Science at Trinity

Faculty of Engineering, Mathematics and Science

TR060 Biological & Biomedical Sciences Senior Fresh Handbook 2025-2026

tcd.ie/science

This programme booklet applies to all students taking TR060 Biological and Biomedical Sciences. 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/tr060-biological-and-biomedical-science/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/calendar/undergraduate-studies/general-regulations-and-information.pdf

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Welcome message from Professor Andrew Jackson, Director of TR060

Welcome to the second year of the Biological and Biomedical Sciences Stream at Trinity College Dublin.

This year you will consolidate your understanding of the biology learned in your first year. The material introduced in the first-year core modules From Molecules to Cells I and From Organisms to Ecosystems I will be developed further in the second-year modules From Molecules to Cells II and From Organisms to Ecosystems II. A third core module From Cells to Organisms will bring the student from the functioning of the cell to the integrated functioning of perceiving, thinking and acting in prokaryotic and eukaryotic organisms. Statistical and computational skills that are relevant for the analysis of biological systems and the history, philosophy and ethics of science comprise the remaining core modules.

Students will have the opportunity to expand their scientific knowledge and pursue their individual interests by choosing open modules from a cohort of topics such as geoscience, chemistry for biologists, sustainable production, infection and immunity, genomics, geometry and human & animal behaviour.

This year will see you deciding on which of the eleven possible exit routes you will choose which are called Moderatorships: Biochemistry; Botany; Environmental Science; Genetics; Human Genetics; Immunology; Microbiology; Molecular Medicine; Neuroscience; Physiology; Zoology.

Professor Andrew Jackson
Director, TR060 Biological and Biomedical Sciences Course

Professor Andrew Jackson - People Finder Profile

TR060 Biological and Biomedical Sciences Overview and Module Selection

The second year will build on and expand on topics presented in the first year. The year is divided into Semester 1 (Michaelmas term) and Semester 2 (Hilary term).

Students 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.

MODULE SELECTION

All students must take core modules for a total of 40 ECTS (20 ECTS per semester) as follows:

Code	Module Title	Semester	ECTS
BYU22201:	From Molecules to Cells II	Semester 1	10
BYU22202:	From Cells to Organisms	Semester 2	10
BYU22203:	From Organisms to Ecosystems II	Semester 2	10
BYU22S01:	Statistics and Computation	Semester 1	5
PIU22991:	History, Philosophy and Ethics of Science	Semester 1	5

Students will choose Open modules to the value of 20 credits (10 per semester) from the following:

BYU22209:	Fundamentals of Behaviour	Semester 1	5
BYU22210:	Sustainable Agriculture and the Bioeconomy	Semester 1	5
BYU22208:	Molecular Nutrition	Semester 1	5
GSU22201:	From Atoms to Rocks: Introduction to Geochemistry	Semester 1	5
GSU22205:	Sedimentary Processes & Environments	Semester 1	5
BYU22206:	Microbes, Immune Systems, and their Interaction	Semester 2	5
BYU22207:	Genomes, Disease and Diversity	Semester 2	5
CHU22205:	Chemistry for Biologists	Semester 2	5
GGU22006:	Physical Geography: Dynamic Earth	Semester 2	10

Semester Structure

CORE MODULES (mandatory) 20 credits per semester ***Teaching term dates may be subject to change.**	
SEMESTER 1 – Michaelmas Term **15 September 2025 – 05 December 2025**	**SEMESTER 2 – Hilary Term** **19 January 2026 –10 April 2026**
BYU22201: From Molecules to Cells II (10 credits)	BYU22202: From Cells to Organisms (10 credits)
BYU22S01: Statistics and Computation (5 credits)	BYU22203: From Organisms to Ecosystems II (10 credits)
PIU22991: History, Philosophy and Ethics of Science (5 credits)	
OPEN MODULES Students must choose 10 credits from each semester	
BYU22210: Sustainable Agriculture and the Bioeconomy (5 Credits) – **Semester 1**	BYU22207: Genomes, Disease and Diversity (5 credits) – **Semester 2**
BYU22209: Fundamentals of Behaviour - (5 Credits) - **Semester 1**	BYU22206: Microbes, Immune Systems and Their Interaction (5 credits) - **Semester 2** ***Prerequisite: BYU11101**
BYU22208: Molecular Nutrition (5 Credits) - **Semester 1** ***Prerequisites: BYU11101 & CHU11B01**	CHU22005: Chemistry for Biologists - (5 Credits) - **Semester 2**
GSU22201: From Atoms to Rocks: Introduction to Geochemistry (5 credits) **Semester 1** ***Prerequisite: GSU11001**	GGU22006: Physical Geography: Dynamic Earth (10 credits) - **Semester 2**
GSU22205: Sedimentary Processes & Environments (5 credits) - **Semester 1** ***Prerequisite: GSU11005**	

Open Module Choice Form

The module choice form is available in the following link https://forms.office.com/e/fgmWWi0wPy
The deadline for completing the form is **5pm on Friday 18th April 2025**

"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/fgmWWi0wPy.

All change of module requests must be submitted via the online module form **by Monday 29th September 2025.**

Moderatorships

In the first and second years TR060 students complete a course of study which will qualify them to compete for a place in the Junior Sophister year of one of the following 11 Moderatorships:

Biochemistry*
Botany
Environmental Sciences
Genetics
Human Genetics
Immunology*
Microbiology*
Molecular Medicine*
Neuroscience*
Physiology*
Zoology

* Students intending to apply for moderatorships marked with an asterisk are very strongly advised to take **'Chemistry for Biologists'** as an open module in semester 2. This module is specifically designed and tailored to provide the foundational chemistry that supports these moderatorships in the molecular biological sciences.

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 portal 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/

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

TR060 BIOLOGICAL AND BIOMEDICAL SCIENCES - CORE 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 practical's

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, practical's and an essay writing exercise: four lectures a week, Monday at 13:00, Wednesday at 17:00, Friday at 9:00 and 12:00, practical's Tuesday or Wednesday

Lecture Topic	Lecturer	Practical
Introduction to Module BYU22201 "From Molecules to Cells"	E. Creagh	Practical 1. Solutions & Dilutions
Cell structure & intracellular transport	E. Creagh	
Cell cytoskeleton I	E. Creagh	
Cell cytoskeleton II	E. Creagh	
Proteins & amino acids	K. Mok	
Protein folding and purification	K. Mok	
Oxygen binding proteins	K. Mok	
Enzymes, catalysis and assays	A. Khan	
Enzyme kinetics, inhibition & regulation	A. Khan	Practical 2. Spectrophotometry & Chromatography
Glycolysis	M. Hankir	
Gluconeogenesis	M. Hankir	
TCA Cycle	M. Hankir	
Glycogen biosynthesis & degradation	M. Hankir	
Powering Life: energy transduction & life	D. Nolan	
Bioenergetics 1: oxidative phosphorylation	D. Nolan	Practical 3. Enzyme Kinetics
Bioenergetics 2: the universality of chemiosmosis	D. Nolan	

Lecture Topic	Lecturer	
Harvesting the light: photosynthesis	D. Nolan	
Lipids - fatty acids & phospholipids	J. Hayes	
Lipids – beta-oxidation & fatty acid synthesis	J. Hayes	
Summary & integration of metabolism	D. Nolan	
DNA – structure, replication, repair, recombination I	M. Ramaswami	Practical 4. Oxidative Phosphorylation (online)
DNA – structure, replication, repair, recombination II	M. Ramaswami	
DNA – structure, replication, repair, recombination III	M. Ramaswami	
Transcription – RNA types, mRNA processing	M. Ramaswami	
Reading Week		
		Oxidative Phosphorylation Lab session
Regulation of gene expression: general principles	S. Martin	Practical 6. Genetic & phenotypic variation I
Gene expression in prokaryotes and eukaryotes	S. Martin	
Chromatin and epigenetic effects on gene expression	S. Martin	
Alternative splicing and protein translation	S. Martin	
Mendelian inheritance	M. Campbell	Practical 7. Genetic & phenotypic variation II
Mapping Mendelian traits	M. Campbell	
Quantitative traits and heritability	M. Campbell	
Genetics of common diseases	M. Campbell	
Virology: Replication cycles I	K. Roberts	Online Practical exercise: Bioinformatics
Virology: Replication cycles II	K. Roberts	
Revision Week		

Lecture Content:

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

- Protein folding and protein misfolding diseases / neurodegenerative diseases. Protein purification and protein characterization techniques.
- Oxygen-binding proteins as an example of protein-ligand binding. Comparison of myoglobin and haemoglobin. Cooperativity. Bis-phosphoglycerate's role in oxygen affinity. 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

Practical's 5 and 6: Differential Gene Expression

Practical 7: Assessment of Genetic Variation through Computational Analysis

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

Learning Outcomes:

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

- Students should be able to collate, synthesise and present information in written reports and essays.

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

Essential Cell Biology. Alberts, Hopkin, Johnson, David Morgan, Raff, Roberts, Walter. (4th / 5th Editions). W. W. Norton & Company.
Biochemistry. Berg, Tymoczko, Gatto, Stryer (8th edition). Macmillan International.
Introduction to Genetic Analysis. Griffiths, Wessler, Carroll, Doebley (11th edition). W.H. Freeman and Co.

Assessment Details:

(A) **End of semester written examination: 50% of module mark**
The examination paper is divided into two sections, equally weighted.

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

(B) **Course Work: 50% of module mark**
1. In course essay, 5% of module
2. Practical assignments 20% of module mark
3. End of Module practical exam, 15% of module
4. MCQ test of lecture material, 10% of module

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

Contacts:

Module Coordinator:	Emma Creagh	ecreagh@tcd.ie	Ph: 01 8962539
Biology Teaching Manager:	Mirela Dardac	mdardac@tcd.ie	Ph: 01 8962895
Chief Technical Officer:	Audrey Carroll	aucarrol@tcd.ie	Ph: 01 8961620
Executive Officer:	Daniel McCormick	btcadmin@tcd.ie	Ph: 01 8961117

BYU22202: From Cells to Organisms

Semester 2, 10 credits

Prerequisite: BYU11101

Module coordinator: Prof Colm Cunningham

Contact Hours: 37 hours lectures, 15 hours practical's.

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

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

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

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

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

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

Lecture Content:
Unicellular to multicellular life

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

Cell-cell communication & Signal Transduction

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

Development

- **Organising a body plan in multicellular organisms:** The concepts of multicellular life and how an organized body plan, composed of different cell types and tissues, is established. Examples of relatively simple (hydra) organisms to the most complex (examples of drosophila, mouse, human and others) will be used. Fundamental similarities and differences in the organisation of animals and plants will be covered. Molecular and biophysical mechanisms governing cellular behaviour will be discussed.

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

Human Physiology

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

Neuroscience and Behaviour

- Sensation and perception. Students will gain an understanding of how the brain makes sense of sensory input. They will be aware of and able to explain fundamental discoveries (e.g. Hubel & Wiesel). They will be able to describe neuronal circuitry that enables us to distinguish between sensory input from the external world and that which is internally generated (sensory cancellation and efference copy mechanisms).
- Pain, nociception, and interoception. Students will attain 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 (Practical's).
- Articulate the concepts of how biological complexity is established as the body plan of multicellular organisms emerge and integrate these concepts in the context of how body plans have evolved.
- Describe the contribution of the nervous, endocrine and immune systems to regulation of whole-body physiological homeostasis in humans and detail cell, tissue and organ integration in the cardiovascular, respiratory, immune, renal and digestive systems.
- Describe how alterations in physiological variables as a result of exercise, changes in barometric pressure or pathophysiological processes impact on homeostasis in different organ systems
- Measure and understand fundamental cardiovascular and respiratory variables in human subjects (Practical).
- Articulate how the brain achieves basic functions for the animal using examples from invertebrate & vertebrate neurobiology.
- Provide explanatory accounts of movement and motor control; sensation and interoception; emotion and memory, and how brain injury in human patients can inform us about brain function.
- Describe, integratively, how the fundamental physiology of neural circuits can be used to explain behavioural function in both vertebrates and invertebrates.
- Demonstrate good practice in essay writing: including planning, drafting, responding to constructive review and timely submission of a final draft (Practical, graded for continuous assessment).

Recommended Reading List:

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

- Biology, A global Approach. Campbell *et al.* 12TH Edition. Pearson.
- Prescott's Microbiology 10th edition. McGraw Hill.
- Biochemistry. Berg, Tymoczko, Gatto, Stryer 8th edition. Macmillan International.
- Molecular Cell Biology. Lodish *et al*.., 8th edition. Macmillan International.
- Principles of Development. Wolpert, Tickle, Martinez-Arias. 5th Edition Oxford University Press.
- Developmental Biology. Gilbert, Barresi, 11th Edition. Sinauer, Oxford University Press
- Human Physiology from Cells to Systems. Sherwood. 9th Edition. Cengage Learning.
- Principles of Neurobiology. Liqun Luo. 1st edition. Garland Science.

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

Contacts

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

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 practical's.

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

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

Module content:
Programme of lectures and practical's, four lectures a week, Thursday at 12:00 and 15:00, Friday at 11:00 and 13:00, practical's on alternate Wednesdays.

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

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

Lecture Content:

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

- **Diversity of life: Conquering the land**
- This lecture explores the challenges that had to be overcome by organisms conquering 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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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 practise clinics. Attendance at practical's and computational practise clinics 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 practise sessions (reinforcement of practical learning), and formative assessment (problem solving) we will provide students with a broad overview of the kinds of statistical and computational approaches that are commonly used across the biosciences and geosciences.

We will introduce the basics of programming techniques that are transferable across programming languages. This module will emphasise the importance of hypothesis generation and testing for different data types. We will introduce the basics of data driven modelling. We will enable students to work individually and in small groups to problem-solve and communicate the problem and solution in different formats.

Module content: Programme of lectures and practical's

Lecture Topic	Practical
Introduction to Statistics & Computation for Biologists, part of the scientific method	Computational Practise Clinic 1 (Set-Up Clinic)
Communicating quantitative biology	
Variables: types, sample distributions, summary statistics	Practical 1: R-Studio
Principles of probability	
Data visualisation, regression, correlation , precision & accuracy	Computational Practise Clinic 2
Normal distribution z score, p values correlation	
Computation Control Structures: branching & loops	Practical 2: Hypotheses
Reusing code: functions and blocks	
Functional programming in R	
Programming in practice: document, debug, test & distribute	
Type I, type II errors	Practical 3: Programming
Sample error of the mean	
The t distribution and t tests	
The basics of Analysis of variance	
Chi squared testing, contingency tables	Mid Term Test (MCQ)
Non-parametric tests	

Simple linear regression & parameter estimation	Computational Practise Clinic 3
Multiple linear regression & ANCOVA	
Linear regression assumptions & generalised linear models	Practical 4: Modelling 1
Implementing an analysis workflow (support for final exam)	
	Practical 5: Modelling 2

Description of Lecture Content:

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

Description of Practical Content:

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

Learning Outcomes:

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

Recommended Reading List:

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

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

Assessment Details:

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

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

Computational practise submissions (three) = 5% of module

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

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

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

Contacts:

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PIU22991: History, Philosophy and Ethics of Science

Semester 1, 5 credits

Contact Hours:
22 hours of lectures + 10 hours of tutorials

Module Personnel: Dr Richard Teague (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? How can we tell? This course will examine the workings of science through four core topics: how we reason to science, how scientific theories explain, the role of values in science, and what scientific theories tell us about the world.

Module Learning Outcomes:

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

- Think critically about philosophical problems and their relevance for scientific practice.
- Communicate ideas effectively to others, both in discussion and in writing.
- Reflect on the aims and methodology of science, in ways that facilitate ongoing exploration of scientific practice.
- Demonstrate awareness of ethical issues that arise in scientific practice, and of the role of the individual and communities in upholding ethical standards.

Module content: Programme of Lectures and Tutorials

Week	Lecture Topic	Lecturer
1	What is Science?	Prof Fernandes
	The Demarcation Problem	Prof Fernandes
2	The Scientific Revolution	Prof Fernandes
	The History of Science	Prof Fernandes
	Tutorial: What is Science?	
3	The Problem of Induction	Prof Fernandes
	Popper's Falsificationism	Prof Fernandes
	Tutorial: History of Science	
4	Theories of Confirmation	Prof Fernandes
	Kuhn	Prof Fernandes
	Tutorial: Induction and Falsificationism	
5	What is Explanation?	Prof Fernandes
	Problems for Law-based Accounts of Explanation	Prof Fernandes
	Tutorial: Kuhn and Confirmation	
6	Causal Accounts of Explanation	Prof Fernandes
	Explanation and Understanding	Prof Fernandes
	Tutorial: Law-based Accounts of Explanation	
7	**Reading Week**	

8	Trust in Science: Why Ethics Matters	Prof Hogan
	What Makes Something Ethical? Ends and Means	Prof Hogan
	Tutorial: Causal Accounts of Scientific Explanation	
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	Epistemic Values in Science	Prof Fernandes
	Non-epistemic Values in Science	Prof Fernandes
	Tutorial: Applied Ethics in Science	
11	The Aims of Science: Scientific Realism	Prof Fernandes
	The No-Miracles Argument for Scientific Realism	Prof Fernandes
	Tutorial: Values in Science	
12	The Aims of Science: Scientific Anti-Realism	Prof Fernandes
	In-Class Writing Assignment	Prof Fernandes
	Tutorial: Scientific Realism and Anti-Realism	
13	**Revision Week** **Open MCQ**	
14	**Assessment Week**	

Lecture Content and Assessment Schedule

W1L1: What is Science?
Introduction to the module. What is science? What does it aim to achieve?

W1L2: The Demarcation Problem
Contemporary attempts to demarcate science from non-science. The aims and methods of science.

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: The History of Science
The histories of chemistry and the geosciences.

W3L1: The Problem of Induction
The distinction between two forms of inference: deduction and induction. How do observations of past behaviour constrain our predictions about future behaviour? Can induction be justified? Hume's 'Problem of Induction'.

W3L2: Popper's Falsificationism
Popper's deductive scientific method (conjecture and refutation), which claims that science can do without induction and rely instead on deduction. Criticisms of Popper from Quine and Duhem.

<End of material for Response 1. Response 1 due end of Week 4.>

W4L1: Probabilities in Confirmation
Attempts to use probabilities to account for theory confirmation: Bayesian approaches to theory confirmation.

W4L2: Kuhn
Kuhn's Account of Scientific Change. Seeing science as a historical process that goes through periods of normal and revolutionary change.

W5L1: What is Explanation?
How does science provide understanding? Law-based models of scientific explanation: Hempel's 'Deductive-Nomological Model' of Explanation.

W5L2: Problems for Law-based Accounts of Explanation
Problems for law-based accounts of explanation. The role of laws and probability in explanation. The case of the flagpole and the shadow: the 'Asymmetry Problem'.

W6L1: Causal Accounts of Explanation
Does causal information explain phenomena? What causal information is relevant?

W6L2: Explanation and Understanding
How do explanations provide understanding? Causal and unificationist accounts of understanding.

<End of material for Response 2. Response 2 due beginning of Week 9.>

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.

W10L1: Epistemic Values in Science
What 'epistemic' values are in play in the practice of science? Kuhn's approach to 'paradigms' and the distinction between normal and revolutionary science.

W10L2: Non-epistemic Values in Science
Do other (non-epistemic) values play a role in science? Should we aim for science to be value-free? Does the role of values in science compromise the objectivity of science?

W11L1: The Aims of Science: Scientific Realism
What do scientific theories aim to achieve? Can they provide us with an objective *description* of reality? Do they *correspond* with reality?

W11L2: The No-Miracles Argument for Scientific Realism
What explains the success of scientific theories? Must we be 'realists' about science in order to explain their success?

W12L1: Alternative Approaches to the Aims of Science
What makes a scientific theory objective? Can scientific theories depend on our interests? Can scientific theories be mere instruments for making predictions, rather than descriptions of reality?

<End of material for in-class writing assignment.>

W12L2: In-class Writing Assignment

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 Responses of 750 words (1–2 pages) (50% total; 25% each)

1 In-class Writing Assignment (25%)

7 Discussion Posts (15%)

Attendance (10%)

Contacts:

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TR060 BIOLOGICAL AND BIOMEDICAL SCIENCES - OPEN Modules

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 practical's.

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

Learning Aims:
An extensive microbial world existed successfully on earth for 1.5 billion years before multicellular organisms began to appear. During that time, microbes evolved multiple defence mechanisms against potential competitors. Many of these mechanisms are conserved in multicellular organisms and used in defence against potential pathogens, together with many additional immune/defence mechanisms that provide survival advantage to all species. In this module, students will learn about the cells and molecules of defence systems and about the complex interactions between microbes and their hosts which can lead to significant disease, but which are also required for health. Students will learn about the molecular and cellular biology of key pathogens (viral, bacterial and parasitic) which currently threaten human populations. They will learn about immune systems and the diverse mechanisms used by immune molecules and cells to detect and respond to these microbes; they will be introduced to concepts of immune manipulation by vaccines and 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 Topic	Lecturer	Practical / Discussion Session
Introduction: Microbes, Immune Systems and their Interaction	Prof O'Farrelly / Prof Kröger	Practical 1: Microbial Offence and Defence 1 (Nicky O'Boyle)
Microbial Offence Mechanisms	Prof Kröger	
Microbial Defence Mechanisms:	Prof Kröger	Practical 2: Cells and Organs of the Immune System (Mary Canavan)
Combatting Infectious Disease: antimicrobials and antimicrobial resistance	Prof Kröger	
Introduction to Vertebrate Immune Systems	Prof O'Farrelly	
Where and how immunology happens: Molecules, Cells & Organs of the Immune System.	Prof O'Farrelly	Practical 3: Antibody Specific Detection (Rachel McLoughlin)
Innate Immunity:	Prof O'Farrelly	
Adaptive Immunity 1: Immunisation	Prof O'Farrelly	

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

Lecture Content:

- **Evolution of microbial and multicellular organisms**
  An introduction to how multicellular organisms evolved 'around' the microbial world and how the microbial world continues to exist successfully on the planet.
- **Microbial defence mechanisms**
  The microbial world existed successfully for 1.5 billion years before multicellular organisms began to evolve. During that time, microbes evolved multiple defence mechanisms against potential competitors e.g. bacteriocins, ways of blocking nutrient uptake, CRISPR cas9, restriction modification systems
- **Introduction to vertebrate anti-microbial defence**
  An overview of what vertebrate immunology is; how so much of microbial defence has been conserved**;** how competition for nutrient resources underpins immunometabolism immune activity and immune regulation; immune systems detect altered self as well as foreign and danger – anti-cancer immunity, virally infected cells, Natural Killer cells.
- **Where immunology happens and how: molecules, cells & organs of the immune system**
  Overview of the key immune organs, cells and molecules, their location structure and principle functions; introduction to haematopoiesis.
- **Microbiomes in health & disease**
  The human body is inhabited by communities of bacteria and other microbes on the skin, in the respiratory tract and oral cavity, the intestine and the genito-urinary tract. The composition of these communities differs significantly between different anatomical sites. The presence of a balanced microbial community is essential for appropriate immune system function and health and dysbiosis of the microbiota is associated with infection and with a variety of chronic disorders.
- **Innate immunity**
  Macrophages, epithelial cells and neutrophils - how they detect infection & danger; pathogen recognition receptors; how they signal.
- **Inflammation in health & disease**
  Inflammatory cytokines, chemokines, local inflammation systemic inflammation; chronic inflammatory disease, anti-inflammatory therapies.

- **Bacterial pathogens, mycobacterium.**
  Biology of the pathogen, intracellular life of *Mycobacterium tuberculosis* pathogenesis, epidemiology of the disease**.**
- **Adaptive immunity 1: immunisation**:
  Global effect of successful vaccines; structure and function of antibodies; primary and secondary responses, B lymphocytes, induction of an effective antibody response; infectious agents without vaccines.
- **Adaptive immunity 2 anti TB immunity:**
  How T lymphocytes are activated, DCs antigen processing and presentation; 4 populations of T cells; Mtb evasion of adaptive immunity; granuloma formation; role of TNF
- **Viral pathogens - influenza:**
  The influenza virus, pathogenesis of influenza virus infections, anti-virals.
- **Adaptive immunity 3: anti-'flu immunity**
  The adaptive immune response against viruses; cytotoxic T cells; flu vaccine.
- **Parasite pathogens, malaria.** Parasites are the giants of the pathogen world – they are responsible for major burden of disease across the globe. An introduction will be given to the major pathogenic parasites, with a focus on malaria.
- **Immune responses to malaria:**
  Innate and adaptive immune responses to natural malarial infection; malarial evasion of immunity; vaccine challenges
- **Combatting infectious disease – antimicrobials and antimicrobial resistance:** How antibiotics (and other antimicrobials) revolutionised the treatment of infectious disease. How microbes become resistant to antimicrobial chemotherapy. The current global crisis of antimicrobial resistance.

Practical Content:

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:

Module Coordinator:	Carsten Kroger	krogerc@tcd.ie	Ph: 01 8961414
Biology Teaching Manager:	Mirela Dardac	mdardac@tcd.ie	Ph: 01 8962895
Chief Technical Officer:	Audrey Carroll	aucarrol@tcd.ie	Ph: 01 8961620
Executive Officer:	Daniel McCormick	btcadmin@tcd.ie	Ph: 01 8961117

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 practical's.

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 practical's, two lectures a week, Tuesday and Thursday, practical's on Mondays

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

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

Lecture Content:
Lectures are grouped in five themes:
The inherited genome, with topics including:

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

The non-inherited genome, with topics including:

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

The social genome, with topics including:

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

The microbiome, with topics including:

- Microbiology without culture
- the human microbiome
- Environmental microbiomics

The ecological genome, with topics including

- Conversation genomics
- Biodiversity
- De-extinction

Practical Content:

Practical 1
Cancer Genomics: Single Cell RNA Sequencing. Students will be introduced to the use of single cell RNA sequencing of tumors to assess cellular and genetic heterogeneity of oncogenic tissue samples. Advanced clustering techniques such as t-SNE will be utilized to assess tumor cell diversity, and gene enrichment tests will be performed using Gene Ontology (GO) criteria.

Practical 2
Microbial Genomics: Phylogenies and outbreak genetics. In the first of three computer-based practical's 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:

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

BYU22208: Molecular Nutrition

Semester 1, 5 credits

Prerequisites: BYU11101 and CHU11B01

Module coordinator: Derek Nolan

Contact Hours: 16 lectures; 2 x 3 hour practical's; 2 x 2 hour workshops.

Module Personnel: D. Nolan, K. Mok, G. Davey, F. Sheedy, J. Hayes

Learning Aims:
The aim of this module is to develop an understanding of the molecular basis of life through study of the role of nutrients, not only as a source of energy but, as key elements that determine our cellular and whole-body physiology. The metabolism of carbohydrates, proteins and lipids and the role of vitamins will be presented in the context of human health and disease. The consequences of vitamin deficiencies, mechanisms that allow cells to survive starvation and metabolic derangements such as diabetes and those caused by alcohol consumption will be discussed.

The module builds on Section 2 (Chemistry of Life) of BYU11101 (Molecules to Cells I) and CHU11B01 (Chemistry for Biologists). While this module is a free standing and open module it does complement and expand on the lectures on metabolism in Module BYU22201 (Molecules to Cells II). An aim of the module is to prepare students hoping to pursue a moderatorship in the molecular biological sciences.

Module content:
Programme of lectures, practical's and workshops, two lectures a week, Thursday and Friday, tutorials or practical's some Mondays and Wednesdays.

Lecture	Staff	Practical's/ Workshops
Lecture 1: Introduction	Derek Nolan	Workshop 1: Revision of Functional Group Chemistry
Lecture 2: Vitamins & Micronutrients 1	Derek Nolan	
Lecture 3: Vitamins & Micronutrients 2	Derek Nolan	
Lecture 4: Vitamins & Micronutrients 3	Derek Nolan	
Lecture 5: Advanced Lipids 11	Jerrard Hayes	
Lecture 6: Advanced Lipids 2	Jerrard Hayes	
Lecture 7: Advanced Lipids 3	Jerrard Hayes	
Lecture 8: Sugar, Fats, Obesity & Diabetes 1	Fred Sheedy	
Lecture 9: Sugar, Fats, Obesity & Diabetes 2	Fred Sheedy	
Reading Week		
Lecture 10: Sugar, Fats, Obesity & Diabetes 3	Fred Sheedy	Workshop 2: Preparing for Subcellular Fractionation Practical
Lecture 11: Alcohol Metabolism & Addiction 1	Gavin Davey	
Lecture 12: Alcohol Metabolism & Addiction 2	Gavin Davey	

Lecture 13: Alcohol Metabolism & Addiction 3	Gavin Davey	Practical 1: Subcellular Fractionation
Lecture 14: Nitrogen 1	Derek Nolan	
Lecture 15: Nitrogen 2	Derek Nolan	Practical 2: Lipids
Lecture 16: Nitrogen 3	Derek Nolan	
Conclusions/wrap up	Derek Nolan	

Lecture Content:

Lecture 1: An overview of metabolism
Lecture 2, 3, 4: Vitamins & Micronutrients What are vitamins for? what do vitamins enable enzymes to do? key vitamins in metabolism & disease, the role of iron and minerals in nutrition.
Lectures 5, 6, and 7: Lipids in Health & Disease Key lipids & essential fatty acids, regulation of cholesterol and lipoproteins, lipidaemias & cardiovascular disease.
Lectures 8, 9, and 10: Sugar, Fats, Obesity & Diabetes Obesity & diabetes, dysfunctional metabolism in obesity and diabetes, treatment of obesity and diabetes.
Lectures 11, 12, 13: Alcohol metabolism, risks and benefits of alcohol consumption, addiction, and the brain
Lectures 14, 15, and 16: Nitrogen Capturing nitrogen, mobilizing amino acids, the essential role of nitrogen in life.

Practicals and Workshop Content:

Workshop 1: Revision of the organic chemistry functional groups introduced in first year and that are key to an understanding of molecular nutrition: acid, ester, amide, alcohol, thiol *etc.*

Workshop 2: Preparing for subcellular fractionation practical, making sense of enzyme activity calculations. This workshop will use given data to teach students how to calculate enzyme reaction rates, enzyme specific activity and yield and prepare students for the presentation of their experimental data obtained in the laboratory session.

Practical 1: Subcellular localisation of key enzymes of metabolism. The associated laboratory report will involve presentation of student's own data and analysis of the class data as a whole.

Practical 2: Lipid analysis by thin layer chromatography

Learning Outcomes:

On completion of this module students will be able to:

- demonstrate an understanding of nutrient metabolism in humans.
- demonstrate an understanding of the mechanisms that regulate the transport and metabolism of sugars, lipids and amino acids.
- describe and explain, with examples, the importance of coenzymes (vitamins) in nutrition.
- describe how cells alter metabolism in response to variations in fuel / nutrient availability.
- describe and explain, with specific examples, how nutritional stress alters metabolism and contributes to the pathogenesis of disease.
- Collect and interpret experimental data from laboratory and workshop sessions and use the data to solve problems themed around metabolism.

Recommended Reading List:
One of these general textbooks:
Lehninger Principles of Biochemistry (Seventh edition) Nelson & Cox (2017)
Biochemistry (Eighth edition) Berg, Tymoczko, Gatto & Stryer (2015)
Textbook of Biochemistry with clinical correlations 8th edition (2014) Thomas M. Devlin (Ed.) Wiley Press
Further reading will be recommended in lectures.

Assessment Details:

End of semester written examination: 70% of module mark

Three essays from a choice of five

Continuous assessment of course work: 30% of module mark

Practical 1 Laboratory Report = 15%. Note that attendance at Practical 1 and submission of the associated laboratory report is compulsory.
Practical 2 Assignment = 10%
Engagement with course work: Attendance at two practical's and two workshops = 5%
To pass the module students must obtain an overall module mark of 40%.

Contacts:

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BYU22209: Fundamentals of Behaviour

Semester 1, 5 credits

Prerequisite: none

Module coordinator: Greg Albery

Contact Hours: 19 hours

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 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.

Lecture Topic	Practical
1. What is behaviour?	**Practical 1: Dublin Zoo: Animal Behaviour** Introduced in lecture 1 and completed within three weeks in student's own time.
2. Learning and the acquisition of behaviour	
3. Memory, recall, and the maintenance of behaviour	
4. Intentionality, imitation, and theory of mind	
5. GUEST LECTURE (Jim Barnett): Senses and behaviour I	
6. Behavioural variation, personalities, and polymorphisms	**Practical 2 due***: Animal behaviour video quizzes.*

7. GUEST LECTURE (Jim Barnett): Senses and behaviour II	
8. Spatial behaviour, optimality, and trade-offs	
9. Interactions between behaviour and physiology	
10. Behavioural responses to environmental stress and change	
11. GUEST LECTURE (Andrew Jackson) Collective behaviour lecture [recorded]	
12. Behaviour and the transmission of disease	
13. GUEST LECTURE (Andrew Jackson) Collective behaviour discussion	
14. Why be social?	**Practical 3: Collective Behaviour** Assessment introduced in Lecture 13, completed by end of lecture series.
15. Social learning, innovation, and culture	
16. Applied behaviour 1: Conservation and population management	
17. Applied behaviour 2: Health and welfare	
18. The future of behaviour 1: Advancing methods	
19. The future of behaviour 2: Advancing complexity	
20. Discussion & End of Module Summary	

Practical Content:

Practical 1: Zoo animal behaviour
Self-directed visit to Dublin Zoo and completion of worksheet on animal signalling. Ticket provided by Biology Teaching Centre. After the visit students complete an online quiz in Blackboard.
Practical 2: Trials of Life Videos
Students watch, in their own time, up to four videos from the BBC series "Trials of Life" by David Attenborough. For at least two of the videos' students must demonstrate understanding of the concepts explored in the videos by completing associated MCQ tests.

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

Learning Outcomes:
On successful completion of this module, students will 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 decision making, 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.

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

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

Exam Format: 10 compulsory short answer questions

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

Contacts:

Module Coordinator:	Greg Albery	alberyg@tcd.ie	
Biology Teaching Manager:	Mirela Dardac	mdardac@tcd.ie	Ph: 01 896 2895
Chief Technical Officer:	Audrey Carroll	aucarrol@tcd.ie	Ph: 01 896 1620
Biology Admin	Daniel McCormick	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 hours lectures, 12 hours practical's

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

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 practical's, two lectures a week.

Lecture Topic	Practical
1. Introduction to the module: course structure, concept of sustainability, sustainable indicators	
2. Agricultural trends and the green revolution	
3. Plant breeding and biotech 1	Genetic techniques applied in crop biotechnology (in person)
4. Plant breeding and biotech 2	
5. Plant breeding and biotech 3	
6. Diets and health	Dietary Analysis (virtual practical)
7. Environmental impacts of agriculture (GHG Production)	
8. Environmental Impacts of Agriculture (Reactive Nitrogen Pollution)	
9. Life Cycle Analysis	Life Cycle Analysis (hybrid)
10. Life Cycle Analysis 2	
11. Biodiversity and Pollinators	
12. Land Use Change	
13. Society and Sustainability 1	
14. Society and Sustainability 2	
15. Society and Sustainability 3	
16.Summary and Exam Preparation	

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:

Module Coordinator:	Richard Nair	RICHARD.NAIR@tcd.ie	
Biology Teaching Manager:	Mirela Dardac	mdardac@tcd.ie	Ph: 01 8962895
Chief Technical Officer:	Audrey Carroll	aucarrol@tcd.ie	Ph: 01 8961049
Executive Officer:	Daniel McCormick	btcadmin@tcd.ie	Ph: 01 8961117

CHU22205: Chemistry for Biologists

Semester 2, 5 credits

Prerequisites: CHU11B01

Module Coordinator: Eoin Scanlan

Contact Hours: 20 lectures, 6 tutorials, 2 x 3hr practical
Module Personnel: Physical Chemistry: Prof Mike Lyons and Organic Chemistry: Prof Eoin Scanlan

Learning Aims:
This module is specifically designed to introduce the student to chemical concepts essential to an understanding of the operation of living systems and the chemical technology of medicine, including: the chemical reactivity of important biomolecules, organic reactions of functional groups and their relevance to cell metabolism.

Module content: Programme of lectures and practical's

Teaching Week	Topic
1-3 (6 L)	**Introduction to the physical chemistry of biomolecules:** • Gibbs free energy and spontaneous reactions: link with metabolism and group transfer • The temperature dependence of equilibria: van't Hoff • Binding reactions in biological systems: the dissociation constant • Colligative properties and osmotic pressure • Kinetics: Rate of a reaction, the rate constant, reaction order, concentration dependence, half life • Collision theory • Activation energy • Catalysis and lowering activation energy • Enzymatic catalysis: Michaelis-Menten
4-12 (14 L) Week 7 = study week	• Functional groups: O, N and S groups • Isomerism: Isomers/stereoisomers • Chirality, Isomers in Biology **Chemical reactions in cells** • Substitution, addition, elimination, condensation • Reaction mechanisms, intermediates, and transition states. • Key Functional group chemistry and key/common biochemical reactions **Chemical reactions of enzymes and metabolism:** • Transferring groups by displacement/substitution (transferases, esterases, peptidases, hydrolysis, phosphatases, kinases etc) • Addition across a double bond (e.g. hydratases) • Elimination: removal to create a double bond: e.g. (decarboxylation). • Reactions involving enolates and carbocation intermediates • Addition of R-OH, R-NH_2 and R-SH to polarised double bonds. e.g., carbonic anhydrase, fumarase, enolase • Enolic Intermediates: e.g., aldose-ketose interconversions: triose phosphate isomerase

	• Beta cleavage and condensation, e.g., aldolase and synthases, decarboxylation of b-oxoacids; e.g. aldolase, citrate synthase, Rubisco; PEPcarboxykinase. PEP carboxylase • Oxidation-Reduction reactions: Nicotinamide/Flavin linked • Dehydrogenation of (i) an alcohol; (ii) an amine; (iii) thiol/aldehyde; (iv) acyl-CoA/carboxylic acid

Reading list/ Indicative Resources
Chemistry for the Biosciences, 3rd Edition, J. Crowe and T. Bradshaw, Oxford University Press.
Organic Chemistry, 2nd Edition, Jonathan Clayden, Nick Greeves and Stuart Warren; Oxford University Press.
The Organic Chemistry of Biological Pathways, 2nd Edition, John McMurry and Tadgh P. Begley, Roberts & Co.
Chemistry & Chemical Reactivity, 9th Edition, Paul Treichel, John Kotz, John Townsend, David Treichel, Brooks Cole.
Physical Chemistry for the Life Sciences, 2nd Edition, P. W. Atkins and J. de Paula, Oxford University Press.

Learning Outcomes
Students will develop a fundamental understanding of the physical chemistry principles of biological processes, including kinetics, activation energy and catalysis. They will learn about important biological transformations from an organic chemistry perspective and gain a deep insight into the mechanistic organic chemistry associated with a range of critical enzymatic processes. They will be able to recognize and assign stereochemistry in biomolecules. They will be able to understand the reactivity of key amino acids in enzyme mediated processes.

Methods of Teaching and Student Learning
A mixture of lectures, tutorials and hands-on laboratory practical's are used in the delivery of this module. The concepts are provided in traditional didactic style prior to the practical sessions. The practical sessions are formatted in order to further clarify concepts thus reinforcing learning. Tutorials provide an additional opportunity for the lecturer to assess understanding and gauge knowledge level of the students.

Methods of Assessment
Exam 80%
Lab 20%

Evaluation
Feedback given by students to DTL(UG) via online poll
Lecture and Tutorial Contact Hours

	Lectures	**Tutorials**
Physical Chemistry	6	2
Organic Chemistry	14	4
Overall Total	**20**	**6**
Lab	**6**	

Lab Hours = 2 x 3 hours = 6 hours
Students have 1 practical every other week

Contacts:
Module Coordinator: Eoin Scanlan eoin.scanlan@tcd.ie
Administrative Officer: AnneMarie Farrell farrea25@tcd.ie Phone: 01 896 1726

GSU22201: From Atoms to Rocks: Introduction to Geochemistry

Semester 1, 5 credits
Module Prerequisite: GSU11001 Spaceship Earth

Contact Hours
2 x 1-hour lectures / week for 10 weeks = 20 hours
1 x 3 hours laboratory / week for 10 weeks = 20 hours

Module Personnel
Dr. Michael Stock and Dr Juan Diego Rodriguez-Blanco

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

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

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

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

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

Contacts:

Module Coordinator:	Michael Stock	MICHAEL.STOCK@tcd.ie	Ph: 01 896 2957
Administrative Officer:	Debora Dias	TR062Admin@tcd.ie	Ph: 01 896 1074

GSU22205: Sedimentary Processes & Environments

Semester 1, 5 credits

Module Prerequisite – GSU11005

Contact Hours

Lectures = 20 hrs

Module Personnel

Dr Micha Ruhl, Prof Jerry Dickens, Dr Robin Edwards

Module Aims:

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

The module will develop understanding of:

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

Module Content:

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

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

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

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

Learning Outcomes:

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

- Classify sediments and sedimentary rocks
- Provide technical descriptions of common sedimentary rock types and textures from hand samples and thin sections
- Explain the basic concept of “source-to-sink”, and how this links weathering of mountains, and transport and deposition of sediments
- Describe changes in sedimentary archives from outcrop observations, stratigraphic logs and/or petrological evidence
- Describe (changes in) in sedimentary archives, and interpret these in regard to changes in physical, geochemical and biological Earth surface processes, and changing environments.
- Distinguish and describe temporal and spatial variability in Earth surface processes and how this links to sediment deposition locally
- Illustrate how Global Change processes (physical/ geochemical/biological) (have) shape(d) Earth’s surface, in the past, present, and future

Contacts

Module Coordinator:	Dr Micha Ruhl	MICHA.RUHL@tcd.ie	Ph: 01 896 1165
Administrative Officer:	Debora Dias	TR062Admin@tcd.ie diasd@tcd.ie	Ph: 01 896 1074

GGU22006: Physical Geography: Dynamic Earth

Semester 2, 10 credits

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

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

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

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

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

Assessment Details:

In course tests and assessment (100%)

Contacts:

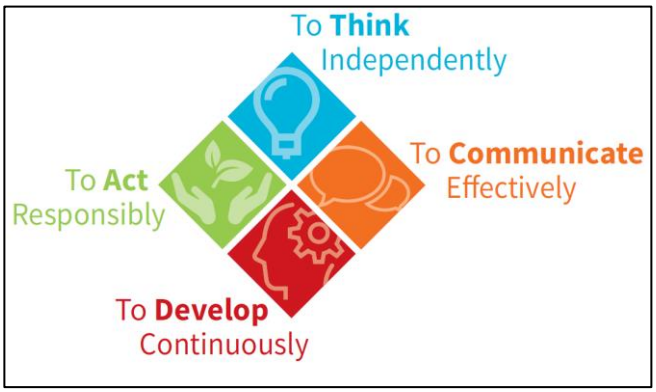
Module Coordinator:	Dr Pete Akers	pete.akers@tcd.ie	
Geography Admin:	Helen O'Halloran	geography@tcd.ie	
Administrative Officer:	Debora Dias	TR062Admin@tcd.ie diasd@tcd.ie	Ph: 01 896 1074

Graduate Attributes

The Trinity Graduate Attributes are the qualities, skills and behaviours you will develop as a student at Trinity College, not only in the classroom, but also through your engagement in co- and extra-curricular activities (such as summer work placements, internships, or volunteering).

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

The Graduate Attributes enhance your employability. Whilst your degree is your fundamental qualification, these Graduate Attributes will differentiate you as they encapsulate the transversal skills and capabilities sought by employers.

How will I develop these Graduate Attributes?

The Trinity Graduate Attributes will be developed and acquired by engagement with all aspects of your course and college experience throughout the four or five years of your programme of study. They are embedded in the curriculum and in assessments, through for example, undertaking independent research for your final year project, giving presentations, and engaging in group work. They will also be developed through co-curricular and extra-curricular activities. Running a club or society will improve your leadership skills while playing a sport will develop your communication and team-work skills.

Important Information

Progression and Awards

Information on progression and awards can be found via the following webpage:
https://www.tcd.ie/teaching-learning/academic-affairs/ug-prog-award-regs/index.php

Attendance

All students should enter 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 or in Blackboard before the beginning of Semester 1 (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 noticeboards, and/or in handbooks and elsewhere, as appropriate.

Attendance and Completion of Course Work: Year 1 and 2 TR060.

1. Attendance in first, and second-year BYU module laboratory sessions and completion of the associated exercises is compulsory, so that students acquire the competencies necessary for the Sophister level.
2. A student who does not attend a practical cannot submit an assignment based on, or associated with, that practical.
3. A student who fails to attend more than one-third (1/3) of practical sessions in a module without submission of appropriate certification cannot pass that module without completion of a supplementary practical session, or an alternative exercise in the event that a practical is not possible.
4. Regardless of circumstances, a student who has passed the module overall but has failed the course work component may be required to complete additional exercises to acquire essential skills when deemed necessary by the module coordinator in consultation with the Directors of Fresh Biology Teaching and/or Biological and Biomedical Sciences.
5. Individual cases and exceptional circumstances will be considered on their merits

Assessment: Procedures for 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 non-submission of coursework can be found via the following:
https://www.tcd.ie/media/tcd/science/pdfs/Science-ABSENCE-NON-SATISFACTORY-regulations---TSPMC-August-2024.pdf

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

At the end of the teaching term, students who have not satisfied the school or department requirements may be reported as non-satisfactory for that term. Students reported as non-satisfactory for the Michaelmas and Hilary terms of a given year may be refused permission to take their semester two assessment/examinations and may be required by the Senior Lecturer to repeat their year.

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.
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 Coordinator

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).

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 their tutor.

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 and Appointments
The Senior Tutor's Office is open for student appointments between 10.30am - 12.30pm and 2.30pm - 4.00pm Monday to Friday ONLY (email stosec@tcd.ie to arrange an appointment).

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?
You should visit your Tutor whenever you are worried or concerned about any aspect of College life or indeed your personal life, especially if it is affecting your academic work. The conversation with your Tutor takes place in strictest confidence. Unless you give him/her permission to do so, s/he will not divulge information given to them to anybody, whether a member of College or to anyone outside College (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 Services-** 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/

Learning Development
Student Learning Development offers support in a variety of study and learning skills including essay writing, exam preparation, study skills, self and time-management and note taking. Mechanisms of support are workshops, individual appointments and drop-in clinics.
https://www.tcd.ie/Student_Counselling/student-learning/services/

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) 896 1407
Email: student-counselling@tcd.ie

For further information visit the following webpage:
https://www.tcd.ie/StudentCounselling/

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

CAMPUS: 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 01 896 1177 during office hours. After hours you can contact Front Gate at 896 3978 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 01 896 1999 (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/

TRINITY HALL: The Accommodation Office is open Monday to Thursday from 9am to 4pm, and on Fridays from 8.30am to 4pm. The reception area is staffed 24 hours a day. During office hours the reception area is staffed by a member of the Accommodation Office Administrative Staff. Outside of office hours the reception desk is staffed by a member of the RSA (security) team. In the event of a serious emergency, particularly where you require an ambulance, fire, or police services, please ring our office number 01 8968024 for assistance or call-in person.

KAVANAGH COURT: Reception is at the entrance to the building, and it is open from 9am -5:30pm weekdays and closed at the weekend. However, reception opens for two hours over the weekend for parcel collections. (12pm-2pm) Phone number: +353 1 567 6977

Academic Year Structure 2025-26

Key Dates:

Semester 1 teaching term begins:	Monday 15 September 2025
Study/revision week Semester 1:	Monday 27 October to 31 October 2025
Semester 1 teaching term ends:	Friday 05 December 2025
Semester 1 Examinations:	Monday 15 December to 19 December 2025
Semester 2 teaching term begins:	Monday 19 January 2026
Study/Revision week Semester 2	Monday 02 March to Friday 06 March 2026
Semester 2 teaching term ends:	Friday 10 April 2026
Revision Week	Monday 13 April to Friday 17 April 2026

Teaching Term Dates 2025-2026

Michaelmas Term Monday 15 September - Friday 05 Dec 2025			**Hilary Term Monday 19 January 2026 - Friday 10 April 2026**		
Teaching wk. 1	Week 04	15 Sept – 19 Sept	Teaching wk. 1	Week 22	19 Jan - 23 Jan
Teaching wk. 2	Week 05	22 Sept – 26 Sept	Teaching wk. 2	Week 23	26 Jan – 30 Jan
Teaching wk. 3	Week 06	29 Sept – 03 Oct	Teaching wk. 3	Week 24	02* Feb – 6 Feb
Teaching wk. 4	Week 07	06 Oct – 10 Oct	Teaching wk. 4	Week 25	09 Feb – 13 Feb
Teaching wk. 5	Week 08	13 Oct – 17 Oct	Teaching wk. 5	Week 26	16 Feb – 20 Feb
Teaching wk. 6	Week 09	20 Oct - 24 Oct	Teaching wk. 6	Week 27	23 Feb – 27 Feb
Study week	**Week 10**	**27 Oct – 31 Oct**	**Study week**	**Week 28**	**02 Mar – 06 Mar**
Teaching wk. 8	Week 11	03 Nov – 07 Nov	Teaching wk. 8	Week 29	09 Mar – 13 Mar
Teaching wk. 9	Week 12	10 Nov – 14 Nov	Teaching wk. 9	Week 30	16* Mar – 20 Mar
Teaching wk. 10	Week 13	17 Nov – 21 Nov	Teaching wk. 10	Week 31	23 Mar – 27 Mar
Teaching wk. 11	Week 14	24 Nov – 28 Nov	Teaching wk. 11	Week 32	30 Mar - 03 Apr *
Teaching wk. 12	Week 15	01 Dec – 05 Dec	Teaching wk. 12	Week 33	06* Apr – 10 Apr

- October bank holiday – Monday 27th October 2025
- February bank holiday – Monday 2nd February 2026
- St Patrick's Day - Tuesday 17th March 2026
- Good Friday – 3rd April 2026
- Easter Monday – 6th April 2026

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 webpage https://www.tcd.ie/science/undergraduate/tr060-biological-and-biomedical-science/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/calendar/undergraduate-studies/general-regulations-and-information.pdf

TR060: Biological and Biomedical Sciences - Contact Details

Professor Andrew Jackson	Course Director, TR060 Biological and Biomedical Sciences	jacksoan@tcd.ie
Professor Tomás Ryan	Academic Advisor – Dual BA Neuroscience	tomas.ryan@tcd.ie
Mirela Dardac	Biology Teaching Manager	mdardac@tcd.ie Ph: 01 896 2895
Audrey Carroll	Chief Technical Officer	aucarrol@tcd.ie Ph: 01 896 1049
Daniel McCormick	Biology Teaching Centre - Executive Officer	BTC.Administrator@tcd.ie Ph: 01 8961117
Science Course Office		
Professor Fraser Mitchell	Associate Dean of Undergraduate Science Education	Fraser.Mitchell@tcd.ie Ph: 01 896 2025
Ann Marie Brady	Science Course Office Manager	ennisa@tcd.ie Ph: 01 896 2829
Helen Sherwin Murray	Administrative Officer	sherwinh@tcd.ie Ph: 01 896 2799
Romarey Segura Orea	Executive Officer	segurar@tcd.ie Ph: 01 896 2022
Andressa Dos Santos Melo	Executive Officer	dossanta@tcd.ie Ph: 01 8961970

Appendix 1

Item	Reference/Source
General College Regulations	Calendar, Part II, General Regulations and Information,Section II, Item 12
Emergency Procedures	In the event of an emergency, **dial Security Services on extension 1999** Security Services provide a 24-hour service to the college community, 365 days a year. They are the liaison to the Fire, Garda and Ambulance services and all staff and students are advised to always telephone extension 1999 (+353 1 896 1999) in case of an emergency. 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 studentshave 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/teaching-learning/ug-egulations/Academic_credit_system.php
Assessment and Progression Regulations	https://www.tcd.ie/media/tcd/about/policies/pdfs/academic/assess-acad-prog-nov2021.pdf https://www.tcd.ie/teaching-learning/academic-affairs/ug-prog-award-regs/ Calendar, Part II, General Regulations and Information,Section II, Item 35
Academic Awards	https://www.tcd.ie/teaching-learning/academic-policies/assets/academic-awards-jan2021.pdf
Equality, Diversity and Inclusion	https://www.tcd.ie/equality/
Prizes, medals, and other scholarships	https://www.tcd.ie/calendar/undergraduate-studies/prizes-and-other-awards.pdf

Item	Reference/Source
Teaching and Learning Study Abroad	https://www.tcd.ie/study/study-abroad/
Marking Scales	Calendar, Part II, General Regulations & Information,Section II, Item 30 Please consult Schools or Disciplines directly or programme handbooks for further information.
Framework of qualifications Trinity Pathways	https://www.qqi.ie/national-framework-of-qualifications Trinity PathwaysTrinity Courses
Capstone (UG Programmes)	https://www.tcd.ie/teaching-learning/ug-regulations/Capstone.php
Careers Information	https://www.tcd.ie/Science/careers/ For further information refer to School/Discipline Handbooks.
Careers Advisory Service	https://www.tcd.ie/Careers/
Attendance Requirements	Calendar, Part II, General Regulations and Information,Section II, Items 17-23 Calendar, Part III, General Regulations and Information,Section I 'Attendance and Off-Books'; Section II 'Attendance'; Section III 'Attendance, Registration, Extensions'; Section IV
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	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.

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

tcd.ie/science