Science at Trinity

Faculty of Engineering, Mathematics and Science (STEM)

TR062 Geography and Geosciences Senior Fresh Handbook 2026-2027

This programme booklet applies to all students taking TR062 Geography and Geosciences. It is a guide to what is expected of you on the programme and the supports available to you. Please retain for future reference.

The information provided is correct at the time of publication. Any necessary revisions will be notified to students via email and the TR060 Biological and Biomedical Sciences senior fresh **web address here:** https://www.tcd.ie/science/undergraduate/tr062-geography-and-geosciences/senior-fresh/

In the event of any conflict or inconsistency between the General Regulations published in the University Calendar and the information provided in this course programme, the general college regulations will prevail: https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/general-regulations-and-information.pdf

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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

Dr Sean McClenaghan

Semester Structure

TR062: GEOGRAPHY AND GEOSCIENCE Senior Fresh Year	
SEMESTER 1 – Michaelmas Term **14 September 2026 – 04 December 2026**	**SEMESTER 2 – Hilary Term** **18 January 2027 –09 April 2027**
CORE MODULES (40 Credits)	
BYU22S01: Statistics and Computation (5 credits)	GGU22006: Physical Geography: Dynamic Earth (10 credits)
GSU22201: From Atoms to Rocks: Introduction to Geochemistry (5 credits)	GSU22003: Tectonics: Shaping Planet Earth (5 credits)
GSU22202: Sedimentary Processes & Environments (5 credits)	PIU22992: History, Philosophy and Ethics of Science (5 Credits)
GSU22004: Senior Fresh Field Course (5 credits)	
OPEN MODULES (20 Credits) *: **Students must choose 10 credits in each Semester*	
BYU22201: From Molecules to Cells (10 credits)	BYU22202: From Cells to Organisms (10 credits)
BYU22210: Sustainable Agriculture and the Bioeconomy (5 Credits)	BYU22203: From Organisms to Ecosystems (10 credits)
BYU22209: Fundamentals of Behaviour – (5 Credits)	BYU22206: Microbes, Immune Systems & their Interaction (5 credits)
CHU22201: Chemistry 1 (10 credits)	BYU22207: Genomes, Disease & Diversity (5 credits)
GGU22008: History & Philosophy of Geography (5 credits)	GGU22009: Spatial Data & GIS (5 credits)
GGU22925: Human Geography: Changing Worlds (10 credits)	GLU22007: The History and Evolution of Life on Earth (5 credits)

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

Open Module Choice Forms

Module choice forms must be submitted online by **5pm on Friday 17th April 2026**. Forms are available online via the following link: https://forms.office.com/e/b6zABJKQRX

Please note: Trinity Columbia Dual BA students will be contacted separately from columbiadualba@tcd.ie about their module enrolment process for senior fresh year; please **do not** complete this form if you are a Trinity Columbia Dual BA student.

Change of Open Modules

If, after a couple of weeks, a student feels that they have 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.

Change of module form is available online via the following link:
https://forms.office.com/e/b6zABJKQRX

All change of module requests must be submitted via the online module form by **Monday 28th September 2026.**

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:

- TR062 Geography Moderatorship = 18 places
- TR062 Geoscience Moderatorship = 42 places
    - Earth System Science Path = 24 Places
    - Geology Path = 18 Places

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

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/
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%).

Recommended reading lists
Ryan, P. (2014) Environmental and Low Temperature Geochemistry. Wiley-Blackwell.
White, W. M. (2013) Geochemistry. Wiley-Blackwell.

Contacts:

Module Coordinator:	Dr Michael Stock	MICHAEL.STOCK@tcd.ie
TR062 Executive Officer:	TBC	Tr062Admin@tcd.ie

GSU22202: Sedimentary Processes & Environments

Semester 1, 5 credits
Contact Hours
Lectures = 20 hrs
Lab Practicals = 8 hrs

Module Coordinator: Dr Micha Ruhl

Module Aims:

Sediments and sedimentary rocks hold a rich history of how physical, chemical, and biological processes vary, and have changed over space and time. This module is designed to provide an introduction of different past and present sedimentary depositional environments, and the processes that control them, 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

All in-course assessment: Practical exercises (50%); In-course problem solving exercise/test(s) (50%)

Contacts:

Module Coordinator:	Dr Micha Ruhl	MICHA.RUHL@tcd.ie
TR062 Executive Officer:	TBC	Tr062Admin@tcd.ie

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 Coordinator: Prof. David Chew

Module Aims:
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%)

Contacts:

Module Coordinator:	Prof David Chew	chewd@tcd.ie
TR062 Executive Officer:	TBC	Tr062Admin@tcd.ie

GSU22004: Senior Fresh Field Course

Semester 1, 5 credits
Contact Hours
1-week field course usually held in and around Dublin during the study/review week.
Anticipated cost: Approximately €100
Module Coordinator: Prof. Gerald Dickens

Learning Aims
To provide foundation-level knowledge of:

- To present core concepts that will be used and discussed in sophister modules of TR062, particularly those involving or interpreting field work
- To gather basic field observations relevant to multiple Geoscience pursuits and present these in a meaningful way so that you and others can understand later and away from the field
- To realize uncertainty and complexities with data collection and presentation
- To appreciate the needs to work alone and with others, and to place individual, group, and external observations into a larger framework
- To consider locations on Earth as a product of processes connecting over space and time

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:
The collection and interpretation of information from our surroundings (aka "field work") frames much of geoscience, geography and geology. How and why does the landscape around us and its key components (rocks, sediment, water and inhabitants) change and evolve over space and time? This module is designed to give you the basic means to assess such a question by focusing on locations in and around Co. Dublin. The module comprises a week-long set of day trips during which time you will collect information that will enable the presentation of field-based products. 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 sophister years.

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

- Collect and record basic properties at field sites pertinent to geoscience.
- Use basic field equipment
- Describe and understand a range of landforms and how they relate.
- 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 (50%) and field-based products (50%)

Contacts:

Module Coordinator:	Prof Gerald Dickens	DICKENSG@tcd.ie
TR062 Executive Officer:	TBC	Tr062Admin@tcd.ie

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 contribute to scientific efforts to understand the emergence of truly globally significant human– environmental linkages by 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 landscapes to understand the processes that shape our planet's features and why they vary spatially. 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. Learning in this module is a combination of in-class Lectures and at-home directed Google Earth activities where you explore, examine, and measure real world landscapes. The module builds upon previous geographic ideas introduced in JF Spaceship Earth and Anthropocene, but is accessible to a broad scientific audience. For those continuing on with a geography or geoscience sophister degree, the concepts covered in this module will provide a firm foundation for more advanced later modules.

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

- Critically evaluate the influence of topography, climate, and humans on a variability of landforms and landscapes.
- Explain the theories underlying how and why specific landforms vary over space and time.
- 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:
2-hour examination (60%) and continuous assessment of Google Earth activities (40%)

Contacts:

Module Coordinator:	Dr Pete Akers	pete.akers@tcd.ie
Geography Admin:	Helen O'Halloran	geography@tcd.ie
TR062 Executive Officer:	TBC	Tr062Admin@tcd.ie

BYU22S01: Statistics and Computation

Semester 1, 5 credits

Prerequisite: none

Module Coordinator: Professor Thomas Connor

Contact Hours: 20 hours Lectures; 5 x 3-hour practical's; 3 x 1-hour computational tutorial. Attendance at practicals and computational tutorials is mandatory & will be assessed.

Module Personnel: Professor Thomas Connor, Professor Dan Bradley, Professor Máire Ní Leathlobhair, Dr Karsten Hokamp

Learning Aims:

Through lectures (content delivery, explanation), practical's (learning how to problem-solve, program and design), computational tutorial 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 practical's

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 simulation. 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 workflow 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: 50% of the module, broken down as follows:

Practical Assessments: = 37.5% of module (all practical's weighed same 7.5%).

Mid-term test based on lecture material in 1st half of semester = 12.5% of module

A student cannot submit if they don't attend the practical.

End of module examination: One hour exam = 50% of module

To pass the module a student must obtain an overall module mark of 40%. All practical's are compulsory.

Contacts:

Module Coordinator:	Professor Thomas Connor, Contact details TBC
Biology Teaching Manager:	Mirela Dardac, mdardac@tcd.ie, Ph: 01 8962895
Chief Technical Officer:	Audrey Carroll, aucarrol@tcd.ie, Ph: 01 896 1620
Executive Officer:	Gena Zapodianu, btcadmin@tcd.ie, Ph: 01 896 1117

PIU22992: History, Philosophy and Ethics of Science

Semester 2, 5 credits
Contact Hours:
22 hours of lectures + 10 hours of tutorials

Module Personnel: TBC (Prof. Alison Fernandes) (Philosophy) & Prof. Linda Hogan (Ecumenics)

Science looks to be our best hope of discovering the way the world is. We use it to predict climate change, map the human genome and identify the Higgs boson. Science seems to give us an objective view on the world. How does it manage to do this? Does it succeed in its aims? Insofar as science is successful, can we rely on it to solve our problems? This course will examine the workings of science through four core topics: what is science and the scientific method, the unity of science, ethical conduct in science and ethical issues that arise in addressing climate change.

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

- Think critically about the historical, philosophical and ethical dimensions of science.
- Reflect on the aims and methods of science, in ways that facilitate ongoing exploration of scientific practice.
- Demonstrate awareness of competing ethical demands that arise in scientific practice and of the role of scientists, individuals and communities in promoting ethical standards.
- Communicate their ideas effectively to others in writing using clear and precise language.
- Engage in reasoned debate in classroom and lecture settings.

Module content: Programme of Lectures and Tutorials

Week	Lecture Topic	Lecturer
1	Module Introduction	
	What is Science? The Demarcation Problem	
2	The Scientific Revolution	
	Other Scientific Revolutions	
	Tutorial: What is Science?	
3	Scientific Method: The Problem of Induction	
	Popper's Falsificationism	
	Tutorial: Scientific Revolutions	
4	Scientific Method: How are Theories Confirmed?	
	Kuhn on Scientific Method and Revolutions	
	Tutorial: Induction and Falsificationism	
5	The Unity of Science: Reduction and Emergence	
	Why was Vitalism Discarded?	
	Tutorial: Kuhn on Scientific Method and Revolutions	
6	The Problem of the Direction of Time	
	What is Causation?	
	Tutorial: Unity at Work: Why was Vitalism Discarded?	
7	**Reading Week**	
8	Trust in Science: Why Ethics Matters	Prof Hogan

	What Makes Something Ethical? Ends and Means	Prof Hogan
	Tutorial: Finding the Direction of Time and Causation in Physics	
9	What Makes Something Ethical? Duties and Virtues	Prof Hogan
	From Principle to Practice: Navigating the Ethics Ecosystem	Prof Hogan
	Tutorial: Trust in Science and Ethical Principles	
10	Sustainability: The Climate Change Consensus	
	Climate Responsibility and Energy	
	Tutorial: Applied Ethics in Science	
11	Ethical Decision Making and Values	
	Decision-making and Disagreement: Eating Animals	
	Tutorial: Climate Responsibility and Energy	
12	Distraction Tactics: Waste and Fast Fashion	
	Review Lecture	
	Tutorial: Ethical Decision-making	
13	**Revision Week** **Open MCQ**	
14	**Assessment Week**	

Lecture Content and Assessment Schedule

Component 1: What is Science and its Method?

W1L1: Module Introduction
Introduction to the module. What is it to approach science historically, philosophically and ethically?

W1L2: What is Science? The Demarcation Problem
What is Science? How is science different from other disciplines and activities? Contemporary attempts to demarcate science from non-science using its aims or methods.

W2L1: The Scientific Revolution
The early practice of science, including the use of mathematics and geometry in pursuit of explanation and prediction. How the Scientific Revolution changed the practice of science, with a focus on experimentation.

W2L2: Other Scientific Revolutions
To what extent do sciences like chemistry and the geosciences also have revolutions? Is there a clear demarcation between science and non-science?

W3L1: Scientific Method: The Problem of Induction
What is it to follow the scientific method? The distinction between two forms of inference: deduction and induction. Do observations of the past constrain our predictions of the future? Can induction be justified? Hume's 'Problem of Induction'.

W3L2: Popper's Falsificationism
Can scientific theories be refuted? Is there no more to scientific method that choosing unrefuted (but refutable) theories? Popper's deductive scientific method—avoiding the problem of induction. Are specific scientific claims or theories refutable? Criticisms of Popper from Quine and Duhem.

W4L1: Scientific Method: How are Theories Confirmed?

What is it for evidence to count in favour of a theory? Can probabilities be used to give a complete account of theory confirmation? Bayesian approaches to theory confirmation.

W4L2: Kuhn on Scientific Method and Revolutions
Is science a rational enterprise? To what extent do sciences at all times follow the same rules? To what extent are scientists led by paradigms of good science? Kuhn's account of science: science as a historical process that goes through periods of normal and revolutionary change.

Component 2: The Unity of Science

W5L1: The Unity of Science: Reduction and Emergence
To what extent is science a unified enterprise? Do all sciences have to agree? What is the relation between more 'fundamental' and 'higher-level' sciences? How do sciences depend on each other?

W5L2: Why was Vitalism Discarded?
The historical case of Vitalism. Why did scientists used to believe in a distinctive force possessed by only living things? What led to the demise of vitalism? What, if anything, do we learn about the relation between biology and other sciences?

W6L1: The Problem of the Direction of Time
Is there a direction of time? Is there a direction of time in (relatively) fundamental physics? How might a direction of time emerge from dynamics that are temporally symmetric? The role of entropy.

W6L2: What is Causation?
What is it for one thing to cause another? How do causal relations relate to laws? Are there causal relations in fundamental physics? If not, where are they? What are causal relations *for*?

Component 3: The Ethics of Scientific Practice

W8L1: Trust in Science: Why Ethics Matters
This lecture considers the role ethics plays in the creation and maintenance of a culture of trust in science, looking specifically at issues of integrity, transparency, autonomy and accountability.

W8L2: What Makes Something Ethical? Ends and Means
This lecture considers some approaches to ethics and ethical reasoning, namely, Ends and Means, Duties, and Virtues, and assesses their relevance and persuasiveness in the context of a range of examples from science.

W9L1: From Principle to Practice: Navigating the Ethics Ecosystem (I)
These lectures examine critical contemporary ethical issues that arise in the different scientific fields, focusing on bioethics, animal ethics, geoethics and information ethics.

W9L2: From Principle to Practice: Navigating the Ethics Ecosystem (II)
These lectures examine critical contemporary ethical issues that arise in the different scientific fields, focusing on bioethics, animal ethics, geoethics and information ethics.

Component 4: Sustainability and Climate Change

W10L1: Sustainability: The Climate Change Consensus
What was the role of science and scientists in establishing global consensus on climate change? What is the state of climate change and our attempts to address it?

W10L2: Climate Responsibility and Energy
Who is responsible for historical climate change? Who is responsible for addressing climate change now? Climate change and equality. What is the role of the energy sector? Is new technology enough? What is the role of economic policy? What role (if any) do arguments about 'personal responsibility' have? The idea of your 'carbon footprint'.

W11L1: Ethical Decision Making and Values
How should we decide what to do? What should we value? How should the needs of the present be weighed against the needs of the future? What psychological biases might impede ethical decision-making about the climate?

W11L2: Decision-making and Disagreement: Eating Animals
What is the role of food production and land use in climate change? What values and interests shape choices about food? Who is responsible for what we eat? Is there value to eating meat? How can we disagree productively?

W12L1: Distraction Tactics: Waste and Fast Fashion
What happens to waste? What role does the fashion industry play in climate change? How have companies addressed (or not addressed) climate change? Are carbon offsets a reasonable way to reduce emissions? What about carbon capture or geo-engineering?

W12L2: Review
Review lecture, in preparation for final in person exam.

Recommended Reading List:
Introductory reading:
Lewens, T. (2016) *The Meaning of Science*. Penguin.
Chalmers, A. (2013) *What is this Thing Called Science?* Hackett Publishing.

Full reading list: See Module Syllabus on Blackboard.

Assessment Details:
2 Written assignments of 500 words (1–2 pages) (30% total; 15% each)
1 hr end of term in person exam (50%)
7 Discussion posts (10%)
Attendance at tutorials (10%)

Module Coordinator: PIU22991: History, Philosophy and Ethics of Science		
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TR062 Geography and Geoscience – **OPEN MODULES**

BYU22201: From Molecules to Cells II

Semester 1, 10 credits

Prerequisite: BYU11101

Module coordinator: Prof Emma Creagh

Contact Hours: 34 hours Lectures, 21 hours Practicals

Module Personnel: E. Creagh, K. Mok, A. Khan, M. Hankir, J. Hayes, D. Nolan, 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 enter cells to replicate 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 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. Sickle 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: Introduction to viral replication - we will touch upon how viruses are transmitted and then explore the different ways viruses enter cells. We will discuss the diversity of viral genomes and compare examples of viral strategies for producing mRNA.
- Virology II: Replication continued– we will explore how replication and assembly of new virions is dependent on specific locations within the cell and also the cellular processes a virus needs to utilise during replication.

Practical Content:
Practical 1 Solutions & dilutions - This numerical skills activity will prepare students for numerical calculations relevant for lab work (eg. calculating molarites, 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 spectrophotomeric 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 Km and Vmax for uninhibited series, use Lineweaver-Burk plots to demonstrate competitive inhibition, and determine the Ki.
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:

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BYU22202: From Cells to Organisms

Semester 2, 10 credits

Prerequisite: BYU11101

Module coordinator: Prof Colm Cunningham

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, Mathew Dorman

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 Practicals 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.
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 is 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 and 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 (Practicals).
- 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:

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BYU22203: From Organisms to Ecosystems II

Semester 2, 10 credits

Prerequisite: BYU11102

Module coordinator: Professor Nessa O'Connor

Contact Hours: 38 hours Lectures, 15 hours Practicals.

Module Personnel: N. O'Connor, F. Mitchell, L. Cassidy, D. Bradley, N. Payne, G. Albery, J. Waterman, 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.

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 theland in the geological past. The adaptations required will be addressed and how these adaptions 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 form 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 in 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: CO_2 and O_2.
- **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:

1. **Practical 1 – Molecular Phlyogenetics.** 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).
2. **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.
3. **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.
4. **Practical 4 - Plant Physiology.** Leaf photosynthesis of C3 and C4 plants using infra-red gas analysis to monitor changes in concentration of CO_2 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 CO_2 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.

5. **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:

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Chief Technical Officer:	Audrey Carroll	aucarrol@tcd.ie, Ph: 018961620
Executive Officer:	Gena Zapodianu	btcadmin@tcd.ie, Ph: 01 8961117

BYU22209: Fundamentals of Behaviour

Semester 1, 5 credits

Prerequisite: none

Module coordinator: Greg Albery**,** alberyg@tcd.ie

Contact Hours: 19 hours
Module Personnel: G. Albery, J. Barnett, A. Jackson,
Self-directed Learning (practical activities): 9 hours

Learning Aims:
Behaviour is a unique trait in animals that allows them to respond rapidly to a changing environment. Most of the exciting, fast-moving phenomena we associate with living organisms – fighting, flying, flocking, swimming, sensing, mating, communicating, spreading disease, and more – fall under the umbrella of behaviour. As well as being important to understand in natural contexts, all of these traits and processes also have correlates or analogues in human behaviour and society, adding further motivation to understanding them deeply and on a fundamental level. Ultimately, taking this perspective, the study of behaviour is the study of rapid responses and interacting agents in all forms.
In this course, students will be introduced to the fundamental mechanisms and theories underlying behavioural processes and taught how to think like a behavioural scientist. I detail what behaviour is and how it works across all possible scales, conveying the groundwork in the underlying structure of nervous systems and building through physiology, learning, communication, collective behaviour, and social systems, up to the global-scale consequences of responses to environmental stress. Drawing these lessons together, I discuss the role that behavioural science plays in understanding and managing animal populations and species in a rapidly changing world. In all cases, I pepper the Lectures with equivalent or similar behavioural processes in humans, encouraging students to apply the lessons more generally. Ultimately, this helps to derive an understanding of behaviour to take away in this and many other fields.

Module content:
Programme of two Lectures a week. Three self-directed practical activities spread across the Semester.

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; attendance at the zoo must be evidenced by providing a photo of the animals interacting.
Practical 2: Trials of Life Videos:
Students watch, in their own time, four videos from the BBC series "Trials of Life" by David Attenborough. 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 gain a fundamental understanding of:

- The nature of behaviour as a unique yet universal trait.
- How behaviour is acquired, and the factors contributing to learning.
- How memories and behaviours are recalled, and the factors that make recall easier or harder.
- What we know about animals' self-awareness and consciousness, and how we study it.
- What senses animals use to interrogate their environment, and how this defines other elements of their biology including their behaviour.
- What makes individuals vary in their behaviours, and why this has costs and advantages.
- The theory underlying tradeoffs and optimal decisionmaking, and how this underlies animal behaviour.
- Why and how animals move in space.
- The physiological processes that underlie variation in behaviour.
- The consequences of behaviour for transmission of disease.
- How behaviours are used to respond to changing environments.
- How complex collective behaviours emerge from simple individual-level rules.
- The costs and benefits of being social, and why animals often evolve complex social structures.
- How social structures lead to the spread of innovations.
- Culture and its origins in social learning.
- How cultural development results in optimal and suboptimal structures through incremental change and path dependency.
- How an understanding of behaviour can be used to inform animal conservation.
- How an understanding of behaviour can be used to improve animal and human health and welfare.
- How advancing technologies are contributing to our understanding of animal behaviour.
- The intersections between behavioural science, complex systems and network sciences, and the many ways in which behavioural understanding can be used to inform complex processes.
- The generalisation of behavioural responses to plants and other organisms.

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: Two hours duration, 10-15 multiple choice or short answer questions.

Course work components:
- Practical 1 assessment: Worksheet from zoo marked (30%); online quiz marked electronically = 20% of course work.
- Practical 2 assessment: Trials of Life, four online MCQs= 20% of course work.
- Practical 3 assessment: Online quiz for collective behaviour, marked electronically = 30% of course work

Contacts:

Module Coordinator:	Greg Albery alberyg@tcd.ie
Biology Teaching Manager:	Mirela Dardac mdardac@tcd.ie , Phone: 01 896 2895
Chief Technical Officer:	Audrey Carroll aucarrol@tcd.ie, Ph: 01 896 1620
Executive Officer:	Gena Zapodianu btcadmin@tcd.ie, Ph: 01 896 1117

BYU22210: Sustainable Agriculture and the Bioeconomy

Semester 1, 5 credits

Prerequisite: none

Module coordinator: Richard Nair

Contact Hours: 16-hour Lectures, 12 hours Practicals

Module Personnel: Dr Richard Nair, Dr Ailbhe Brazel, Dr Jaime Waterman, Dr Silvia Caldararu,

Dr Marcus Collier, Dr María Elena Varela Álvarez

Learning Aims:

Students will understand the broad concepts of sustainable development.

- Sustainability as a holistic and urgent societal issue
- The role of diets in sustainability
- Environmental impacts of agriculture
- Sustainability advances in the food, drink and drug industry, including how these are assessed using Life Cycle Analysis
- Societal aspects of a sustainable transition

Practical sessions 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
1. Introduction to the module: Sustainability	
2. Agricultural trends and the green revolution	
3. Plant breeding and biotech 1	Practical 1: Dietary Analysis Dr Richard Nair (on-line)
4. Plant breeding and biotech 2	
5. Plant breeding and biotech 3	
6. Diets and health	
7. Environmental impacts of agriculture (GHG Production)	Practical 2a: Genetic Techniques applied to Crop Biotechnology – Part A Dr. Ailbhe Brazel
8. Environmental Impacts of Agriculture (Reactive Nitrogen Pollution)	
9. Life Cycle Analysis	Practical 2b: Genetic Techniques applied to Crop Biotechnology – Part B Dr. Ailbhe Brazel
10. Life Cycle Analysis 2	
11. Environmental Impacts of Agriculture: Pollinators	
12. Environmental Impacts of Agriculture: Land Use Change	Practical 3: Life Cycle Analysis Dr Richard Nair
13. Biofuels	
14. Seaweed agriculture and blue biofuels	
15. Socio-Ecological Systems	
16. Environmental Policy	

Learning Outcomes:

At completion of this module students should understand sustainability issues around agriculture and biological production systems (especially food, drink and drug production) in a holistic manner. Students will:

1. Understand the role of agriculture in global change and the current sustainability crisis
2. Understand the role of diet in meeting nutritional needs in different societies
3. Understand, and gain practical experience in, the key techniques that are used in crop biotechnology
4. Be familiar with concepts and methodology of life cycle analysis of food production pathways

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. Roschanger 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 compulsory short answer questions (40% of examination). Practical activities will be assessed by laboratory report and data analysis as appropriate.

Contacts:

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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,, 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 immunotherapaies.

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 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:

1. **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

2. **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

3. **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:

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BYU22207: Genomes, Disease and Diversity

Semester 2, 5 credits

Prerequisite: BYU11101 or BYU11102

Module Coordinator: Dr Lara Cassidy

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 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 , Ph: 01 896 3521
Biology Teaching Manager:	Mirela Dardac	mdardac@tcd.ie,Ph: 01 8962895
Chief Technical Officer:	Audrey Carroll	aucarrol@tcd.ie, Ph: 01 8961620
Executive Officer:	Gena Zapodianu	btcadmin@tcd.ie, Ph: 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

No of Lectures	Topic
14 L	**Inorganic Course Title: Introduction to Inorganic Chemistry 2** The aim of this module is to introduce molecular symmetry and cover aspects of group theory in order to help develop an understanding of electronic spectroscopy of transition metal complexes. The student will learn basic concepts in electronic spectroscopy to develop an understanding of the UV/Vis spectra of transition metal complexes, the influence of the metal and its oxidation state, the nature of the ligand and the coordination number and geometry of the complex on its electronic properties. The application of UV-visible absorption spectroscopy to the characterisation of metal complexes and the effective interpretation of spectra is also discussed in detail developing skills in the manipulation of data and in spectral analysis. **Electronic Spectroscopy of Transition Metal Compounds:** Lecture 1: An introduction to molecular symmetry. Symmetry operations and symmetry elements Lecture 2: Point groups; Determining the point group of a molecule or molecular ion Lecture 3: An introduction to character tables Lecture 4: Why do we need to recognize symmetry elements? Lecture 5: Introduction to electronic spectroscopy. Absorption of light by transition metal complexes. Review of ligand field splitting for octahedral, tetrahedral and square planar geometries, factors affecting the magnitude of splitting. Limitations of ligand field theory – interelectron repulsion. Lecture 6: Coupling of orbital and spin angular momenta, Russell-Saunders coupling, application to first row transition metal ions. Formation of microstates in metal ions and generation of term symbols Lecture 7: Use of Hund's first and second rules to identify the ground term. Lecture 8: Crystal field splitting of free ion terms; Orgel diagrams for the weak-field limit (D and F ground term diagrams), the hole formalism. Interpretation of weak field spectra using Orgel diagrams.

	Tutorial 1 & 2: Point group assignments. Determination of ground term. Assignment of UV-Vis spectra of transition metal complexes. Lecture 9: Quantum mixing. Calculation of quantum mixing term *x* and Racah parameter *B* Lecture 10: Selection rules for electronic transitions. d^5 spectra. Understanding and reasons for the broadening of electronic transitions. Molecular vibrations, Franck-Condon Principle. Spin-orbit coupling, Jahn-Teller distortion Lecture 11: Tanabe-Sugano diagrams, the high-spin/low spin transition, calculation of octahedral splitting, *E* and *B*, use of Tanabe-Sugano diagrams to predict the positions of missing bands. Lecture 12: Origins and consequences of the nephelauxetic effect. Spectra of pseudooctahedral complexes e.g., D_3 complexes such as $Cr(en)_3^{3+}$ – analysis as a small perturbation from the octahedral case, limitations. Continuation of problem-based exercises using Tanabe Sugano Diagrams Lecture 13: Ligand-to-metal and metal-to-ligand charge transfer transitions Lecture 14: Excited state complexes and their resulting emissive properties. Tutorial 3&4: *Assignment of UV-Vis spectra of transition metal complexes. Charge transfer transitions.*
5 L	Molecular Spectroscopy • 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.
12 L	Introduction to Organic Synthesis • In-depth discussion of stereochemistry including definition of chemo-, regio- 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.
9 L	• 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. • 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.

Reading list/ Indicative Resources

- Organic Chemistry, by Jonathan Clayden and Nick Greeves; Publisher: OUP Oxford; 2 ed.
- Inorganic Chemistry, Catherine E. Housecroft and Alan G. Sharpe, Pearson Education Limited 2005 (An introduction to molecular symmetry - Chapter 3; d-Block chemistry: coordination complexes – Chapter 20)
- Characterisation Methods in Inorganic Chemistry, M. T. Weller, N. A. Young, Oxford University Press, 2017. (Electronic Spectroscopy – Chapter 5)
- Inorganic Chemistry: Principles of Structure and Reactivity, J. E. Huheey, E. A. Keiter, R. L. Keiter, HarperCollins, 1997, 4th Ed. (Electronic Spectroscopy – Chapter 11)
- Inorganic Chemistry, M. Weller, T. Overton, J. Rourke, F. Armstrong, Oxford University Press, 2018, 7th Ed. (Electronic Spectroscopy – Chapter 20)

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)

Important Note on Examinations, Assessments and Reassessments in the School of Chemistry:

- There is a minimum mark requirement of **35%** in the **Examination** component and the **40% Laboratory** component, in order for a Pass or Qualified Pass mark in this module to be granted. Other components making up fewer marks are not included in this requirement. A mark of less than 35% in the Examination or 40% Laboratory components leads to a Qualified Fail and requires reassessment examination or a repeat of the year.
- There is a maximum mark or cap of 40% on any reassessed component in this module if reassessment is required. The final module mark is calculated based on the reassessed component mark and any already achieved marks for components that did not need to be reassessed, according to the published weightings of these components.
- Re-assessment capping does not apply to deferred 1st attempts at assessment.
- These requirements apply to all students in this module.
- For more details see the section on 'Progression Regulations applying to Chemistry modules' under the 'Progression and Awards' within this booklet.

Learning Outcomes:

1. Explain the basics of symmetry operators and symmetry elements
2. Explain the basics of group theory
3. Be able to show how one given molecule belongs to a specific point group.
4. Summarize the process for the absorption of light and the mechanism by which this leads to electronic rearrangement in a transition metal complex
5. Explain the implications that absorption has for the origin of the wide-ranging and characteristic optical properties of coordination complexes.
6. State the importance of both the wavelength and intensity of the light absorbed in determining the nature of the transitions between electronic energy levels involving the metal centre.
7. Describe the influence of the metal and its oxidation state, the nature of the ligand and the coordination number and geometry of the complex on its electronic properties.
8. Describe the application of UV-visible absorption spectroscopy in the characterisation of metal complexes and the effective interpretation of spectra.
9. Illustrate the skills required to manipulate relevant data sets and in analyzing spectra.
10. Illustrate the main principles of homogeneous catalysis by transition metals complexes, mechanisms and catalytic cycles.
11. Identify and explain stereochemical features of organic molecules.
12. Describe strategies for controlled formation of stereochemical centres in organic synthesis.
13. Formulate reasonable retrosynthetic pathways for the design of simple organic molecules.
14. Explain the principles of standard organic spectroscopy techniques.
15. Determine information about the structure of unknown organic materials using spectroscopic data.
16. Categorise and explain the principal reactions of aromatic molecules.

Module Coordinator: Professor Mike Southern	E-mail: southerj@tcd.ie Phone: 01 896 3411
Coordinator Fresh Teaching: Dr Noelle Scully	E-mail: pnscully@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

Module Coordinator: Dr Martin Sokol

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 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%)

Contacts:

Module Coordinator:	Dr Martin Sokol, sokolm@tcd.ie
Geography Admin:	Helen O'Halloran, geography@tcd.ie
TR062 Executive Officer:	TBC , Tr062Admin@tcd.ie

GGU22008: History & Philosophy of Geography

Semester 1, 5 credits
Module Coordinator: To be announced

Contact Hours
11 x 1 hr Lectures = 11 hours

Module Content
A. The classical world. 1. Hecataeus, Eratosthenes and the early Greek geographers. 2. Ptolemey, 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 Recus 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%)

Contacts:

Module Coordinator:	TBC
Geography Admin:	Helen O'Halloran, geography@tcd.ie
TR062 Executive Officer:	TBC , Tr062Admin@tcd.ie

GGU22009: Spatial Data & GIS

Semester 2, 5 credits

Module Coordinator: Dr John Connolly, john.connolly@tcd.ie

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%)

Contacts:

Module Coordinator:	Dr John Connolly, john.connolly@tcd.ie
Geography Admin:	Helen O'Halloran, geography@tcd.ie
TR062 Executive Officer:	TBC, Tr062Admin@tcd.ie

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 Emma Dunne

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%)

Contacts:

Module Coordinator: Dr Emma Dunne, Emma.Dunne@tcd.ie
TR062 Executive Officer: TBC, Tr062Admin@tcd.ie

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

Progression regulations applying to Chemistry modules.

An overview of the progression regulations within the Chemical Sciences programme is detailed here.

(a) Minimum mark requirement and Qualified Fails in Fresher years

The progression and regulations rules for chemistry modules are different to modules associated to different Schools. In modules with a practical component (CHU11101, CHU11102, CHU22201 and CHU22202) a minimum mark requirement applies to the examination and practical separately as outlined below:

(i) These regulations apply to the Fresher JF and SF 10 credit modules that are core to Chemical Sciences (TR061), and which are available as Open modules to JF and SF Physical Sciences (TR063) and Geosciences (TR062) students.
These modules are JF: CHU11101 and CHU11102; and in SF: CHU22201 and CHU22202. *(This does not include CHU22M03 and CHU22204).*

(ii) In these Fresher modules there is a **minimum mark requirement of 35%** in the Examination component and **40%** the Laboratory component, in order for either a Pass or a Qualified Pass mark in the module to be granted. The Progression threshold is not simply an overall module mark of 40% or higher but requires minimum marks in these components.

(iii) A mark of less than 35% in the Examination or less than 40% in the Laboratory components leads to a Qualified Fail. A Qualified Fail requires reassessment in that component before progression to the next year can occur. Reassessment of the exam component is in the reassessment examination period; reassessment of the laboratory component occurs before the beginning of the reassessment examination period.

(iv) If a mark of less than 35% occurs or recurs in the examination or less than 40% in the laboratory component following the reassessment period, the student cannot progress and must repeat the year. This necessarily applies to students who had deferred their first attempt at examinations to the reassessment period.

(v) Students who fail a module with a module mark of <40%, but >=35% are not eligible for Pass by Compensation, or a Qualified Pass, if the examination is less than 35% or laboratory components is less than 40%.

(b) Capping of reassessed components in the reassessment session in Fresher years

In all chemistry related reassessments (with or without a practical component), a cap (maximum mark) of 40% will apply as outlined below:

(i) All the reassessed components for Junior Fresh and Senior Fresh Chemistry modules delivered as part of the Chemical Sciences (and available to students in the Physical Sciences and Geosciences courses as Open modules). These modules are JF: CHU11101 and CHU11102; and in SF: CHU22201, CHU22202, CHU22M03 and CHU22204.
(ii) Re-assessment capping does not apply to deferred 1st attempts at assessment.

The full text of these derogations from the College Progression and Award rules can be found at: https://www.tcd.ie/academic-affairs/academic-regulations/-undergraduate-progression-and-awards/

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 Exams

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 Attendance/Non-attendance for Junior and Senior Fresh can be found via the following:
https://www.tcd.ie/media/tcd/science/pdfs/Science-ABSENCE-NON-SATISFACTORY-regulations---TSPMC-August-2024.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 example s 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 COMPRESHENSIVE 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.

Academic Integrity Policy

Trinity College Dublin, the University of Dublin, is committed to upholding academic integrity, and recognises that it underpins all aspects of university life, including all activities relating to research, learning, assessment, and scholarship.

Trinity therefore considers academic misconduct to be serious and academically fraudulent and an offence against academic integrity that is subject to the Trinity procedures in cases of suspected misconduct.

The Academic Integrity Policy (https://www.tcd.ie/media/tcd/about/policies/pdfs/academic/Academic-Integrity-Policy.pdf) should be read in conjunction with (and is subject to) the University Calendar, Part II on Academic Integrity (This policy replaces the Plagiarism Policy).

Other sources of information are available:
https://www.tcd.ie/calendar/undergraduate-studies/
https://libguides.tcd.ie/academic-integrity

https://www.tcd.ie/teaching-learning/academic-affairs/academic-integrity/
https://www.tcd.ie/teaching-learning/academic-affairs/academic-integrity/mandatory-academic-integrity-training/

Guidance on the use of AI and Generative-AI in College

The advent of commonly available artificial intelligence tools are disruptive in both positive and negative ways. Before using them in your studies it is important that you familiarise yourself with College policies on its use. Unless otherwise instructed for particular modules or assessments, **the default expectation would be that you do not submit AI generated content as an attempt at an assessment**.

Below is some basic overview of the College policy on AI and GenAI. This has been taken from the more detailed policy which is informative and wide ranging. You are expected to have read and familiarised yourself with this policy.
https://www.tcd.ie/academicpractice/resources/generative_ai/

Artificial Intelligence (AI)

Artificial intelligence is generally understood to be a set of technologies that enable computers to perform a variety of functions usually perceived as requiring human intelligence – for example, understanding speech, recognising objects in images, composing written answers and problem reasoning. A more formal definition of an AI system from the European Union AI Act (2024) is:
...a machine-based system designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments[.] (EU AI Act 2024)

Generative Artificial Intelligence (GenAI)

Generative AI is the sub-area of AI, involving AI systems which generate content — for example, human dialogue, speech, images and video. GenAI systems are capable of generating such content based on a user's request or instruction. More formally, GenAI is defined by UNESCO **as "an artificial intelligence (AI) technology that automatically generates content in response to prompts written in natural-language conversational interfaces" (UNESCO 2023).**

AI and GenAI in Trinity

As Ireland's leading university and as a world leader in AI research, Trinity recognises that AI and GenAI offer new opportunities for teaching, learning, assessment and research. We also recognise that these technologies present challenges and risks, including to academic integrity, ethics, privacy, impartiality, intellectual property and sustainability.

Acknowledging these opportunities and challenges, Trinity commits to supporting the opportunity for students and staff to become AI literate and fluent, thereby helping them to navigate and respond to the challenges and risks of AI and GenAI in order to harness the potential of (Gen)AI to enhance teaching, learning, assessment and research – and to be prepared for future challenges as these technologies evolve. We also commit to providing ongoing resources and guidance to support students and staff to use AI and GenAI in ways that are appropriate, responsible and ethical – and to ensure that academic integrity is maintained in its usage.

College aspires to develop best practice guidelines in this area. In addition to the resources and supports that College provides and recognising that appropriate uses of AI and GenAI tools vary across academic disciplines, Schools will have some flexibility to customise their own discipline-specific practices in line with this institutional statement, other institutional policies as they develop, and national and international regulation. The College goal is to enable overall consistency in the regulation of GenAI usage, while also respecting where disciplines or degree programmes require specific restrictions in GenAI usage in assessment preparation and execution. Thus, where disciplines or degree programmes wish to refine specific regulations on student use of GenAI for learning, general as well as programme-specific regulations should be communicated in the relevant discipline/degree programme handbook.

Such regulation could range from how student GenAI usage is acknowledged or cited within student assessment submissions, to prohibition of GenAI usage in the production of student assessment submissions.

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.

You will find the link to the form on the following page Science Absence Form

Absence from Laboratories, Continuous Assessments Tests and Non-Submission of Lab Reports (must read)

The online absence form covers the following…

1. Medical Certificates/Absence due to Illness

Where a student misses an assigned laboratory practical class through illness, they should

(a) fill in the online absence form.

(b) upload supporting documentation from a Doctor/ GP or hospital.

(c) If your absence is going to be longer than three days, you should inform your Course Organiser

2. Other Absences

Students who have sports commitments to the College should supply confirmation from the appropriate committee to the Module Coordinator/Course Director well in advance of any event.

Students who anticipate that their sporting commitments may necessitate more than an occasional absence from College (e.g., Sports Scholars etc.) should discuss their situation with their tutor and the Associate Dean of Undergraduate Science Education (ADUSE).

Excuses for absence presented after the event, will not be accepted.

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.

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 2026-27

Key Dates:

Semester 1 teaching term begins:	Monday 14 September 2026
Study/revision week Semester 1:	Monday 26 October to 30 October 2026
Semester 1 teaching term ends:	Friday 04 December 2026
Semester 1 Examinations:	Monday 14 December to 22 December 2026
Semester 2 teaching term begins:	Monday 18 January 2027
Study/Revision week Semester 2	Monday 01 March to Friday 05 March 2027
Semester 2 teaching term ends:	Friday 09 April 2027
Revision Week	Monday 12 April to Friday 16 April 2027

Teaching Term Dates 2026-27

Michaelmas Term Monday 15 September - Friday 04 Dec 2026			**Hilary Term Monday 18 January 2027 - Friday 09 April 2027**		
Teaching wk. 1	Week 04	14 Sept - 18 Sept	Teaching wk. 1	Week 22	18 Jan - 22 Jan
Teaching wk. 2	Week 05	21 Sept - 25 Sept	Teaching wk. 2	Week 23	25 Jan – 29 Jan
Teaching wk. 3	Week 06	28 Sept - 02 Oct	Teaching wk. 3	Week 24	01 Feb - 05 Feb
Teaching wk. 4	Week 07	05 Oct - 09 Oct	Teaching wk. 4	Week 25	08 Feb – 12 Feb
Teaching wk. 5	Week 08	12 Oct - 16 Oct	Teaching wk. 5	Week 26	15 Feb – 19 Feb
Teaching wk. 6	Week 09	19 Oct - 23 Oct	Teaching wk. 6	Week 27	22 Feb – 26 Feb
Study week	**Week 10**	**26 Oct - 30 Oct**	**Study week**	**Week 28**	**01 Mar – 05 Mar**
Teaching wk. 8	Week 11	02 Nov - 06 Nov	Teaching wk. 8	Week 29	08 Mar – 12 Mar
Teaching wk. 9	Week 12	09 Nov - 13 Nov	Teaching wk. 9	Week 30	15 Mar – 19 Mar
Teaching wk. 10	Week 13	16 Nov - 20 Nov	Teaching wk. 10	Week 31	22 Mar - 26 Mar
Teaching wk. 11	Week 14	23 Nov - 27 Nov	Teaching wk. 11	Week 32	29 Mar – 02 Apr
Teaching wk. 12	Week 15	30 Nov to 4 Dec	Teaching wk. 12	Week 33	05 Apr – 09 Apr

- Orientation week - 21st to 25th September 2026
- October bank holiday – Monday 26th October 2026
- February bank holiday – Monday 1st February 2027
- St Patrick's Day – Wednesday 17th March 2027
- Good Friday – 26th March 2027
- Easter Monday – 29th March 2027

The information provided is correct at the time of publication. Any necessary revisions will be notified to students via email and the TR060: Biological and Biomedical Sciences Web page https://www.tcd.ie/science/undergraduate/tr062-geography-and-geosciences/senior-fresh/. In the event of any conflict or inconsistency between the General Regulations published in the University Calendar and the information provided in this course programme, the general college regulations will prevail: https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/general-regulations-and-information.pdf

TR062: Geography and Geosciences Contact details:

TR062 Geography and Geoscience	
Course Director	Professor Sean McClenaghan E-mail: mcclens@tcd.ie
Executive Officer	Debora Dias E-mail: TR062Admin@tcd.ie
Science Course Office	
Associate Dean of Undergraduate Science Education	Professor Andrew Jackson E-mail: jacksoan@tcd.ie Ph: 01 896 2025
Science Course Office Manager	Ms Ann Marie Brady E-mail: ennisa@tcd.ie Ph: 01 896 2829
Science Course Office Administrative Officer	Ms. Helen Sherwin Murray E-mail: sherwinh@tcd.ie Ph: 01 896 2799
Science Course Office Administrative Officer	Ms Romarey Segura Orea E-mail: segurar@tcd.ie Ph: 01 896 2022
Science Course Office Executive Officer	Ms Andressa dos Santos Melo E-mail: dossanta@tcd.ie Ph: 01 896 1970

Appendix 1

Item	Reference/Source
General College Regulations	https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/complete-part-II.pdf
Emergency Procedures	In the event of an emergency, **dial Security Service on extension 1999** Security Services provide a 24-hourservice 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 alwaystelephone extension 1999 (+353 1 896 1999) in case of an emergency. 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. It is recommended that all studentssave at least one emergency contact in their phone under ICE (In Case of Emergency).
Health and Safety	Faculty of Science, Technology, Engineering and Mathematics website - https://www.tcd.ie/stem/undergraduate/health-safety.php School Handbooks will have School/Discipline information on Health and Safety.
Data Protection	https://www.tcd.ie/dataprotection/ https://www.tcd.ie/dataprotection/assets/docs/dataprotectionhandbook/DP_Handbook_15042021.pdf
Academic Integrity	https://www.tcd.ie/teaching-learning/academic-integrity/
Research Ethics	https://www.tcd.ie/research/support/ethics-integrity.php
Blackboard	Blackboard
Explanation of Weightings	https://www.tcd.ie/academic-affairs/academic-regulations/ug-module-sizes-and-capstone/
Assessment and Progression Regulations	https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/complete-part-II.pdf https://www.tcd.ie/teaching-learning/academic-policies/
Academic Awards	https://www.tcd.ie/academic-affairs/academic-regulations/

Item	Reference/Source
Equality, Diversity and Inclusion	https://www.tcd.ie/equality/
Prizes, medals, and other scholarships	https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/prizes-and-other-awards.pdf
Teaching and Learning Study Abroad	https://www.tcd.ie/global/mobility/study-abroad/
Marking Scales	https://www.tcd.ie/media/tcd/science/pdfs/Trinity-Science-Guidelines-on-Marking---TSPMC-2024.pdf
Framework of qualifications Trinity Pathways	https://www.qqi.ie/national-framework-of-qualifications Trinity PathwaysTrinity Courses
Capstone (UG Programmes)	https://www.tcd.ie/academic-affairs/academic-regulations/ug-module-sizes-and-capstone/
Careers Information & events	https://www.tcd.ie/Science/careers/ For further information refer to School/Discipline Handbooks.
Attendance Requirements	https://www.tcd.ie/media/tcd/calendar/undergraduate-studies/complete-part-II.pdf
Student Cases	https://www.tcd.ie/academicregistry/student-cases/
Student complaints procedures	https://www.tcd.ie/media/tcd/about/policies/pdfs/Student-Complaints-Procedure-21.07.22.pdf
General Examination Guidelines	Exam Guidelines - Academic Registry - Trinity College Dublin
Feedback and Evaluation	Student Evaluation andFeedback Procedure for the conduct ofFocus Groups
Academic Policies and Procedures	https://www.tcd.ie/teaching-learning/academic-policies/
Registration (UG only) – Academic Registry	https://www.tcd.ie/academicregistry/student-registration/
Student supports	https://www.tcd.ie/students/
STEM Schools and Disciplines	https://www.tcd.ie/structure/faculties-and-schools/#d.en.2024679
GradIreland Career advice, graduate jobs and internships	https://gradireland.com/

NOTE: 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 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 (STEM), 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.

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tcd.ie/science