaching wk. 12	Week 14	25 Nov – 29 Nov	Teaching wk. 12	Week 33	07 Apr - 11 Apr

*October bank holiday – Monday 28th October 2024

*February bank holiday – Monday 3rd February 2025

*St Patrick's Day - Monday 17th March 2025

TR062: Geography and Geosciences Contact details:

Professor Micha Ruhl

Course Director TR062 Geography and
Geoscience

E-mail: micha.ruhl@tcd.ie

Ph: 01-8961165

TR062 Administrator

E-mail: TR062Admin@tcd.ie

Ph: 01 896 1074

Science Course Office

Professor Fraser Mitchell

Associate Dean of Undergraduate Science
Education

Ph: 01 896 2025

E-mail: Fraser.Mitchell@tcd.ie

Ms Ann Marie Brady

Science Course Office Manager

E-mail: ennisa@tcd.ie

Ph: 01 896 2829

Ms Helen Sherwin Murray

Administrative Officer

E-mail: sherwinh@tcd.ie

Ph: 01 896 2799

Ms Romarey Segura Orea

Executive Officer

E-mail: segurar@tcd.ie

Ph: 01 896 2022

Ms Andressa Dos Santos Melo

Executive Officer

E-mail: dossanta@tcd.ie

Ph: 01 8961970

Appendix 1: General Information

ITEM	REFERENCE/Source
General Regulations	<p>Calendar, Part II - General Regulations and Information, Section II, Item 12: https://www.tcd.ie/calendar/undergraduate-studies/general-regulations-and-information.pdf</p> <p><u>Attendance Requirements:</u> Refer to the Calendar, Part II, General Regulations and Information, Section II, Items 17-23</p> <p><u>Absence from Examinations:</u> Refer to the Calendar, Part II, General Regulations and Information, Section II Link here for more information https://www.tcd.ie/teaching-learning/academic-policies/assets/assess-nonsub-absence-sep2020.pdf</p> <p><u>Plagiarism Policy and information:</u> https://www.tcd.ie/teaching-learning/UG_regulations/Plagiarism.php https://libguides.tcd.ie/friendly.php?s=plagiarism</p>
General Information	<p>Timetables are available via my.tcd.ie portal: https://my.tcd.ie/urd/sits.urd/run/siw_lgn</p> <p>Blackboard: https://tcd.blackboard.com/webapps/login/</p> <p>Academic Registry: https://www.tcd.ie/academicregistry/</p> <p>Data Protection: https://www.tcd.ie/info_compliance/data-protection/student-data/</p> <p>Dignity & Respect Policy https://www.tcd.ie/equality/policy/dignity-and-respect-policy/</p>
Foundation Scholarship	<p>Foundation and Non Foundation Scholarship: Calendar, Part II www.tcd.ie/calendar/undergraduate-studies/foundation-and-non-foundation-scholarships.pdf</p> <p>Science Foundation Scholarship information sheet can be found here: https://www.tcd.ie/Science/assets/documents/PDF/foundation-scholarship/TR062/TR062-foundation-scholarship-information-22-23.pdf</p> <p>Foundation Scholarship Examination 2022/23 - TR062 Geography and Geosciences</p>
Teaching and Learning	<p>Academic Policies: https://www.tcd.ie/teaching-learning/academic-policies/</p> <p>Student Learning Development: https://www.tcd.ie/Student_Counselling/student-learning/</p>

	<p>Student Complaints Procedure: https://www.tcd.ie/about/policies/160722_Student%20Complaints%20Procedure_PUB.pdf</p> <p>Student Evaluation and Feedback: https://www.tcd.ie/teaching-learning/quality/quality-assurance/evaluation.php</p> <p>National Framework of Qualifications: National Framework of Qualifications Quality and Qualifications Ireland (qqi.ie)</p>
Student support	<p>Student Support Services: https://www.tcd.ie/students/supports-services/</p> <p>Student Services Booklet: https://www.tcd.ie/students/assets/pdf/Student%20Services%20Handbook.pdf</p> <p>Senior Tutor & Tutorial Service www.tcd.ie/students/assets/pdf/Student%20Services%20Booklet%20(web%20version).pdf</p> <p>Mature Student Office https://www.tcd.ie/maturestudents/</p>
Co-curricular activities	<p>Central Societies Committee: https://www.tcd.ie/calendar/general-information/students-unions-societies-and-clubs.pdf</p> <p>DUCAC: Dublin University Central Athletic Club - Trinity Sport - Trinity College Dublin (tcd.ie)</p> <p>Student Sport - Trinity Sport - Trinity College Dublin (tcd.ie)</p>
Information on TCDSU Including student representative structures	<p>TCDSU https://www.tcdsu.org/</p>
Emergency Procedure	<p>In the event of an emergency, dial Security Services on extension 1999. Security Services provide a 24-hour service to the college community, 365 days a year. They are the liaison to the Fire, Garda and Ambulance services and all staff and students are advised to always telephone extension 1999 (+353 1 896 1999) in case of an emergency.</p> <p>Should you require any emergency or rescue services on campus, you must contact Security Services. This includes chemical spills, personal injury or first aid assistance.</p> <p>It is recommended that all students save at least one emergency contact in their phone under ICE (In Case of Emergency).</p>

NOTE: All of the information contained in this booklet is accurate at time of publication. However, the Science Course Office reserves the right to modify information, dates and times as necessary. Students will be notified of any changes via e-mail and the Science webpage.



Trinity College Dublin

Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin



Science Course Office

Faculty of Science, Technology, Engineering and Mathematics, Trinity College Dublin 2, Ireland.

Oifig na gCúrsaí Éolaíochta Dámh na hinne-altóireachta, na Matamaitce agus na hÉolaíochta Ollscoil Átha Cliath, Coláiste na Tríonóide Baile Átha Cliath 2. Éire.

PH: _____ +353 1 896 1970
E-mail: _____ science@tcd.ie
Web: _____ www.tcd.ie/Science

tcd.ie/science