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

Science Course Office

TR060: Biological and Biomedical Sciences

Sophister Course Programme 2025-2026

This programme booklet applies to all student 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 webpage: https://www.tcd.ie/science/undergraduate/tr060-biological-and-biomedical-science/junior-sophister/

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 from the Associate Dean of Undergraduate Science Education (ADUSE)

Dear Students

Congratulations – you are nearing the end of the second year of your degree and are ready to make the important decision about which science moderatorship you wish to pursue. The Fresh course structure has given you an excellent grounding in your core subject to prepare you for the advanced material you will cover in your Sophister years. You have also had opportunities to take open modules in other science subjects that have given breadth and context to your science education.

Development of educational breadth continues in the Sophister years via the opportunity to take further open modules and also Trinity Electives. Trinity Electives are stand-alone, College-wide modules that enable you to broaden your knowledge outside of your chosen subject. There is a wide range of choice available to you that encompasses languages and cultures, key societal challenges and Trinity's ground-breaking research activities.

A list of the modules can be found at this link (https://www.tcd.ie/trinity-electives/). Having the opportunity to develop these broader skills, particularly in communication and presentation, will allow you to derive the greatest benefits from your particular choice of moderatorship subject and will give you important insights into other subjects and modes of scholarship outside of the sciences.

I wish you the very best in your Sophister years and look forward to seeing your future successes and achievements.

Prof Fraser Mitchell
Associate Dean of Undergraduate Science Education

Foreword by Professor Andrew Jackson, Director of TR060 Biological and Biomedical Science

The purpose of this booklet is to provide information on the moderatorship choices that are available to you in the Sophister (3rd and 4th) years of the TR060 Biological and Biomedical Sciences (BBS) Programme.

Having successfully completed the Fresh years, of the BBS programme, you must now decide on the discipline in which you wish to specialise for your moderatorship. For some of you this will be an easy decision, as you have known from entry the subject you wish to study. For others the choice may be more difficult. However, it is important for all of you to be open-minded and reflect carefully on the broad range of topics presented in the Fresh biology modules.

My strong advice to you is - follow your interests! You will excel in the areas of biology in which you are most interested. Equally, as I have indicated to you in presentations, biology is such a fluid subject that whatever area you end up specialising in does not close off any doors to you for your subsequent career. Biologists chop and change between disciplines all the time and there are always new and relevant insights that can be brought from one area to another.

I recommend that you read this booklet very carefully before making your choices. You will see that the Biological and Biomedical Sciences Programme allows you to choose from 11 moderatorships covering a broad range of disciplines. You should also note the overlap in content between disciplines, afforded by the system of 'Core' and 'Open' modules that will give breadth to your scientific education. For example: those who specialise in Microbiology also have the opportunity to choose modules in 'BIU33150 Biochemistry for Biosciences'; 'Introduction to Immunology and Immunometabolism'; 'Genomics and Systems Biology' and 'Introduction to Parasitology' in the Junior Sophister year.

Junior Sophister students also have the opportunity to broaden their education by taking one or two Trinity Elective(s) in a topic outside of their moderatorship subject. The list of Trinity Elective modules reflects the very wide range of engagement in scholarship across college. Trinity Electives therefore affords the opportunity to study subjects of interest to you, presented by the leaders in the field.

Detailed information on each moderatorship can be obtained from the Junior Sophister Course Advisor. You are also welcome to visit the Science Course Office to discuss any personal needs you may have.

I wish you every success in your chosen field of study over the next two years.

Professor Andrew Jackson
Director, TR060: Biological and Biomedical Science

Introduction

Sophister courses in science are organised so that students follow a continuous programme of work over two years leading to a moderatorship in a particular subject. Each module (whether lecture, tutorial, seminar or practical) has a specified credit value, which is an approximate measure of the workload associated with the module and is in turn reflected in its proportional weighting in assessment. One credit is normally considered to represent a minimum of 20 hours of work on the part of a student. Students take modules to the value of 60 credits in each of the Sophister years.

The Sophister Course Booklet is intended as a detailed and comprehensive guide to all moderatorships within the Biological and Biomedical Sciences course (BBS). Full course descriptions and reading lists are available from individual schools/ departments and Course Advisors.

While every effort will be made to give due notice of major changes, the Science Course Office reserves the right to suspend, alter or initiate modules, timetables, examinations and regulations at any time.

The information in this booklet is accurate at the time of going to print but maybe subject to minor changes.

Description of ECTS system

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 value of a module and its level of difficulty.

The European **norm for full-time study over one academic year is 60 credits**. Within Undergraduate courses 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. Within Postgraduate courses 1 credit represents 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 programme year. Progression from one year to the next is determined by the programme regulations. Students who fail a year of their programme will not obtain credit for that year even if they have passed certain components. Exceptions to this rule are one-year and part-year visiting students, who are awarded credit for individual modules successfully completed.

Junior Sophister Course Advisors

Biochemistry	Prof D. Nolan	denolan@tcd.ie
Botany	Prof J McElwain	jmcelwai@tcd.ie
Environmental Sciences	Prof Jay Piggott	jeremy.piggott@tcd.ie
Genetics	Prof J.P. Labrador	labradoj@tcd.ie
Human Genetics	Prof J.P Labrador	labroadoj@tcd.ie
Immunology	Prof F. Sheedy	fsheedy@tcd.ie
Microbiology	Prof Carsten Krörger	carsten.kroeger@tcd.ie
Molecular Medicine	Prof K. Mok	MOK1@tcd.ie
Neuroscience	Roisin MacKin	mcmackro@tcd.ie
Physiology	Prof M. Caldwell	caldwelm@tcd.ie
Zoology	Prof Nessa O'Connor	oconnn18@tcd.ie

Senior Sophister Course Advisors

Biochemistry	Prof Danny Zisterer	dzistrer@tcd.ie
Botany	Prof J McElwain	jmcelwai@tcd.ie
Environmental Sciences	Prof Jay Piggott	Jeremy.Piggott@tcd.ie
Genetics	Prof Matthew Campbell	CAMPBEM2@tcd.ie
Human Genetics	Prof Matthew Campbell	CAMPBEM2@tcd.ie
Immunology	Prof Emma Creagh	ecreagh@tcd.ie
Microbiology	Prof Marta Martins	mmartins@tcd.ie
Molecular Medicine	Prof Gareth Brady	bradyg@tcd.ie
Neuroscience	Prof Colm Cunningham	cunninco@tcd.ie
Physiology	Prof Alice Witney	awitney@tcd.ie
Zoology	Prof Nessa O'Connor	oconnn18@tcd.ie

Moderatorship Quotas

To be qualified for a moderatorship, students must have successfully completed both Fresh years. While every effort will be made to give due notice of major changes in the quotas, the Science Course Office reserves the right to alter pre-requisites and quotas, if necessary.

Moderatorship	**Quotas**
Biochemistry	24
Botany	24
Environmental Sciences	25
Genetics	14
Human Genetics	21
Immunology	20
Microbiology	30
Molecular Medicine	18
Neuroscience	22
Physiology	18
Zoology	36

First year Modules 2023-24

Module Code	Title	Credits
Core Modules		
BYU11101	From Molecules to Cells	10
BYU11102	From Organisms to Ecosystems	10
CHU11B01	Chemistry for Life Sciences	10
MAU11002	Mathematics, Statistics & Computation 2	10
OPEN MODULES		
GSU11001	Spaceship Earth – An Introduction to Earth System Science	10
GSU11005	Introduction to Geology – A Beginners Guide to Planet Earth	10
*PYU11F10/20	Foundation Physics for Life and Earth Scientists 1 & 2	10
*EDU11001/02	Science Education and Communication 1& 2	10

***** Foundation Physics and Science Education modules in either semester 1 or semester 2 (10 credits each)

Second year Modules 2024-25

Module Code	Title	Credits
BYU22201	From Molecules to Cells	10
BYU22202	From Cells to Organisms	10
BYU22203	From Organisms to Ecosystems	10
BYU22S01	Statistics & Computation	5
PIU22991	History Philosophy & Ethics of Science	5
Open Modules		
BYU22204	Sustainable Production: Food, Drink & Drugs	5
BYU22205	Influences on Animal Behaviour	5
BYU22206	Microbes, Immune Systems & their Interaction	5
BYU22207	Genomes, Disease and Diversity	5
BYU22208	Molecular Nutrition	5
CHU22205	Chemistry for Biologists	5
GSU22201	From Atoms to Rocks: Introduction to Geochemistry	5
GSU22205	Sedimentary Processes & Environments	5
GGU22006	Human Geography: Dynamic Earth	10
MAU23302	Euclidean and Non-Euclidean Geometry	5

Allocation of Places

The Science Course office coordinates and processes the applications for Junior Sophister places in the TR060: Biological and Biomedical Science course. The procedures documented below show students that those places are allocated in a fair, transparent, and efficient manner.

The number of places available in each moderatorship is limited by quota. **Allocation is based on the overall mark obtained in the Senior Fresh year** and the order of choice expressed by the student.

The Science Course Office allocates Junior Sophister places. Students cannot be allocated a place by circumventing the Science Course Office and going directly to disciplines. All enquiries regarding the allocation of places, made to disciplines, will be redirected to the Science Course Office via the sophistersco@tcd.ie email address.

Places will be allocated as follows until quotas are reached:

1. All students passing their Senior Fresh year will be placed in **rank order** based on their **overall Senior Fresh year mark**.
2. Students who fail and are required to sit reassessment must reapply for the remaining unfilled places until quotas are reached. Second round forms will be made available via the relevant course page on the Science website: https://www.tcd.ie/Science/ following publication of the first round.
3. Students who are given permission by the Senior Lecturer to defer assessments and or examinations until the reassessment session may defer a place in their **first** preference only. Following publication of the results, students who pass at the reassessment session will be allocated a place based on the same criteria used in the first-round allocation of places. If the student in this category does not qualify for the deferred place, the Science Course Office will allocate that student a place in one of the subjects available in the second round and the deferred place will be offered to the next qualified student from the first-round allocation.
4. In the event a student fails at the reassessment session, be that a deferred exam or reassessment, and are eligible to repeat the SF year, they can do so in **one** of the following ways:
    - Repeating the year in full on books, such students will be treated in the same way as all other SF students in that year.
    - Students may request permission from the Senior Lecturer, via their tutor, to repeat the year off books taking assessment (**OBA**). Sitting an exam OBA is a repeat examination therefore, such students will be allocated a place in one of the remaining Moderatorships available at the **reassessment session** the following year. Students may not repeat more than 20 credits OBA.
5. Students who have passed in the **first round** who then opt to go 'off books' for the year (**OBN**) rather than take up the place offered, will be allocated a place in the first round along with rising JS students in the following year. Places will **not** be reserved for such students.
6. Students who pass in the second round and opt to go "off books" prior to places being allocated, will be allocated a place at the **reassessment session** in the following year.
7. Results will be available on your personal portal at my.tcd.ie by the stated publication date.
8. Publication of first round JS places will be available through the my.tcd.ie portal once the academic year rollover happens in July.
9. Students are informed by email when the places are published, and the procedures followed are clearly outlined in the email.

Special note: Students who have passed their Senior Fresh year may not repeat the SF year to improve their performance.

Important Dates		
Week	**Date**	**Trinity Term 2025**
32	02.04.25	TR060 Moderatorship Fair – opposite Biology and Chemistry Labs
33	18.04.25	Closing date for submission of Moderatorship Preference Forms https://forms.office.com/e/iuqhrDF7jy
36	22.04.25 – 02.05.25	Semester two examinations
40	29.05.25	Publication of Science Examination results – mytcd.ie portal
45	07.07.25	Publication of Junior Sophister places via my.tcd.ie

Choice of Moderatorship Form

Students are required to complete the choice of subject form. You will rank your subject preferences from 1-11 i.e., Biochemistry 1, Genetics 2, Immunology 3 etc.
The form is available online: https://forms.office.com/e/iuqhrDF7jy . The closing date is Friday 18th April 2025.

Open Module Choices

Students take modules totalling 60 credits in the Junior Sophister year. There are 40 credits of core modules, and 20 credits of open modules spread equally over two semesters in the academic year. The module structure for each individual moderatorship is listed in the following pages.

In addition, students can choose one or two (one per semester) 5 credit Trinity Elective modules as shown in the module structure table for each moderatorship subject.

Students can choose their open modules with the help of the Moderatorship Course Adviser following the allocation of moderatorship places. **Online forms will be available from your moderatorship disciplines.**

Students should note that due timetable constraints Open Modules may be delivered via a blended learning approach involving face to face and online teaching for some open modules.

Please consider your Open module/Trinity Elective pattern choices carefully as changes will not be permitted. If necessary, please seek advice from the relevant Course Advisor.

Trinity Electives

https://www.tcd.ie/trinity-electives/

The Trinity Electives are a unique feature of your Trinity Education. They are stand alone, College-wide 5 credit modules. They cover a broad range of topics in the arts, humanities, sciences, health and social science, and technology. They are designed to allow students to study topics outside of their core discipline and thus provide breadth in their education. BBS students take a minimum of one and a maximum of two (one per semester) Trinity Electives in the Junior Sophister year. Depending on your moderatorship, you will choose a combination of Trinity Electives and Open Modules as described in this handbook.

Choosing your Trinity Elective

The choice of Trinity Elective is student driven. Almost all Trinity Electives are open to all students. However, students of some moderatorships may be precluded from taking certain Trinity Electives (e.g. the module 'From Planets to the Cosmos' is not available to TR063 Physical Sciences students, as this topic is part of their core discipline). The list of exemptions is outlined in the Trinity Electives webpage: https://www.tcd.ie/trinity-electives/

Selection of Trinity Electives will be made through online enrolment which will open in July 2025, after publication of examination results and allocation of moderatorship places. You will select your Trinity Electives on a first come first served basis through online module enrolment in your TCD portal.

The Trinity Electives website provides full details of each of the Trinity Electives. A list of the Trinity Electives can be found at https://www.tcd.ie/trinity-electives/

You need to think carefully about your choice of Trinity Elective as the semester in which you take it (Semester 1, Semester 2 or both) will affect your choice of Open Modules. That is: taking one Trinity Elective in the first semester, restricts you to the open modules in Option 1; taking one Trinity Elective in the second semester, restricts you to the open modules in Option 2 while taking two Trinity Electives, (one in each semester) restricts you to the open modules in Option 3. Please refer carefully to the tables in this handbook.

Open Module Changes

If you wish to change your open module scenario, you must consult the relevant Course Advisor for advice prior to submitting your request.

Closing dates for change of Open Modules/TE's scenarios for Science Students

Semester one: 5pm on Friday 26th September 2025
Semester two: 5pm on Friday 28th November 2025

NOTE: Trinity Elective changes submitted directly to the Academic Registry will not be accepted without the relevant sign off from the Course Advisor.

Junior Sophister Examination Information

Modules are assessed by continuous assessment and/or by examination. The Junior Sophister year is comprised of modules to a total of 60 credits. The distribution scheme of marks between papers and practical work at the Sophister examinations will be published by individual schools or departments/disciplines.

Calculation of Moderatorship results

The final moderatorship results are calculated as a weighted average of the overall result for the Junior and Senior Sophister examination results.

Junior Sophister 30%, Senior Sophister 70%:

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

Reassessment - Regulation 8: Undergraduate Progression and awards regulations

- Same progression regulations, including compensation, for assessments relating to semesters 1 & 2 and to reassessment.
- Automatic right to reassessment for a student who has achieved a fail grade in any of their modules and is not eligible for compensation.
- Students (in all years) should only be required to re-sit examinations or re-submit coursework for failed modules or components thereof.
- Students are not permitted to present for reassessment in any module for which they have achieved a pass grade, in order to improve their academic performance.
- Rescheduled exams within the session will no longer be permitted.
- Different reassessment modalities permitted.
- No capping of marks

Repetition of a year: Regulation 7: Undergraduate Progression and awards regulations

- Students are not permitted to repeat any academic year more than once and may not repeat more than two academic years within a programme.
- Repetition of a year is in full, i.e., all modules and all assessment components
- A student's academic record on their transcript will show clearly the time lost through repetition of a year.
- There will be an option to repeat a year on an 'off-books' basis.

Full Progression and Awards regulations can be found via the following:
https://www.tcd.ie/teaching-learning/academic-affairs/ug-prog-award-regs/index.php

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 for TR060

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.

BIOCHEMISTRY

Junior Sophister Biochemistry Course Advisor: Prof D Nolan denolan@tcd.ie

Biochemistry is a unique discipline because it sits at the interface between chemistry and biology and consequently it is an underpinning subject for many disciplines in the biological and biomedical sciences. Biochemistry is concerned with the study of the structure and function of the building blocks of life, *i.e.* proteins, carbohydrates, lipids and nucleic acids, and how these various components work together in living organisms. Crucially, biochemists seek to provide mechanistic explanations for biological processes and ask questions about how things work, why they work and what happens when they don't! This is the approach that provides the molecular understanding of disease which is essential for the development of new therapeutics. Moreover, biochemists developed many of the key quantitative and analytical technologies that are now used widely in the life and medical sciences.
The Biochemistry moderatorship is run by the School of Biochemistry and Immunology (http://www.tcd.ie/Biochemistry/) and the course at Trinity reflects the longstanding, and internationally recognised, strengths of the school in diverse areas of biochemistry.

All international visiting student queries should please contact Prof Andrei Budanov (budanova@tcd.ie).

The junior sophister year consists of four core modules, each worth 10 credits. These modules cover three central themes in biochemistry: Protein Structure & Function; Membranes and Cell Biology; Nucleic Acids and consist of lectures and extensive practical classes. The fourth core module is unique and seeks to develop those explicit skills that are essential for a graduate biochemist, i.e. organisational, technical, analytical and communication skills.

In addition to the Core Biochemistry modules, students will take Open modules in: Genomics and Systems Biology (5 credits, S1) and an Introduction to Immunology and Immunometabolism (5 credits, S2). Biochemistry students then have the option of further Open Modules in association with a Trinity Elective, as indicated in the Module Structure Table.

Senior Sophister students spend a number of weeks in one of the research laboratories in the Biomedical Sciences Institute where they conduct state-of-the-art research in areas such as cancer, obesity, ageing, neurobiology, immunology, parasitology and biotechnology. Graduates in the discipline of biochemistry will be able to describe cellular function and regulation in terms of the molecules, proteins and structures involved, be trained in the application of appropriate technologies to investigate these processes and have a special insight into the nature of human pathological states and their treatment at a molecular level.

Junior Sophister Biochemistry Course Structure

Biochemistry	
Semester 1	**Semester 2**
Core Modules	
BIU33110 Protein Structure and Function. (10 credits)	BIU33010 Nucleic acids. (10 credits)
BIU33120 Membranes and Cell Biology. (10 credits)	BIU33160 Research skills in Biochemistry. (10 credits)
Open Modules – Option 1	
GEU33045 Genomics and Systems Biology (5 Credits)	BIU33250 Introduction to Immunology and Immunometabolism (5 Credits)
Trinity Elective (5 Credits)	GEU33215 Medical Genetics (5 Credits) OR BIU33475 Basic Neurobiology (5 Credits)
Open Modules - Option 2	
GEU33045 Genomics and Systems Biology (5 Credits)	BIU33250 Introduction to Immunology and Immunometabolism (5 Credits)
PGU33905 Cell Physiology and Pharmacology (5 Credits)	Trinity Elective (5 Credits)
Open Modules - Option 3	
GEU33045 Genomics and Systems Biology (5 Credits)	BIU33250 Introduction to Immunology and Immunometabolism (5 Credits)
Trinity Elective (5 Credits)	Trinity Elective (5 Credits)

Junior Sophister Biochemistry Core Modules

BIU33110 PROTEIN STRUCTURE (S1) **10 credits**

Profs A Khan, K H Mok, A Budanov, E Creagh, D Nolan, J Hayes

This module introduces the concept of proteins as molecular nanomachines that act as the workhorses in living cells. The topics covered include: the relationship between protein structure and function, enzyme structure, mechanism, analysis and regulation; how drugs can be exploited to target proteins to treat diseases. As well as lectures the module includes a set of linked practical sessions.

The module will be assessed by in-course continuous assessment and by an individual end of term exam paper.

BIU33120 MEMBRANE AND CELL BIOLOGY (S1) **10 credits**

Profs M Caffrey, D Nolan, E Creagh, A Dunne

This module covers the structure and function of biological membranes, the cytoskeleton, related signal transduction pathways and associated pathological conditions important in human health. As well as lectures the module includes a set of linked practical sessions. The module will be assessed by in-course continuous assessment and by an individual end of term exam paper.

BIU33010 NUCLEIC ACIDS (S2) **10 credits**

Profs V Kelly, M Carty, D Zisterer, A Bowie, D Finlay & F Sheedy

This module covers the structure and function of nucleic acids and the molecular basis of gene regulation/expression including DNA replication and repair, transcription and translation. As well as lectures the module includes a set of linked practical sessions.
The module will be assessed by in-course continuous assessment and by an individual end of term exam paper.

BIU33160 RESEARCH SKILLS (S2) **10 credits**

All biochemistry staff

This purpose of this module is to teach the essential skills in laboratory research, experimental design, survey & critical analysis of the literature and communication (written and oral) that are essential for a graduate biochemist. Students will undertake a series of thematic, mini-project style practical classes that extend over a number of laboratory sessions covering: (i) RAS and cancer and (ii) culture and differentiation of a medically important protozoan parasite. In addition, students will be trained in the analysis of primary experimental data through a combination of lectures and tutorial sessions.

Finally, students will undertake a major written review of a subject area of biochemical relevance under the supervision of a member of staff of the school. Students will also give a short oral presentation of their review.
This module is entirely in-course assessed

Junior Sophister Biochemistry - Open modules

GEU33045 Genomics and Systems Biology (S1) **5 credits**
Instructors: Mike Dolan, Ken Mok, Adrian Bracken, Carsten Kröger,

Module Description: The aim of this module is to equip students with a comprehensive understanding of the methods used in the fields of genomics, proteomics and metabolomics and how these methods are used for basic research, biotechnology, agriculture and medicine. To this end, several applications from work in diverse organisms (bacteria, fungi, plants, animals including humans) in addition to specific diseases and disorders (Schizophrenia and Cancer) will be presented. The module further introduces students to the field of systems biology and outlines how systems biology differs from the classic reductionist approach used in biology.

Assessment: 100% end of semester examination.

PGU33905 Cell Physiology and Pharmacology. Credit Value (S1) **5 credits**
Prof K Connor
The lectures in this module focus on (i) membrane structure, proteins and properties; (ii) receptors and neurotransmitters, (iii) the principles of drug action, drug development and drug targets. The module is designed to consider the structure of the membrane, the changes that occur in the membrane under different biological circumstances using age as an example, and role of membrane proteins. Cell functions, for example, the control of intracellular calcium by cells and transmitter release will be considered in the context of the membrane proteins that impact on these functions. There is a problem-based learning element to this course that will be a team-based exercise. An overall theme will be chosen and groups of 3 or 4 students will be assigned specific aspects of the theme. The objective is to undertake research on the theme and prepare a presentation that is cohesive across the topic. Each team member will contribute to the presentation.

BIU33250 Introduction to Immunology & Immunometabolism (S2) **5 credits**
Profs F Sheedy, J Fletcher, M Carty, E Lavelle, R Porter & L O'Neill.
This module introduces students to the basic components and function of the immune system – the molecules, cells, tissues and organs that make up the immune system. It will illustrate the immune responses to infection. Additionally, it will introduce students to the importance of central energy and intermediary metabolic pathways or bioenergetics before considering how they are dysregulated in diseases like cancer and how we can harness this knowledge for new immunotherapies.
The module will be assessed through a combination of in-course assessment (MCQ) and an individual end of term exam.
**Entry into this module will be subject to scheduling requirements of home moderatorship*

BIU33475 Basics of Neurobiology (S2) **5 credits**
Profs G Davey & D Loane
This module focuses on chemical transmission between neurons, how neurotransmitters are classified and identified and describes typical and atypical neurotransmitters and their functions in the brain. It considers mechanisms in which abnormal neurotransmission gives rise to common neurological & psychiatric disorders. The module will be assessed by in-

course continuous assessment (30%) and by an individual end of term exam paper (70%). The in-course assessment element will consist of a review article (2,500 words) to be submitted before the end of the semester.

GEU33215 Medical Genetics (S2) **5 credits**

Profs J Farrar, , R McLaughlin

The module provides an introduction to core concepts in medical genetics highlighting the importance and power of genetic information in the era of genomic medicine and the impact of such information for all of us. Learning objectives include: (1) discussion of the genetic basis of single gene disorders (Mendelian) and complex disorders; (2) overview of the history of medical genetics; (3) insights into key developments in medical genetics up to 2020 including state-of-art technologies and novel innovative therapies; (4) discussion of the key technologies and methodologies currently used to elucidate the genetic basis of human traits; (5) discussion of the individualisation of medicine and the important roles of genetic information in disease diagnosis, prognosis and the design and choice of therapy. In summary, the module provides an introduction to:

- The genetic basis of mendelian & complex disorders
- Genetic technologies & methodologies used to elucidate the genetic basis of human traits
- The exploitation of genomic data in diagnosis, prognosis & treatment of disease
- The individualization of medicine using genetic information

Assessment: 100% end of semester examination.

Senior Sophister Biochemistry

Course Advisor: Prof Danny Zisterer dzistrer@tcd.ie

Senior Sophister Biochemistry Course Structure

Biochemistry	
Semester 1 (S1)	**Semester 2 (S2)**
Core Modules	
BIU44010 Advanced Research Skills (10 credits)	BIU44110 Biochemistry in Health and Disease II (10 credits)
BIU44120 Immunology & Microbiology (10 credits)	BIU44130 Cancer Biology & Cell Signalling (10 credits)
Capstone Project	
BIU44190 Research Project in Biochemistry (20 Credits)	

BIU44190 RESEARCH PROJECT IN BIOCHEMISTRY (S1) 20 credits

Each project will be supervised by an academic member of staff in the School of Biochemistry & Immunology.

The module comprises an original research project in biochemistry, a research thesis and an oral and poster presentation.

BIU44010 ADVANCED RESEARCH SKILLS (S1) 10 credits

All Biochemistry Teaching Staff contribute to this module.

This purpose of this module is to further develop research, critical analysis and communication skills that are essential for a graduate biochemist. Students will be trained in data handling as well as solving quantitative problems in biochemistry. In addition, this module will introduce students to a wide array of cutting-edge techniques and strategies used in biochemistry.

BIU44110 BIOCHEMISTRY IN HEALTH & DISEASE II (S2) 10 credits

Profs G Davey, D Loane, J Hayes.

This module covers the structure, function and pharmacology of neurotransmitters, neuron-glia interactions, intraneuronal signalling and the neurobiology of behaviour and neurodegenerative disorders. This module also covers the biochemistry of genetic deficiency diseases and metabolic diseases.

BIU44120 IMMUNOLOGY & MICROBIOLOGY (S2) 10 credits
Profs L O'Neill, G Brady, A Dunne, F Sheedy, D Finlay, R McLoughlin, D Nolan, P Fallon & H Windle.
This module covers pathogen recognition by and signal transduction in immune cells. Bacterial pathogens of medical importance will also be covered in detail. It will provide an introduction to parasitic protozoa such as trypanosomes and helminths. Finally, the biochemical and genetic mechanisms by which bacteria, viruses and parasites evade the host immune responses will be covered.

BIU44130 CANCER BIOLOGY & CELL SIGNALLING (S2) 10 credits
Profs V Kelly, K Mills, T McElligott, D Zisterer .
This module covers the cellular and regulatory mechanisms that control the cell cycle. It also covers the molecular basis of a stem cell and its potential use in therapies. Furthermore, it covers the molecular basis of cancer, the progression of the disease and the therapeutic treatment strategies.

Biochemistry Learning Outcomes

- Demonstrate in written and oral form a foundation level of knowledge and understanding of the biological, physical and quantitative sciences underpinning Biochemistry;
- Discuss core and specialised areas of Biochemistry in depth and analyse and solve biochemical problems.
- Demonstrate a comprehensive understanding of the theory behind techniques used in Biochemistry and show a critical awareness of how these techniques can be applied to biological problems.
- Design and implement a wide range of experimental procedures, critically analyse and interpret experimental data, synthesise hypotheses from a wide range of information sources, critically evaluate research literature and write a research dissertation.
- Work effectively as an individual and in a team.
- Display computer literacy and use advanced computer skills to aid in conducting scientific research.
- Communicate effectively with the scientific community and with society at large and articulate how the improved knowledge of Biochemistry impacts on society.

Botany

Junior Sophister Course Adviser: **Prof S Caldararu, caldaras@tcd.ie**

Botany is the study of plants which are the source of the food we eat, the oxygen we breathe, most of the medicines we use, and the timbers and fiber which shelter, warm and clothe us. Plants are the core to understanding one of the greatest issues of our time – global climate change. In Trinity we specialise in the study of the evolution, genetics, ecophysiology, vegetation structure, history and dynamics, sustainability, and conservation of all forms of plant life.

If you are interested in the future of the planet and life on it, then Botany is for you. Almost no other course offers you the opportunity to study the natural, living World in the field and laboratory. Our graduates enter into a large range of careers and, as there is a global shortage of plant scientists, find employment in a huge range of careers.

Trinity's Botany moderatorship is unique in content in Ireland and uncommon in a European context. Uniquely, we integrate small-group teaching, field-based activities, and the laboratory. Field based teaching in ecology, ecophysiology and plant evolution is at its heart: We consider both the whole plant and how it works in a natural context. All staff are research active with high profile, strong research interests in Ireland and the tropics. Consistently, our graduates have rated our course very highly indeed: we believe that our course offers you the best possible training in Ireland for your future career.

The JS year consists of a diverse programme of lectures, laboratory practical's, field trips, tutorials and seminars. In the Senior Sophister year, students attend a series of lectures, laboratory practical's, field work, seminars, tutorials and workshops. In addition, they are required to undertake a 20 credits research project which culminates in the submission of a dissertation. The year consists of a total of 50 mandatory credits and 10 optional credits. These modules are indicated in greater detail in the following pages.

Field trips are a central part to Botany teaching, and during your two years study you will be allowed to take up to 10 credits in residential field trip modules, including trips to Gran Canaria.

Junior Sophister Botany Course Structure

<table>
<tr><th colspan="2">Botany</th></tr>
<tr><th>Semester 1 (S1)</th><th>Semester 2 (S2)</th></tr>
<tr><td colspan="2">Core Modules</td></tr>
<tr><td colspan="2">ESU33004 Scientific Communication (5 credits)[1]</td></tr>
<tr><td>BOU33100: Plant Physiology (5 Credits)</td><td>BOU33107: Plant Molecular Biology (5 Credits)</td></tr>
<tr><td>ZOU33010: Fundamentals of Ecology (5 Credits)</td><td>ZOU33070: Experimental Design and Analysis (5 Credits)</td></tr>
<tr><td>BOU33108: Plants in the Irish Environment (5 Credits)</td><td>BOU33112: Botanical Diversity 1 (5 credits)</td></tr>
<tr><td></td><td>BOU33121: Field Skills in Plant and Environmental Sciences (5 Credits - Gran Canaria field trip)</td></tr>
<tr><td colspan="2">Open Modules – Option 1</td></tr>
<tr><td>In addition to the 5 credits of Trinity Electives, choose <u>ONE</u> module from the following two:
GSU33003: Ice Age Earth (5 credits)
BOU33123: Soil Science (5 credits)
BOU33114: Conservation Horticulture (5 credits)</td><td>In addition to the 5 credits of Trinity Electives, choose <u>ONE</u> module from the following two:
ZOU33006 Ecology and Evolution of Infectious Diseases (5 credits)
BOU33122: Entomology (5 credits)
BOU33105 Global Environmental Change (5 credits)</td></tr>
<tr><td>Trinity Elective (5 credits)</td><td>Trinity Elective (5 credits)</td></tr>
<tr><td colspan="2">Open Modules – Option 2</td></tr>
<tr><td rowspan="2"><u>Students will automatically be enrolled on module below in semester 1:</u>

GSU33003: Ice Age Earth (5 credits)
BOU33123: Soil Science (5 credits)
BOU33114: Conservation Horticulture (5 credits)</td><td>In addition to the 5 credits of Trinity Electives, choose <u>ONE</u> module from the following two:
ZOU33006 Ecology and Evolution of Infectious Diseases (5 credits)
BOU33122: Entomology (5 credits)
BOU33105 Global Environmental Change (5 credits)</td></tr>
<tr><td>Trinity Elective (5 credits)</td></tr>
<tr><td colspan="2">Open Module – Option 3</td></tr>
<tr><td>In addition to the 5 credits of Trinity Electives, choose <u>ONE</u> module from the following three:

GSU33003: Ice Age Earth (5 credits)
BOU33123: Soil Science (5 credits)
BOU33114: Conservation Horticulture (5 credits)</td><td><u>Students will automatically be enrolled on module below in semester 2:</u>
ZOU33006 Ecology and Evolution of Infectious Diseases (5 credits)
BOU33122: Entomology (5 credits)</td></tr>
<tr><td>Trinity Elective (5 credits)</td><td>BOU33105 Global Environmental Change (5 credits)</td></tr>
</table>

Junior Sophister Botany Core modules

BOU33100 Plant Physiology (S1) **5 credits**
Prof J Waterman
This module covers major biochemical and physiological processes in plants which control plant function and underly plant diversity, with a focus on photosynthesis. Students will be introduced to concepts in plant physiology at cell, leaf, and whole plant level as an introduction to the field of plant physiology and as underlying principles across botany and environmental science. Continual assessment for this module will be a mini review on a given subject area relevant to photosynthesis, and an exercise in writing a scientific paper from raw data from a growth study of plants maintained at different light intensities.

ZOU33010 Fundamentals of Ecology (S1) **5 credits**
Profs I Donohue and F Mitchell
This module examines the factors that affect the distribution, growth and survival of plant and animal communities. It describes how organisms interact with their environment and the role that they have in ecosystem and community structure. There is an introduction to the concepts and models that help to explain and predict organism distributions and interactions. The module comprises interrelated components of lectures, practical sessions and fieldwork. It has been designed to provide a foundation to ecological theory and its application.

BOU33108 Plants in the Irish Environment (S1) **5 credits**
Profs M Collier, F Mitchell, T Hodkinson, J McElwain, M Saunders, S Larragy
This module combines an introduction to the Botany and Environmental Sciences moderatorships with a series of field-based activities including a residential field trip during the first week of the teaching term (Week 3). There will also be a series of lectures given following the field trip on specific aspects of the Irish flora.

BOU33114 Conservation Horticulture (S1) **5 credits**
Prof J McElwain
The loss of plant diversity is happening at an extraordinarily fast rate, the urgent need for conservation action has never been so crucial. Botanic Gardens are well-positioned to take on this challenge – they have a large pool of specialist horticultural expertise trained in propagation and cultivation techniques, scientific staff with an understanding of population and genetic basis of a conservation collection, and the accurate record-keeping and management of genetically representative living plant collections – skills and knowledge essential to the successful recovery of threatened plant species. Conservation horticulture is an emerging field in plant science that brings together the disciplines of conservation and horticulture. It remains formally undefined; however we define it here, as the practice within mainly Botanic Gardens and Arboreta of targeting, collecting and maintaining living plant collections that are representative of the genetic diversity of wild populations for ex situ conservation and habitat restoration purposes. This unique, timely and highly practical-focused module will be co-taught by staff at Trinity College Botanic Garden, Trinity Botany Department and the National Botanic Gardens, Glasnevin. Five practical sessions in hands-on conservation horticulture will be held at NBG and TCBG. 10 lectures will cover theory and

both global and national case studies. One optional full Saturday field excursion will show case examples of good conservation horticulture practice in Ireland.

ESU33004[1] Scientific Writing and Communication (S1 and S2) 5 credits
Profs P Luijckx and C Harper
Scientific communication and writing are used to communicate knowledge to other researchers through the publication of research articles, reports and oral and poster presentations. Writing such articles or essays and presenting scientific results can be difficult and challenging. The aim of this module is to introduce students to scientific writing, presentation techniques and responsible use of AI. Throughout the duration of both semesters, students will be presented with a brief overview of the steps involved in reading, publishing, organising, and disseminating research findings. To experience this process students will undertake desk-based research, using scientific literature to synthesise and write an extended essay on a selected topic of interest related to a key challenge in Environmental Science, Botany or Zoology (depending on your discipline). The finished essay will consist of a general-format scientific review article.

BOU33107 Plant Molecular Biology (S2) 5 credits
Prof T Hodkinson
Plant Molecular Biology plays a major part in most fields of botanical research including ecology, systematics and physiology. The aim of this module is to cover the fundamentals of plant molecular biology and to explore applied aspects, including molecular systematics, molecular ecology, conservation genetics and genetic engineering.

ZOU33070 Experimental Design and Analysis (S2) 5 credits
Prof S Caldararu
This module will aim to put data collection and analysis in the context of research design and will be an important foundation for the Senior Sophister research project. The emphasis will be practical with a more 'hands on' approach rather than the theory of statistics. Initially students will be taught about experimental design, data collection and sampling. This will lead on to preliminary data exploration and issues of normality. Emphasis will be placed upon the importance of visually exploring the data prior to the use of statistical tests. Summary statistics, including measures of centre and spread, skewness, kurtosis, percentiles and boxplots, will be covered. Then the module will move on to explore the concept of hypothesis testing and the need to compare two or more means. This will involve the use of t-tests and analysis of variance. Other types of data will also be introduced including the analysis of frequencies. The relationship between two variables in the context of regression analysis will also be explored. Finally, a data set will be used to bring the entire process together starting with simple data exploration through summary statistics to more complex analyses. The module will also cover fundamentals of big data in ecology.

BOU33112 Botanical Diversity 1 (S2) 5 credits
Prof J McElwain
There are over 400,000 land plant species known to science. This module will explore the evolution and classification of land plants (embryophytes) and how to identify them in the field. By undertaking this module you will become acquainted with the evolutionary history, life cycle and general distinguishing attributes of the major land plant evolutionary groups:

Bryophytes (mosses, hornworts and liverworts), Monilophytes (ferns and fern alies), Lycophytes, Gymnosperms (e.g. conifers, cycads) and Angiosperms (flowering plants). The module will discuss evolutionary origins, various systems of classification, compare and contrast molecular and morphological phylogenetic signals and discuss various large groups of land plants with a particular focus on the most ancient (bryophytes) and the most recent and highly diverse (Angiosperms, flowering plants). This module will include laboratory practical classes, self-guided fieldwork and lectures. Students will produce their own herbarium plant collection on a small selection of native species in the Irish flora as part of the module.

BOU33121 Field Skills in Plant and Environmental Sciences (S2) **5 credits**
Profs P Moonlight, S Larragy, T Hodkinson, M Saunders
This module combines a lecture series with a residential field trip to the Canary Islands. The Canary Islands represent very different environments to Ireland: they have different ecology, different threats and pressures. They also contain highly variable landscapes and there are lots of different types of habitats in small area. In addition, they are home to many endemic species, particularly plants, which are not found anywhere else in the world, and face many man-made environmental challenges. The lecture series explores the geography, flora and fauna of the Canary Islands, as well as the history of the islands, and the impacts that humans have and continue to have on its ecosystems.

Junior Sophister Botany Open Modules

GSU33003: Ice Age Earth (S1) **5 credits**
Profs Robin Edwards and F Mitchell
The last 2.6 million years of Earth history have witnessed dramatic climatic and environmental changes. This module provides an overview of these major environmental changes, their causes, and their significance for human development. It contrasts 'glacial' and 'interglacial' worlds, examines the nature of the transitions between them, explores some potential causes of change, and illustrates their environmental impacts. In the process, a range of key environmental records are considered, along with the "proxies" used to develop them.

BOU33123 Soil Science (S1) **5 credits**
Prof M Saunders
Soils are important for plants as they provide the key resources required for growth and also essential structural support. This module will provide an overview of the fundamental concepts of soil formation and characterisation; how soil characteristics influence plant distribution and productivity through water and nutrient availability; how soil organisms (bacteria, fungi) interact with plants and how soils influence global biogeochemical cycles (carbon and nitrogen). Particular focus will be given to the role of soils in the production of food, fuel and fibre and how sustainable land management practices are required to ensure the long-term health and fertility of soil systems.

BOU33122 Entomology (S2) **5 credits**

Profs S Larragy

There are more species of insects on Earth than any other group of organisms and they are of massive ecological and economic importance. This module will address behavioural, social, ecological and applied aspects of entomology, including their role in delivering ecosystem services (such as biocontrol and pollination), invasive species (such as fire ants and harlequin ladybirds) and conservation (both in Ireland and internationally). The practicals will provide students with the skills for sampling and identification of insects, which will be further enhanced through an individual project.

ZOU33006 Ecology and Evolution of Infectious Diseases (S2) **5 credits**

Prof P Luijckx

The recent pandemic reminds us that diseases and parasites can do great harm to their hosts and thereby affect human health, food security and biodiversity. This course provides students with an understanding of the ecological and evolutionary principles that underly disease symptoms, emergence, and outbreak. Though a series of lectures, supplemented with practicals we will explore how natural selection acts on hosts and their pathogens, what factors facilitate disease outbreaks, and how we might prevent pathogens from escaping our control. Using examples in human medicine, animals, and plants we will explore: 1) why we get sick; 2) how diseases emerge; 3) super spreaders, individuals who generate many infections; 4) how global warming can alter the interaction between diseases and their host; 5) the evolution of antibiotic resistance and the evolution virulence; 6) evolution proofing our drugs; and 7) many other concepts in evolutionary medicine, ecology, and evolution.

BOU33105 Global Environmental Change **5 credits**

Profs M Saunders, J Waterman, R Nair and S Caldararu

The global environment is changing more rapidly at present than at any time during the human occupancy of the planet. This module will assess both the climatic and non-climatic drivers of global change and will focus on physical patterns within the atmosphere, climate change due to both natural and anthropogenic forcing mechanisms, and projections of future change at various spatial scales. Students will also explore key drivers of climate change with a focus on land use and land use change, and will examine the techniques used to develop historical climatic reconstructions, current assessments of biogeochemical cycling as climatic feedbacks in terrestrial and aquatic systems, the prediction of impacts of future climate change and how this information is used to develop key policy-based mitigation strategies.

BOU33126: Mycology **5 Credits**

Prof C Harper

Mycology, or the study of fungi and fungus-like organisms, is a fundamentally important aspect of biology that impacts nearly all of portions of our daily lives. From the food and drinks we enjoy (e.g., bread, beer, cheese) to medically important fungi, to the ecological roles that fungi play as symbionts, fungi are everywhere. This module will focus on the biology and taxonomy of fungi and fungus-like organisms (e.g., slime moulds, oomycetes, lichens), as well as an introduction to the ecological role(s) they play. There will be a focus on the mycological biodiversity of Ireland.

Senior Sophister Botany

Course Advisor: **Prof S Caldararu, caldaras@tcd.ie**

Senior Sophister Botany Course Structure

Botany	
Semester 1 (S1)	**Semester 2 (S2)**
Core Modules	
ZOU44030: Data Handling (5 credits)	BOU44110: The Evolution of Plants and Plant Atmosphere Interactions (5 credits)
BOU44060: Plant Breeding and Biotechnology (5 credits)	BOU44103: Plant Conservation and Biodiversity (5 credits)
BOU44109: Botanical Diversity 2 (5 credits)	FBU44000 Capstone Project (20 credits)
	BOU44112: Plants and the Planet (5 credits)
Choose two modules from the selection below	
BOU44107: Plant-Animal Interactions (5 credits) BOU44108 Plant Environment Interactions (5 credits) BOU44111: Restoration Ecology and Re-wilding (5 credits)	

ZOU44030 Data Handling (S1) **5 credits**

Prof A Jackson

Being able to form research questions and challenge our hypotheses by collecting and analysing data forms the basis of scientific inquiry. An understanding of data analysis is an essential skill set for all scientists. This module will consist of 2 tutorial sessions per week spanning all of semester 1. One of the tutorials each week will be used to develop class-directed questions relevant to current scientific thinking. As a class, we will form hypotheses, collect data and develop appropriate analytical techniques to answer our research questions. Concurrently, online material including video podcasts will be used to develop hands-on skills in the use of the very powerful and flexible statistics package R for data analysis. The module will start with basic probability theory, introduce different statistical distributions and culminate in learning how General Linear Models form a common framework for conceptualising and analysing your data.

At the end of the module you will have analysed a wide variety of data types and will have used the transferable and widely applicable statistics package R to analyse your data.

BOU44109 Botanical Diversity 2 (S1) **5 credits**

Prof P Moonlight

Flowering plants are the most species and biomass rich primary producers in most of the earth's land surface. They vary from parasitic or aquatic herbs to giant rainforest trees, each species with its own rich web of ecological interactions. The ability to identify flowering plants, first to major group, then to family, and then to species, is a fundamental tool in the toolkit of any botanist and ecologist. The scientific names we assign plants are the entire basis of our knowledge system in botany – *a rose by any other name may smell as sweet*, but without a name we cannot access any knowledge about that species. In this module, you will gain an understanding of the evolutionary history and morphological, anatomical, and ecological diversity of flowering plants. You will leave with the ability to identify flowering plants to the most ecologically important and species rich flowering plant families, before learning to find and use the resources required to identify it to species, including using traditional (books, herbaria) and modern (genetic) identification techniques. We will focus jointly on the flowering plants of Ireland and the world. This will be a "hands on" module, with both lectures and labs taking advantage of the world class living and reference collections in Trinity College Botanic Garden and Herbarium to ensure students have as much "plant contact time" as possible.

BOU44060 Plant-Breeding Biotechnology (S1) **5 credits**

Prof T Hodkinson

The module covers the principles and practice of plant breeding and biotechnology. Lectures cover key topics such as the origins of agriculture, genetic resources, disease resistance, conventional breeding, modern breeding, genetic engineering, plant microbiomes and case studies in breeding and biotechnology. Practicals cover crop diversity, polyploid estimation, crop microbiomes and at least one site visit to a Teagasc Research Centre (e.g Ashtown Dublin).

BOU44112 Plants and the Planet (S1) **5 credits**

Prof A Brazel

Plants have the power to shape the world around us, and how we utilise plants and the ecosystems in which they grow can have both positive and negative implications. This module, through a series of interactive tutorials, will allow students to further explore the research undertaken in the Botany department to better understand how this work and the plants and ecosystems involved are shaping the world in which we live. Furthermore, a key component of the module involes the Ecology, Evolution and the Environment seminar series, where invited speakers from across the globe will discuss their reseach in more detail.

BOU44103 Plant Conservation and Biodiversity (S2) **5 credits**

Prof T Hodkinson

Loss of biodiversity is one of the major problems facing humanity. The theoretical background to the evolution of plant diversity is firstly developed, and the principles of conservation are then used to develop approaches to conserve plant diversity. The module is taught through lectures and practical workshops.

BOU44110 The Evolution of Plants and Plant Atmosphere Interactions (S2) 5 credits
Prof J McElwain
We are currently experiencing major changes in our climatic and atmospheric environment. Conservative estimates project that the concentration of greenhouse gas carbon dioxide will double by the end of this century and global temperatures are expected to rise by 1 to 4 degrees C. A major issue facing the scientific and political community is understanding how these projected changes will influence natural ecosystems, plant and animal ecology and biodiversity. This module will explore the evolution of plants in the context of long-term changes in climate and atmospheric composition. Examples of plant-atmosphere and plant-climate interactions in the deep geological past will be examined in addition to modern experimental studies.

The course will provide a framework for understanding the nature and scale of evolution, adaptation and ecophysiological responses of plants to their atmospheric and climatic environment over the past 500 million years of Earth history. Continual assessment will be through a programme of tutorials and student reviews of primary research papers linked to lectures.

FBU44000: Research Project (S2) 20 credits
Prof R Rolfe and all Botany and Zoology staff
The project provides an important opportunity for students to plan and carry out a detailed and original piece of scientific research and communicate the results. It culminates in the production of a thesis and communication of the results through a poster presentation at an undergraduate research conference. Students will be assigned to a member of staff who will support an appropriate topic and will supervise the work. As part of the project students will be expected to outline clearly a scientific problem, review the associated literature, design and execute an appropriate research programme, analyse and present the results and draw clear conclusions and record progress in a notebook (physical or electronic as appropriate). Detailed guidance notes on writing and submitting the thesis and poster may be found on the FBU44000 Blackboard site. The FBU44000 module culminates in the submission of a thesis and presentation of a poster on the results.

Senior Sophister Botany Open Modules

BOU44107 Plant-Animal Interactions (S1) 5 credits
Prof J Waterman
In The Origin of Species (1859) Darwin emphasized that “plants and animals, most remote in the scale of nature, are bound together by a web of complex relations”. Plant-animal interactions have become increasingly recognized as drivers of evolutionary change and important components of ecological communities. This module will focus on pollination (the transfer of pollen between male and female reproductive structures in flowers) and herbivory (the consumption of plants by animals). The first half of the module will focus on antagonistic interactions between plants and herbivores, and explore plant and animal adaptations to herbivory, plant-herbivore dynamics and applications of interactions to ecosystem management.

The second part of the module will focus on plant-pollinator interactions, including pollinator-mediated evolution of floral traits, community level interactions, pollinator decline and conservation. Practical's will investigate plant and animal adaptations to herbivory, floral characteristics and adaptations for pollination and pollinator networks.

BOU44111 Restoration Ecology and Re-Wilding (S1) 5 credits
Prof M Collier

Restoration ecology, like conservation biology, is a 'crisis' discipline, having emerged as a science/practice response to the social and ecological impacts directly and indirectly driven by human activities. Restoration ecology has proven to be highly effective in some cases but has also given rise to some controversy as well as policy difficulties. In recent years the phrase 'rewilding' has emerged as a concept that embodies ecological restoration but with more future-oriented targets. Rewilding and novel ecosystems are new and controversial areas within restoration ecology making it difficult to know how and when to intervene. This module will introduce you to the challenges and opportunities, failings and fallacies of the complex world of restoration ecology, rewilding, and the work of restoration ecologists. It will look at how rewilding could be the most efficient of nature-based solutions and asks if this is feasible in the modern world. As the discipline struggles to navigate global climate issues, integrate with the social sciences, incorporate politics and economics, and derive policy actions, this module will draw on case studies of restoration globally to will challenge students to rethink ecology and ecosystems in the Anthropocene. It will also discuss areas of employment where students might consider after graduation, with some invited guests providing insight into the practice of restoration and rewilding.

BOU44108 Plant-Environment Interactions (S1) 5 credits
Profs M Saunders and C Harper

Plant growth is significantly influenced by the surrounding physical, chemical and biological environment. This module will address the key inter-related concepts of carbon assimilation and sequestration, plant water relations and energy balance components across the soil-plant-atmosphere continuum. Moreover, and as plants do not occur in isolation, this module will examine how fungi and fungus-like (e.g., Oomycota) interact with plants and the surrounding environment at multiple levels (soil interactions, roots, stems, leaves, and plant reproductive structures). The physiological response of plants to respond to a broad range of environmental conditions including abiotic and biotic extreme events will be explored, and the implications for natural and production-based systems will be assessed.

Botany Learning Outcomes

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

- Demonstrate in written, oral and visual form a foundation level of knowledge and understanding of the biological, physical and quantitative concepts underpinning Plant Sciences.
- Demonstrate awareness, particularly in relation to the contributions that plant science makes to society, such as maintaining biodiversity, assessing the impacts of global change, reducing environmental pollution, and ensuring sustainable food and energy production, taking into account scientific, social, political, moral and ethical considerations.
- Articulate the fundamental concepts in plant science.

- Discuss current research developments in plant science.
- Review and criticize published scientific information.
- Utilise innovative techniques and modern research facilities to develop combined theoretical and technical competence so enabling the development of high-quality independent research and of the ability to work accurately, efficiently and safely in both field and laboratory environments.
- Demonstrate numerical competency and the ability to analyse quantitative data by appropriate statistical tests, as well as the use of a programming language.
- Collaborate effectively in teams and work independently.
- Communicate accurately, clearly, persuasively and imaginatively, in both oral and written form.

[1] ESU33004 Scientific Communication will take place in semester 1 and semester 2; credits are applied in semester 2

Environmental Science

Junior Sophister Course Advisor: Prof J Piggott - jeremy.piggott@tcd.ie

Environmental Sciences is by its nature a multidisciplinary academic field, comprising a study of the frequently complex interactions between the biological, chemical and physical components of our environment. The environmental science discipline has evolved over the last numbers of decades as key environmental problems such as climate change, pollution, sustainable development, deforestation, and desertification to name a few, have become the focus of scientists, policy makers and the general public.

Environmental scientists have training that is similar to other physical or life scientists but is specifically applied to the environment. A broad scientific knowledge is required which involves a fundamental understanding of the physical and life sciences in addition to economics, law and the social sciences.

The undergraduate degree course offered by the School of Natural Sciences has been designed to provide for the needs of students with an interest in this rapidly developing academic and professional field. The programme comprises specially designed modules plus suitable modules from contributing disciplines.

Field study and laboratory skills represent a core component of the programme and these are blended with the theoretical content to provide our graduates with the training required to become highly successful practitioners in this field.

Environmental Sciences Learning Outcomes

Our mission is to:

- make you aware of the basic concepts, key challenges, and current research developments in Environmental Science.
- enable you to understand the basis of good experimental design.
- teach you to work efficiently and safely in laboratories.
- enable you to become a competent field researcher.
- teach you to critically analyse quantitative data.
- develop your written and oral communication skills.
- develop your skills to work effectively in a group and independently; and
- make you socially aware, particularly in relation to the contribution that Environmental Science makes to society.

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

- identify and describe plant and animal communities and analyse their distribution.
- demonstrate the principles of geochemical cycling in the global context with specific reference to environmental change.
- discuss the principles of hydrology and its relationship with groundwater quality.
- discuss the causes and effects of terrestrial, atmospheric, and marine pollution and present-day mitigation strategies.

- show a good working knowledge of skills and tools, such as spatial data analysis and statistical techniques, which can be used selectively to address complex problems, or to conduct closely guided research.
- identify, formulate, analyse, and suggest reasoned solutions to current environmental problems.
- design an Environmental Impact Assessment for a range of diverse habitats.
- critically assess scientific literature.
- work effectively as an individual, in teams and in multidisciplinary settings; and communicate effectively with both the scientific community and with society at large.

Junior Sophister Environmental Sciences Course Structure

<table>
<tr><th colspan="2">Environmental Sciences</th></tr>
<tr><th>Semester 1 (S1)</th><th>Semester 2 (S2)</th></tr>
<tr><th colspan="2">Core Modules</th></tr>
<tr><td colspan="2">ESU33004 Scientific Writing and Communication (5 credits)</td></tr>
<tr><td>BOU33108 Plants in the Irish Environment (5 credits)</td><td>BOU33105 Global Environmental Change (5 credits)</td></tr>
<tr><td>ZOU33010 Fundamentals of Ecology (5 credits)</td><td>GGU33931 Environmental Governance 1 (5 credits)</td></tr>
<tr><td>ESU33040 Environmental Monitoring (5 credits)</td><td>ZOU33070: Experimental Design and Analysis (5 credits)</td></tr>
<tr><td>BOU33123 Soil Science (5 credits)</td><td></td></tr>
<tr><th colspan="2">Open Modules – Option 1</th></tr>
<tr><td>GSU33003 Ice Age Earth (5 credits) OR
BOU33100 Plant Physiology (5 credits) OR
GLU33002 Blue Earth: Understanding the Function of Marine Ecosystems (5 credits) OR
BOU33114 Conservation Horticulture OR
BOU33126: Mycology</td><td rowspan="2">GLU33009 Hydrology and Groundwater Quality (5 credits) OR
BOU33121 Field Skills in Plant and Environmental Sciences (5 credits) OR
ZOU33086 Terrestrial Wildlife and Field Ecology (5 credits) OR
BOU33122: Entomology (5 credits) OR
ZOU33006: Ecology and Evolution of Infectious Diseases</td></tr>
<tr><td>Trinity Elective (5 credits)</td></tr>
<tr><th colspan="2">Open Modules - Option 2</th></tr>
<tr><td rowspan="2">GSU33003 Ice Age Earth (5 credits) OR
BOU33100 Plant Physiology (5 credits) OR
GLU33002 Blue Earth: Understanding the Function of Marine Ecosystems (5 credits) OR
BOU33114 Conservation Horticulture OR
BOU33126: Mycology</td><td>GLU33009 Hydrology and Groundwater Quality (5 credits) OR
BOU33121 Field Skills in Plant and Environmental Sciences (5 credits) OR
ZOU33086 Terrestrial Wildlife and Field Ecology (5 credits) OR
BOU33122: Entomology (5 credits) OR
ZOU33006: Ecology and Evolution of Infectious Diseases</td></tr>
<tr><td>Trinity Elective (5 credits)</td></tr>
<tr><th colspan="2">Environmental Sciences</th></tr>
<tr><th colspan="2">Open Modules- Option 3</th></tr>
<tr><td>GSU33003 Ice Age Earth (5 credits) OR
BOU33100 Plant Physiology (5 credits) OR
GLU33002 Blue Earth: Understanding the Function of Marine Ecosystems (5 credits) OR
BOU33114 Conservation Horticulture OR
BOU33126: Mycology</td><td>GLU33009 Hydrology and Groundwater Quality (5 credits) OR
BOU33121 Field Skills in Plant and Environmental Sciences (5 credits) OR
ZOU33086 Terrestrial Wildlife and Field Ecology (5 credits) OR
BOU33122: Entomology (5 credits) OR
ZOU33006: Ecology and Evolution of Infectious Diseases</td></tr>
<tr><td>Trinity Elective (5 credits)</td><td>Trinity Elective (5 credits)</td></tr>
</table>

Junior Sophister Environmental Sciences Core Modules

BOU33108 PLANTS AND THE IRISH ENVIRONMENT (S1) **5 credits**
Profs M Collier, F Mitchell, T Hodkinson, J McElwain, M Saunders, S Larragy
This module combines an introduction to the Botany and Environmental Sciences moderatorships with a series of field-based activities including a residential field trip during the first week of the teaching term (Week 3). There will also be a series of lectures given following the field trip on specific aspects of the Irish flora.

ZOU33010 FUNDAMENTALS OF ECOLOGY (S1) **5 credits**
Profs I Donohue and F Mitchell
This module examines the factors that affect the distribution, growth and survival of plant and animal communities. It describes how organisms interact with their environment and the role that they have in ecosystem and community structure. There is an introduction to the concepts and models that help to explain and predict organism distributions and interactions. The module comprises interrelated components of lectures, practical sessions and fieldwork. It has been designed to provide a foundation to ecological theory and its application.

ESU33040 ENVIRONMENTAL MONITORING (S1) **5 credits**
Prof J Piggott
This module covers the tools and sampling approaches, both traditional and novel, used to characterize and monitor the quality of the environment across Europe. Students will be provided with relevant background information to understand the principles and applications of monitoring programmes. Techniques taught encompass the collection and analysis of chemical and biological samples and their application to environmental quality indices. Students will have the opportunity to apply some of these techniques during two field trips (freshwater and marine) and to a range of sample types (water, sediment, invertebrates) in subsequent laboratory sessions. Field trips will conclude with a written report, detailing student's findings in a scientific format.

BOU33123 SOIL SCIENCE (S1) **5 credits**
Prof M Saunders
Soils are important for plants as they provide the key resources required for growth and also essential structural support. This module will provide an overview of the fundamental concepts of soil formation and characterisation; how soil characteristics influence plant distribution and productivity through water and nutrient availability; how soil organisms (bacteria, fungi) interact with plants and how soils influence global biogeochemical cycles (carbon and nitrogen). Particular focus will be given to the role of soils in the production of food, fuel and fibre and how sustainable land management practices are required to ensure the long-term health and fertility of soil systems.

BOU33105 Global Environmental Change **5 credits**
Profs M Saunders and J Waterman, R Nair and S Caldararu
The global environment is changing more rapidly at present than at any time during the human occupancy of the planet. This module will assess both the climatic and non-climatic drivers of global change and will focus on physical patterns within the atmosphere, climate

change due to both natural and anthropogenic forcing mechanisms, and projections of future change at various spatial scales. Students will also explore key drivers of climate change with a focus on land use and land use change, and will examine the techniques used to develop historical climatic reconstructions, current assessments of biogeochemical cycling as climatic feedbacks in terrestrial and aquatic systems, the prediction of impacts of future climate change and how this information is used to develop key policy-based mitigation strategies.

GGU33931 ENVIRONMENTAL GOVERNANCE 1 (S2) 5 credits
Prof R Rowan
The "environment" emerged as a new object of concern in the 1960s. Since then, and largely through the work of citizens, scientists, environmental justice movements, and NGOs, many different environmental problems have come to light - from chemical contamination to climate change, from oil spills to plastic-filled oceans. Despite growing awareness of these many forms of environmental degradation and risk, the political and societal response has been far from adequate. How can we explain this? One starting point is to interrogate the contested history and development of environmental politics since the 1960s. What we learn from such an approach is that there have been radically different ways of framing environmental problems, giving rise to radically different proposals on how to deal with these problems. This historically informed understanding thus invites us to consider how re-framing current environmental problems may help us to orientate society towards a more just and sustainable future.

This module will introduce students to the emergence of environmental politics as a unique field of policymaking, scientific production, and conflict since the 1960s. It will discuss key texts, writers and thinkers, whose work has been instrumental in shaping how we think about the environment, as well as how private, public and civil society actors have responded to environmental problems in recent times.

ZOU33070 EXPERIMENTAL DESIGN AND ANALYSIS (S2) 5 credits
Prof S Caldararu
This module will aim to put data collection and analysis in the context of research design and will be an important foundation for the Senior Sophister research project. The emphasis will be practical with a more 'hands on' approach rather than the theory of statistics. Initially students will be taught about experimental design, data collection and sampling. This will lead on to preliminary data exploration and issues of normality. Emphasis will be placed upon the importance of visually exploring the data prior to the use of statistical tests. Summary statistics, including measures of centre and spread, skewness, kurtosis, percentiles and boxplots, will be covered. Then the module will move on to explore the concept of hypothesis testing and the need to compare two or more means. This will involve the use of t-tests and analysis of variance. Other types of data will also be introduced including the analysis of frequencies. The relationship between two variables in the context of regression analysis will also be explored. Finally, a data set will be used to bring the entire process together starting with simple data exploration through summary statistics to more complex analyses. The module will also cover fundamentals of big data in ecology.

ESU33004: SCIENTIFIC WRITING AND COMMUNICATION (S1 & S2) **5 credits**

Profs P Luijckx and C Harper

Scientific communication and writing are used to communicate knowledge to other researchers through the publication of research articles, reports and oral and poster presentations. Writing such articles or essays and presenting scientific results can be difficult and challenging. The aim of this module is to introduce students to scientific writing, presentation techniques and responsible use of AI. Throughout the duration of both semesters, students will be presented with a brief overview of the steps involved in reading, publishing, organising, and disseminating research findings. To experience this process students will undertake desk-based research, using scientific literature to synthesise and write an extended essay on a selected topic of interest related to a key challenge in Environmental Science, Botany or Zoology (depending on your discipline). The finished essay will consist of a general-format scientific review article.

Junior Sophister Environmental Sciences Open Modules

GSU33003: ICE AGE EARTH (S1) **5 credits**

Prof R Edwards

The last 2.6 million years of Earth history have witnessed dramatic climatic and environmental changes. This module provides an overview of these major environmental changes, their causes, and their significance for human development. It contrasts 'glacial' and 'interglacial' worlds, examines the nature of the transitions between them, explores some potential causes of change, and illustrates their environmental impacts. In the process, a range of key environmental records are considered, along with the "proxies" used to develop them.

BOU33100 PLANT PHYSIOLOGY (S1) **5 credits**

Prof J Waterman

This module covers major biochemical and physiological processes in plants which control plant function and underly plant diversity, with a focus on photosynthesis. Students will be introduced to concepts in plant physiology at cell, leaf, and whole plant level as an introduction to the field of plant physiology and as underlying principles across botany and environmental science. Continual assessment for this module will be a mini review on a given subject area relevant to photosynthesis, and an exercise in writing a scientific paper from raw data from a growth study of plants maintained at different light intensities.

GLU33002: BLUE EARTH: UNDERSTANDING THE FUNCTION OF MARINE ECOSYSTEMS (S1)
5 credits

Prof C Rocha

This is an introductory course in marine biogeochemistry. The ocean plays a central role in Earth's climate system, and marine biogeochemical processes regulate the impact of human activity on the global environment. Marine biogeochemistry hence provides a working knowledge of how the earth system functions and reacts to human activity, providing insights into how life formed, evolved, is sustained, and is endangered on Earth. This knowledge provides an understanding of how to adapt to climate and environmental change, enhance food production, manage fisheries and aquaculture, mitigate pollution, and innovate by developing new products including more sustainable food and decarbonation technologies.

This module concentrates on the marine biogeochemical phenomena that regulate the earth's climate and control the diversity, distribution, and productivity of marine life. Topics covered include the physical, biological, geological, and chemical processes that control the creation, distribution, and fate of organic matter in the marine environment, the composition of seawater and the atmosphere, and the formation and preservation of marine sediments. The course will prepare students for related courses, field and laboratory work in the marine, earth, and environmental sciences and careers in the marine & environmental sector.

BOU33114 CONSERVATION HORTICULTURE (S1)
J McElwain
The loss of plant diversity is happening at an extraordinarily fast rate, the urgent need for conservation action has never been so crucial. Botanic Gardens are well-positioned to take on this challenge – they have a large pool of specialist horticultural expertise trained in propagation and cultivation techniques, scientific staff with an understanding of population and genetic basis of a conservation collection, and the accurate record-keeping and management of genetically representative living plant collections – skills and knowledge essential to the successful recovery of threatened plant species. Conservation horticulture is an emerging field in plant science that brings together the disciplines of conservation and horticulture. It remains formally undefined; however we define it here, as the practice within mainly Botanic Gardens and Arboreta of targeting, collecting and maintaining living plant collections that are representative of the genetic diversity of wild populations for ex situ conservation and habitat restoration purposes. This unique, timely and highly practical-focused module will be co-taught by staff at Trinity College Botanic Garden, Trinity Botany Department and the National Botanic Gardens, Glasnevin. Five practical sessions in hands-on conservation horticulture will be held at NBG and TCBG. 10 lectures will cover theory and both global and national case studies. One optional full Saturday field excursion will show case examples of good conservation horticulture practice in Ireland.

GLU33009 HYDROLOGY AND GROUNDWATER QUALITY (S2) 5 credits
Dr Eyad Abushandi
This module covers theoretical concepts and analytic practices of catchment hydrology and groundwater quality. The hydrology component of this module includes the following topics: the hydrological cycle, catchment water balances; precipitation, evapotranspiration; soil water, hillslope hydrology; river flow; hydrogeology; and groundwater – surface water interaction. The groundwater quality component includes groundwater flow, chemistry, and quality problems. The interaction of groundwater and surface water quality is also considered. The module involves computer demonstrations to conduct geo-spatial hydrologic analyses. As an integral part, the module includes a local field trip to conduct flow measurements.

BOU33121 FIELD SKILLS IN PLANT AND ENVIRONMENTAL SCIENCE (S2) 5 credits
Profs P Moonlight, S Larragy, T Hodkinson and M Saunders
This module combines a lecture series with a residential field trip to the Canary Islands. The Canary Islands represent very different environments to Ireland: they have different ecology, different threats and pressures. They also contain highly variable landscapes and there are lots of different types of habitats in small area. In addition, they are home to many endemic species, particularly plants, which are not found anywhere else in the world, and face many

man-made environmental challenges. The lecture series explores the geography, flora and fauna of the Canary Islands, as well as the history of the islands, and the impacts that humans have and continue to have on its ecosystems.

ZOU33086 Terrestrial Wildlife and Field Ecology (S2) 5 credits
Prof J Barnett
This two-part module begins with a series of lectures in Hilary Term, which offer an introduction to terrestrial biodiversity and wildlife biology, both globally and regionally. Topics covered will include: assessment of biodiversity from individual, population, community and landscape scales and the importance of foraging ecology, habitat selection, inter- and intra-specific competition, territoriality, dispersion, population dynamics and regulation for determining diversity and distribution of animals. There will also be a particular focus on the origins, development and current status of the Irish vertebrate fauna. The lecture series will be complemented, in week 35 (tbc), by a five day residential field course in Glendalough, Co. Wicklow, during which field techniques used for the study of terrestrial ecosystems will be introduced, with an emphasis on habitat and population assessment of mammals, insects and birds and their interactions with plants and the abiotic environment. Field visits will help with an understanding of contrasting habitats and approaches to conservation management. Students will carry out and present a mini-project during the last two days of the course.

BOU33122 Entomology (S2) 5 credits
Profs S Larragy
There are more species of insects on Earth than any other group of organisms and they are of massive ecological and economic importance. This module will address behavioural, social, ecological and applied aspects of entomology, including their role in delivering ecosystem services (such as biocontrol and pollination), invasive species (such as fire ants and harlequin ladybirds) and conservation (both in Ireland and internationally). The practicals will provide students with the skills for sampling and identification of insects, which will be further enhanced through an individual project.

BOU33126: Mycology 5 Credits
Prof C Harper
Mycology, or the study of fungi and fungus-like organisms, is a fundamentally important aspect of biology that impacts nearly all of portions of our daily lives. From the food and drinks we enjoy (e.g., bread, beer, cheese) to medically important fungi, to the ecological roles that fungi play as symbionts, fungi are everywhere. This module will focus on the biology and taxonomy of fungi and fungus-like organisms (e.g., slime moulds, oomycetes, lichens), as well as an introduction to the ecological role(s) they play. There will be a focus on the mycological biodiversity of Ireland.

ZOU33006 Ecology & Evolution of Infectious Diseases (S2) 5 credits
Dr Pepijn Luijckx
The recent pandemic reminds us that diseases and parasites can do great harm to their hosts and thereby affect human health, food security and biodiversity. This course provides students with an understanding of the ecological and evolutionary principles that underly disease symptoms, emergence, and outbreak. Though a series of lectures, supplemented

with practicals we will explore how natural selection acts on hosts and their pathogens, what factors facilitate disease outbreaks, and how we might prevent pathogens from escaping our control. Using examples in human medicine, animals, and plants we will explore: 1) why we get sick; 2) how diseases emerge; 3) super spreaders; individuals who generate many infections; 4) How global warming can alter the interaction between diseases and their hosts; 5) the evolution of antibiotic resistance and the evolution virulence; 6) evolution proofing our drugs; and 7) many other concepts in evolutionary medicine, ecology, and evolution.

Senior Sophister Environmental Sciences

Course Advisor: Prof Jeremy Piggott - jeremy.piggott@tcd.ie

Senior Sophister Environmental Sciences Course Structure

<table>
<tr><th colspan="2">Environmental Sciences</th></tr>
<tr><th>Semester 1 (S1)</th><th>Semester 2 (S2)</th></tr>
<tr><th colspan="2">Core Modules</th></tr>
<tr><td>ZOU44030 Data Handling (5 credits)</td><td rowspan="3">FBU44000: Capstone Project (20 credits)</td></tr>
<tr><td>ZOU44092 Environmental Impact Assessment (5 credits)</td></tr>
<tr><td>BOU44111 Restoration Ecology and re-wilding (5 credits)</td></tr>
<tr><td colspan="2">ZOU44060 Research Comprehension (5 credits)</td></tr>
<tr><td colspan="2">ESU44052 General Environmental Sciences (5 credits)</td></tr>
<tr><th colspan="2">Open Modules
Students will choose 3 modules</th></tr>
<tr><th>Semester 1</th><th>Semester 2</th></tr>
<tr><td>ZOU44021 Tropical Ecology and Conservation (5 Credits)
BOU44107 Plant-Animal Interactions (5 Credits)
BOU44108 Plant Environment Interactions (5 credits)
ZOU44013 Conservation and Wildlife Management (5 Credits)
ESU44054 Spatial Analysis using GIS (5 Credits)</td><td>BOU44103 Plant Conservation and Biodiversity (5 Credits)
GGU44927 Environmental Governance 2 (5 Credits)**</td></tr>
</table>

**** This module has a quota of 5 students**

ZOU44030 DATA HANDLING (S1) 5 credits

Coordinator: Prof A Jackson

Being able to form research questions and challenge our hypotheses by collecting and analysing data forms the basis of scientific inquiry. An understanding of data analysis is an essential skill set for all scientists. This module will consist of 2 tutorial sessions per week spanning all of semester 1. One of the tutorials each week will be used to develop class-directed questions relevant to current scientific thinking. As a class, we will form hypotheses,

collect data and develop appropriate analytical techniques to answer our research questions. Concurrently, online material including video podcasts will be used to develop hands-on skills in the use of the very powerful and flexible statistics package R for data analysis. The module will start with basic probability theory, introduce different statistical distributions and culminate in learning how General Linear Models form a common framework for conceptualising and analysing your data. At the end of the module you will have analysed a wide variety of data types and will have used the transferable and widely applicable statistics package R to analyse your data.

ZOU44092 ENVIRONMENTAL IMPACT ASSESSMENT (S1) 5 credits
Prof P Murphy
This module involves an introduction to the principles and processes of Environmental Impact Assessment, particularly in relation to national and international requirements. All stages of the EIA process, from initial project screening to the final review, are covered, with the emphasis throughout on the role of the natural scientist. Strategic Environmental Assessment and Appropriate Assessment are also covered. In addition to the lectures, students carry out a group scoping exercise for a proposed development and conduct a quality review of an actual EIAR.

ZOU44060 RESEARCH COMPREHENSION (S1 & S2) 5 credits
Prof P Murphy
No matter what you do when you graduate, in most jobs you will be expected to read, understand and interpret data. Often this will be in a subject you are unfamiliar with or will use unfamiliar methods or study organisms. The aim of this module is to help you to develop the ability to understand and interpret research from a broad range of scientific areas, and then to develop opinions about this research and how it fits into the "big picture". This module also aims to improve your ability to communicate all kinds of scientific research to a general audience, a skill that is currently in great demand.

BOU44111 RESTORATION ECOLOGY AND RE-WILDING (S1) 5 credits
Prof M Collier
Restoration ecology, like conservation biology, is a 'crisis' discipline, having emerged as a science/practice response to the social and ecological impacts directly and indirectly driven by human activities. Restoration ecology has proven to be highly effective in some cases but has also given rise to some controversy as well as policy difficulties. In recent years the phrase 'rewilding' has emerged as a concept that embodies ecological restoration but with more future-oriented targets. Rewilding and novel ecosystems are new and controversial areas within restoration ecology making it difficult to know how and when to intervene. This module will introduce you to the challenges and opportunities, failings and fallacies of the complex world of restoration ecology, rewilding, and the work of restoration ecologists. It will look at how rewilding could be the most efficient of nature-based solutions and asks if this is feasible in the modern world. As the discipline struggles to navigate global climate issues, integrate with the social sciences, incorporate politics and economics, and derive policy actions, this module will draw on case studies of restoration globally to will challenge students to rethink ecology and ecosystems in the Anthropocene. It will also discuss areas of employment where students might consider after graduation, with some invited guests providing insight into the practice of restoration and rewilding.

ESU44052 GENERAL ENVIRONMENTAL SCIENCES (S1 & S2) 5 credits
Prof J Piggott
This module provides an opportunity for students to build on the content covered throughout the Sophister Environmental Sciences programme, and to explore in greater detail the key challenges facing Environmental Scientists today. Conference attendance (Environmental Science Association of Ireland Annual Meeting) during Semester 2 connects theory with practice in the environmental sciences field. Students are expected to integrate their approach to this material with the perspectives and skills they develop during their Sophister years. Appropriate literature relating to the Junior and Senior Sophister core (mandatory) modules will be recommended for detailed study.

FBU44000: Research Project (S2) 20 credits
Prof R Rolfe and all Botany and Zoology staff
The project provides an important opportunity for students to plan and carry out a detailed and original piece of scientific research and communicate the results. It culminates in the production of a thesis and communication of the results through a poster presentation at an undergraduate research conference. Students will be assigned to a member of staff who will support an appropriate topic and will supervise the work. As part of the project students will be expected to outline clearly a scientific problem, review the associated literature, design and execute an appropriate research programme, analyse and present the results and draw clear conclusions and record progress in a notebook (physical or electronic as appropriate). Detailed guidance notes on writing and submitting the thesis and poster may be found on the FBU44000 Blackboard site. The FBU44000 module culminates in the submission of a thesis and presentation of a poster on the results.

ZOU44021 TROPICAL ECOLOGY AND CONSERVATION (S1) 5 credits
Prof I Donohue
The module comprises of a short lecture series followed by a ten-day residential field course in East Africa that will run during the reading week mid-end October. The course will focus on the ecology and biodiversity of a range of ecosystems and habitats (including tropical mountain forest, aquatic ecosystems [freshwater rivers and lakes, wetlands and saline lakes] and grasslands) and the connectivities among them. Issues and problems to do with human impacts and the conservation and management of these diverse habitats will also comprise an important element of the course.

BOU44107 Plant-Animal Interactions (S1) 5 credits
Prof J Waterman
In The Origin of Species (1859) Darwin emphasized that “plants and animals, most remote in the scale of nature, are bound together by a web of complex relations”. Plant-animal interactions have become increasingly recognized as drivers of evolutionary change and important components of ecological communities. This module will focus on pollination (the transfer of pollen between male and female reproductive structures in flowers) and herbivory (the consumption of plants by animals). The first half of the module will focus on antagonistic interactions between plants and herbivores, and explore plant and animal adaptations to herbivory, plant-herbivore dynamics and applications of interactions to ecosystem management. The second part of the module will focus on plant-pollinator

interactions, including pollinator-mediated evolution of floral traits, community level interactions, pollinator decline and conservation. Practical's will investigate plant and animal adaptations to herbivory, floral characteristics and adaptations for pollination and pollinator networks.

BOU44108: Plant-Environment Interactions (S1) 5 credits
Profs M Saunders and C Harper
Plant growth is significantly influenced by the surrounding physical, chemical and biological environment. This module will address the key inter-related concepts of carbon assimilation and sequestration, plant water relations and energy balance components across the soil-plant-atmosphere continuum. Moreover, and as plants do not occur in isolation, this module will examine how fungi and fungus-like (e.g., Oomycota) interact with plants and the surrounding environment at multiple levels (soil interactions, roots, stems, leaves, and plant reproductive structures). The physiological response of plants to respond to a broad range of environmental conditions including abiotic and biotic extreme events will be explored, and the implications for natural and production-based systems will be assessed.

ZOU44013: CONSERVATION AND WILDLIFE MANAGEMENT (S1) 5 credits
Prof P Murphy
This module, which consists of both lectures and tutorials, looks at some of the practical applications of wildlife biology to the conservation and management of animals, both in- and ex-situ, including the role of zoos in captive breeding programmes. Among the topics covered are: planning for wildlife management, the principles of managing wildlife for sustainable harvest or control, management of scarce or endangered species, practical issues associated with the ex-situ management of species, and the design and management of conservation areas. In the second part of the module, we will concentrate on anthropogenic impacts on biodiversity conservation, including the development and implementation of biodiversity conservation strategies in the wake of the Convention on Biological Diversity, other national and international wildlife legislation, biosecurity and the role of Invasive Alien Species, Biological Data Management and the development of Species Action Plans, and the role of reintroductions in biodiversity conservation.

ESU44054: SPATIAL ANALYSIS USING GIS (S1) 5 credits
Prof P Morrissey
This module introduces students to the framework and methods used in real-life problems related to the field of Spatial Analysis by applying the theoretical knowledge gathered during the module to live project work. The module seeks to impart the necessary skills and knowledge to enable graduates to engage as team members and leaders in the types of large and complex sustainable environment projects that are increasingly being planned across the world. It aims to help fill a major and increasingly obvious skills gap. A unique feature of this module is the use of Dublin and Ireland as a learning laboratory, where the students will take responsibility of a project. The Spatial Analysis using GIS Module is designed to introduce the student to spatial analysis using a widely used Geographic Information Systems (GIS) platform.

BOU44103 Plant Conservation and Biodiversity (S2) 5 credits
Prof T Hodkinson
Loss of biodiversity is one of the major problems facing humanity. The theoretical background to the evolution of plant diversity is firstly developed, and the principles of conservation are then used to develop approaches to conserve plant diversity. The module is taught through lectures and practical workshops.

GGU44927 ENVIRONMENTAL GOVERNANCE 2 (S2) 5 credits
Prof R Rowan
There is little disagreement that far-reaching societal, technological, political, and economic transformations are required if we are to avoid the worst effects of global, anthropogenic environmental change. What form these transformations should take and who should take responsibility for them are questions that are, however, far from settled. This module considers some of the key conceptual debates and environmental conflicts arising in this context. Examination of these debates and conflicts will demonstrate the contested and uneven nature of environmental change and the measures sought to address these changes.

The overall aim of the module is to help students develop a more nuanced, critical and multi-disciplinary understanding of environmental change and the different, often contested, ways of responding to such changes.

The module will consist of weekly interactive lectures/seminars, guest lectures, and set readings. Lectures will introduce students to key concepts and perspectives drawn from the broad field of political ecology. Each week part of the class will be set aside for students to develop their research projects. These projects will focus on a key area of environmental contestation in Ireland through a political ecology lens. The projects will involve group work and individual work, written assignments, oral presentations, and primary research. ****This module has a quota of 5 students**

Genetics

Junior Sophister Course Advisor: Prof Juan Pablo Labrador - labradoj@tcd.ie

Description of Moderatorship:

What is Genetics?

Genetics is the study of genes, genomes and heredity. It has developed rapidly in the last decade as new technology has made it possible to study genes in much greater detail and to rap

- The application of gene editing to plant and bacterial systems for biotechnology -The detailed description of the evolutionary relationships of all organisms
- The application of DNA fingerprinting to forensic science
- The development of CRISPR technology for genome editing

Genetics: The course for you?

If you are interested in understanding the principles of inheritance; how genetic mechanisms control different developmental and physiological processes in biology; and how a perturbation of these mechanisms leads to disorders and diseases, this is the right course for you.

Genetics @ Trinity

Genetics is run by the Department of Genetics, which is part of the School of Genetics and Microbiology and is located in the Smurfit Institute of Genetics with state-of-the-art research facilities. There are 14 members of faculty and a number of academic associates, working in a wide range of areas of Genetics areas covering everything from medical genetics, pharmacogenomics, stem cells to evolutionary genetics, bacterial and plant genetics, amongst other areas. The Department of Genetics has an international reputation for high-quality research and more than 50 years of experience in teaching Genetics to undergraduate students. The teaching of the Department is research-driven; undergraduates are taught by research-active scientists with excellent track records in their chosen fields.

Graduate skills and career opportunities

Many Genetics graduates go on to higher degrees (M.Sc. and/or Ph.D.) and take up careers in research in either academia or industry. Opportunities exist in biotechnology and pharmaceutical companies, agricultural organisations, medical or clinical diagnostic laboratories, forensics, public health and epidemiology programmes, and in teaching. Other graduates have gone into careers such as medicine, patent law or science journalism. Even if you choose a career not directly related to the scientific subject, the skills of critical thinking and problem solving provided by the Genetics degree will put you in high demand.

Your degree and what you'll study

During third year, students will learn about the fundamentals of genetics through a combination of lecture courses and practical classes. To this end, students will be exposed to different areas of genetics ranging from bacterial genetics, to plant genetics, to medical genetics. Practical classes teach the students about key techniques and analysis methods

that are widely used in genetics laboratories. In fourth year, students can choose, largely depending on their interests, from a number of lecture courses on different areas of genetics. They also spend 10 to 12 weeks in a laboratory of the institute and participate in ongoing research projects. They further write an in-depth literature review on a current topic of genetics.

Junior Sophister Genetics Course Structure

Genetics	
Semester 1	**Semester 2**
Modules	
MIU33302 - Molecular genetics I - Regulation of gene expression (5 credits)	GEU33301 Bioinformatics (5 credits)
GEU33007 Molecular Genetics Laboratory (5 credits)	GEU33303 - Molecular genetics II - Genome structure and dynamics (5 credits)
GEU33075 Evolutionary and Population Genetics (5 credits)	GEU33008 Analytical Genetics Laboratory (5 credits)
GEU33085 Science Structure, Discussion and Presentation for Genetics (5 credits)	GEU33035 Genetic Analysis of Nervous Systems (5 credits)
Open Modules Scenario I	
GEU33045 Genomics and Systems Biology (5 credits)	GEU33055 Developmental Genetics (5 credits)
Trinity Elective (5 credits)	GEU33215 Medical Genetics (5 credits) **OR** BIU33250 Introduction to Immunology and Immunometabolism (5 credits) **OR** BIU33475 Basic Neurobiology (5 credits)
Open Modules Scenario II	
GEU33045 Genomics and Systems Biology (5 credits)	GEU33055 Developmental Genetics (5 credits)
BIU33150 Biochemistry for Biosciences (5 credits)	Trinity Elective (5 credits)
Open Modules Scenario III	
GEU33045 Genomics and Systems Biology (5 credits)	GEU33055 Developmental Genetics (5 credits)
Trinity Elective (5 credits)	Trinity Elective (5 credits)

Junior Sophister Genetics Core Modules

MIU33302 Molecular genetics I - Regulation of gene expression (S1) 5 credits
Instructors: Kevin Mitchell**,** Carsten Kröger, Mani Ramaswami, Adrian Bracken

Module Description: This module will examine the principles and processes of regulation of gene expression, in prokaryotes and eukaryotes. It will be anchored around the problems that organisms have to solve in order to survive. These include modulating the cellular economy and maintaining homeostasis in response to dynamically changing internal and external states. This is crucial in microbes for adapting to environmental change and in multicellular organisms for coordinating cellular differentiation and development and regulating cellular, tissue-level and organismal physiology. The module will cover mechanisms and principles of regulation of transcription, chromatin regulation, gene regulatory motifs and networks, mRNA splicing, mRNA turnover, translation, non-coding RNA functions, and protein folding and localisation..

Assessment: 50% Group project and 50% end of semester examination.

GEU33007 Molecular Genetics Laboratory (S1) 5 credits
Instructor: Kevin Mitchell, Mike Dolan, David Noone

Module Description: The module comprises a set of robust experiment-based projects in microbial and molecular genetics. The central theme is gene expression and its regulation. In the labs, students work in groups of two performing successive experiments in two or three different projects during each session. The experiments provide invaluable hands-on experience of widely used experimental strategies and techniques in molecular genetics/ molecular biology, which include: the isolation and purification of genomic and plasmid DNA; the polymerase chain reaction (PCR); the use of agarose and polyacrylamide gel electrophoresis in the analysis of DNA, RNA and proteins; genetic transformation of E. coli; gene cloning and analysis in plasmid vectors; lacZ, GUS and GFP reporter gene assays; transduction etc.

Assessment: 100% continuous assessment.

GEU33075 Evolutionary and Population Genetics (S1) 5 credits
Instructors: Lara Cassidy, Russell McLaughlin, Ross McManus

Module Description: This module provides an in-depth exploration of genetic variation, from its origins to its evolutionary consequences. The information in DNA is not always transmitted accurately from one generation to the next. DNA sequences can change spontaneously by the process of mutation and inaccurate DNA repair, resulting in genetic variation (polymorphism) within populations. Variable sites at different positions in the genome get shuffled into new combinations by the process of genetic recombination that occurs during sexual reproduction. Whether a particular allele survives for a long time in a population or goes extinct depends on the evolutionary forces acting on the population.

If a new allele is advantageous to the population, Darwinian natural selection will tend to increase its frequency in the population; alternatively, if the new allele is disadvantageous natural selection will tend to eliminate it. However, selection is only one of several evolutionary processes that change allele frequencies within populations over generations. In this module, students will learn about the origin of genetic variation, its distribution within populations and long-term changes brought about by evolutionary processes.

Assessment: This module will be graded through an invigilated MCQ examination (60%) and continual assessment (40%).

GEU33085 Science Structure Discussion and Presentation for Genetics
(S1) 5 credits
Instructors: Adrian Bracken, Dan Bradley, Matthew Campbell, Lara Cassidy, Jane Farrar, Seamus Martin, Kevin Mitchell, Juan Pablo Labrador, Aoife Mc Lysaght, Russell Mc Laughlin, Mani Ramaswami, Frank Wellmer, Mike Dolan

Module Description: In this module students meet in small groups with lecturers for discussion and problem-solving in an informal setting. Topics include genetic or medical genetics analysis, mathematical genetics, medical genetics and ethics. Students will also write a review of the recent literature in a particular area of genetics research, supervised by individual members of the academic staff. The objective of the review is to bring the reader up-to-date on the subject under review. In addition the module will have discussion of how to research, design and write a literature review and how to make an effective scientific presentation. Students will make a 10 minute presentation on a paper within the topic of their literature review at the annual field-trip GEU33100.

Assessment: 100% continuous assessment.

GEU33301 Bioinformatics (S2) 5 credits
Instructors: Karsten Hokamp, Carsten Kröger, Máire Ní Leathlobhair, Fiona Roche

Module Description: This module is taught in combination with the Microbiology department and contains web-based bioinformatics, Python programming and a data handling component. Lectures will be held in computer labs to enable a hands-on approach. The bioinformatics component provides a practical introduction to the use of commonly used bioinformatic databases and tools with a focus on web-based applications. Students will become familiar with accessing biological sequence databases and exploring various sequence analysis tools to understand evolutionary relationships and how this can help to draw protein functional and structural inferences. The Python programming component introduces students to computer programming in Python using bioinformatics-related examples and exercises. It will be carried out within an internal JupyterLab environment.

The data handling part contains a biolab component in which samples will be prepared for whole-genome sequencing (WGS). The combined lectures and practicals cover basic techniques for processing next-generation sequencing data and, more specifically, approaches for the analysis of WGS data.

Assessment: (1) A bioinformatics exam 33%, (2) a Python programming exam 33% and (3) a report based on NGS data analysis with an R programming component 34%

GEU33303 Molecular genetics II - Genome structure and dynamics (S2) 5 credits
Instructors: Frank Wellmer, Fergal Hamrock
Module Description: The aim of this module is to introduce students to fundamental concepts in Molecular Genetics. By focusing on plant and microbial genetics, we want to highlight the overlap between these seemingly disparate biological systems. The microbial genetics component will focus on critical regulatory aspects of the gene expression machinery (transcription and translation), and genome replication (DNA replication, homologous recombination, mutagenesis and DNA repair). In relation to plant genetics, students will be introduced to major topics such as the structure and evolution of the nuclear genome, the importance of model plants, including Arabidopsis thaliana, light-regulated gene expression, hormone receptors and signal transduction systems. The evolutionary origins of plant cell organelles (chloroplasts and mitochondria) via endosymbiosis involving ancestral microbes will also be explored as will be the many facets of plant-microbe interactions including plant immunity and symbiosis.

Assessment: 100% end of semester examination

GEU33035 Genetic Analysis of Nervous Systems (S2) 5 credits
Instructors: Juan Pablo Labrador, Mani Ramaswami

Module Description: The module is focused on understanding how experimental genetics are used to manipulate genes in organisms to address problems in biology. Areas covered are 1) Experimental Genetics: structure and conservation of genes, nature of mutations and their effects on protein structure and function, model organisms in genetic research and experimental manipulation of animal genomes. 2) Developmental Neurogenetics: the purpose and design of genetic screens, genetic analysis of neurogenesis and genetic analysis of axon guidance 3) Behavioral Genetics: cell organization and methods of cell biology, cell biology of neurons and synapses, creation and use of molecular reporters of specific gene or cell activity, methods to study nervous systems, sensory circuits, sensation; transduction; perception; coding; behavior, learning and memory, sleep and circadian rhythms.

Assessment: 100% Continuous assessment.

GEU33008 Analytical Genetics Laboratory (S2) 5 credits
Instructor: Juan Pablo Labrador

Module Description: This module is a practical module that introduces the fundamentals of Genetic analysis and the use of *Drosophila melanogaster* as a genetic model organism. The module will cover different aspects of model organisms handling and experiments to understand Mendelian genetics and non Mendelian inheritance including segregation, recombination, gene mapping, lethal genes and sex-linked inheritance.

Assessment: 100% continuous assessment

GEU3100 Field trip (S2)
Instructors: Adrian Bracken, Dan Bradley, Matthew Campbell, Lara Cassidy, Mike Dolan, Jane Farrar, Seamus Martin, Kevin Mitchell, Juan Pablo Labrador, Aoife Mc Lysaght, Russell McLaughlin, Mani Ramaswami, Frank Wellmer

Module Description: The field trip takes place over two days on the week 27 (27^{th} – 28^{th} Feb 2025, Hilary Term). It is a great opportunity for staff and students to meet scientifically and socially in an informal setting. Each student is expected to present a short (10 minute) presentation on paper related to their review chosen together with their supervisor. At the end of this module, students should be able to deliver a professional presentation on a scientific subject.

Assessment: 10 min presentation on week 27. Attendance and presentation are **compulsory.**

Junior Sophister Genetics Open Modules

GEU33045 Genomics and Systems Biology (S1) 5 credits
Instructors: Mike Dolan, Ken Mok, Adrian Bracken, Carsten Kröger,

Module Description: The aim of this module is to equip students with a comprehensive understanding of the methods used in the fields of genomics, proteomics and metabolomics and how these methods are used for basic research, biotechnology, agriculture and medicine. To this end, several applications from work in diverse organisms (bacteria, fungi, plants, animals including humans) in addition to specific diseases and disorders (Schizophrenia and Cancer) will be presented. The module further introduces students to the field of systems biology and outlines how systems biology differs from the classic reductionist approach used in biology.

Assessment: 100% end of semester examination.

BIU33150 Biochemistry for Biosciences (S1) 5 credits
Instructors: Amir Khan, K.H. Mok, Vincent Kelly, Martin Caffrey, Andrei Budanov, Derek Nolan, Emma Creagh, Aisling Dunne, Daniela Zisterer.

Module Description: This module follows on from the biochemistry/cell biology component of the "Molecules to Cells" BYU22201 module of year 2. The aim is to provide Junior Sophister students of other disciplines with the grounding in biochemistry necessary to (i) understand biology at a molecular level, (ii) form a mechanistic view of biological processes and (iii) appreciate the pathobiochemical basis of disease. The module covers four major themes in biochemistry: Proteins and Nucleic Acids , Membranes, Cytoskeleton and Signalling. The module will be assessed through a combination of in course assessment and an individual end of term exam

Assessment: 60% end of year examination, 40% continuous assessment

GEU33055 Developmental Genetics (S2) 5 credits
Instructors: Seamus Martin, Frank Wellmer, Adrian Bracken

Module Description: This module aims at introducing students to fundamental concepts in developmental genetics and to experimental approaches that are used to study development. To this end, the module takes a comparative approach: the development of different organisms (insects, vertebrates, plants) will be taught together to demonstrate differences and commonalities in the genetic mechanisms controlling morphogenesis. Students will be introduced to important developmental control mechanisms, including morphogens, homeotic selector genes and signal transduction cascades. The module will also introduce students to stem cell biology and how stem cells are programmed to undergo growth and differentiation.

Assessment: 100% end of semester examination.

GEU33215 Medical Genetics (S2) 5 credits
Instructors: Jane Farrar, Russell McLaughlin

Module Description: The module provides an introduction to core concepts in medical genetics highlighting the importance and power of genetic information in the era of genomic medicine and the impact of such information for all of us. Learning objectives include: (1) discussion of the genetic basis of single gene disorders (Mendelian) and complex disorders; (2) overview of the history of medical genetics; (3) insights into key developments in medical genetics up to 2020 including state-of-art technologies and novel innovative therapies; (4) discussion of the key technologies and methodologies currently used to elucidate the genetic basis of human traits; (5) discussion of the individualisation of medicine and the important roles of genetic information in disease diagnosis, prognosis and the design and choice of therapy. In summary, the module provides an introduction to:

- The genetic basis of mendelian & complex disorders
- Genetic technologies & methodologies used to elucidate the genetic basis of human traits
- The exploitation of genomic data in diagnosis, prognosis & treatment of disease
- The individualization of medicine using genetic information

Assessment: 100% end of semester examination.

BIU33250 Introduction to Immunology & Immunometabolism (S2) 5 credits
Profs F Sheedy, J Fletcher, M Carty, E Lavelle, R Porter & L O'Neill.
This module introduces students to the basic components and function of the immune system – the molecules, cells, tissues and organs that make up the immune system. It will illustrate the immune responses to infection. Additionally, it will introduce students to the importance of central energy and intermediary metabolic pathways or bioenergetics before considering how they are dysregulated in diseases like cancer and how we can harness this knowledge for new immunotherapies.
The module will be assessed through a combination of in-course assessment (MCQ) and an individual end of term exam.
**Entry into this module will be subject to scheduling requirements of home moderatorship*

BIU33475 Basics of Neurobiology (S2) **5 credits**
Instructors: G Davey & D Loane

Module Description: This module focuses on chemical transmission between neurons, how neurotransmitters are classified and identified and describes typical and atypical neurotransmitters and their functions in the brain. It considers mechanisms in which abnormal neurotransmission gives rise to common neurological & psychiatric disorders.

Assessment: in course continuous assessment (30%) and by an individual end of term exam paper (70%).

Senior Sophister Genetics

Senior Sophister Course Advisor: Prof Matthew Campbell - CAMPBEM2@tcd.ie

Senior Sophister Genetics Course Structure

Genetics	
Semester 1 (S1)	**Semester 2 (S2)**
Core Modules	
GEU44008 Advanced Topics in Genetics (10 credits)	
GEU44009 From Individuals to Populations to Species: Development, Behavior, Population Genetics and Evolution (10 credits)	
GEU44010 Dealing with Data in Genetic Research (10 credits)	
GEU44011 Molecular and Cellular Genetics (10 credits)	
Capstone Project	
GEU44012 (20 credits)	

GEU440008 Advanced Topics in Genetics (S 1 & 2) **10 credits**
Instructors: Daniel Bradley, Aoife McLysaght, Frank Wellmer

Module Description: In this module, we will introduce students to several advanced topics of genetics. These will include: (a) aspects of microbial genetics, including the CRISPR/Cas system of adaptive immunity; (b) the genetics of plant development; (c) plant molecular genetics, engineering and breeding; (d) the genomics of domestic animal origins and improvement; and (e) advanced aspects of molecular evolution.
The module will highlight examples from all kingdoms of life; it will also provide students with an understanding of selected aspects of applied genetics.
Assessment: 100% end of year examination.

GEU44009 From Individuals to Populations to Species: Development, Behavior, Population Genetics and Evolution (S 1 & 2) 10 credits

Instructors: Dan Bradley, Kevin Mitchell, Aoife McLysaght, J. Pablo Labrador
Module Description: This module builds on the knowledge from earlier academic years and encompasses core concepts in genetics to develop a deeper conceptual and specific knowledge and understanding of the interplay of development, heritability and evolutionary processes.

The molecular evolution lectures will consider various aspects of evolution covering large-scale genomic events down to small changes in genes and regulatory sequences. These will be discussed in the context of speciation, adaptation, the evolution of sex and sex chromosomes, the evolution of development (morphological evolution), and fundamental patterns of genetic variation arising through mutation and selection.

The population genetics lectures will explore evolutionary concepts in a more recent timeframe, specifically looking at human population genetics. These lectures will consider human adaptive evolution, the migratory paths of ancient modern humans as illustrated by patterns of genetic diversity, the contributions and legacy of archaic humans, and regional diversity and adaptations in human populations.

The development lectures will focus on the genetics of neural and neuronal specification. There will be special emphasis on the generation of diversity in the nervous system and a focus on the spinal cord and axon guidance.

Finally, this module will consider the genetics of behaviour and explore this in terms of how it is shaped by the interplay of evolution and development. These lectures will consider how organisms are adapting to their environment and how evolution shapes that, and how development realises that. These lectures will encompass fundamental concepts of heritability and association studies and expand into the genetics of complex traits including intelligence, sexuality and personality. The lectures will also consider how all of these concepts can be used to understand the genetics of neurodevelopmental disorders.

Assessment: 100% end of year examination.

GEU44010 Dealing with data in genetic research (S1 & S2) 10 credits
Instructors: Russell McLaughlin, Lara Cassidy, Dan Bradley, J. Pablo Labrador

Module Description: This module will explore data science in genetics as it stands in the 21st century, covering multiple layers of abstraction from the fundamentals of computer science to high-level statistical models used to relate data to biology. Through a taught component, students will learn how genetic data are represented in a computer, how the problem of data manipulation and processing is optimised and structured into algorithms, how these algorithms are chained into analytical pipelines and the form taken by the outputs, from file format specifications to model-based representations of error and uncertainty.

Students will gain applied experience at each of these levels of abstraction and will become familiar with some of the most commonly used academic software in genetics and genomics. This taught component will be evaluated through continual assessment, supplemented with

an examination presenting analytical problems in genetics drawn from the diversity of subject areas taught in their undergraduate programme. Students will also gain experience in synthesis and meta-analysis of data across studies through the submission of a literature review.

Upon completion of the module, students will understand the relevance of data science in genetics and will be equipped with a highly transferrable skillset that enables them to structure a problem algorithmically, manipulate commercial and academic software for their own purposes, and relate the outputs of their approach back to the biological question.
Assessment: Continual assessment assignments 20%, Problems in genetics examination 40% & Literature review 40%

GEU44011 Molecular and Cellular Genetics (S 1 & 2) **10 credits**
Instructors Seamus Martin, Adrian Bracken, Mani Ramaswami

Module Description: This module will deepen the student's understanding of a range of core concepts in in molecular and cellular genetics, including: chromatin organization and regulation, the non-coding genome, epigenetic control of gene expression (Chromatin Biology and Epigenetics). The module will also overview protein structure, post-translational modifications of proteins, the diverse impacts of mutation on protein function, as well as cellular organization and organelle function (General concepts in molecular biology). We will explore cell signaling and the activation of gene expression programmes; genetic conservation and divergence of a key cellular process (programmed cell death) from lower to higher organisms will also be covered in detail (Genetic control of Programmed Cell Death).

This module will also examine genetic mutation and disease by looking at cancer and how this arises, spanning from the discovery of cancer-promoting genes (oncogenes and tumor suppressor genes) and how the latter drive tumor formation, as well as how mutations affecting genes that play a role in the regulation of the epigenome contribute to the development of cancer. We will also explore cancer therapy via targeting specific cancer-associated mutations (precision oncology), as well as recent developments in targeting chromatin-remodeling proteins in cancer (Cancer Genetics).

Overall, this module on Molecular and Cellular Genetics will cover a broad sweep of molecular biology, illustrating key principles of how genes are expressed, how they exert their functions, how the protein products of genes are folded, post-translationally modified and degraded, and how gene mutations lead to the subversion of these functions to provoke disease.

Assessment: 100% end of year examination

GEU44012 Capstone Project (S 1 & 2) **20 credits**

Instructors: Aoife Mc Lysaght, Russell Mc Laughlin, Juan Pablo Labrador, Frank Wellmer, Seamus Martin, Matthew Campbell, Dan Bradley, Adrian Bracken, Mani Ramaswami, Kevin Mitchell, Mike Dolan

Module Description: In this module the student will undertake a capstone project a 10-week **research project** to be conducted on a topic within the full breadth of the Genetics discipline.

Assessment: 100% continuous assessment

Genetics Moderatorship Learning Outcomes

- Attain a deep understanding of Genetics and Heredity and related fields, from Mendelian genetics to the latest technological advances in Genomics, Genome Engineering etc.
- Gather, synthesize, organize and present information in written reports.
- Demonstrate experimental skills in a range of laboratory/bioinformatics techniques; demonstrate the development of practical scientific numerical and analytical skills on data analysis.
- Apply the scientific method as fundamental mechanisms for critical analysis and problem solving.
- Use of general texts, reference books, scientific literature, reports and a range of digital resources to develop future personal knowledge of scientific issues through continued independent learning

Human Genetics

Junior Sophister Course Advisor: Prof Juan Pablo Labrador - labradoj@tcd.ie

Description of Moderatorship:

What is Human Genetics?

Human Genetics is the study of genes - or heredity - in humans. It examines the effects of these genes on both individuals and societies. It has developed rapidly in the last decade as new technology has made it possible to study genes in much greater detail and to rapidly sequence the genomes of humans and other species. A few examples of remarkable advances in knowledge include:

- Sequencing and analysis of hundreds of thousands of complete human genomes
- Development of gene-based and stem-cell-based therapies for inherited disorders employing diverse technologies from viral gene delivery to genome editing
- The ability to trace the evolution of humankind using ancient genomics
- The application of genomics to cancer medicine
- The individualisation of medicine to develop targeted treatments and avoid adverse side effects
- The use of the unique identification of individuals in forensic science

Human Genetics: The course for you?

If you are interested in understanding how genetics is central to controlling every cell and its functions including the 40 trillion cells in the human body, to directing intricate programmes of development and to causing many different disorders when perturbed, this is the right course for you. If you want to understand how genetic information is driving development of novel therapies, is enabling individualisation of medicines targeted towards patients' needs, is revealing our ancestries and how it underpins evolutionary biology, this is the degree for you.

Human Genetics @ Trinity

Human Genetics is run by the Genetics Department in the School of Genetics and Microbiology and is located in the Smurfit Institute of Genetics with state-of-the-art research facilities. There are 14 members of faculty and a number of academic associates, working in diverse areas of Human Genetics covering medical genetics, gene-based medicines, pharmacogenomics, stem cells, human population genetics, among others. The Genetics Department has an international reputation for excellent research and more than 50 years of experience in teaching Genetics and Human Genetics. The teaching is research driven; undergraduates are taught by research-active scientists with excellent track records in their fields.

Graduate skills and career opportunities

Many Human Genetics graduates go on to higher degrees (MSc/PhD) and take up careers in research in either academia or industry. Opportunities exist in biotechnology and pharmaceutical companies, medical or clinical diagnostic laboratories, forensics, genetic counselling, public health and epidemiology programmes, and in teaching. Some graduates have gone into careers such as medicine, patent law or science journalism. Even if you choose a career not directly related to the scientific subject, the skills of critical thinking and problem solving provided by the Human Genetics degree will put you in high demand.

Your degree and what you'll study

During third year, students will learn about the fundamentals of Human Genetics through lecture courses and practical classes. Students will be exposed to different areas of Human Genetics ranging from medical genetics to the genetic programmes underpinning cell biology. Practical classes teach students about key techniques and analysis methods widely used in Human Genetics. In fourth year, students can choose, largely depending on their interests, from lecture courses in different areas of Human Genetics. Students spend 10 to 12 weeks in a laboratory in the Institute and participate in on-going cutting-edge research projects. Furthermore, students write an in-depth literature review on a current topic in Human Genetics.

Junior Sophister Human Genetics Course structure

Human Genetics	
Semester 1	**Semester 2**
Core Modules	
MIU33302 - Molecular genetics I - Regulation of gene expression (5 credits)	GEU33301 Bioinformatics (5 credits)
GEU33007 Molecular Genetics Laboratory (5 credits)	GEU33303 - Molecular genetics II - Genome structure and dynamics (5 credits)
GEU33075 Evolutionary and Population Genetics (5 credits)	GEU33008 Analytical Genetics Laboratory (5 credits)
GEU33285 Science Structure, Discussion and Presentation for Genetics (5 credits)	GEU33035 Genetic Analysis of Nervous Systems (5 credits)
Open Modules Scenario I	
GEU33045 Genomics and Systems Biology (5 credits)	GEU33215 Medical Genetics (5 credits)
Trinity Elective (5 credits)	GEU33055 Developmental Genetics (5 credits) **OR** BIU33250 Introduction to Immunology and Immunometabolism (5 credits) **OR** BIU33475 Basic Neurobiology (5 credits)
Open Modules Scenario II	
GEU33045 Genomics and Systems Biology (5 credits)	GEU33215 Medical Genetics (5 credits)
BIU33150 Biochemistry for Biosciences (5 credits)	Trinity Elective (5 credits)
Open Modules Scenario III	
GEU33045 Genomics and Systems Biology (5 credits)	GEU33215 Medical Genetics (5 credits)
Trinity Elective (5 credits)	Trinity Elective (5 credits)

Junior Sophister Human Genetics Core Modules

MIU33302 Molecular genetics I - Regulation of gene expression (S1) 5 credits
Instructors: Kevin Mitchell**,** Carsten Kröger, Mani Ramaswami, Adrian Bracken

Module Description: This module will examine the principles and processes of regulation of gene expression, in prokaryotes and eukaryotes. It will be anchored around the problems that organisms have to solve in order to survive. These include modulating the cellular economy and maintaining homeostasis in response to dynamically changing internal and external states. This is crucial in microbes for adapting to environmental change and in multicellular organisms for coordinating cellular differentiation and development and regulating cellular, tissue-level and organismal physiology. The module will cover mechanisms and principles of regulation of transcription, chromatin regulation, gene regulatory motifs and networks, mRNA splicing, mRNA turnover, translation, non-coding RNA functions, and protein folding and localisation..

Assessment: 50% Group project and 50% end of semester examination.

GEU33007 Molecular Genetics Laboratory (S1) 5 credits
Instructor: Kevin Mitchell, Mike Dolan, David Noone

Module Description: The module comprises a set of robust experiment-based projects in microbial and molecular genetics. The central theme is gene expression and its regulation. In the labs, students work in groups of two performing successive experiments in two or three different projects during each session. The experiments provide invaluable hands-on experience of widely used experimental strategies and techniques in molecular genetics/ molecular biology, which include: the isolation and purification of genomic and plasmid DNA; the polymerase chain reaction (PCR); the use of agarose and polyacrylamide gel electrophoresis in the analysis of DNA, RNA and proteins; genetic transformation of E. coli; gene cloning and analysis in plasmid vectors; lacZ, GUS and GFP reporter gene assays; transduction etc.

Assessment: 100% continuous assessment.

GEU33075 Evolutionary and Population Genetics (S1) 5 credits
Instructors: Lara Cassidy, Russell McLaughlin, Ross McManus

Module Description: This module provides an in-depth exploration of genetic variation, from its origins to its evolutionary consequences. The information in DNA is not always transmitted accurately from one generation to the next. DNA sequences can change spontaneously by the process of mutation and inaccurate DNA repair, resulting in genetic variation (polymorphism) within populations. Variable sites at different positions in the genome get shuffled into new combinations by the process of genetic recombination that occurs during sexual reproduction. Whether a particular allele survives for a long time in a population or goes extinct depends on the evolutionary forces acting on the population. If a new allele is advantageous to the population, Darwinian natural selection will tend to increase its frequency in the population; alternatively, if the new allele is disadvantageous

natural selection will tend to eliminate it. However, selection is only one of several evolutionary processes that change allele frequencies within populations over generations. In this module, students will learn about the origin of genetic variation, its distribution within populations and long-term changes brought about by evolutionary processes.

Assessment: This module will be graded through an invigilated MCQ examination (60%) and continual assessment (40%).

GEU33085 Science Structure Discussion and Presentation for Genetics (S1) 5 credits
Instructors: Adrian Bracken, Dan Bradley, Matthew Campbell, Lara Cassidy, Jane Farrar, Seamus Martin, Kevin Mitchell, Juan Pablo Labrador, Aoife Mc Lysaght, Russell Mc Laughlin, Mani Ramaswami, Frank Wellmer

Module Description: In this module students meet in small groups with lecturers for discussion and problem-solving in an informal setting. Topics include genetic or medical genetics analysis, mathematical genetics, medical genetics and ethics. Students will also write a review of the recent literature in a particular area of genetics research, supervised by individual members of the academic staff. The objective of the review is to bring the reader up-to-date on the subject under review. In addition the module will have discussion of how to research, design and write a literature review and how to make an effective scientific presentation. Students will make a 10 minute presentation on a paper within the topic of their literature review at the annual field-trip GEU33100.

Assessment: 100% continuous assessment.

GEU33301 Bioinformatics (S2) 5 credits
Instructors: Karsten Hokamp, Carsten Kröger, Máire Ní Leathlobhair, Fiona Roche

Module Description: This module is taught in combination with the Microbiology department and contains web-based bioinformatics, Python programming and a data handling component. Lectures will be held in computer labs to enable a hands-on approach. The bioinformatics component provides a practical introduction to the use of commonly used bioinformatic databases and tools with a focus on web-based applications. Students will become familiar with accessing biological sequence databases and exploring various sequence analysis tools to understand evolutionary relationships and how this can help to draw protein functional and structural inferences.

The Python programming component introduces students to computer programming in Python using bioinformatics-related examples and exercises. It will be carried out within an internal JupyterLab environment. The data handling part contains a biolab component in which samples will be prepared for whole-genome sequencing (WGS). The combined lectures and practicals cover basic techniques for processing next-generation sequencing data and, more specifically, approaches for the analysis of WGS data.

Assessment: (1) A bioinformatics exam 33%, (2) a Python programming exam 33% and (3) a report based on NGS data analysis with an R programming component 34%

GEU33303 Molecular genetics II - Genome structure and dynamics (S2) 5 credits
Instructors: Fergal Hamrock, Frank Wellmer

Module Description: The aim of this module is to introduce students to fundamental concepts in Molecular Genetics. By focusing on plant and microbial genetics, we want to highlight the overlap between these seemingly disparate biological systems. The microbial genetics component will focus on critical regulatory aspects of the gene expression machinery (transcription and translation), and genome replication (DNA replication, homologous recombination, mutagenesis and DNA repair). In relation to plant genetics, students will be introduced to major topics such as the structure and evolution of the nuclear genome, the importance of model plants, including Arabidopsis thaliana, light-regulated gene expression, hormone receptors and signal transduction systems. The evolutionary origins of plant cell organelles (chloroplasts and mitochondria) via endosymbiosis involving ancestral microbes will also be explored as will be the many facets of plant-microbe interactions including plant immunity and symbiosis.

Assessment: 100% Continuous assessment.

GEU33035 Genetic Analysis of Nervous Systems (S2) 5 credits
Instructors: Juan Pablo Labrador, Mani Ramaswami

Module Description: The module is focused on understanding how experimental genetics are used to manipulate genes in organisms to address problems in biology. Areas covered are 1) Experimental Genetics: structure and conservation of genes, nature of mutations and their effects on protein structure and function, model organisms in genetic research and experimental manipulation of animal genomes. 2) Developmental Neurogenetics: the purpose and design of genetic screens, genetic analysis of neurogenesis and genetic analysis of axon guidance 3) Behavioral Genetics: cell organization and methods of cell biology, cell biology of neurons and synapses, creation and use of molecular reporters of specific gene or cell activity, methods to study nervous systems, sensory circuits, sensation; transduction; perception; coding; behavior, learning and memory, sleep and circadian rhythms.

Assessment: 100% Continuous assessment.

GEU33008 Analytical Genetics Laboratory (S2) 5 credits
Instructor: Juan Pablo Labrador

Module Description: This module is a practical module that introduces the fundamentals of Genetic analysis and the use of *Drosophila melanogaster* as a genetic model organism. The module will cover different aspects of model organisms handling and experiments to understand Mendelian genetics and non Mendelian inheritance including segregation, recombination, gene mapping, lethal genes and sex-linked inheritance.

Assessment: 100% continuous assessment

GEU3100 Field trip (S2)
Instructors: Adrian Bracken, Dan Bradley, Matthew Campbell, Lara Cassidy, Mike Dolan, Jane Farrar, Seamus Martin, Kevin Mitchell, Juan Pablo Labrador, Aoife Mc Lysaght, Russell McLaughlin, Mani Ramaswami, Frank Wellmer

Module Description: The field trip takes place over two days on the week 27 (27^{th} – 28^{th} Feb 2025, Hilary Term). It is a great opportunity for staff and students to meet scientifically and socially in an informal setting. Each student is expected to present a short (10 minute) presentation on paper related to their review chosen together with their supervisor. At the end of this module, students should be able to deliver a professional presentation on a scientific subject.

Assessment: 10 min presentation on week 27. Attendance and presentation are **compulsory.**

Junior Sophister Human Genetics Open Modules

GEU33045 Genomics and Systems Biology (S1) **5 credits**
Instructors: Mike Dolan, Ken Mok, Adrian Bracken, Carsten Kröger,

Module Description: The aim of this module is to equip students with a comprehensive understanding of the methods used in the fields of genomics, proteomics and metabolomics and how these methods are used for basic research, biotechnology, agriculture and medicine. To this end, several applications from work in diverse organisms (bacteria, fungi, plants, animals including humans) in addition to specific diseases and disorders (Schizophrenia and Cancer) will be presented. The module further introduces students to the field of systems biology and outlines how systems biology differs from the classic reductionist approach used in biology.

BIU33150 Biochemistry for Biosciences (S1) **5 credits**
Instructors: Amir Khan, K.H. Mok, Vincent Kelly, Martin Caffrey, Andrei Budanov, Derek Nolan, Emma Creagh, Aisling Dunne, Daniela Zisterer.

Module Description: This module follows on from the biochemistry/cell biology component of the "Molecules to Cells" BYU22201 module of year 2. The aim is to provide Junior Sophister students of other disciplines with the grounding in biochemistry necessary to (i) understand biology at a molecular level, (ii) form a mechanistic view of biological processes and (iii) appreciate the pathobiochemical basis of disease. The module covers four major themes in biochemistry: Proteins and Nucleic Acids , Membranes, Cytoskeleton and Signalling.

Assessment: The module will be assessed through a combination of in course assessment and an individual end of term exam.

GEU33215 Medical Genetics (S2) **5 credits**
Instructors: Jane Farrar, Russell McLaughlin

Module Description: The module provides an introduction to core concepts in medical genetics highlighting the importance and power of genetic information in the era of genomic medicine and the impact of such information for all of us. Learning objectives include: (1) discussion of the genetic basis of single gene disorders (Mendelian) and complex disorders; (2) overview of the history of medical genetics; (3) insights into key developments in medical genetics up to 2020 including state-of-art technologies and novel innovative therapies; (4) discussion of the key technologies and methodologies currently used to elucidate the genetic basis of human traits; (5) discussion of the individualisation of medicine and the important roles of genetic information in disease diagnosis, prognosis and the design and choice of therapy. In summary, the module provides an introduction to:

- The genetic basis of mendelian & complex disorders
- Genetic technologies & methodologies used to elucidate the genetic basis of human traits
- The exploitation of genomic data in diagnosis, prognosis & treatment of disease
- The individualization of medicine using genetic information

Assessment: 100% end of semester examination.

GEU33055 Developmental Genetics (S2) **5 credits**
Instructors: Seamus Martin, Frank Wellmer, Adrian Bracken

Module Description: This module aims at introducing students to fundamental concepts in developmental genetics and to experimental approaches that are used to study development. To this end, the module takes a comparative approach: the development of different organisms (insects, vertebrates, plants) will be taught together to demonstrate differences and commonalities in the genetic mechanisms controlling morphogenesis. Students will be introduced to important developmental control mechanisms, including morphogens, homeotic selector genes and signal transduction cascades. The module will also introduce students to stem cell biology and how stem cells are programmed to undergo growth and differentiation.

Assessment: 100% end of semester examination.

BIU33250 Introduction to Immunology & Immunometabolism (S2) **5 credits**
Instructors: F Sheedy, J Fletcher, M Carty, E Lavelle, R Porter, L O'Neill, Emma Creagh

Module Description: This module introduces to the basic components and function of the immune system – the molecules, cells, tissues and organs that make up the immune system. It will illustrate the immune responses to infection. Additionally, it will introduce students to the importance of central energy and intermediary metabolic pathways or bioenergetics before considering how they are dysregulated in diseases like cancer and also how we can harness this knowledge for new immunotherapies.

Assessment: 70% End of year examination, 30% in course assessed. In course assessment: In-class end of module MCQ exam covering lecture material.

BIU33475 Basics of Neurobiology (S2) **5 credits**
Instructors: G Davey & D Loane

Module Description: This module focuses on chemical transmission between neurons, how neurotransmitters are classified and identified and describes typical and atypical neurotransmitters and their functions in the brain. It considers mechanisms in which abnormal neurotransmission gives rise to common neurological & psychiatric disorders.

Assessment: in course continuous assessment (30%) and by an individual end of term exam paper (70%). The in-course assessment element will consist of a review article (2,500 words) to be submitted before the end of the semester.

Senior Sophister Human Genetics

Senior Sophister Course Advisor: Prof Matthew Campbell - CAMPBEM2@tcd.ie

Senior Sophister Human Genetics Course Structure

Human Genetics	
Semester 1 (S1)	**Semester 2 (S2)**
Core Modules	
GEU44208 Medical Genetics in the Era of Precision Medicine (10 credits)	
GEU44009 From Individuals to Populations to Species: Development, Behavior, Population Genetics and Evolution (10 credits)	
GEU44010 Dealing with Data in Genetic Research (10 credits)	
GEU44011 Molecular and Cellular Genetics (10 credits)	
Capstone Project	
GEU44212 (20 credits)	

GEU44208 Medical Genetics in the Era of Precision Medicine (S1 & S2) **10 credits**
Instructors: Prof Jane Farrar, Prof Matthew Campbell

Module Description: The study of genomes, and predominantly but not exclusively the human genome, is radically altering health care today and will do so even to a greater extent in the future. The module aims to provide an overview of the burgeoning field of molecular medicine/precision medicine and the genetic information that underpins this field and incorporates basic and applied aspects of medical genetics.

A key focus of the module will be to illuminate how genomic information is currently being utilised in medicine. Topics covered will include current disease diagnostics using genetic methodologies and information, the interpretation of genetic information and provision of information to patients in a clinical setting. The clinical trial process and pharmacogenomics will also be briefly covered.

Genomic information as a driver of novel therapeutic development for a range of disorders will be outlined with powerful examples in the clinic or in preclinical development. The multivalent aspects of genomic medicine including development of therapies for Mendelian and multifactorial diseases will be outlined. Identification of disease targets and development of targeted therapies from gene replacement therapies to gene editing therapies will be reviewed. Ethical debates regarding genetic information will be discussed, as will issues such as somatic versus germline therapies, among others. The student will be provided with a comprehensive overview of this truly powerful and rapidly expanding field.

Assessment: 100% end of year examination.

GEU44009 From Individuals to Populations to Species: Development, Behavior, Population Genetics and Evolution (S1 & S2) 10 credits
Instructors: Dan Bradley, Kevin Mitchell, Aoife McLysaght, J. Pablo Labrador

Module Description: This module builds on the knowledge from earlier academic years and encompasses core concepts in genetics to develop a deeper conceptual and specific knowledge and understanding of the interplay of development, heritability and evolutionary processes.

The molecular evolution lectures will consider various aspects of evolution covering large-scale genomic events down to small changes in genes and regulatory sequences. These will be discussed in the context of speciation, adaptation, the evolution of sex and sex chromosomes, the evolution of development (morphological evolution), and fundamental patterns of genetic variation arising through mutation and selection.

The population genetics lectures will explore evolutionary concepts in a more recent timeframe, specifically looking at human population genetics. These lectures will consider human adaptive evolution, the migratory paths of ancient modern humans as illustrated by patterns of genetic diversity, the contributions and legacy of archaic humans, and regional diversity and adaptations in human populations.

The development lectures will focus on the genetics of neural and neuronal specification. There will be special emphasis on the generation of diversity in the nervous system and a focus on the spinal cord and axon guidance.

Finally, this module will consider the genetics of behaviour and explore this in terms of how it is shaped by the interplay of evolution and development. These lectures will consider how organisms are adapting to their environment and how evolution shapes that, and how development realises that. These lectures will encompass fundamental concepts of heritability and association studies and expand into the genetics of complex traits including intelligence, sexuality and personality. The lectures will also consider how all of these concepts can be used to understand the genetics of neurodevelopmental disorders.

Assessment: 100% end of year examination.

GEU44010 Dealing with Data in Genetic Research (S1 & S2) **10 credits**
Instructors: Russell McLaughlin, Lara Cassidy, Dan Bradley, J. Pablo Labrador

Module Description: This module will explore data science in genetics as it stands in the 21st century, covering multiple layers of abstraction from the fundamentals of computer science to high-level statistical models used to relate data to biology. Through a taught component, students will learn how genetic data are represented in a computer, how the problem of data manipulation and processing is optimised and structured into algorithms, how these algorithms are chained into analytical pipelines and the form taken by the outputs, from file format specifications to model-based representations of error and uncertainty.

Students will gain applied experience at each of these levels of abstraction and will become familiar with some of the most commonly used academic software in genetics and genomics. This taught component will be evaluated through continual assessment, supplemented with an examination presenting analytical problems in genetics drawn from the diversity of subject areas taught in their undergraduate programme.

Students will also gain experience in synthesis and meta-analysis of data across studies through the submission of a literature review. Upon completion of the module, students will understand the relevance of data science in genetics and will be equipped with a highly transferrable skillset that enables them to structure a problem algorithmically, manipulate commercial and academic software for their own purposes, and relate the outputs of their approach back to the biological question.

Assessment: 100% end of year examination

GEU44011 Molecular and Cellular Genetics (S1 & S2) **10 credits**
Instructors: Seamus Martin, Adrian Bracken, Mani Ramaswami

Module Description: This module will deepen the student's understanding of a range of core concepts in in molecular and cellular genetics, including: chromatin organization and regulation, the non-coding genome, epigenetic control of gene expression (Chromatin Biology and Epigenetics). The module will also overview protein structure, post-translational modifications of proteins, the diverse impacts of mutation on protein function, as well as cellular organization and organelle function (General concepts in molecular biology). We will explore cell signaling and the activation of gene expression programmes; genetic conservation and divergence of a key cellular process (programmed cell death) from lower to higher organisms will also be covered in detail (Genetic control of Programmed Cell Death).

This module will also examine genetic mutation and disease by looking at cancer and how this arises, spanning from the discovery of cancer-promoting genes (oncogenes and tumor suppressor genes) and how the latter drive tumor formation, as well as how mutations affecting genes that play a role in the regulation of the epigenome contribute to the development of cancer.

We will also explore cancer therapy via targeting specific cancer-associated mutations (precision oncology), as well as recent developments in targeting chromatin-remodeling proteins in cancer (Cancer Genetics). Overall, this module on Molecular and Cellular Genetics will cover a broad sweep of molecular biology, illustrating key principles of how genes are expressed, how they exert their functions, how the protein products of genes are folded, post-translationally modified and degraded, and how gene mutations lead to the subversion of these functions to provoke disease.

Assessment: 100% end of year examination.

GEU44212 Capstone Project (S1 & S2) **20 credits**

Instructors: Aoife Mc Lysaght, Russell Mc Laughlin, Juan Pablo Labrador, Frank Wellmer, Seamus Martin, Matthew Campbell, Dan Bradley, Adrian Bracken, Mani Ramaswami, Kevin Mitchell, Mike Dolan

Module Description: In this module the student will undertake a capstone project a 10-week **research project** to be conducted on a topic directly related to Human Biology or medical research

Assessment: 100% continuous assessment

Human Genetics Learning Outcomes

- Attain a deep understanding of Genetics and Heredity and related fields, from Mendelian genetics to the latest technological advances in Genomics, Genome Engineering etc.
- Gather, synthesize, organize, and present information in written reports.
- Demonstrate experimental skills in a range of laboratory/bioinformatics techniques; demonstrate the development of practical scientific numerical and analytical skills on data analysis.
- Apply the scientific method as fundamental mechanisms for critical analysis and problem solving.
- Use of general texts, reference books, scientific literature, reports, and a range of digital resources to develop future personal knowledge of scientific issues through continued independent learning

Immunology

Junior Sophister Course Advisor: Prof F Sheedy - fsheedy@tcd.ie

Immunology is a moderatorship course run by the School of Biochemistry and Immunology (http://www.tcd.ie/Biochemistry/). Immunology is the study of the molecules and cells of the body that are involved in recognising and fighting infection and disease and how we can use this knowledge to develop better treatments, including vaccines. Some of the course content is shared with other degree programmes offered by the School (particularly in the areas of cell and molecular biology in JS), but there are specialised courses, assignments and practicals in Immunology in both Sophister years.

For all international visiting student queries please email Prof Andrei Budanov at budanova@tcd.ie.

Junior Sophisters:
The JS year consists of a varied programme of lectures, tutorials, a literature review, data-handling and laboratory practicals. In addition to the Core Immunology courses, students will take Open modules in Biochemistry and Microbiology and have the option of further Open modules in Genetics or Infectious Diseases in association with a Trinity Elective, as indicated in the following Table (subject to availability). Please note that the selection of Trinity Electives is subject to exclusion criteria and further information can be found at https://www.tcd.ie/trinity-electives/electives/.

Junior Sophister Immunology Course Structure

Immunology	
Semester 1 (S1)	**Semester 2 (S2)**
Core Modules	
BIU33220 Core Concepts in Immunology (10 credits)	BIU33230 Gene Regulation (10 credits)
BIU33270 Immunity & Disease (10 credits)	BIU33260 Research Skills in Immunology (10 credits)
Open Modules Option I	
BIU33150 Biochemistry for Biosciences (5 credits)	MIU33012 Microbial Pathogenesis (5 credits)
Trinity Elective (5 credits)	ZOU33006 Ecology & Evolution of Infectious Disease (5 credits)*
Open Modules Option II	
BIU33150 Biochemistry for Biosciences (5 credits)	MIU33012 Microbial Pathogenesis (5 credits)
GEU33045 Genomics and Systems Biology (5 credits)	Trinity Elective (5 credits)
Open Modules Option II	
BIU33150 Biochemistry for Biosciences (5 credits)	MIU33012 Microbial Pathogenesis (5 credits)
Trinity Elective (5 credits)	Trinity Elective (5 credits)

Subject to availability

Junior Sophister Immunology Core Modules

BIU33220 Core Concepts in Immunology (S1) **10 credits**
Profs F Sheedy, C Gardiner, J Fletcher, C O' Farrelly, J Hayes
D Nolan, A Budanov,
This module gives students an introduction to the basic components and functions of the immune system including the molecules, cells, tissues and organs that make up the innate and adaptive immune systems. This module also introduces basic concepts in cellular signalling and protein structure. Associated practical classes will give students an introduction to basic biochemical lab skills, metabolism and enzyme kinetics and binding/signalling assays.

BIU33270 Immunity & Disease (S1) **10 credits**
Profs R McLoughlin, A Bowie, E Lavelle, M Canavan,
D Zisterer
This module will consider the basics covered in BIU33220 & apply this knowledge to the specificity of immune responses to infection covering anti-viral and bacterial immunity in detail, as well as considering how we can boost immunity through vaccination. It will consider dysregulation of immune processes associated with human disease including

autoimmunity, allergy, and cancer. Associated practicals will introduce students to basic immunology techniques including cell culture, flow cytometry and bacterial killing assays.

BIU33230 Gene Regulation (S2) **10 credits**
Profs F Sheedy, A Bowie, D Zisterer, C Gardiner, D Finlay
This module concerns the use of molecular biology and control of gene expression in immune processes. Students will be introduced to basic molecular biology techniques and processes like DNA structure, replication, transcription and translation, and repair. Students will also consider how immunogenetics impacts antigen recognition by the innate immune system, transplantation biology and inherited immune deficiencies. Associated practicals and workshops will give students hands-on experience with recombinant DNA technology, quantitative PCR and transcriptomics.

BIU33160 Research Skills in Immunology (S2) **10 credits**
Profs F Sheedy, C Gardiner, A Bowie, Various others
This module prepares and trains students for a research career by introducing them to critical analysis and synthesis of the immunology literature in the form of a mini review which will be supervised by an academic staff member with expertise in the topic. They will also present their findings orally. Students will also participate in quantitative problem sessions where an academic staff member will demonstrate and train students how to handle and present experimental data. Associated practicals will give students advanced skills in immunological techniques including ELISA, immuno-blotting, tissue extraction and flow cytometry.

Junior Sophister Immunology Open Modules:

BIU33150 Biochemistry for Biosciences (S1) **5 credits**
Profs A Kahn, K H Mok, M Caffery, D Nolan, E Creagh & A Dunne.
This module follows on from the biochemistry/cell biology component of the "Molecules to Cells" BYU22201 module of year 2. The aim is to provide Junior Sophister students of other disciplines with the grounding in biochemistry necessary to (i) understand biology at a molecular level, (ii) form a mechanistic view of biological processes and (iii) appreciate the pathobiochemical basis of disease. The topics covered will include: the biochemistry of protein structure, enzymes and their role in metabolism, membranes and transport, signalling and the cytoskeleton and related cell biology. The module will be assessed through a combination of in course assessment and an individual end of term exam.

Microbial Pathogenesis (S2) **5 credits**
Prof K Roberts
This module gives basic grounding in microbial pathogenicity and medical microbiology. It covers the molecular basis of bacterial pathogenesis, including adhesion to host cells and tissue, invasion of mammalian cells, survival within professional phagocytes, evasion of innate immune responses and damage of host tissue. Major bacterial protein toxins are also covered as are important bacterial pathogens, vaccines and laboratory techniques for the identification of bacterial pathogens. The module also includes a viral pathogenicity component which deals with the properties of viruses compared to other microorganisms, classification of viruses, virus structure, the molecular biology of virus multiplication and

viruses of topical interest. This module is examined during the examination period at the end of Semester 2.

Open Modules – Elective (to be take in association with a choice of Trinity Electives):

GEU33045 Genomics and Systems Biology (S1) 5 credits
Profs F Wellmer, K Hun Mok, A Bracken, R McLaughlin, C Kröger
This module will introduce students to core concepts of genomics and systems biology. Topics discussed will include structural genomics and genome sequencing; DNA sequencing methods and the story of the human genome project; genome annotation and gene finding; comparative genomics; functional genomics; epigenomics; transcriptomics; regulatory networks; and the *cis*-regulatory code. Furthermore, students will be introduced to the use of genomics techniques in medicine and will learn about methods used to analyse the proteome of an organism.

ZOU33006 Ecology & Evolution of Infectious Disease (S2) * 5 credits
Dr Pepjin Luijck
The recent pandemic reminds us that diseases and parasites can do great harm to their hosts and thereby affect human health, food security and biodiversity. This course provides students with an understanding of the ecological and evolutionary principles that underly disease symptoms, emergence and outbreak. Through a series of lectures, supplemented with practicals, we will explore how natural selection acts on hosts and their pathogens, what factors facilitate disease outbreaks and how we might prevent pathogens from escaping our control. Using examples in human medicine, animals and plants we will explore 1) why we get sick, 2) how diseases emerge, 3) super spreaders, 4) how global warming can alter the interaction between diseases and their hosts, 5) the evolution of antibiotic resistance and the evolution of virulence, 6) evolution proofing our drugs and 7) many other concepts in evolutionary medicine, ecology and evolution.
***Entry into this module is subject to quota**

Senior Sophister Immunology

Course Advisor: Prof Emma Creagh ecreagh@tcd.ie

Senior Sophister Immunology Course Structure

Immunology	
Semester 1 (S1)	**Semester 2 (S2)**
Core Modules	
BIU44210: General Immunology 10 credits	BIU44220: Infection & Immunity 10 credits
BIU44230: Immunological diseases & immunotherapy 10 credits	BIU44010: Advanced Research Skills 10 credits
Capstone Project	
BIU44290: Research Project in Immunology (20 Credits)	

BIU44290 Research Project in Immunology (S1) 20 credits

Each research project is supervised by an academic member of staff in the School of Biochemistry & Immunology.
The module comprises an original research project in Immunology, a research thesis and both an oral and poster presentation.

BIU44010 Advanced Research Skills (S1) 10 credits

This purpose of this module is to further develop research, critical analysis and communication skills that are essential for a graduate immunologist. Students will be trained in data handling as well as solving quantitative problems in biochemistry. In addition, this module will introduce students to a wide array of cutting-edge techniques and strategies used in Immunology.

BIU44210 General Immunology (S2) 10 credits

Profs A Bowie, C Gardiner, C O'Farrelly, E Lavelle, K Mills, C Cunningham, D Zisterer, L O'Neill, S Martin, D Finlay,

This module familiarizes students with the components of the immune system in more detail and examines local immunity at specific organs including the liver, brain and mucosal sites. Detailed immune signalling pathways will be discussed and the impact of biochemistry and metabolism on immune function introduced through specialized lectures in immunometabolism.

BIU44220 Infection & Immunity (S2) 10 credits

Profs K Mills, A Bowie, R McLoughlin, F Sheedy, J Keane, H Windle, D Nolan, P Fallon

This module will integrate knowledge about how the innate and adaptive immune systems work together to eliminate specific bacterial and viral pathogens ranging from intracellular bacteria, helminths, trypanosomes, viruses and enteric bacteria. Students will also consider how pathogens subvert both innate and adaptive immune responses and learn about current thinking in vaccinology.

BIU44230 Immunological diseases & Immunotherapy (S2) 10 credits

Profs L O'Neill, E Creagh, J Fletcher, K Mills, C Cunningham, A Dunne, V Kelly, C Gardiner

This module will give students a detailed understanding of the contribution of immunology to a range of important human diseases including autoimmunity (rheumatoid arthritis), auto inflammatory diseases, obesity and neurological diseases. Importantly, students will consider how this knowledge has been harnessed to develop a range of immunotherapies and in particular apply this to cancer, where the interaction between the immune system and tumours has multiple outcomes. This will include an introductory course in cancer biology.

Immunology Learning Outcomes

- Describe the cells and molecules involved in the induction and regulation of innate and adaptive immune responses
- Identify how the immune system specifically deals with different pathogens including bacteria, viruses and parasites. Strategies for effective immunisation will also be discussed.
- Critically evaluate the contribution of immunology to a range of important human diseases including autoimmunity, obesity and neurological diseases and cancer.
- Pursue with a degree of independence an original research project in Immunology. Design and implement a wide range of experimental procedures, critically analyse and interpret experimental data, synthesise hypotheses from a wide range of information sources, critically evaluate research literature and write a research dissertation.
- Show that they have acquired the learning skills to undertake future independent research and learning with a high degree of autonomy.
- Demonstrate the ability to communicate effectively with the scientific community and with society at large and articulate how Immunology impacts on society.

Microbiology

Junior Sophister Course Advisor: Prof Carsten Kröger Carsten.Kroeger@tcd.ie
Microbiology is a two-year moderatorship course run by the School of Genetics and Microbiology. It encompasses microbial & molecular genetics, microbial genomics, cellular & molecular biology, microbial pathogenesis, medical microbiology, immunology, virology, antimicrobial chemotherapy, vaccinology, applied microbiology and biotechnology. Senior Sophister students study in specialized areas of modern microbiology and carry out a full-time, nine-week research project.

Microbiology graduates find employment in research laboratories, universities, industry, hospitals, the scientific civil service, police forensic labs, public health labs, quality control labs in the food, dairy, beverage, and pharmaceutical industries, as well as in education, scientific publishing, technical sales and services, marketing and in management.

Junior Sophister

The Junior Sophister (JS) year consists of a diverse programme of lectures, laboratory practical's, tutorials and a research essay.

Junior Sophister Course Structure

Microbiology	
Semester 1 (S1)	**Semester 2 (S2)**
Core Modules	
MIU33011 Microbial Physiology (5 credits)	MIU33012 Microbiology Pathogenicity (5 credits)
MIU33016 Applied Microbiology & Antimicrobial Agents (5 Credits)	GEU33301 Bioinformatics (5 credits)
MIU33019 Experimental Microbiology I (5 credits)	MIU33020 Experimental Microbiology II (5 credits)
MIU33302 Molecular Genetics I: Regulation of Gene Expression (5 credits)	GEU33003 Molecular Genetics II: Genome Structure and Dynamics (5 credits)
Open Modules Scenario I	
BIU33150 Biochemistry for Biological Sciences (5 credits)	BIU33250 Introduction to Immunology and Immunometabolism (5 credits)
Trinity Elective (5 credits)	ZOU33006 - Ecology and evolution of infectious disease (5 credits)
Open Modules Scenario II	
BIU33150 Biochemistry for Biological Sciences (5 credits)	BIUI33250 Introduction to Immunology and Immunometabolism (5 credits)
GEU33045 Genomes and Systems Biology (5 credits)	Trinity Elective (5 credits)
Open Modules Scenario III	
BIU33150 Biochemistry for Biological Sciences (5 credits)	BIU33250 Introduction to Immunology and Immunometabolism (5 credits)
Trinity Elective (5 credits)	Trinity Elective (5 credits)

MIU33011 Microbial Physiology (S1) 5 credits

Prof. Prof. Alastair Fleming & Prof. Siobhán O'Brien

This course considers various aspects of microbial physiology. The best understood bacterial and yeast systems are used as examples throughout. The lectures deal with specialised bacterial and fungal cell wall components, nutrient uptake mechanisms and regulation, microbial metabolism (glycolysis, aerobic and anaerobic respiration, fermentation), adaptation to nutrient depletion, and cell death. The aim is to give an overview of how microbial cells take up and utilise nutrients, and how cells cope with nutrient exhaustion. Indeed, how microbes contend with low nutrient conditions is arguably the most relevant physiological condition yet is the least studied.

The lectures on bacterial cell structure aim to provide a comprehensive overview of the structure and function of bacterial envelope components, surface proteins and polysaccharides. The contribution of each component to bacterial survival, biofilm formation and pathogenesis is examined. Biosynthesis, post-translational modification and export of protein and polysaccharide structures are described. The potential to use bacterial surface structures as vaccine antigens and to exploit our knowledge of biosynthetic pathways to discover new antimicrobial drug targets are discussed.

This module is examined during the examination period at the end of Semester 1.

MIU33016 Applied Microbiology and Antimicrobial Agents (S1) 5 credits

Prof. Marta Martins & Dr. Anna Ershova

Applied microbiology: Lectures will discuss the essential features of microbiology relevant to the environment, agriculture, food, pharmaceutical industries and clinical settings. While food and medicinal applications are a big portion of applied microbiology, the study of microorganisms has led to commercial industries which are involved and affect almost all aspects of human life. The production of specific products, such as monoclonal antibodies and the use of new sequencing technologies, will also be the subject of these lectures. The course includes lectures that will cover main areas in (i) Air and Water quality; (ii) Agricultural microbiology; (iii) Food microbiology; (iv) Biotechnology and Pharmaceutical. During the lectures, we will discuss how OMICS technologies can be used in Applied Microbiology.
Antimicrobial Agents: Antimicrobial Agents are one of the most important molecules that have been discovered and developed to treat from animal to human infections, among other relevant applications.

In these lectures we will focus on the general properties of the major antimicrobial agents in use, their cellular targets and mechanisms of action of current drugs. We will also discuss the mechanisms of drug resistance in microbial pathogens, from fungi to bacteria.

This module is examined during the examination period at the end of Semester 1.

Experimental Microbiology I (S1) 5 credits

Prof. Marta Martins, Prof. Alastair Fleming & Prof. Kim Roberts

This module offers students an opportunity to explore concepts described in the microbiology lectures through a series of laboratory-based practical classes and tutorials. The classes and activities aim to deepen understanding of the curriculum, inspire broader thinking across

modules and encourage numerical, reasoning and problem-solving skills. Students are encouraged to develop the technical and experimental skills required to work in a modern microbiology or molecular biology lab and to become competent, independent bench-lab scientists. This module allows students to put into practice key concepts of the discipline of microbiology.

This module is assessed 'in-course' using a variety of assessment modes including written exams, take-home assignments, lab reports, data handling, interpretation exercises and student presentations.

MIU33302 Microbial & Molecular Genetics (S1) 5 credits
Prof. Carsten Kröger & Prof. Kevin Mitchell
This module will examine the principles and processes of regulation of gene expression, in prokaryotes and eukaryotes. It will be anchored around the problems that organisms have to solve in order to survive. These include modulating the cellular economy and maintaining homeostasis in response to dynamically changing internal and external states. This is crucial in microbes for adapting to environmental change and in multicellular organisms for coordinating cellular differentiation and development and regulating cellular, tissue level and organismal physiology.

The module will cover mechanisms and principles of regulation of transcription, chromatin regulation, gene regulatory motifs and networks, epigenetics, mRNA splicing, mRNA turnover, translation, non-coding RNA functions, and protein folding and localisation. This module is taught in combination with the Genetics Department.

Assessment: 50% continuous assessment, 50% end of semester exam

MIU33012 Microbial Pathogenicity (S2) 5 credits
Prof. Kim Roberts & Prof. Nicky O'Boyle
This module covers two topics: Bacterial Pathogenicity and Virology. The bacterial pathogenicity section covers the molecular basis of bacterial pathogenesis including adhesion of bacteria to host cells and tissue, invasion of mammalian cells, evasion of innate immune responses and damage to host tissue. The major bacterial protein toxins will be covered (cholera enterotoxin, clostridial neurotoxins, membrane damaging cytolysins (e.g., α-toxin of *Staphylococcus aureus*). Several important bacterial pathogens will be discussed including *Listeria monocytogenes*, *Shigella flexneri*, *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Pseudomonas aeruginosa* and *Vibrio cholerae*. The lecture on S. aureus provides important background information for the laboratory practical course for Microbiology students.

The virology component of this course will compare and contrast the diversity of viral genomes and virus replication strategies. We will discuss how virus replication and evasion of host immune responses contribute to disease. Several important viruses are used to illustrate the core concepts including SARS-CoV-2, Mpox, influenza A viruses, and HIV. Emerging viruses, virus evolution, virus transmission and methods for interrupting virus replication, including vaccines, antiviral drugs and non-pharmaceutical interventions, will also be discussed.

This module is examined during the examination period at the end of Semester 2.

Experimental Microbiology II (S2) **5 credits**
Prof. Kim Roberts & Prof. Carsten Kröger
This module offers students an opportunity to explore concepts described in the Microbiology lectures through a series of laboratory-based practical classes and tutorials. The classes and activities aim to deepen understanding of the curriculum, inspire broader thinking across modules and encourage numerical, reasoning and problem-solving skills. Students are encouraged to develop the technical and experimental skills required to work in a modern microbiology or molecular biology lab and to become competent, independent bench-lab scientists.

This module allows students to put into practice key concepts of the discipline of Microbiology. This practical module will cover topics of bacterial pathogenicity, virology and bacterial genetics.This module is assessed 'in-course' using a variety of assessment modes including written exams, take-home assignments, data handling and interpretation exercises and short presentations.

GEU33303 Molecular Genetics II: Genome Structure and Dynamics (S2) **5 credits**
Prof. Frank Wellmer, Prof. Nicky O'Boyle
The aim of this module is to introduce students to fundamental concepts in Molecular Genetics. By focusing on plant and microbial genetics, we want to highlight the overlap between these seemingly disparate biological systems. The microbial genetics component will focus on critical regulatory aspects of the gene expression machinery (transcription and translation), and genome replication (DNA replication, homologous recombination, mutagenesis and DNA repair). In relation to plant genetics, students will be introduced to major topics such as the structure and evolution of the nuclear genome, the importance of model plants, including *Arabidopsis thaliana*, light-regulated gene expression, hormone receptors and signal transduction systems.

The evolutionary origins of plant cell organelles (chloroplasts and mitochondria) *via* endosymbiosis involving ancestral microbes will also be explored as will be the many facets of plant-microbe interactions including plant immunity and symbiosis. This module is taught in combination with the Genetics Department.

This module is examined during the examination period at the end of Semester 2.

Bioinformatics (S2) **5 credits**
Prof. Máire Ní Leathlobhair, Prof. Carsten Kröger, Dr. Karsten Hokamp & Dr. Fiona Roche
This module is taught in combination with the Genetics Department and contains web-based bioinformatics, Python programming and a data handling component. Lectures will be held in computer labs to enable a hands-on approach. The bioinformatics component provides a practical introduction to the use of commonly used bioinformatic databases and tools with a focus on web-based applications. Students will become familiar with accessing biological sequence databases and exploring various sequence analysis tools to understand evolutionary relationships and how this can help to draw protein functional and structural inferences.

The Python programming component introduces students to computer programming in Python using bioinformatics-related examples and exercises. It will be carried out within an internal JupyterLab environment. The data handling part contains a biolab component in which samples will be prepared for whole-genome sequencing (WGS). The combined lectures and practicals cover basic techniques for processing next-generation sequencing data and, more specifically, approaches for the analysis of WGS data.

Assessment: (1) A bioinformatics exam (33%), (2) a Python programming exam (33%) and (3) a report based on NGS data analysis with an R programming component (34%).

Junior Sophister Microbiology Open Modules

BIU33150 Biochemistry for Biological Sciences (S1) 5 credits
Profs. A Kahn, K Mok, J Murray, M Caffery, D Nolan and A Dunne
This module follows on from the biochemistry/cell biology component of the "Molecules to Cells" BYU22201 module of year 2. The aim is to provide Junior Sophister students of other disciplines with the grounding in biochemistry necessary to: (i) understand biology at a molecular level; (ii) form a mechanistic view of biological processes; and (iii) appreciate the pathobiochemical basis of disease. The topics covered will include: the biochemistry of protein structure, enzymes and their role in metabolism, membranes and transport, signalling and the cytoskeleton and related cell biology. The module will be assessed through a combination of in course assessment and an individual end of term exam.

GEU33045 Genomics and Systems Biology (S1) 5 credits
Prof. K Hun Mok, Prof. A Bracken, Prof. C Kröger
The aim of this module is to provide students with a general overview of methods used in the fields of genomics, proteomics and metabolomics and to explain how these methods are used for basic research, biotechnology, agriculture and medicine. To this end, a number of examples from work with diverse organisms (bacteria, fungi, plants, animals including humans) will be presented. The module further introduces students to the field of systems biology and outlines how systems biology differs from the classic reductionist approach used in biology.

This module is examined during the examination period at the end of Semester 1.

Introduction to Immunology and Immunometabolism (S2) 5 credits
Profs A Dunne, C O'Farrelly, J Fletcher, R Porter, F Sheedy
This module introduces the basic components and function of the immune system – the molecules, cells, tissues and organs that make up the immune system. It will illustrate the immune responses to infection. Additionally, it will introduce students to the importance of central energy and intermediary metabolic pathways before considering how they are dysregulated in diseases like cancer and to fuel immune function.

The module will be assessed by in course continuous assessment and an individual end of term exam paper.

ZOU33006 Ecology and evolution of infectious disease (S2) 5 credits

Prof. Pepijn Luijckx

The recent pandemic reminds that diseases and parasites can do great harm to their hosts and thereby affect human health, food security and biodiversity. This course provides students with an understanding of the ecological and evolutionary principles that underly disease symptoms, emergence, and outbreak. Though a series of lectures, supplemented with practical's we will explore how natural selection acts on hosts and their pathogens, what factors facilitate disease outbreaks, and how we might prevent pathogens from escaping our control. Using examples in human medicine, animals, and plants we will explore: 1) why we get sick; 2) how diseases emerge; 3) super spreaders, individuals who generate many infections; 4) How global warming can alter the interaction between diseases and their hosts; 5) the evolution of antibiotic resistance and the evolution virulence; 6) evolution proofing our drugs; and 7) many other concepts in evolutionary medicine, ecology, and evolution.

Senior Sophister Microbiology

Course Advisor: Professor Marta Martins; mmartins@tcd.ie

Senior Sophister Microbiology Course Structure

Microbiology	
Semester 1 (S1)	**Semester 2 (S2)**
Core Modules	
MIU44002: Microbial Molecular & Cellular Biology (10 credits) MIU44003: Microbial Pathogenicity (10 credits) MIU44004: Advanced Topics in Microbiology (10 credits) MIU44005: Data Handling (10 credits)	
Capstone Project	
MIU44001: Research in Microbiology Research Project, Literature Review (20 Credits)	

MIU44001: Research in Microbiology (S1 & S2) **20 credits**
This research-oriented module involves a full-time 9-week research project and thesis, the writing of a research essay and discussions of professional and ethical issues in Microbiology.

MIU44002: Microbial Molecular & Cellular Biology (S1 & S2) **10 credits**
This module involves core lectures, attendance at research seminars and self-directed study guided by reading material in Microbial Molecular & Cellular Biology.

MIU44003: Microbial Pathogenicity (S1 & S2) **10 credits**
This module involves core lectures and self-directed study, attendance at research seminars and self-directed study guided by reading material in Microbial Pathogenicity.

MIU44004: Advanced Topics in Microbiology (S1 & S2) **10 credits**
In this module students select **three advanced topics** from a list which currently includes: cell biology of intracellular pathogens, viral pathogenesis, small RNA-mediated gene regulation, regulation of bacterial gene expression, antimicrobial resistance, immune evasion by bacterial pathogens, lessons from yeast and chromatin, epigenetics and disease. Students are required to carry out self-guided study on primary literature sources in preparation for class participation and presentations.

MIU44005: Data Handling (S2) **10 credits**
Students receive tutorials in data analysis, data interpretation and problem solving in Microbiology to complement the lectures in the core themes.

Microbiology Learning Outcomes

Upon successful completion of this programme, students will be able to:

- Demonstrate in written and oral form a foundation level of knowledge and understanding of the biological, physical and quantitative sciences underpinning microbiology.
- Demonstrate in written and oral form an advanced level of knowledge and understanding of the principles of microbiology, including
    - the nature and diversity of microorganisms and the methods of studying them;
    - the genetic, biochemical and physiological processes occurring in some of the best-characterised microorganisms;
    - the interactions between some of the best-characterised pathogenic microorganisms and their hosts;
    - the roles, uses and manipulation of microorganisms in health and disease, agriculture, biotechnology and the environment;
    - the roles of microorganisms as model systems in related fields;
    - the scientific method of investigation and testing of hypotheses and the distinction between scientific and unscientific arguments.
- Demonstrate in written and oral form a detailed, critical knowledge and understanding, supported by the use of advanced textbooks, journal articles and data sets, of one or more specialist areas, some of it at the current boundaries of the field.
- Apply the knowledge and understanding gained to the critical analysis of experimental data, to sustaining evidence-based arguments on microbiological hypotheses, to solving microbiological problems and to designing microbiological experiments.
- Pursue with a degree of independence an original microbiological research project including project planning; identification, appraisal and safe application of the appropriate experimental techniques; accurate recording and presentation of data; identification of the limitations of and sources of error in experiments; analysis and interpretation of complex data; formulation of logical conclusions; and appraisal of the project outcome in the context of related, published work.
- Demonstrate proficiency in the application of computers to such problems as the searching of literature databases, analysis of biological sequence data, visualisation of biological macromolecules and analysis of experimentally acquired data.
- Demonstrate recognition of the value of scientific inquiry and an understanding of the ethical responsibilities of scientists.
- Demonstrate the capacity to apply international standards and practices within the discipline.
- Act effectively, under the guidance of senior scientists as necessary, as an individual, as part of a team, and/or in a multidisciplinary environment.
- Communicate information and ideas at a high level to both specialist and non-specialist audiences.
- Show that they have acquired the learning skills necessary to update their knowledge and to undertake further study with a high degree of autonomy.

Molecular Medicine

Junior Sophister Course Advisor: Prof K.H Mok - mok1@tcd.ie

Molecular medicine is the area of study that explores cutting edge advances in disease diagnosis, therapy and prevention driven by advanced bio-molecular research. The Molecular Medicine course is a unique collaboration between the School of Biochemistry & Immunology, Trinity Biomedical Sciences Institute (TBSI) and the School of Medicine. In this course, modules are designed to show how basic science is translated from 'theory to treatment.' Key areas of focus include cancer, neuroscience, genetic diseases, microbiology and immunology. Students will obtain a unique perspective on modern-day molecular medicine and an appreciation for the importance of both basic and clinical research in drug discovery, molecular diagnostics and personalised medicine.

In addition to highly engaging course material, students will gain experimental skills in a range of cutting-edge techniques and technologies through practicals and laboratory placements in the final year. The modules are designed to integrate and equip graduates to work in all major aspects of state-of-the-art medical biosciences. The course content has relevance to both academia and the healthcare/pharmaceutical sector therefore former graduates have gone on to study medicine, engage in postgraduate research (Ph.D.; M.Sc.), and pursue careers in industrial and government organizations. Opportunities also exist in hospital and commercial labs as well as in clinical biochemistry, biotechnology, food science, teaching, information systems, communications, and management.

The module content that is offered is under constant revision and evolution, to reflect the rapidly changing advances in Molecular Medicine. Current third year modules cover topics including Proteins and Drugs; Cell Biology; Disease Mechanisms – Cancer, Inflammation and Metabolic Disease; Nucleic Acids – Gene Expression, Molecular Genetic Mechanisms, Bioanalysis and Research Skills. Fourth year modules cover Neurobiology; Innate and Adaptive Immunity in Disease; Molecular Haematology and Oncology; Microbial Diseases; Autoimmune and Inflammatory Conditions; Genomics, Metabolism and Disease; Molecular Diagnostics and Therapeutics; Cell Cycle and Cancer. In addition, each student undertakes a bespoke capstone research project in their final year in laboratories based in Trinity Translational Medicine Institute on the St. James's Hospital campus, or Trinity Biomedical Sciences Institute.

Finally, the School of Biochemistry and Immunology awards internships at the end of the third year. The awards will take the form of salaries for six weeks to work in one of the research laboratories in the School of Biochemistry and Immunology. Our students can also avail of internships in various laboratories in the US and Europe. Pharmaceutical companies have also sponsored a number of summer internships for our third-year students.

For all international visiting student queries please email Prof Andrei Budanov at budanova@tcd.ie.

Junior Sophister Molecular Medicine Course Structure

Molecular Medicine	
Semester 1 (S1)	**Semester 2 (S2)**
Core Modules	
BIU33370 Proteins to Cells (10 credits)	BIU33390 Nucleic Acids (Molecular Medicine) (10 credits)
BIU33380 Disease Mechanisms and Drug Discovery (10 credits)	BIU33360 Research skills in Molecular Medicine (10 credits)
Open Module Option I	
GEU33045 Genomics and Systems Biology (5 credits)	*BIU33250 Introduction to Immunology and Immunometabolism (5 credits)
Trinity Elective (5 credits)	GEU33215 Medical Genetics (5 credits) OR BIU33475 Basic Neurobiology (5 credits)
Open Module Option II	
GEU33045 Genomics and Systems Biology (5 credits)	*BIU33250 Introduction to Immunology and Immunometabolism (5 credits)
PGU33905 Cell Physiology & Pharmacology (5 credits)	Trinity Elective (5 credits)
Open Module Option III	
GEU33045 Genomics and Systems Biology (5 credits)	*BIU33250 Introduction to Immunology and Immunometabolism (5 credits)
Trinity Elective (5 credits)	Trinity Elective (5 credits)

* **Subject to availability.**

Junior Sophister Molecular Medicine Core Modules

BIU33370 Proteins to Cells (S1) **10 credits**
Profs A Khan, K H Mok, D Finlay, A Budanov, D Nolan & E Creagh.
This module covers topics that reflect the biochemistry of cells. This includes an appreciation of protein structure, enzyme regulation and activity, enzyme inhibition, the function of biological membranes and membrane trafficking, how cells maintain structure through the actin and microtubule networks and how this all relates to disease pathology. Practical's will involve analysis of enzyme kinetics and recombinant protein expression, purification and analysis.

BIU33380 Disease Mechanisms and Drug Discovery (S1) **10 credits**
Profs E Creagh, A Dunne, K Gately, M Barr, T McElligott, & F Sheedy
This module covers cell signalling, oncogenic signalling, key pathways that become deregulated in human disease, the molecular basis of cancer, neurodegeneration and other ageing-related diseases. The module also covers enzyme inhibition and core aspects in Medicinal Chemistry, including the programme of drug discovery, ADME/ADMET and its relationship to the treatment of human disease. Practicals include measuring ion channel function, in vitro cell culture, and second messenger analysis.

BIU33360 Research skills in Molecular Medicine (S2) **10 credits**
All lecturers in the Schools of Medicine, and Biochemistry & immunology could potentially contribute.
This module provides research and transferable skills training, including developing approaches to reading and assessing the scientific literature in the form of a written minireview and presentation, data processing, quantitative analysis of data and interpretation based on real world experimental problems, combined with advanced technical and laboratory skills in a series of extended mini-project style practicals.

BIU33390 Nucleic Acids (Molecular Medicine) (S2) **10 credits**
Profs V Kelly, M Carty, D Zisterer, A Bowie, D Finlay & F Sheedy.
This module focuses on understanding nucleic acid biochemistry, DNA structure, gene transcription and mRNA translation, advanced molecular biology techniques including qPCR and gene editing, and DNA damage response mechanisms and their relevance to disease. The module includes appropriate laboratory sessions related to molecular biology and recombinant gene technology.

Junior Sophister Molecular Medicine Open Modules

GEU33045 Genomics and Systems Biology (S1) **5 credits**
Profs F Wellmer, K H Mok, A Bracken, R McLaughlin & C Kröger
This module will introduce students to core concepts of genomics and systems biology. Topics discussed will include structural genomics and genome sequencing; DNA sequencing methods and the story of the human genome project; genome annotation and gene finding; comparative genomics; functional genomics; epigenomics; transcriptomics; regulatory networks; and the *cis*-regulatory code. Furthermore, students will be introduced to the use

of genomics techniques in medicine and will learn about methods used to analyse the proteome of an organism.

PGU33905 Cell Physiology and Pharmacology (S1) 5 credits
Prof K Connor

The lectures in this module focus on (i) membrane structure, proteins and properties; (ii) receptors and neurotransmitters, (iii) the principles of drug action, drug development and drug targets. The module is designed to consider the structure of the membrane, the changes that occur in the membrane under different biological circumstances using age as an example, and role of membrane proteins. Cell functions, for example, the control of intracellular calcium by cells and transmitter release will be considered in the context of the membrane proteins that impact on these functions. There is a problem-based learning element to this course that will be a team-based exercise. An overall theme will be chosen and groups of 3 or 4 students will be assigned specific aspects of the theme. The objective is to undertake research on the theme and prepare a presentation that is cohesive across the topic. Each team member will contribute to the presentation.

BIU33250 Introduction to Immunology & Immunometabolism (S2) 5 credits
Profs F Sheedy, J Fletcher, M Carty, E Lavelle & L O'Neill.

This module introduces to the basic components and function of the immune system – the molecules, cells, tissues and organs that make up the immune system. It will illustrate the immune responses to infection. Additionally, it will introduce students to the importance of central energy and intermediary metabolic pathways or bioenergetics before considering how they are dysregulated in diseases like cancer and how we can harness this knowledge for new immunotherapies.

The module will be assessed through a combination of in-course assessment (MCQ) and an individual end of term exam.

**Entry into this module will be subject to scheduling requirements of home moderatorship*

GEU33215 Medical Genetics (S2) 5 credits
Profs J Farrar, P Humphries, R McLaughlin

The module will introduce core concepts in medical genetics and will highlight the exciting advances in this field in the past few years. It will provide an overview of the history of field and insights into key developments in medical genetics up to 2020 including state-of-art powerful technologies such as genome editing. A key objective of the module is to provide an overview of the dominant technologies and methodologies currently used to elucidate the genetic pathogenesis of human disorders. The module will illuminate the enormous role that genetic information now has in disease diagnosis and prognosis, and in directing therapeutic choices for patients for many disorders. This module provides an introduction to: the genetic basis of mendelian and multifactorial diseases, the genetic methodologies and technologies used to define the causes of disease, the exploitation of genomic data in the diagnosis, prognosis and treatment of disease, the genetic basis of why different individuals can respond so differently to therapeutics and the individualization of medicine in the genomics era (pharmacogenomics).

BIU33475 Basics of Neurobiology (S2) **5 credits**

Profs G Davey & D Loane

This module focuses on chemical transmission between neurons, how neurotransmitters are classified and identified and describes typical and atypical neurotransmitters and their functions in the brain. It considers mechanisms in which abnormal neurotransmission gives rise to common neurological & psychiatric disorders. The module will be assessed by in course continuous assessment (30%) and by an individual end of term exam paper (70%). The in-course assessment element will consist of a review article (2,500 words) to be submitted before the end of the semester.

Senior Sophister Molecular Medicine

Course Advisor: Prof G Brady - bradyg@tcd.ie

Senior Sophister Molecular Medicine Course Structure

Molecular Medicine	
Semester 1 (S1)	**Semester 2 (S2)**
Core Modules	
BIU44010 Advanced Research Skills (10 credits)	BIU44310 Neurobiology & Immunology (10 credits)
BIU44320 Microbial Diseases & Immune System Disorders (10 credits)	BIU44330 Cell Cycle, Cancer Biology and Therapeutics (10 credits)
Capstone Project	
BIU44390 Research Project in Molecular Medicine (20 credits)	

BIU44390 RESEARCH PROJECT IN Molecular Medicine (S1) **20 credits**

Each project will be supervised by a member of staff in the School of Biochemistry & Immunology and School of Medicine. The module comprises an original research project in Molecular Medicine, a research thesis and an oral and poster presentation.

BIU44010 ADVANCED RESEARCH SKILLS (S1) **10 credits**

All Teaching Staff contribute to this module.

The purpose of this module is to further develop research, critical analysis and communication skills that are essential for a graduate biochemist. Students will be trained in data handling as well as solving quantitative problems in biochemistry. In addition, this module will introduce students to a wide array of cutting-edge techniques and strategies used in molecular medicine.

BIU44310 NEUROBIOLOGY & IMMUNOLOGY (S2) 10 credits
Profs G Davey, D Loane, C Cunningham, E Lavelle, M Armstrong, F Sheedy, D Finlay and L O'Neill.
This module covers the structure, function and pharmacology of neurotransmitters, neuron-glia interactions, intraneuronal signalling and the neurobiology of behaviour and neurodegenerative disorders. This module also covers the molecular basis of immune mediated responses.

BIU44320 MICROBIAL DISEASES & IMMUNE SYSTEM DISORDERS (S2) 10 credits
Profs D Nolan, P Fallon, H Windle, F Sheedy, K Mills, L O'Neill, J Fletcher, E Creagh, D Doherty, N Bourke & G Brady.
This module covers the pathogenesis of infectious diseases. Bacterial and viral pathogens of medical importance will also be covered in detail. It will provide an introduction to parasitic protozoa such as trypanosomes and helminths. The biochemical and genetic mechanisms by which bacteria, viruses and parasites evade the host immune responses will be covered. This module will also cover the pathogenesis of autoimmune and inflammatory disease.

BIU44330 CELL CYCLE, CANCER BIOLOGY & THERAPEUTICS (S2) 10 credits
Profs V Kelly, K Mills, T McElligott, G Pigeon, J Lysaght, K Gately & S Gray.
This module covers the cellular and regulatory mechanisms that control the cell cycle. Furthermore, it covers the molecular basis of cancer, the progression of the disease and the therapeutic treatment strategies.

Molecular Medicine Learning Outcomes:

- Demonstrate in written and oral form a foundation level of knowledge and understanding of the biological, physical, and quantitative sciences underpinning Molecular Medicine.
- Discuss core and specialised areas of Molecular Medicine in depth and analyse and solve biomedical problems.
- Demonstrate a comprehensive understanding of the theory behind techniques used in Molecular Medicine and show a critical awareness of how these techniques can be applied to biomedical problems.
- Design and implement a wide range of experimental procedures, critically analyse, and interpret experimental data, synthesise hypotheses f0rom a wide range of information sources, critically evaluate research literature and write a research dissertation.
- Work effectively as an individual and in a team.
- Display computer literacy and use advanced computer skills to aid in conducting scientific research.
- Communicate effectively with the scientific community and with society at large and articulate how the improved knowledge of Molecular Medicine impacts on society.

Neuroscience

Junior Sophister Course Advisor: Prof R McMackin- mcmackro@tcd.ie

Neuroscience is a discipline that is devoted to the scientific study of the nervous system and is at the interface between biology and psychology. It includes study of the nature and functioning of the nervous system at all levels, from the molecules that make up individual nerve cells, to the complexities of how behaviour, thoughts and emotions are produced. Neuroscience is unique in that it makes use of a variety of methods and investigations from a wide range of traditional disciplines. Understanding the functioning of the nervous system requires an integrated knowledge of anatomy, physiology, biochemistry, molecular biology, pharmacology, and psychology. Consequently, although the degree is housed within the School of Biochemistry and Immunology, the Sophister Neuroscience program is comprised of modules from all of these disciplines and is the only degree in Trinity to be taught by lecturers from all three faculties.

In the Junior Sophister year, our aim is to lay a solid foundation in the various disciplines that make up Neuroscience but will also begin to really delve into the integration of circuits in the brain and to examine how the brain generates behaviour. In addition, the Junior Sophister year will give you experience in data handling, biostatistics, experimental design, computing, written and oral communication skills, and interpretation and critical analysis of scientific research papers. We regard the 'open modules' in Cell Physiology and Pharmacology, in Biochemistry for Biosciences and in Human Neuropsychology as essential underpinnings for the core Neuroscience curriculum and these 3 are strongly recommended. Thus, you will be well prepared for the Senior Sophister year. **It is also important to remember that your Junior Sophister marks contribute 30% to your final degree.** The senior sophister year will take you deeper into some of the areas you explored in the junior sophister year, but also will take on new areas like glial biology, neuroimmunology and neurodegenerative & neuropsychiatric conditions as well as undertaking a major capstone project in one of the many research labs that make up the neuroscience community in Trinity.

In order to have the option to study abroad in Junior Sophister Neuroscience you must show that you can take the equivalent of 30 ECTS of modules per semester, covering equivalent topics to those covered in the Junior Sophister Neuroscience's core modules, including practicals. The course coordinators do not organise exchanges for students with specific institutions and do not select or promote specific universities. If you wish to study abroad, please liaise with your university of choice to orgainise a planned combination (or options of combinations) of modules that you will take. Send the proposed module combination(s) including module descriptors and the TCD core modules to which the correspond, to Prof R McMacking at mcmakdro@tcd.ie. You will then be informed if the exchange is suitable and if the exchange can be permitted. Exchanges cannot be permitted in the absence of approval from Prof McMackin prior to formal application to the reviewing institute. This process must be completed well in advanced of any application deadline specified by the Global Office.

Junior Sophister Neuroscience Course Structure

<table>
<tr><th colspan="2">Neuroscience</th></tr>
<tr><th>Semester 1 (S1)</th><th>Semester 2 (S2)</th></tr>
<tr><td colspan="2">Core Modules</td></tr>
<tr><td>BIU33455 Research Skills (5 credits)</td><td>ANU33001 Neuroanatomy (5 credits)</td></tr>
<tr><td rowspan="2">BIU33465 Integrative Neuroscience (5 credits)</td><td>BIU33445 Neurochemistry I (5 credits)</td></tr>
<tr><td>GEU33004 Genetic analysis of Nervous System (5 credits)</td></tr>
<tr><td rowspan="2">NSU33PH1 General Principles of Pharmacology (5 credits)</td><td>Neurophysiology I (5 credits)</td></tr>
<tr><td>BIU33495 Nucleic Acids & Molecular Biology Techniques (5 credits)</td></tr>
<tr><td colspan="2">Open Modules Option I</td></tr>
<tr><td>PGU33905 Cell Physiology and Pharmacology (5 credits)</td><td rowspan="3">Neuropsychology module delivered by School of Psychology (code and content changed annually) (5 credits)</td></tr>
<tr><td>BIU33150 Biochemistry for Biosciences (5 credits)</td></tr>
<tr><td>Trinity Elective (5 credits)</td></tr>
<tr><td colspan="2">Open Modules Option II</td></tr>
<tr><td>PGU33905 Cell Physiology and Pharmacology (5 credits)</td><td rowspan="3">Trinity Elective (5 credits)</td></tr>
<tr><td>BIU33150 Biochemistry for Biosciences (5 credits)</td></tr>
<tr><td>GEU33045 Genomics and Systems Biology (5 credits)</td></tr>
<tr><td colspan="2">Open Modules Option III</td></tr>
<tr><td>PGU33905 Cell Physiology and Pharmacology (5 credits)</td><td rowspan="3">Trinity Elective (5 credits)</td></tr>
<tr><td>BIU33150 Biochemistry for Biosciences (5 credits)</td></tr>
<tr><td>Trinity Elective (5 credits)</td></tr>
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*** The human neuropsychology module is subject to change on a yearly basis but will always run in the second semester**

Junior Sophister Neuroscience Core Modules

BIU33455 Research Skills (S1) **5 credits**

Prof E Jimenez-Mateos

This module uses a 'journal club' format and is designed to provide students with an opportunity to read individual scientific articles and to develop the necessary skills to critically evaluate them. This will encourage a focus on methodological approaches, statistical analyses and interpretation of data. Through this module, students will gain confidence in reading and evaluating scientific articles. To support this module a revision of statistical analysis and computing science will be also taught.

BIU33465 Integrative Neuroscience (S1) **5 credits**

Prof T Ryan

The intention of this course is firstly to provide students with a firm grounding in the sub-fields of neuroscience that are conventionally referred to as systems neuroscience, cognitive neuroscience, and behavioural neuroscience; and secondly to introduce students to integrative frameworks for synthesizing existing neuroscience literature from different fields and to help orientate students to hypothesis driven and explanatory research. Students will learn how to approach any brain function (e.g. learning and memory) from a functional and evolutionary standpoint and will apply heuristic conceptual and computational approaches for developing frameworks within which hypotheses can be developed. They will learn how such hypotheses can be tested through multi-disciplinary research projects that combine behavioural, cognitive, physiological, and molecular investigations of brain function using cutting edge experimental methods. They will learn how to assess the validity and quality of such research with the utmost scepticism. They will learn how outcomes of progressive experimental investigations can develop and refine theories that aim to explain the brain and behaviour. This Junior Sophister module is designed to be comprehensive, in order to provide all students with a firm and holistic platform that can be applied to students' interpretation of other courses and/or of their own independent reading and research.

NSU33PH1 General Principles of Pharmacology (S1) **5 credits**

Prof A Harkin

Targets of drug action; receptor pharmacology and cell signalling; pharmacodynamics (drug action, agonism and antagonism; specificity and side-effects); Dose-response; basic pharmacokinetics (drug absorption, distribution, metabolism and excretion); general ANS pharmacology - sympathetic and para-sympathetic nervous transmission; cholinergic drugs, anticholinesterases; direct and indirect acting sympathomimetics; non-adrenergic and non-cholinergic transmitters; neuromuscular transmission and neuromuscular blocking agents; central neurotransmission and the biochemical basis of neuropharmacology; excitatory and inhibitory transmitters; neuromodulatory transmitters: biogenic amines and acetylcholine; application of basic principles in selected examples of drug use; overview of drug development and testing. **Practical classes include:** 1. Drug targets and receptor transduction - computer simulated programme with assignment, 2. Introduction/Dose response Guinea Pig Ileum: agonists - computer simulated experiments and data analysis, 3. Water Maze (CAL), 4. PA2 Guinea Pig Ileum: antagonists - computer simulated experiments and data analysis, 5. Basic Pharmacokinetics (CAL), 6. Drug development and testing – clinical trials; computer simulated programme with assignment.

Neurophysiology I (S2) **5 credits**

Prof E Jimenez-Mateos

The lectures in this module focus on how the nervous system works. Lectures will describe the structure and function of neurons, how they communicate and how they are arranged to form the nervous system. Topics include electrical properties of neurons, properties and physiological functions of ion channels, synaptic excitability, transmission and plasticity and the delivery and interpretation of sensory information into the central nervous system. Part of the course is also devoted to describing methods to record both cellular and brain activity. Practical classes focus on computer-simulated recordings of individual nerves to understand features of neuronal activity, recording brain function via electroencephalogram and sensory-evoked potentials. This module is designed to provide understanding of how the brain functions at a cellular and systems level.

ANU33001 Neuroanatomy (S2) **5 credits**

Prof Denis Barry

On successful completion of this module the student should be able to:

- recognise and describe the major subdivisions of the central nervous system (CNS).
- describe the ventricular system and the production, circulation, absorption and function of the cerebrospinal fluid.
- name the major vessels visible and outline the blood supply of the CNS.
- identify CNS structures associated with major sensory and motor systems, their connections, and outline their pathways outside the CNS.
- locate and describe CNS regions associated with language and their connections.
- name and classify the cranial nerves and list their major connections.
- apply anatomical knowledge to explain the normal function of CNS regions in activities of daily life.
- use anatomical knowledge to explain the pathogenesis and natural history of common clinical disorders of the CNS.
- list the cortical nuclei associated with the limbic system and their function where known.

BIU33495 Nucleic Acids & Molecular Biology Techniques (S2) **5 credits**

Prof Daniela Zisterer

This module covers the structure and function of nucleic acids in a eukaryotic context. The basis of gene transcriptional regulation and mRNA translation are described at a mechanistic and structural level in addition to the processes involved in transcriptional regulation and DNA replication and repair. The module includes several practicals, including preparation and use of buffers and spectrophotometric assays. There will then be a molecular biology 'project' in which students will learn aseptic technique, perform antibiotic screens of E. coli cells, restriction digests on plasmid DNA and use of agarose gel electrophoresis.

BIU33445 Neurochemistry I (S2) **5 credits**

Profs G Davey & D Loane (12 Lectures; 4 Practicals)

This module focuses on chemical transmission between neurons, how neurotransmitters are classified and identified and describes typical and atypical neurotransmitters and their functions in the brain. Individual lectures will discuss cell types in the brain and their functions, neurotransmitter types and the criteria they must satisfy to be regarded as neurotransmitters and the techniques used for studying neurotransmission. Specifically, acetylcholine release & exocytosis will be discussed, followed by a treatment of biogenic amines, glutamatergic and GABAergic neurotransmitter systems and atypical neuro-transmitters. This will be followed by a discussion of brain lipilds, gangliosides and lipid mediators, intracellular trafficking and signalling before finishing on neurodegenerative and metabolic disorders of the brain. Practical classes will be devoted to: subcellular fractionation of brain tissue, ligand binding and acetylcholine metabolism.

GEU33004 Genetic Analysis of Nervous System (S2) **5 credits**

Profs P Labrador and M Ramaswami (24 Lectures)

Experimental Genetics: manipulating genes in organisms to address problems in biology.

Experimental Genetics

1. Structure and conservation of genes, nature of mutations and their effects on protein structure and function.
2. Model organisms in genetic research
3. Experimental manipulation of animal genomes.
4. Creation and use of transgenic animals to probe gene function in vivo.

Developmental Neurogenetics

1. The purpose and design of genetic screens.
2. Genetic analysis of neurogenesis.
3. Genetic analysis of axon guidance

Behavioural Genetics:

1. Cell organization and methods of cell biology.
2. Cell biology of neurons and synapses (structures, electrical properties, synaptic transmission and molecular determinants thereof).
3. Creation and use of molecular reporters of specific gene or cell activity. Methods to study nervous systems (behaviour, imaging, electrophysiology, anatomy)
4. Sensory circuits. (vision; taste and smell) Sensation; Transduction; Perception; Coding; Behaviour.
5. Behavioural Plasticity (learning and memory).
6. Sleep and Circadian Rhythms.

Junior Sophister Neuroscience Open Modules

PGU33905 Cell Physiology and Pharmacology. Credit Value (S1) 5 credits
Prof K Connor
This module has two sections. The first half of the module covers lectures focused on (i) membrane structure, proteins and properties; (ii) receptors and neurotransmitters, (iii) the principles of drug action, drug development and drug targets. These lectures are designed to consider the structure of the membrane, the changes that occur in the membrane under different biological circumstances using age as an example, and role of membrane proteins. Cell functions, for example, the control of intracellular calcium by cells and transmitter release will be considered in the context of the membrane proteins that impact on these functions. The second half of the module covers lectures focused on (i) a general introduction to pharmacokinetics and pharmacodynamics, (ii) pharmacology of the autonomic nervous system, (iii) therapeutic targets in neurodegenerative and affective disorders and (iv) drug treatments for cardiovascular disease

BIU33150 Biochemistry for Biosciences (S1) 5 credits
Prof D Nolan This module follows on from the biochemistry/cell biology component of the "Molecules to Cells" BYU22201 module of year 2. The aim is to provide Junior Sophister students of other disciplines with the grounding in biochemistry necessary to (i) understand biology at a molecular level, (ii) form a mechanistic view of biological processes and (iii) appreciate the pathobiochemical basis of disease. The module covers four major themes in biochemistry: Proteins and Nucleic Acids, Membranes, Cytoskeleton and Signalling. The module will be assessed through a combination of in course assessment and an individual end of term exam.

Neuropsychology
The Psychology modules offered in semester 2 of JS varies annually and is to be determined for 2025/2026. Content centers on the neuroscience of psychology, and the role of the brain in cognition and behaviour. As an example of a module offered, the descriptor for PSU34180 Perceptual Neuroscience is below, although this module will not be offered for 2025/2026.

PSU34180: This course aims to provide an overview of the main human sensory systems and related perceptual functions from basic physiological mechanisms to behaviour. The approach will be mainly from a neuroscience and behavioural perspective, with related cortical systems (structural and functional) discussed. Insights from latest research on the effect of multisensory integration on perceptual function and learning will be discussed with reference to computational models of perception, sensory deprivation, and rehabilitation of perceptual function. Topics include: organisation of the sensory brain, neurophysiology of the occipital cortex; functional organisation of the visual brain; Somatosensory system and tactile perception; Auditory system and sound perception; Neuroimaging the human perceptual brain; Multisensory integration and perception; Sensory deprivation and cortical plasticity; Perceptual disorders; Linking phenomenology with perceptual processing in the human brain; Plasticity, recovery and rehabilitation of perceptual processes.

GEU33045 Genomics and Systems Biology (S1) **5 credits**
Instructors: Mike Dolan, Ken Mok, Adrian Bracken, Carsten Kröger,

Module Description: The aim of this module is to equip students with a comprehensive understanding of the methods used in the fields of genomics, proteomics and metabolomics and how these methods are used for basic research, biotechnology, agriculture and medicine. To this end, several applications from work in diverse organisms (bacteria, fungi, plants, animals including humans) in addition to specific diseases and disorders (Schizophrenia and Cancer) will be presented. The module further introduces students to the field of systems biology and outlines how systems biology differs from the classic reductionist approach used in biology.

Assessment: 100% end of semester examination

Senior Sophister Neuroscience

Course Advisor: Prof C Cunningham – colm.cunningham@tcd.ie

Senior Sophister Neuroscience Course Structure

Neuroscience	
Semester 1 (S1)	**Semester 2 (S2)**
Core Modules	
PGU44004 Neurophysiology II (5 credits)	BIU44445 Neurochemistry II (5 credits)
NSU44PH2 Neuropharmacology (5 credits)	BIU44455 Neuroimmunology & Neurodegeneration (5 credits)
PSU34540* Social Neuroscience **OR** Case studies in Neuropsychology (5 Credits)	GEU44500 Neurogenetics (5 Credits)
BIU44415 Research Literature skills (10 credits)	
Capstone Project	
Laboratory project, incorporating literature review (20 credits, S1 & S2)	

*** The human neuropsychology module is subject to change on a yearly basis**

PGU44004 Neurophysiology II. (S1) 5 credits

Profs (* Coordinators): M Caldwell*, E Jimenez-Mateos*, A Kelly, C Cunningham, A Dunne.

This module is designed to explore the neurobiology non-neuronal cells, with particular focus on glia and assess the impact of glia on the function of the nervous system. The first half of the module is designed to provide an understanding of stem cells and their differentiation into neural subtypes including glia. The concept of adult neurogenesis and the effect of exercise will also be discussed. This half of the module proceeds to provide an understanding of astrocytes and microglia and appreciate their ability to adopt different phenotypes. The diverse roles of astrocytes and microglia will be considered. We will compile practical examples of how astrocytes and microglia help to maintain homeostasis and respond to injury. Astrocytes are the most prevalent glial cell in the brain and the module will continue by exploring the many functions of astrocytes from the very well-defined role in providing metabolic support to neurons to the finding that astrocytes, like microglia, are active players in cerebral innate immunity. The role of astrocytes in blood brain barrier function will be described and the impact of changes in its permeability will be considered in different Options.

The second half of the module focuses on the physiological properties of neurons, synaptic transmission and synaptic plasticity. In particular, the module builds on knowledge acquired from PG3360 and describes, in-depth, biophysical membrane properties of neurons including membrane resistance and capacitance; time and length constants; ion fluxes and permeabilities and membrane potential, Nernst equilibrium potentials and the GHK equation for determining membrane potential; electrical properties of neurons; Hodgkin-Huxley recording of the squid giant action potential and modern electrophysiological techniques; the quantal nature and probability of neurotransmitter release; molecular features of ion channels including conductance, selectivity filters and gating; integrative properties of neurons, dendrites, and dendritic conductance; spatial and temporal summation; synaptic plasticity mechanisms; neuronal and network functions, oscillatory networks, pacemakers, resonators and rebound activity. The module also describes methodology for investigating neuronal function e.g. current and voltage-clamping, patch-clamping and optogenetics.

NSU44PH2 Neuropharmacology (S1) 5 credits

Prof A Harkin, Associate Prof (Pharmacology) School of Pharmacy and Pharmaceutical Sciences & Trinity College Institute of Neuroscience

The aim of this module is to teach the principles of neuropharmacology and drug therapies for disorders of the central nervous system and includes lectures on the following topics.

1. Depression and antidepressants
2. Mood stabilizers – Lithium
3. Anxiety disorders and anxiolytics
4. Hypnotics
5. Schizophrenia and antipsychotics
6. Drug dependence – reward circuitry and drugs of abuse
7. Anaesthetics - Local, General
8. Epilepsy and anticonvulsants
9. Pain – nociception, spinal and supra spinal pain pathways

10. Narcotic analgesics and other CNS acting analgesics
11. Parkinson's disease and anti-Parkinsonian drugs
12. Alzheimer's disease and drug treatment of Alzheimer's disease
13. Brian ischemia and neuroprotection

Students are provided with a list of additional recommended reading relating to these topics. Overall the module comprises 25 lectures, 1 tutorial with 74 guided study hours.

Neuropsychology
The Psychology modules offered in semester 1 of SS will rotate (on alternate years) between PSU34710 Case Studies in Neuropsychology (Paul Dockree) and PSU34540 Social Neuroscience (Redmond O'Connell)

PSU34710 (even years: 2024, 2026 etc.): Case studies of patients with brain damage remain a critical part of cognitive neuropsychology's methods for understanding the organisation of cognitive systems and devising principled approaches to rehabilitation. In this topic, there is great scope for clinicians and researchers to inform and learn from one another with respect to the manifestation of clinical disorders, their potential causes, and paths to rehabilitation. Students are aware of famous patients with brain damage (e.g. Phineas Gage and patient H.M.) but this module will address lesser-known cases, who have nevertheless provided important insights into contemporary research problems across several domains including attention, memory, dysexecutive syndrome and disorders of meta-cognition and social-cognitive processing. The module aims to 1) introduce the value of case studies in neuropsychology for dissociating mechanisms of human cognition and contributing to the development of theory. 2) highlight different methodological approaches that are employed to study patients with brain damage, and their advantages and limitations. 3) discuss the role of case studies in complementing other approaches in cognitive neuroscience, including imaging and electrophysiological studies. 4) explain the role of case studies in shaping novel approaches to neuropsychological rehabilitation

PSU34540 (odd years: 2025, 2027 etc.): Social Neuroscience is one of the newest fields in Psychology and explores the neural systems underlying social behaviour. Emerging from a synthesis of ideas and methods from social psychology and the neurosciences, social neuroscience seeks to broaden our understanding of human brain function beyond basic motor, perceptual and cognitive processes by elucidating the brain's fundamental role in governing interpersonal relations. This endeavour has the potential to greatly improve our understanding of how the brain works and, at the same time, to refine theories of social processes. This course will outline the theoretical origins of the field, basic neuroanatomy and core methodologies including brain imaging techniques and behavioural paradigms. In addition, key areas that will be covered include how the brain enables the processing of faces, emotions, theory of mind, prejudice and stereotypes, moral judgments and economic decision making. In so doing, the course will highlight prominent disorders of social function, such as autism, and how limitations in seemingly 'non-social' cognitive abilities can greatly influence our social behavior. Finally, the course will also consider some of the ethical implications associated with our growing understanding of the neural determinants of interpersonal behaviour and the impact this knowledge can have on our notion of free will and responsibility.

BIU44415 Research Literature Skills (S1) 5 credits
Profs C Cunningham* *(Co-ordinator),* **T Ryan, M Cunningham, D Loane, G Davey, R McMackin, E Jimenez-Mateos**
(a) Tutorial and Journal Club presentations. Students will have to comprehend, present and critically analyse research articles from high impact Neuroscience Journals. Each 2.5-3 hr session will be composed of 5-6 student presentations. Over the duration of this module, each student will be required to present two Journal articles, one chosen by a member of the academic staff, and the second chosen by the student. The Journal articles chosen by the member of academic staff will be circulated to the class approximately 10 days in advance of the journal club. We suggest that that journal article chosen by the student could be related to the topic of their Senior Sophister research project.
(b) Peer review exercise. Students will perform a 'peer-review' exercise in which they critically review a manuscript from the pre-print server 'bioRxiv'. This will be preceeded by 2 tutorials on open science and peer review. An initial review will be followed by a small group discussion, submission of a consensus review and the submission of a proposal for additional experiments.
(c) Tutorials and written assignment. This course will also prepare students for an open-book examination-style assignment that is focused on the comprehension and dissection of a journal article. This 3-hour assignment will take place, in-course, at the end of semester 1.

BIU44445 Neurochemistry II (S2) 5 credits
Profs G Davey & D Loane
This module will examine the neurochemistry of the brain in detail, with an initial focus on brain energy metabolism, including energy substrates for the brain, glucose and lactate transporters and the astrocyte-neuron lactate shuttle hypothesis. The course will examine glucose-sensing neurons and describe the determinants of blood flow in the brain before discussing the pivotal role of mitochondria in brain energy metabolism. A detailed discussion of in vivo techniques for measuring neurotransmitter release will precede detailed discussion of classical and atypical neurotransmitters from glutamate and GABA (and drugs related to these neurotransmitters) to polyamines, melatonin, aspartate and glial transmitters such as D-serine, taurine and neuropeptides).

The biochemical machinery of neurotransmission will be detailed, including the experimental approaches that underpin the SNARE hypothesis and neurotoxins that interfere with these processes. This will lead on to biochemical accounts of cholinergic signalling and voltage-gated versus ligand gated ion channels (focussing on nicotinic versus muscarinic receptors). This part of the module will go on to examine excitatory (glutamatergic) versus inhibitory (GABAergic, glycinergic) neurotransmission through an examination of receptor mechanisms and pharmacology before finishing on the many drug targets of the brain (from cannabinoid signalling to neurotransmitter transporters and the neurobiology of depression and anxiety.

The last part of the module will focus on the ways in which energy metabolism in the brain can be compromised and the consequences that follow. This will include the catastrophic disruption of stroke but also hypoxia and hypoglycaemia as dissociable insults. Brain energy metabolism is also impacted in diabetes, via the development of insulin resistance and the

deployment of alternative energy sources in different scenarios will be discussed. Although neuronal energy disruption will be the main focus, changes in microglial metabolism as part of neuroinflammatory changes during disease and injury will also be considered.

GEU44500 Neurogenetics (S2) **5 credits**
Profs K Mitchell & P Labrador
a) Behavioural Genetics (Dr. K. Mitchell)
This course will examine how genes influence behaviour through effects on cellular physiology and neuroanatomy. More specifically, it will look at how variation in genes can cause variation in behaviour. It will encompass the use of genetic approaches to dissect the cellular and biochemical components of complex behaviours in model organisms (worms, flies, mice) as well as the heredity of behavioural characteristics and psychiatric disorders in humans. Major topics include (examples of relevant psychiatric disorders are shown in parentheses): 1. Circadian rhythms and Sleep, 2. Addiction and appetite, energy balance, 3. Aggression, Social behaviour (Schizophrenia), 4. Sexual behaviour, 5. Anxiety (Depression), 6. Learning and Memory, 7. Language, Handedness and Cerebral Asymmetry (Autism, Dyslexia), 8. Personality and Intelligence (Lack of), cognitive Genetics, Autism.

b) Genetics of Neural Development (Dr. J.P. Labrador)
This half of the module will examine how a developmental programme encoded in the genome directs the assembly of the nervous system, creating a remarkably stereotyped but highly plastic and responsive structure. It will address how nervous tissue is set aside in the early embryo, how it becomes patterned, how individual cell types differentiate through the expression of different combinations of genes, and how these genes specify various properties that define each cell type: cell migration to the correct position, establishment of appropriate connections, electrical properties, neurotransmitter expression, etc. The course covers different aspects of nervous system development from neural induction to early steps of circuitry assembly. There is a focus on different genetic experimental methods employed to identify central mechanisms of nervous system development. We will use different models to explain processes and provide examples of networks and concepts. The emphasis will be on the conservation of signalling pathways in development of very diverse organisms. This will include Drosophila melanogaster, mouse as well as embryological studies in frogs and chick. It will also cover a number of human genetic disorders associated with defects in these processes.

The goal of this part of the module is to provide a concise and stimulating investigation of the field of Developmental Neurogenetics. Course lectures will explain different developmental processes of the nervous system, discuss the current issues and questions, and provide a framework for reading scientific literature. Each topic will be covered by one or more reviews and its study will be required for a successful completion of the course. Upon completion of this course students will not only understand the basic concepts but will understand the current challenges within each field of study. Students will gain an appreciation for the complexity of neural development at the cellular, molecular and genetic level. Upon completion, students should be able to approach any scientific literature related to this course. Different subjects covered include: Neural Induction, Neurogenesis, Neural stem cells, Temporal control of neuronal specification in Drosophila, Neuronal specification

in vertebrates, Axon guidance genetics, Gradients in retinotectal mapping, Topographic mapping in the olfactory system.

BIU44455 Neuroimmunology & Neurodegeneration (S2) 5 credits
Profs C Cunningham, D Loane (Dept. of Biochemistry & Immunology)
This course will focus on bi-directional communication between the nervous and immune systems, the role of the immune system in neurodegenerative disease states and the ways in which systemic inflammation can impact upon brain behaviour and integrity. The second part of the module will provide and in-depth discussion of neuropathological features and common mechanisms of neurodegenerative disease states and the experimental neuropathological approaches (i.e. animal models) that are used to study them.
Specifically, there will be an Introduction to the immune system & neurotransmitter and stress effects on immune system and an up to date discussion of the brain as an immune privileged organ, embracing multiple sclerosis and immune tolerance. Innate immunity and inflammation in CNS upon acute insults will be examined, with some attention to pathogen and damage associated molecular patterns and their corresponding pattern recognition receptors. In particular, microglial activation and neuroinflammation will be discussed in the context of sterile inflammation such as that caused by stroke, traumatic brain injury and spinal cord injury and the possibilities and obstacles for brain regeneration will be covered in that context. DAMP/inflammatory stimuli in the context of chronic neurodegeneration will also be examined and the additional impacts of systemic inflammatory on the normal (Sickness Behaviour) and diseased brain (delirium, psychosis) will be discussed alongside this role of inflammation in neurodegeneration.
In the second half of the module, we will examine the neuropathological features, the genetic underpinning and the animal model approaches consequently used to study diseases like Alzheimer's, Parkinson's, Huntington's, Motor Neuron and prion diseases. This part of the module will try to provide unifying hypotheses of neurodegeneration by focusing on common themes in neurodegeneration: protein aggregation, ubiquitin proteasome system, dysregulated autophagy, inflammation, Tau, RNA-binding proteins, mitochondrial dysfunction, axonal transport/dysfunction.

NSU44490: Capstone Research Project (S1 & S2) 20 credits
Research Principal Investigators throughout Neuroscience Disciplines in TCD
Students will conduct a 10-week research project in one of the Neuroscience research laboratories across campus, including those in the Trinity College Institute of Neuroscience. These researchers offer an enormous breadth of areas of specialisation from mitochondrial biology, to pluripotent stem cell culture, to animal models of disease right up to optogenetic dissection of memory processes and human EEG and MRI imaging studies. Among these options there are diverse 'wet lab' projects but also several different 'dry' projects that work with human subjects, with electrophysiological datasets, imaging datasets or studies in artificial intelligence/neural networks. There is no other moderatorship that offers this breadth of capstone projects. The research project is a major component of the Senior Sophister year comprising 33 % of the final year mark. The project is assessed in a variety of ways: a comprehensive literature review, an oral presentation outlining the background to your project, the conduct and skill of the student during experimental work, a poster presentation outlining the major findings and a written report (dissertation) of the project.

Neuroscience Learning Outcomes

On successful completion of this moderatorship the student should be able to:

- Describe the form and function of the central nervous system (CNS) and apply this anatomical knowledge to explain the normal function of CNS structures and regions in activities of daily life.
- Demonstrate an understanding of the basic physiology, biochemistry and molecular biology of the multiple cell types of the brain: from the fundamental molecular processes of gene transcription, protein synthesis and energy metabolism to neuronal architecture, neuronal excitability and synaptic function and plasticity.
- Describe how the genome directs a developmental programme to assemble the highly plastic and responsive nervous system and articulate how genetic variation influences behaviour through effects on cellular physiology and neuroanatomy.
- Demonstrate an understanding of the principles of neuropharmacology and how this is applied to understand and develop drug therapies for disorders of the CNS
- Understand methodological approaches in modern neuroscience research and apply the data arising from these to explain integrative functioning of the nervous system across functions including movement, perception, emotion & motivation, learning & memory, decision-making, homeostasis, circadian rhythm, sleep & consciousness.
- Describe the major neurodegenerative and neuropsychiatric conditions affecting the brain and articulate key cellular & molecular mechanisms thought to underpin these.
- Critically read and interpret scientific articles, assessing experimental design and evaluating data and statistical methods as well as demonstrating the ability to communicate effectively with scientific communities and with society at large to articulate the impact and importance of neuroscience.
- Demonstrate an ability to undertake original, independent neuroscientific research through the design and implementation of experimental laboratory or computational procedures, critical analysis and interpretation of experimental data and synthesis and interrogation of hypotheses in the completion of a research dissertation.

Physiology

Junior Sophister Course Advisor: Prof M Caldwell - maeve.caldwell@tcd.ie

The Physiology Moderatorship provides students a thorough grounding in the mechanisms underlying the function of the body, from the cellular to the whole-body level. In the junior sophister year all physiological systems are studied in-depth with the focus on the physiology and pathophysiology of the human body. The lecture material is complemented with laboratory sessions so key concepts in human physiology are explored in a practical setting. These laboratory sessions introduce student-designed projects as a preparation for the Capstone project in the senior sophister year.

In the senior sophister year, students undertake advanced physiology modules and research that reflect the current research interests of the academic staff of the Department. This includes students conducting a full-time individual laboratory-based research project. Projects range from cellular and molecular physiology, neurophysiology and human clinical and exercise physiology.

Students develop a number of key transferable skills including problem solving, critical thinking, IT and numeracy skills. We place an emphasis on developing students' communication skills, with each student giving multiple oral presentations and writing many reports throughout their two years in the Department.

Junior Sophister Physiology Course Structure

Physiology	
Semester 1 (S1)	**Semester 2 (S2)**
Core Modules – (20 credits S1 + 20 credits S2)	
PGU33950 - Cell Physiology and Pharmacology (5 credits) PGU33105Research Skills, Cell and Tissue Structure (5 credits) PGU33006 – Nerve, Muscle and Sensation (5 credits) PGU33008 - Brain, Nerve and Muscle (5 credits)	PGU33007 - Fluid, Heat and Metabolism (5 credits) PGU33010 - Cardiovascular System (5 credits) PGU33011 - Gut, Metabolism and Hormones (5 credits) PGU33112 - Respiratory System (5 credits)
Open Modules Option I	
BIU33350 Molecular Basis of Disease (5 credits)	PGU33109 Neurophysiology (5 credits) OR BIU33250 Introduction to Immunology & Immunometabolism (5 credits)
ZOU33050 Introduction to Developmental Biology (5 credits) **OR** BIU33150 Biochemistry for Biosciences (5 credits)	Trinity Elective (5 credits)
Open Modules Option II	
BIU33350 Molecular Basis of Disease (5 credits)	PGU33109 Neurophysiology (5 credits) OR BIU33250 Introduction to Immunology & Immunometabolism (5 credits).
Trinity Elective (5 credits)	BIU33475 Basic Neurobiology (5 credits) **OR** GEU33215 Medical Genetics (5 credits)
Open Modules Option III	
BIU33350 Molecular Basis of Disease (5 credits)	PGU33109 Neurophysiology (5 credits) **OR** BIU33250 Introduction to Immunology & Immunometabolism (5 credits).
Trinity Elective (5 credits)	Trinity Elective (5 credits)

Junior Sophister Physiology Core Modules

PGU33950 Cell Physiology and Pharmacology (S1) 5 credits
Prof K Connor,

The lectures in this module focus on (i) membrane structure, proteins and properties; (ii) receptors and neurotransmitters, (iii) the principles of drug action, drug development and drug targets. The module is designed to consider the structure of the membrane, the changes that occur in the membrane under different biological circumstances using age as an example, and role of membrane proteins. Cell functions, for example, the control of intracellular calcium by cells and transmitter release will be considered in the context of the membrane proteins that impact on these functions. There is a problem-based learning element to this course that will be a team-based exercise. An overall theme will be chosen and groups of 3 or 4 students will be assigned specific aspects of the theme. The objective is to undertake research on the theme and prepare a presentation that is cohesive across the topic. Each team member will contribute to the presentation.

PGU33005 Research Skills, Cell and Tissue Structure (S1) 5 credits
Profs M Caldwell, E Jimenez-Mateos

This module will cover components of tissues and how they work together in organ function. It will explain pathophysiological examples from a variety of tissues and organs and interpret 2D images as 3D structures. The module will give examples of changes in tissue structure in relation to function; physiological, pathophysiological and developmental states and explain the basis of the classification of tissues according to different criteria. You will learn the value of different types of classification and show an appreciation of the historical development of the bases of classification of tissues and be able to examine, interpret and comment upon a variety of tissues using the light microscope; including preparation artefacts and staining.

PGU33006 Nerve Muscle and Sensation (S1) 5 credits
Prof A Witney

This laboratory-based module examines sensory and motor neurophysiology from the nerve to the brain. First, basic principles of nerve conduction and muscle contraction are examined through computer simulation of the amphibian nerve. Group discussions of clinical case studies enable the theory learned to be applied to understand human sensorimotor control. Senses discussed include pain, audition, touch, taste and olfaction. The module includes group work enabling students to design and write a report on a short project. Tutorial sessions supplement the laboratory sessions for in depth discussion.

PGU33008: Brain, Nerve and Muscle (BNM) (S1) 5 credits
Profs A Witney, M Cunningham & K Connor

This module is divided into three elements. **ELEMENT ONE:** The principal aims of this element are: (i) to introduce the concept of excitable cells. (ii) To understand the sequence of cellular events, which lead to contraction of skeletal muscle. (iii) To explore the structure and mechanical properties of skeletal muscle. (iv) To understand how the neuromuscular system adapts in relation to specific exercise and clinical cases. **ELEMENT TWO:** is set of introductory lectures to synaptic transmission and sensory physiology. The basic properties of sensory processing are covered and details the physiological properties of senses.

PGU33007 Fluid Heat & Metabolism (FHM) (S2) 5 credits

Prof M Egana

This course deals with the regulation of temperature, metabolism and fluids, and particularly how this occurs during thermal stress and exercise. A key focus is on learning basic aspects of regulation, and then applying this learning to interpreting human responses measured in the laboratory. This learning is fostered through short lectures, tutorials and laboratory experiments, as well as through the preparation of a visual and written presentation about a topic of interest to the student.

PGU33010 Cardiovascular System (CVS) (S2) 5 credits

Prof N Gildea

The module will examine function and regulation of the circulatory system, using themes of adaptive responses to exercise and environmental change. Students will be assumed to be already familiar with the basic principles of cardiovascular structure and functions. Some sessions will analyse case histories illustrating typical options of cardiovascular adaptation or abnormality. A short research project will involve project planning, experimental design, data collection, handling and statistical analysis, written project report and oral poster presentation. The laboratory classes will provide insights into the practicalities of quantifying cardiovascular performance during exercise and allow students to conduct a short research project using these techniques.

PGU33011 Gut, Metabolism and Hormones (HOR) (S1 and S2) 5 credits

Profs M Egana, M Caldwell, E Downer & R McMackin

This module will cover Gut function, Metabolism, Renal function, Growth, including the hypothalamic/pituitary axis, Reproduction: regulation of gender, the ovarian cycle, pregnancy and parturition.

PGU33112 Respiratory Systems (RS) (S2) 5 credits

Prof M Egana.

The module content includes respiratory mechanics; lung compliance & airway resistance; diffusion; transport of O2 and CO2; role of respiration in blood acid/base homeostasis; control of ventilation; and respiration in altered environments. The practical classes explore spirometry & lung volumes; respiratory gas analysis & dead space; ventilation/ perfusion with exercise and exercise & acid/base status.

Junior Sophister Physiology Open Modules

BIU33350 Molecular basis of Disease (S1) 5 credits
Profs E Creagh, A Dunne, T McElligot, K Gately, M Barr & K H Mok
This module covers cell signalling, oncogenic signalling, key pathways that become deregulated in human disease, the molecular basis of cancer, neurodegeneration and other ageing-related diseases. The module also covers the programme of drug discovery and ADME/ADMET and its relationship to treatment of human disease.

BIU33150 Biochemistry for Biosciences (S1) 5 credits
Profs A Kahn, K Mok, J Murray, M Caffery, D Nolan & A Dunne.
This module follows on from the biochemistry/cell biology component of the "Molecules to Cells" BYU22201 module of year 2. The aim is to provide Junior Sophister students of other disciplines with the grounding in biochemistry necessary to (i) understand biology at a molecular level, (ii) form a mechanistic view of biological processes and (iii) appreciate the pathobiochemical basis of disease. The topics covered will include: the biochemistry of protein structure, enzymes and their role in metabolism, membranes and transport, signalling and the cytoskeleton and related cell biology. The module will be assessed through a combination of in course assessment and an individual end of term exam.

ZOU33050 Introduction to Developmental Biology (S1) 5 credits
Dr R Rolfe
This module consists of a series of lectures, tutorials and laboratory sessions that deals with a range of developmental topics emphasising a molecular approach to understanding the principles of animal development. A number of animal model systems will be dealt with and the contribution of each to our overall understanding of development discussed. Specific topics will include the following: Developmental genetics: the identification of genes that regulate development in Drosophila and vertebrates, Positional determination: how the body plan of the embryo is laid down including the role of homeo-box genes, Induction: the role of cell and tissue interactions and signalling cascades, Developmental neurobiology: positional determination within the vertebrate central nervous system, neuronal diversity and axonal guidance, neural crest cells and development of the peripheral nervous system. Other topics include limb development, organogenesis, and evolutionary developmental biology.

PGU33109 Neurophysiology I (S2) 5 credits
Prof E Jimenez-Mateos, K Connor.
The lectures in this module focus on how the nervous system works. Lectures will describe the structure and function of neurons, how they communicate and how they are arranged to form the nervous system. Topics include electrical properties of neurons, properties and physiological functions of ion channels, synaptic excitability, transmission and plasticity and the delivery and interpretation of sensory information into the central nervous system. Part of the course is also devoted to describing methods to record both cellular and brain activity. Practical classes focus on computer-simulated recordings of individual nerves to understand features of neuronal activity, recording brain function via electroencephalogram and sensory-evoked potentials. This module is designed to provide understanding of how the brain functions at a cellular and systems level.

BIU33475 Basics of Neurobiology (S2) **5 credits**

Profs G Davey & D Loane

This module focuses on chemical transmission between neurons, how neurotransmitters are classified and identified and describes typical and atypical neurotransmitters and their functions in the brain. It considers mechanisms in which abnormal neurotransmission gives rise to common neurological & psychiatric disorders.

BIU33250 Introduction to Immunology and Immunometabolism (S2) **5 credits**

Prof A Dunne, J Fletcher, M Carthy, E Lavelle, L O'Neill.

This module introduces to the basic components and function of the immune system – the molecules, cells, tissues and organs that make up the immune system. It will illustrate the immune responses to infection. Additionally, it will introduce students to the principles of integrated metabolism and bioenergetics before considering how they are dysregulated in inflammatory diseases and also how we can harness this knowledge for new immunotherapies.

GEU33215 Medical Genetics (S2) **5 credits**

Profs J Farrar, P Humphries, R McLaughlin

The module will introduce core concepts in medical genetics and will highlight the exciting advances in this field in the past few years. It will provide an overview of the history of field and insights into key developments in medical genetics up to 2020 including state-of-art powerful technologies such as genome editing. A key objective of the module is to provide an overview of the dominant technologies and methodologies currently used to elucidate the genetic pathogenesis of human disorders. The module will illuminate the enormous role that genetic information now has in disease diagnosis and prognosis, and in directing therapeutic choices for patients for many disorders. This module provides an introduction to: the genetic basis of mendelian and multifactorial diseases, the genetic methodologies and technologies used to define the causes of disease, the exploitation of genomic data in the diagnosis, prognosis and treatment of disease, the genetic basis of why different individuals can respond so differently to therapeutics and the individualization of medicine in the genomics era (pharmacogenomics).

Senior Sophister Physiology

Course Advisor: Prof A Witney - awitney@tcd.ie

Senior Sophister Physiology Course Structure

Physiology
Semester 1
Core Modules
PGU44006 Biomechanics and Neural Control of Movement (5 credits) PGU44101 Neurophysiology (5 credits) PGU44007 Glial Physiology (5 credits) PGU44009 Techniques in Cell Physiology (5 credits)
S1 and S2
PGU44802 Integrative Physiology 10 Credits PGU44803 General Physiology 10 Credits
Capstone Project (S2)
PGU44020 Capstone Project (20 credits)

PGU44006 Biomechanics & Neural Control of Movement (BNCM) (S1) 5 credits
Prof A Witney

The aim of this module is to understand the biomechanics and neural control of action. First the complementary and overlapping roles of our multiple descending motor pathways are discussed, with the focus on human motor control, but with the contributions of animal models, particularly primates, described and discussed. The control of locomotion is studied, including both the biomechanics and neural control of locomotion. The neural control of locomotion will include the development of the concept of central pattern generators from invertebrates through to man with students having access to computer simulations of the proposed neural circuits. The biomechanics aspect of locomotion focuses on human movement in the context of both athletic performance and the challenges faced in restoring locomotion after spinal cord injury. Musculoskeletal modelling is used to demonstrate how these methods can aid rehabilitation or improvements in performance. Postural control in humans is discussed with the role of different sensory inputs described. Finally, the learning of complex motor skills will be covered including the control of object manipulation. Clinical case studies of movement disorders are included throughout the module as well as a study of key techniques used to study movement and the neural control of movement including motion capture and transcranial magnetic stimulation.

PGU44007 - Glial Physiology (GP) (S1) **5 credits**

Profs M Caldwell & E Jiménez-Mateos

The module is designed to explore the neurobiology of glia and assess the impact of glia on the function of the nervous system. The first part of the module is designed to provide an understanding of stem cells and their differentiation into neural subtypes including glia. The concept of adult neurogenesis and the effect of exercise will also be discussed. The second part of the module is designed to provide an understanding of astrocytes and microglia and appreciate their ability to adopt different phenotypes. The diverse roles of astrocytes and microglia will be considered. We will compile practical examples of how astrocytes and microglia help to maintain homeostasis and respond to injury.

Astrocytes are the most prevalent glial cell in the brain and the module will continue by exploring the many functions of astrocytes from the very well-defined role in providing metabolic support to neurons to the finding that astrocytes, like microglia, are active players in cerebral innate immunity. The role of astrocytes in blood brain barrier function will be described and the impact of changes in blood brain barrier permeability will be considered in different Options.

The third part will consider the changes that occur in disorders of the central nervous system with a focus on exploring the impact of neuroinflammation and oxidative changes in disease pathologies. The changes in glial function in a number of different conditions will be discussed.

PGU44101 Neurophysiology (S1) **5 credits**

Prof M Cunningham

This module focuses on the physiological properties of neurons, synaptic transmission and synaptic plasticity. In particular, the module builds on knowledge acquired in JS Physiology and describes, in-depth, biophysical membrane properties of neurons including membrane resistance and capacitance; time and length constants; ion fluxes and permeabilities and membrane potential, Nernst equilibrium potentials and the Goldman Hodgkin Katz (GHK) equation for determining membrane potential; electrical properties of neurons; Hodgkin-Huxley recording of the squid action potential and modern electrophysiological techniques; the quantal nature and probability of neurotransmitter release; molecular features of ion channels including conductance, selectivity filters and gating; integrative properties of neurons, dendrites, and dendritic conductance; spatial and temporal summation; synaptic plasticity mechanisms; neuronal and network functions, oscillatory networks, pacemakers, resonators and rebound activity. The module also describes methodology for investigating neuronal function e.g. current and voltage-clamping, extracellular local field potential recordings, whole-cell patch-clamp and optogenetics.

PGU44009 - Techniques in Cellular Physiology (TCP) (S1) **5 credits**

Profs R McMackin & K Connor

This module aims to provide theoretical knowledge and practical experience of modern techniques used in cell physiology research. Topics include: The preparation of solutions; benchwork and calculations, biochemical protein analysis, confocal microscopy, cell culture, gel electrophoresis with western immunoblot, and molecular biology techniques with a

physiological application. A practical demonstration will accompany most of the lecture topics where students will gain some 'hands on' experience and write up their laboratory methods in the style of the Journal of Physiology. Lecture notes and learning supports will be available on blackboard, students are also encouraged to refer to research papers.

PGU44803 General Physiology (GP) (S1&S2) 10 credits
Prof Á Kelly

There are two components. First, seminars and workshops ensure students have a solid grounding in the function of all physiological systems, from the basis of cell function at the ionic and molecular level to the integrated behaviour of the whole body and the influence of the external environment. The module emphasises the integration of molecular, cellular, systems and whole-body function as the factor that distinguishes physiology from the other life sciences.

The second aspect of the module focusses on the most important and primary source of scientific knowledge - published research papers. The module trains students with the skills required to critically assess published papers. This component of the module is designed to provide guidelines to attain this skill, which can be improved only with increasing exposure to scientific literature. In this module, students will present, and critically discuss the findings of scientific papers across Physiology.

PGU44802 Integrative Physiology (IP) (S1 &S2) 10 credits
Prof Á Kelly

This interactive, workshop-based module is intended to ensure students can integrate and apply their knowledge of core material covered in all Sophister modules and has a strong research focus. Students are given discussion topics that they are required to research, using material from journal articles, and present the results of their research via oral presentation. Discussion topics include case studies, recent developments in physiology and current topics in physiology relevant to society.

PGU44020 - Capstone Project: Research Skills and Project. (S1 & S2) 20 credits
Prof A Witney

The aim of this module is to develop some of the research skills necessary for successful completion of an independent research project. In the first semester the focus is on the students gaining necessary research skills. Lecture and laboratory sessions are designed to ensure students are familiar with correct handling of data and use of appropriate statistical tests before undertaking their final year research project. The student performs an extensive review of the literature relevant to the proposed final year research project. The focus on the second semester represents the culmination of your training in scientific research in the Physiology moderatorship. You will conduct a full-time research project in one of the laboratories in the Department. Your independent research starts on the first Monday of the Hilary Term. While you are working in your host laboratory you are expected to full participate in the research environment. This includes presentations at laboratory meetings, keeping adequate laboratory records as well as working and discussing research with your laboratory colleagues. You should plan to complete laboratory work just before the St Patrick's day holiday. You are then required to submit a written report and present your research findings in the first week of April. You will also be

assessed on your conduct in your host laboratory and your keeping of laboratory records and data storage.

Physiology Learning Outcomes

By the end of this course students will have:

- Studied all systems of the human body, including the nervous, musculoskeletal, gastrointestinal, immune, endocrine, reproductive, cardiovascular and respiratory systems, in both lecture and practical settings.
- Developed research skills including practical laboratory skills, critical analysis of published journal articles and statistical analysis of data.
- Applied their knowledge of physiology to discuss case studies and general problems in physiology in an integrated manner.
- Completed a full-time, individual original research project in an aspect of physiology, have written-up this project according to the standards of the Journal of Physiology and presented the results to their peers and academic staff in oral form.
- The core textbook for the physiology degree is: Human Physiology: From Cells to Systems. L Sherwood.
- Detailed module descriptions and additional advanced reading material is recommended for each module within Blackboard.

Zoology

Junior Sophister Course Advisor: Prof N O'Connor - n.oconnor@tcd.ie

Junior Sophister students in Zoology follow a training programme that consists of core theory and practical modules relating to ecology, physiology, and biodiversity, as well as experimental design and analysis.

In the Senior Sophister year, in addition to coursework, students will take part in interactive tutorials and seminar presentations based on detailed literature analysis. They will also carry out and write-up an independent piece of research while working with one of the departmental research groups.

Brief descriptions of all modules available to Junior Sophister students in Zoology are given in this handbook.

Programme Structure
Zoology is the scientific study of all aspects of animal biology, from the cell to ecosystems. This encompasses a knowledge, not only of the structure and function of different species, but also of the complex relationships which govern the way in which animals relate to each other and to their surroundings. It provides an integrated view of all biological levels from the gene to the organism and higher.

Zoology provides fundamental knowledge relating to three areas of concern to society, namely the environment and its conservation, food production, and human and animal health and wellbeing. There is a growing awareness of environmental issues, including the conservation of biodiversity and the effects of climate change, to which zoologists contribute at all levels from research to policy making. Zoological research is also important in relation to food products and their pests while studies on a range of animals provide a basis for medical biology. Aspects of both environmental and medical biology feature strongly in the teaching and research programmes in Zoology at Trinity. With a breadth of skills, challenges and responsibilities, we are confident that every one of the Trinity Graduate Attributes are met by the zoology sophister programme: https://www.tcd.ie/TEP/graduateattributes.php

Junior Sophister Zoology Course Structure

<table>
<tr><th colspan="2">Zoology</th></tr>
<tr><th>Semester 1 (S1)</th><th>Semester 2 (S2)</th></tr>
<tr><th colspan="2">Core Modules</th></tr>
<tr><td colspan="2">ESU33004 Scientific Writing and Communication (5 credits)</td></tr>
<tr><td>ZOU33000 Marine Biology (5 credits)</td><td>ZOU33005 Evolutionary Biology (5 credits)</td></tr>
<tr><td>ZOU33003 Animal Diversity 1 (5 credits)</td><td>ZOU33070 Experimental Design and Analysis (5 credits)</td></tr>
<tr><td>ZOU33004 Animal Diversity 2 (5 credits)</td><td>ZOU33086 Terrestrial Wildlife and Field Ecology (5 credits)</td></tr>
<tr><td>ZOU33010 Fundamentals of Ecology (5 credits)</td><td></td></tr>
<tr><th colspan="2">Open Modules Option I</th></tr>
<tr><td>ZOU33050 Developmental Biology (5 credits)
OR
GSU33003 Ice Age Earth (5 credits)</td><td rowspan="2">Choose 2 Modules
ZOU33006: Ecology and Evolution of Infectious Diseases (5 credits) OR
BOU33122 Entomology (5 credits) OR
BIU3325 Introduction to Immunology and Immunometabolism (5 credits) OR
PGU33109 Neurophysiology (5 credits)</td></tr>
<tr><td>Trinity Elective (5 credits)</td></tr>
<tr><th colspan="2">Open Modules Option II</th></tr>
<tr><td rowspan="2">Choose 2 modules
ZOU33050 Developmental Biology (5 credits)
OR
GSU33003 Ice Age Earth (5 credits)</td><td>ZOU33006 Ecology and Evolution of Infectious Diseases (5 credits) OR
BOU33122 Entomology (5 credits) OR
BIU33250 Introduction to Immunology and Immunometabolism (5 credits) OR
PGU33109 Neurophysiology (5 credits)</td></tr>
<tr><td>Trinity Elective (5 credits)</td></tr>
<tr><th colspan="2">Open Modules Option III</th></tr>
<tr><td>ZOU33050 Developmental Biology (5 credits)
OR
GSU33003 Ice Age Earth (5 credits)</td><td>ZOU33006 Ecology and Evolution of Infectious Disease (5 credits) OR
BOU33122 Entomology (5 credits) OR
BIU33250 Introduction to Immunology and Immunometabolism (5 credits) OR
PGU33109 Neurophysiology (5 credits)</td></tr>
<tr><td>Trinity Elective (5 credits)</td><td>Trinity Elective (5 credits)</td></tr>
</table>

Junior Sophister Zoology Core Modules

ZOU33000 Marine Biology (S1) **5 credits**
Prof N O'Connor
This two-part module commences with a 5-day residential field course (in the west of Ireland), followed by a series of lectures on campus. This residential field course will take place during the first teaching week (week 3) of the semester and is assessed during this week. The field course is designed to teach students some of the key techniques and skills required for field-based environmental biology and to introduce key concepts in marine biology. This includes common species identification, benthic and pelagic sampling methods and experimental design. Students are required to keep detailed field notebooks that form part of the assessment. This module introduces students to the oceanographic and ecological processes that underpin marine ecosystems and their associated biodiversity and functioning. Topics include: characteristic features of different marine ecosystems (e.g. rocky shores, coral reefs, deep seas); application (fisheries and aquaculture) and human impacts on marine ecosystems (disturbances, pollution and climate change).

ZOU33003 Animal Diversity 1 (S1) **5 credits**
Prof N Payne
This module provides a detailed consideration and comparison of the structure, life cycles and general biology of animal groups from sponges through to amniotes (reptiles, dinosaurs, birds and mammals) but taking a comparative approach to functional aspects of life by drawing links across all animal groups. The module is based on lectures and tutorials, with additional self-learning exercises. The module will take an evolutionary and comparative rather than taxonomic perspective on animal diversity. The module will open by charting the diversification of several of the main groups of invertebrates (including Porifera, Cnidaria, Echinodermata, hexapoda, Platyhelminthes, Nematoda, Molluscs and Chordates), followed by the evolution of chordates and concludes with the conquest of land by the Tetrapods. Throughout, the module will use form and function to draw comparisons across taxonomic groups, such as considering locomotion across cartilaginous fish, bony fish and amphibia.

ZOU33004 Animal Diversity 2 (S1) **5 credits**
Prof A Jackson
This module provides a detailed consideration and comparison of the structure, life cycles and general biology of animal groups focussing on the amniotes (reptiles, dinosaurs, birds and mammals) but taking a comparative approach to functional aspects of life by drawing links to anamniotes and invertebrates. The module is based on lectures, practicals and tutorials, with additional self-learning exercises. The module will take an evolutionary and comparative rather than taxonomic perspective on amniote diversity. The module will open by describing how amniotes adapted to terrestrial living through the diversification of their morphological, physiological and behavioural characteristics, and the escape into the air by the birds. Throughout, the module will use form and function to draw comparisons across taxonomic groups, such as considering locomotion such as flight across birds, mammals, reptiles and insects.

ZOU33010 Fundamental of Ecology (S1) **5 credits**

Profs I Donohue and F Mitchell

This module examines the factors that affect the distribution, growth and survival of plant and animal communities. It describes how organisms interact with their environment and the role that they have in ecosystem and community structure. There is an introduction to the concepts and models that help to explain and predict organism distributions and interactions. The module comprises interrelated components of lectures, practical sessions and fieldwork. It has been designed to provide a foundation to ecological theory and its application.

ZOU33005 Evolutionary Biology (S2) **5 credits**

Prof P Luijckx

"Nothing in biology makes sense except in light of evolution" – T. Dobzhansky. Evolution plays a central role in almost every biological process ranging from adaptation to rising temperatures, spread of multi drug resistant bacteria, conservation of small populations, spread of invasive species to understanding human and animal behavior. This course will provide students with an advanced understanding of current evolutionary thinking by introducing new ideas and extending concepts already encountered in the fresher years. Special attention will be given to how selection shapes adaptation.

ZOU33070 Experimental Design and Analysis (S2) **5 credits**

Prof S Caldararu

This module will aim to put data collection and analysis in the context of research design and will be an important foundation for the Senior Sophister research project. The emphasis will be practical with a more 'hands on' approach rather than the theory of statistics. Initially students will be taught about experimental design, data collection and sampling. This will lead on to preliminary data exploration and issues of normality. Emphasis will be placed upon the importance of visually exploring the data prior to the use of statistical tests. Summary statistics, including measures of centre and spread, skewness, kurtosis, percentiles and boxplots, will be covered. Then the module will move on to explore the concept of hypothesis testing and the need to compare two or more means. This will involve the use of t-tests and analysis of variance. Other types of data will also be introduced including the analysis of frequencies. The relationship between two variables in the context of regression analysis will also be explored. Finally, a data set will be used to bring the entire process together starting with simple data exploration through summary statistics to more complex analyses. The module will also cover fundamentals of big data in ecology.

ZOU33086 Terrestrial Wildlife and Field Ecology (S2) **5 credits**

Prof J Barnett

This two-part module begins with a series of lectures in Hilary Term, which offer an introduction to terrestrial biodiversity and wildlife biology, both globally and regionally. Topics covered will include: assessment of biodiversity from individual, population, community and landscape scales and the importance of foraging ecology, habitat selection, inter- and intra-specific competition, territoriality, dispersion, population dynamics and regulation for determining diversity and distribution of animals. There will also be a particular focus on the origins, development and current status of the Irish vertebrate fauna.

The lecture series will be complemented, in week 35 (tbc), by a five-day residential field course in Glendalough, Co. Wicklow, during which field techniques used for the study of terrestrial ecosystems will be introduced, with an emphasis on habitat and population assessment of mammals, insects and birds and their interactions with plants and the abiotic environment. Field visits will help with an understanding of contrasting habitats and approaches to conservation management. Students will carry out and present a mini-project during the last two days of the course.

ESU33004 Scientific Writing and Communication (S1 & S2) 5 credits
Profs P Luijckx and C Harper

Scientific communication and writing are used to communicate knowledge to other researchers through the publication of research articles, reports and oral and poster presentations. Writing such articles or essays and presenting scientific results can be difficult and challenging. The aim of this module is to introduce students to scientific writing, presentation techniques and responsible use of AI. Throughout the duration of both semesters, students will be presented with a brief overview of the steps involved in reading, publishing, organising, and disseminating research findings. To experience this process students will undertake desk-based research, using scientific literature to synthesise and write an extended essay on a selected topic of interest related to a key challenge in Environmental Science, Botany or Zoology (depending on your discipline). The finished essay will consist of a general-format scientific review article.

Junior Sophister Zoology Open Modules

ZOU33050 Developmental Biology (S1) 5 credits
Prof P Murphy

This module consists of a series of lectures, tutorials and laboratory sessions that deals with a range of aspects of how a new animal forms during embryonic development. The emphasis is on understanding the principles of animal development at a molecular and cellular level. Experimental evidence from a number of animal model systems will be examined and the contribution of each model system to our overall understanding of development assessed. Specific topics will include the following: Developmental genetics: the identification of genes that regulate development in *Drosophila* and vertebrates,

- Positional determination: how the body plan of the embryo is laid down including the role of HOX genes,
- Induction: the role of cell and tissue interactions and signaling cascades,
- Developmental neurobiology: positional determination within the vertebrate central nervous system, neuronal diversity and axonal guidance, neural crest cells and development of the peripheral nervous system.
- The vertebrate limb as a model for morphogenesis,
- Organogenesis,
- Evolution of body plans (Evo-Devo).

GSU33003: ICE AGE EARTH (S1) **5 credits**

Prof R Edwards

The last 2.6 million years of Earth history have witnessed dramatic climatic and environmental changes. This module provides an overview of these major environmental changes, their causes, and their significance for human development. It contrasts 'glacial' and 'interglacial' worlds, examines the nature of the transitions between them, explores some potential causes of change, and illustrates their environmental impacts. In the process, a range of key environmental records are considered, along with the "proxies" used to develop them.

PGU33009 Neurophysiology I (S2) **5 credits**

Prof E Jimenez-Mateos

The lectures in this module focus on how the nervous system works. Lectures will describe the structure and function of neurons, how they communicate and how they are arranged to form the nervous system. Topics include electrical properties of neurons, properties and physiological functions of ion channels, synaptic excitability, transmission and plasticity and the delivery and interpretation of sensory information into the central nervous system. Part of the course is also devoted to describing methods to record both cellular and brain activity. Practical classes focus on computer-simulated recordings of individual nerves to understand features of neuronal activity, recording brain function via electroencephalogram and sensory-evoked potentials. This module is designed to provide understanding of how the brain functions at a cellular and systems level.

ZOU33006 Ecology & Evolution of Infectious Diseases (S2) **5 credits**

Dr Pepijn Luijckx

The recent pandemic reminds us that diseases and parasites can do great harm to their hosts and thereby affect human health, food security and biodiversity. This course provides students with an understanding of the ecological and evolutionary principles that underly disease symptoms, emergence, and outbreak. Though a series of lectures, supplemented with practicals we will explore how natural selection acts on hosts and their pathogens, what factors facilitate disease outbreaks, and how we might prevent pathogens from escaping our control. Using examples in human medicine, animals, and plants we will explore: 1) why we get sick; 2) how diseases emerge; 3) super spreaders, individuals who generate many infections; 4) How global warming can alter the interaction between diseases and their hosts; 5) the evolution of antibiotic resistance and the evolution virulence; 6) evolution proofing our drugs; and 7) many other concepts in evolutionary medicine, ecology, and evolution.

BOU33122 Entomology (S2) **5 credits**

Profs S Larragy

There are more species of insects on Earth than any other group of organisms and they are of massive ecological and economic importance. This module will address behavioural, social, ecological and applied aspects of entomology, including their role in delivering ecosystem services (such as biocontrol and pollination), invasive species (such as fire ants and harlequin ladybirds) and conservation (both in Ireland and internationally). The practicals will provide students with the skills for sampling and identification of insects, which will be further enhanced through an individual project.

BIU33250 Introduction to Immunology & Immunometabolism (S2) **5 credits**
Prof F Sheedy
This module introduces to the basic components and function of the immune system – the molecules, cells, tissues and organs that make up the immune system. It will illustrate the immune responses to infection. Additionally, it will introduce students to the importance of central energy and intermediary metabolic pathways or bioenergetics before considering how they are dysregulated in diseases like cancer and also how we can harness this knowledge for new immunotherapies.
The module will be assessed through a combination of in course assessment (MCQ) and an individual end of term exam.
**Entry into this module will be subject to scheduling requirements of home moderatorship*

Senior Sophister Zoology

Course Advisor: Prof N O'Connor: n.oconnor@tcdc.ie

Senior Sophister Zoology Course Structure

Zoology	
Semester 1 (S1)	**Semester 2 (S2)**
Core Modules	
ZOU44030 Data Handling (5 credits)	ZOU44020 General Zoology (5 credits)
ZOU44022 Comparative Physiology (5 credits)	
ZOU44060 Research Comprehension (5 credits)	
Open Modules	**Capstone Project**
Choose 4 ZOU44013 Conservation and Wildlife Management ZOU44092 Environmental Impact Assessment ZOU44021Tropical Ecology & Conservation BOU44111 Restoration Ecology and Re-Wilding BOU44107 Plant Animal Interactions BOU44110 Evolution of plants and plant atmosphere interactions ZOU44019 Advances in Behavioural Ecology	FBU44000 Research Project (20 credits)

ZOU44030 Data Handling (S1) **5 credits**

Prof A Jackson

Being able to form research questions and challenge our hypotheses by collecting and analysing data forms the basis of scientific inquiry. An understanding of data analysis is an essential skill set for all scientists. This module will consist of 2 tutorial sessions per week spanning all of semester 1. One of the tutorials each week will be used to develop class-directed questions relevant to current scientific thinking. As a class, we will form hypotheses, collect data and develop appropriate analytical techniques to answer our research questions. Concurrently, online material including video podcasts will be used to develop hands-on skills in the use of the very powerful and flexible statistics package R for data analysis. The module will start with basic probability theory, introduce different statistical distributions and culminate in learning how General Linear Models form a common framework for conceptualising and analysing your data. At the end of the module you will have analysed a wide variety of data types and will have used the transferable and widely applicable statistics package R to analyse your data.

ZOU44060 Research Comprehension (S1 & S2) **5 credits**

Profs P Murphy and J Barnett

No matter what you do when you graduate, in most jobs you will be expected to read, understand and interpret data. Often this will be in a subject you are unfamiliar with, or will use unfamiliar methods or study organisms. The aim of this module is to help you to develop the ability to understand and interpret research from a broad range of scientific areas, and then to develop opinions about this research and how it fits into the "big picture". This module also aims to improve your ability to communicate all kinds of scientific research to a general audience, a skill that is currently in great demand.

ZOU44020 General Zoology (S2) **5 credits**

Prof A Jackson

This module provides an opportunity for students to revise and study, in greater depth, topics from the Junior Sophister Zoology programme. Students are expected to integrate their approach to this earlier material with the perspectives and skills they develop during their final year. Appropriate literature relating to the Junior Sophister mandatory modules will be recommended for detailed study.

FBU44000 Research Project (S2) **20 credits**

Prof R Rolfe and all Botany and Zoology staff

The project provides an important opportunity for students to plan and carry out a detailed and original piece of scientific research and communicate the results. It culminates in the production of a thesis and communication of the results through a poster presentation at an undergraduate research conference. Students will be assigned to a member of staff who will support an appropriate topic and will supervise the work. As part of the project students will be expected to outline clearly a scientific problem, review the associated literature, design and execute an appropriate research programme, analyse and present the results and draw clear conclusions and record progress in a notebook (physical or electronic as appropriate). Detailed guidance notes on writing and submitting the thesis and poster may be found on the FBU44000 Blackboard site. The FBU44000 module culminates in the submission of a thesis and presentation of a poster on the results.

ZOU44013 Conservation and Wildlife Management (S1) **5 credits**

Prof P Murphy

This module, which consists of both lectures and tutorials, looks at some of the practical applications of wildlife biology to the conservation and management of animals, both in- and ex-situ, including the role of zoos in captive breeding programmes. Among the topics covered are: planning for wildlife management, the principles of managing wildlife for sustainable harvest or control, management of scarce or endangered species, practical issues associated with the ex-situ management of species, and the design and management of conservation areas. In the second part of the module, we will concentrate on anthropogenic impacts on biodiversity conservation, including the development and implementation of biodiversity conservation strategies in the wake of the Convention on Biological Diversity, other national and international wildlife legislation, biosecurity and the role of Invasive Alien Species, Biological Data Management and the development of Species Action Plans, and the role of reintroductions in biodiversity conservation.

ZOU44021 Tropical Ecology & Conservation (S1) **5 credits**

Prof I Donohue

The module comprises of a short lecture series followed by a ten-day residential field course in East Africa that will run during the reading week mid-end October. The course will focus on the ecology and biodiversity of a range of ecosystems and habitats (including tropical mountain forest, aquatic ecosystems [freshwater rivers and lakes, wetlands and saline lakes] and grasslands) and the connectivities among them. Issues and problems to do with human impacts and the conservation and management of these diverse habitats will also comprise an important element of the course.

ZOU44022 Comparative Physiology (S1) **5 Credits**

Prof R Rolfe

This module, which consists of both lectures, workshops and self-learning exercises, explores physiological success within the animal kingdom through a synthesis across multiple levels of organisation. The aims of this module are to compare systematically the ways in which various animals carry out similar functions. The specific physiological topics and components include: biomechanics, sensory physiology, metabolism, thermal tolerance and physiological and developmental remodelling. This module will include analysis of how physiological adaptations and tolerances are linked to distributions of organisms and evolutionary developmental biology perspectives in the context of environmental changes and challenges. The module is structured in two parts; the first half of the semester will comprise a “bootcamp’ series of lectures describing specific physiological systems and themes. The second part of the module will consist of research-focused themes from a range of physiological perspectives. It will provide an integrative physiological approach with an emphasis on synthesis across multiple levels of biological organisation, with research topics that probe the relationships between structure and function.

ZOU44092 Environmental Impact Assessment (S1) 5 credits
Prof P Murphy
This module involves an introduction to the principles and processes of Environmental Impact Assessment, particularly in relation to national and international requirements. All stages of the EIA process, from initial project screening to the final review, are covered, with the emphasis throughout on the role of the natural scientist. Strategic Environmental Assessment and Appropriate Assessment are also covered. In addition to the lectures, students carry out a group scoping exercise for a proposed development and conduct a quality review of an actual EIAR.

BOU44107 Plant-Animal Interactions (S1) 5 credits
Prof J Waterman
In The Origin of Species (1859) Darwin emphasized that "plants and animals, most remote in the scale of nature, are bound together by a web of complex relations". Plant-animal interactions have become increasingly recognized as drivers of evolutionary change and important components of ecological communities. This module will focus on pollination (the transfer of pollen between male and female reproductive structures in flowers) and herbivory (the consumption of plants by animals). The first half of the module will focus on antagonistic interactions between plants and herbivores, and explore plant and animal adaptations to herbivory, plant-herbivore dynamics and applications of interactions to ecosystem management. The second part of the module will focus on plant-pollinator interactions, including pollinator-mediated evolution of floral traits, community level interactions, pollinator decline and conservation. Practical's will investigate plant and animal adaptations to herbivory, floral characteristics and adaptations for pollination and pollinator networks.

BOU44110: The Evolution of Plants and Plant-Atmosphere Interaction (S2) 5 credits
Prof J McElwain
We are currently experiencing major changes in our climatic and atmospheric environment. Conservative estimates project that the concentration of greenhouse gas carbon dioxide will double by the end of this century and global temperatures are expected to rise by 1 to 4 degrees C. A major issue facing the scientific and political community is understanding how these projected changes will influence natural ecosystems, plant and animal ecology and biodiversity. This module will explore the evolution of plants in the context of long-term changes in climate and atmospheric composition. Examples of plant-atmosphere and plant-climate interactions in the deep geological past will be examined in addition to modern experimental studies. The course will provide a framework for understanding the nature and scale of evolution, adaptation and ecophysiological responses of plants to their atmospheric and climatic environment over the past 500 million years of Earth history. Continual assessment will be through a programme of tutorials and student reviews of primary research papers linked to lectures.

BOU44111 Restoration Ecology and Re-Wilding (S1) **5 credits**
Prof M Collier
Restoration ecology, like conservation biology, is a 'crisis' discipline, having emerged as a science/practice response to the social and ecological impacts directly and indirectly driven by human activities. Restoration ecology has proven to be highly effective in some cases but has also given rise to some controversy as well as policy difficulties. In recent years the phrase 'rewilding' has emerged as a concept that embodies ecological restoration but with more future-oriented targets. Rewilding and novel ecosystems are new and controversial areas within restoration ecology making it difficult to know how and when to intervene. This module will introduce you to the challenges and opportunities, failings and fallacies of the complex world of restoration ecology, rewilding, and the work of restoration ecologists. It will look at how rewilding could be the most efficient of nature-based solutions and asks if this is feasible in the modern world. As the discipline struggles to navigate global climate issues, integrate with the social sciences, incorporate politics and economics, and derive policy actions, this module will draw on case studies of restoration globally to will challenge students to rethink ecology and ecosystems in the Anthropocene. It will also discuss areas of employment where students might consider after graduation, with some invited guests providing insight into the practice of restoration and rewilding.

ZOU44019 Advances in Behavioural Ecology (S1) **5 credits**
Prof J Barnett
This module will expand the students' grasp of some classic topics in the field of behavioural ecology such as the consequences of group living, optimality models, animal culture and signalling. We will also explore some currently advancing themes, including multi-level societies, co-operation, and the effects of urbanization on animal behaviour. The content will be delivered using a flipped classroom format of worksheets introduced by short lectures as well as independent reading followed by structured discussions. The continuous assessment will be in two parts. The first will involve the students undertaking group research into a currently active field of animal behaviour and presenting their findings to the class, receiving a group mark. The second will involve writing a blog on a paper of their choice taken from one of the leading behavioural journals, which will be individually assessed.

Zoology Learning Outcomes

On successful completion of the two-year Sophister programme in Zoology, students will be able to:

- set out the important basic concepts and current research developments in animal biology and associated disciplines
- structure the diversity and evolution of the animal kingdom
- design useful experiments
- demonstrate technical competence in the handling of research facilities and operate safely in a laboratory environment, both individually and as a team member
- design sampling programmes and carry out fieldwork using standard procedures
- communicate effectively both orally and in in a variety of contemporary scientific writing styles.
- use appropriate editing, web-based, graphical, and analytical software to analyse and interpret data and prepare reports and assignments.
- critically analyse experimental results (including those obtained personally) and use appropriate statistical and other quantitative procedures for data handling
- proficiently search and critically assess scientific literature and databases
- apply a scientific approach to problem solving
- articulate the contribution, including the ethical dimension, made by Zoology to society, in the realms of the environment, agriculture, natural resource management, human behaviour and health.

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 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.

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

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

Full regulations on non-submission of coursework can be found via the following:
https://www.tcd.ie/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/

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/sld/

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.iehttps://www.tcd.ie/studentcounselling/
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
https://www.tcd.ie/accommodation/

Dates to note

Event(s)	Date(s)
TR060 Moderatorship Fair	2nd April 2025
Closing date for submission of Mod Preferences	18th April 2025
Semester two assessments session	22nd April to 2nd May 2025
Publication of Science examination results	29th May 2025
Publication of First Round Sophister Places	Tuesday 8th July 2025
Reassessment Examinations	25th August to 29th August (TBC)
Publication of Second Round Sophister places	10th September 2025 (TBC)
Semester one starts	15th September 2025
Semester one ends	5th December 2025
Semester one examinations	15th December to 19th December

Teaching term dates 2025-26

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

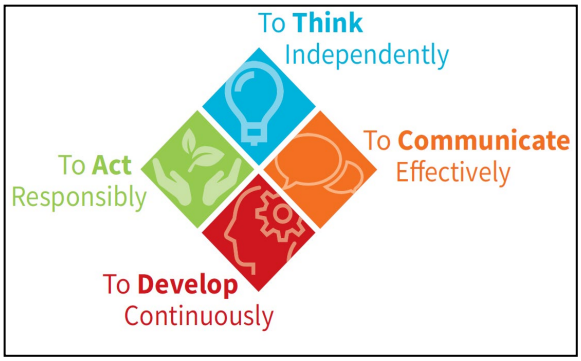
October bank holiday – Monday 27th October 2025
February bank holiday – Monday 2nd February 2026
St Patrick's Day - Tuesday 17th March 2026
Good Friday – 3rd April 2026
Easter Monday – 6th April 2026

Graduate Attributes

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

The four Trinity Graduate Attributes are:

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



Why are the Graduate Attributes important?

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

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

How will I develop these Graduate Attributes?

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

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

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

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 anemergency, **dial Security Service on extension 1999** Security Services provide a 24-hourservice to the college community, 365 days a year. They are the liaison to the Fire, Garda and Ambulance services and all staff and students are advised to always telephone extension 1999 (+353 1 896 1999) in case of an emergency. Should you require any emergencyor rescue services on campus, you must contact Security Services. This includes chemical spills,personal injury or first aid assistance. It is recommended that all studentssave at least one emergency contact in their phone under ICE (In Case of Emergency).
Health and Safety	Faculty of Science, Technology, Engineering and Mathematics website - https://www.tcd.ie/stem/undergraduate/health-safety.php School Handbooks will have School/Discipline information on Health and Safety.
Data Protection	https://www.tcd.ie/dataprotection/ https://www.tcd.ie/dataprotection/assets/docs/dataprotectionhandbook/DP_Handbook_15042021.pdf
Academic Integrity	https://www.tcd.ie/teaching-learning/academic-integrity/
Research Ethics	https://www.tcd.ie/research/support/ethics-integrity.php
Blackboard	Blackboard
Explanation of Weightings	https://www.tcd.ie/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 Policies
Academic Awards	https://www.tcd.ie/teaching-learning/academic-policies/assets/academic-awards-jan2021.pdf

Item	Reference/Source
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.
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
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 & events	https://www.tcd.ie/Science/careers/ For further information refer to School/Discipline Handbooks.
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 (UG only) – Academic Registry	https://www.tcd.ie/academicregistry/student-registration/
Student supports	https://www.tcd.ie/students/
STEM Schools and Disciplines	https://www.tcd.ie/structure/faculties-and-schools/#d.en.2024679
GradIreland Career advice, graduate jobs and internships	https://gradireland.com/
Alumni Student Mentoring programme	https://www.tcd.ie/alumni/mentoring/students.php https://www.tcd.ie/alumni/mentoring/events-guide.php