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

TR060
Biological & Biomedical Science
Sophister Course Programme 2021- 2022
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Welcome

Dear Students

Congratulations – you are nearing the end of the Freshman years of your degree and are ready to make the important decision about which science moderatorship you wish to pursue. The Freshman 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/TEP/trinity_electives.php). 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 Áine Kelly
Associate Dean of Undergraduate Science Education
Foreword

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 Freshman 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 Freshman 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.

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.

Prof Kevin Devine

Director Biological and Biomedical Sciences
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 Advisers.

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 courses, 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.

Allocation of Places

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

The number of places available in each moderatorship subject is limited by quota. Allocation is based on the overall mark obtained in the Senior Freshman examinations and the order of choice as expressed by the student.

The Science Course Office makes the decisions on the allocation of places. Students cannot be allocated a place by circumventing the Science Course Office and going directly to the disciplines. All enquiries with regard to the allocation of places made to the disciplines will be redirected to the Science Course Office sophistersco@tcd.ie.

Places will be allocated in the following way until quotas are reached:

1. All students passing their Senior Freshman semester one and semester two examinations will be ranked in merit order on the basis of their overall mark.
2. Places will be allocated in rank order.
3. Students failing the Senior Freshman examinations must reapply for the remaining unfilled places until quotas are reached. Second round choice of subject forms will be made available on-line:
   https://www.tcd.ie/Science/TR060/junior-sophister/
4. The closing date for the online second round form is Friday 23rd July 2021.
5. Examination results will be available on your personal portal at my.tcd.ie.
6. Publication of the JS places will be available through my.tcd.ie portal by the end of June.

7. Students are informed by email when the places are published, and the procedures followed are clearly outlined in the email.

8. Students opting to go ‘off books’ rather than take up the place offered, will be treated as rising JS students in the following year. Places will not be reserved for such students. Students who apply for readmission will be considered for a place in the same way as the year in which they qualified (if a student did not qualify for a place in the first round, they will not be considered in the first round when they apply for readmission to the College).

9. Students who fail their Junior Sophister examinations will be treated ex-quota in relation to that discipline.

10. Students who are given permission by the Senior Lecturer to defer their examinations until the reassessment examination session can defer a place in their first preference only. Following publication of the reassessment examinations, students who passed Senior Freshman examinations at the reassessment session will be allocated a place based on the same criteria used in the summer allocation of places. If the student in this category does not qualify for the deferred place, the Science Course Administrator will offer 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.

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

**Moderatorship Choice Form**

The choice of subject form is available online: [https://www.tcd.ie/Science/TR060/junior-sophister/](https://www.tcd.ie/Science/TR060/junior-sophister/) click on Moderatorship Choice Form. The closing date for submission of the JS Moderatorship choices form is Friday 30th April 2021.
<table>
<thead>
<tr>
<th>Course Advisors (JS)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Biochemistry</td>
<td>Prof D. Nolan</td>
<td><a href="mailto:denolan@tcd.ie">denolan@tcd.ie</a></td>
</tr>
<tr>
<td>Botany</td>
<td>Prof M. Williams</td>
<td><a href="mailto:willism@tcd.ie">willism@tcd.ie</a></td>
</tr>
<tr>
<td>Environmental Sciences</td>
<td>Prof M. Saunders</td>
<td><a href="mailto:saundem@tcd.ie">saundem@tcd.ie</a></td>
</tr>
<tr>
<td>Genetics</td>
<td>Prof J.P. Labrador</td>
<td><a href="mailto:labradoj@tcd.ie">labradoj@tcd.ie</a></td>
</tr>
<tr>
<td>Human Genetics</td>
<td>Prof J. Farrar</td>
<td><a href="mailto:gjfarrar@tcd.ie">gjfarrar@tcd.ie</a></td>
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<tr>
<td>Immunology</td>
<td>Prof F. Sheedy</td>
<td><a href="mailto:fsheedy@tcd.ie">fsheedy@tcd.ie</a></td>
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<tr>
<td>Microbiology</td>
<td>Prof U. Bond</td>
<td><a href="mailto:ubond@tcd.ie">ubond@tcd.ie</a></td>
</tr>
<tr>
<td>Molecular Medicine</td>
<td>Prof K. Mok</td>
<td><a href="mailto:MOK1@tcd.ie">MOK1@tcd.ie</a></td>
</tr>
<tr>
<td>Neuroscience</td>
<td>Prof E. Jimenez-Mateos</td>
<td><a href="mailto:jimeneze@tcd.ie">jimeneze@tcd.ie</a></td>
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<tr>
<td>Physiology</td>
<td>Prof M. Caldwell</td>
<td><a href="mailto:caldwellm@tcd.ie">caldwellm@tcd.ie</a></td>
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<tr>
<td>Zoology</td>
<td>Prof A. Jackson</td>
<td><a href="mailto:jacksoan@tcd.ie">jacksoan@tcd.ie</a></td>
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<tr>
<td>Biochemistry</td>
<td>Prof Danny Zisterer</td>
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<tr>
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<td>Prof Mike Williams</td>
<td><a href="mailto:willimsm@tcd.ie">willimsm@tcd.ie</a></td>
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<td>Prof Matthew Saunders</td>
<td><a href="mailto:saundem@tcd.ie">saundem@tcd.ie</a></td>
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<td><a href="mailto:labradoj@tcd.ie">labradoj@tcd.ie</a></td>
</tr>
<tr>
<td>Human Genetics</td>
<td>Prof Jane Farrar</td>
<td><a href="mailto:jane.farrar@tcd.ie">jane.farrar@tcd.ie</a></td>
</tr>
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<td>Prof Clair Gardiner</td>
<td><a href="mailto:clair.gardiner@tcd.ie">clair.gardiner@tcd.ie</a></td>
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<tr>
<td>Microbiology</td>
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<td>Prof Gareth Brady</td>
<td><a href="mailto:bradyg@tcd.ie">bradyg@tcd.ie</a></td>
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<td><a href="mailto:cuninisco@tcd.ie">cuninisco@tcd.ie</a></td>
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<tr>
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<td>Prof Alice Witney</td>
<td><a href="mailto:awitney@tcd.ie">awitney@tcd.ie</a></td>
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<tr>
<td>Zoology</td>
<td>Prof Andrew Jackson</td>
<td><a href="mailto:jacksoan@tcd.ie">jacksoan@tcd.ie</a></td>
</tr>
</tbody>
</table>
Moderatorship Quotas

To be qualified for a moderatorship, students must have successfully completed both Freshman 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.

<table>
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<tr>
<th>Moderatorship</th>
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<td>Zoology</td>
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### Junior Freshman Modules 2019/20

<table>
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<tr>
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<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>BYU11101</td>
<td>From Molecules to Cells</td>
<td>10</td>
</tr>
<tr>
<td>BYU11102</td>
<td>From Organisms to Ecosystems</td>
<td>10</td>
</tr>
<tr>
<td>CHU11B01</td>
<td>Chemistry for Life Sciences</td>
<td>10</td>
</tr>
<tr>
<td>MAU11002</td>
<td>Mathematics, Statistics &amp; Computation 2</td>
<td>10</td>
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</table>

**Core Modules**

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>BYU11101</td>
<td>From Molecules to Cells</td>
<td>10</td>
</tr>
<tr>
<td>BYU11102</td>
<td>From Organisms to Ecosystems</td>
<td>10</td>
</tr>
<tr>
<td>CHU11B01</td>
<td>Chemistry for Life Sciences</td>
<td>10</td>
</tr>
<tr>
<td>MAU11002</td>
<td>Mathematics, Statistics &amp; Computation 2</td>
<td>10</td>
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</table>

**OPEN MODULES**

<table>
<thead>
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<th>Module Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSU11004</td>
<td>Spaceship Earth – An Introduction to Earth System Science</td>
<td>10</td>
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<tr>
<td>GSU11005</td>
<td>Introduction to Geology – A Beginners Guide to Planet Earth</td>
<td>10</td>
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<tr>
<td>*PYU11F10/20</td>
<td>Foundation Physics for Life and Earth Scientists 1 &amp; 2</td>
<td>10</td>
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<tr>
<td>*SEU10001/02</td>
<td>Science Education and Communication 1&amp; 2</td>
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* Foundation Physics and Science Education modules in either semester 1 or semester 2 (10 credits each)

### Senior Freshman Modules 2020/21

<table>
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<tbody>
<tr>
<td>BYU22001</td>
<td>From Molecules to Cells</td>
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<tr>
<td>BYU22002</td>
<td>From Cells to Organisms</td>
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<td>BYU22003</td>
<td>From Organisms to Ecosystems</td>
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<tr>
<td>BYU22S01</td>
<td>Statistics &amp; Computation</td>
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<tr>
<td>PIU22991</td>
<td>History Philosophy &amp; Ethics of Science</td>
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**Open Modules**

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYU22004</td>
<td>Sustainable Production: Food, Drink &amp; Drugs</td>
<td>5</td>
</tr>
<tr>
<td>BYU22005</td>
<td>Influences on Animal Behaviour</td>
<td>5</td>
</tr>
<tr>
<td>BYU22006</td>
<td>Microbes, Immune Systems &amp; their Interaction</td>
<td>5</td>
</tr>
<tr>
<td>BYU22007</td>
<td>Genomes, Disease and Diversity</td>
<td>5</td>
</tr>
<tr>
<td>CHU22205</td>
<td>Chemistry for Biologists</td>
<td>5</td>
</tr>
<tr>
<td>GSU22001</td>
<td>From Atoms to Rocks: Introduction to Geochemistry</td>
<td>5</td>
</tr>
<tr>
<td>GSU22005</td>
<td>Sedimentary Processes &amp; Environments</td>
<td>5</td>
</tr>
<tr>
<td>GGU22006</td>
<td>Dynamic Earth</td>
<td>10</td>
</tr>
<tr>
<td>MAU23302</td>
<td>Euclidean and Non-Euclidean Geometry</td>
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</tbody>
</table>
Choice of Subject 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://www.tcd.ie/Science/TR060/junior-sophister/. The closing date is Friday 30th April 2021.

Open Module Choice Forms

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 at https://www.tcd.ie/Science/TR060/junior-sophister/.

Open Module Timetabling Face to Face/Virtual

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

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.

Selection of Trinity Electives will be made through online enrolment which will open in July 2021, after publication of examination results and allocation of moderatorship places. You will be asked to list your choice(s) of Trinity Elective in order of preference. Places are
allocated according to a computer algorithm based on student preference and places available in the Trinity Elective. Exam results are not factored into this algorithm.

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 Scenario 1; taking one Trinity Elective in the second semester, restricts you to the open modules in Scenario 2 while taking two Trinity Electives, (one in each semester) restricts you to the open modules in Scenario 3. Please refer carefully to the tables in this handbook.

Please note that you CANNOT change your Trinity Elective so choose carefully!!!

Summary of Process
May: Results are published
June: Moderatorships are allocated.
   Students apply for Trinity Electives through an online portal on the Trinity Electives website. Trinity Electives are allocated by computer algorithm.
   Students are informed of Trinity Elective allocation. THERE IS NO CHANGE OF MIND.

Following this process, students will select their Open Modules.

Non-Satisfactory Attendance and Coursework
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.

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 https://www.tcd.ie/undergraduate-studies/academic-progress/attendance-course-work.php.

Please refer to your department/discipline handbook for moderatorship regulations.
**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 Regulations**

Reassessment is available in all years.

Students may not present for reassessment in a module they have passed.

Capping of marks will not be applied for reassessment.

**Repeat Year regulations**

Students who fail to satisfy the requirements of their year at the Reassessment session are required to repeat the year in full (i.e. all modules and all assessment components).

Students are permitted to repeat any year of an undergraduate programme subject to, not repeating the same year more than once and not repeating more than two academic years within a degree course, except by special permission of the University Council (see calendar [https://www.tcd.ie/calendar/undergraduate-studies/general-regulations-and-information.pdf page 37].

The option to repeat a year on ‘off-books’ basis will be at the discretion of the Senior Lecturer (see Calendar [https://www.tcd.ie/calendar/undergraduate-studies/general-regulations-and-information.pdf page 40]).
## Dates to Note

<table>
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<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
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<td>19th April 2021</td>
<td>Semester 2 - Hilary Lecture Term ends</td>
</tr>
<tr>
<td>6th April 2021</td>
<td>TR060 Virtual Moderatorship Fair</td>
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<tr>
<td>30th April 2021</td>
<td>Closing date – Submit choice of Moderatorship forms</td>
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<tr>
<td>11th May 2021</td>
<td>Semester 2 Examinations begin (TBC)</td>
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<tr>
<td>23rd May 2021</td>
<td>Semester 2 Examination ends (TBC)</td>
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<tr>
<td>25th May 2021</td>
<td>Deferred Semester 1 Examination begin (TBC)</td>
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<td>30th May 2021</td>
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<td>Closing date – 2nd Round Choice Moderatorship Form</td>
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_N.B. These dates are accurate going to print but may be subject to change._
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 new 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.
## Module Structure

<table>
<thead>
<tr>
<th>Core Modules</th>
<th>Open Modules Scenario I</th>
<th>Open Modules Scenario II</th>
<th>Open Modules Scenario III</th>
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</thead>
<tbody>
<tr>
<td>BIU33110 Protein Structure and Function. (10 credits)</td>
<td>GEU33045 Genomics and Systems Biology (5 Credits)</td>
<td>GEU33045 Genomics and Systems Biology (5 Credits)</td>
<td>GEU33045 Genomics and Systems Biology (5 Credits)</td>
</tr>
<tr>
<td>BIU33120 Membranes and Cell Biology. (10 credits)</td>
<td>Trinity Elective (5 Credits)</td>
<td>PGU33905 Cell Physiology and Pharmacology (5 Credits)</td>
<td>Trinity Elective (5 Credits)</td>
</tr>
<tr>
<td>BIU33010 Nucleic acids. (10 credits)</td>
<td>BIU33250 Introduction to Immunology and Immunometabolism (5 Credits)</td>
<td>BIU33250 Introduction to Immunology and Immunometabolism (5 Credits)</td>
<td>BIU33250 Introduction to Immunology and Immunometabolism (5 Credits)</td>
</tr>
<tr>
<td>BIU33160 Research skills in Biochemistry. (10 credits)</td>
<td>GEU33215 Medical Genetics (5 Credits) OR BIU33475 Basic Neurobiology (5 Credits)</td>
<td>Trinity Elective (5 Credits)</td>
<td>Trinity Elective (5 Credits)</td>
</tr>
</tbody>
</table>

### BIU33110 PROTEIN STRUCTURE (S1) 10 credits

**Profs A Khan, K Hun Mok, D Finlay, A Budanov, ECreagh, D Nolan, N Nic a' Bháird**

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, P Voorheis, D Nolan, E Creagh, R Porter, 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
Professors 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.

Open modules

GEU33045 Genomics and Systems Biology (S1) 5 credits
Professors 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 analyze the proteome of an organism.

PGU33905 Cell Physiology and Pharmacology. Credit Value (S1) 5 credits
Professors T. Boto and M-V. Guillot Sestier
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 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

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, 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).
Module Structure

<table>
<thead>
<tr>
<th>Course</th>
<th>Semester 1 (S1)</th>
<th>Semester 2 (S2)</th>
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<tbody>
<tr>
<td><strong>Core Modules</strong></td>
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</tr>
<tr>
<td>BIU44010 Advanced Research Skills (10 credits)</td>
<td>BIU44110 Biochemistry in Health and Disease II (10 credits)</td>
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<tr>
<td>BIU44120 Immunology &amp; Microbiology (10 credits)</td>
<td>BIU44130 Cancer Biology &amp; Cell Signalling (10 credits)</td>
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<tr>
<td><strong>Capstone Project</strong></td>
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<tr>
<td>BIU44190 Research Project in Biochemistry (20 Credits)</td>
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**BIU44190 RESEARCH PROJECT IN BIOCHEMISTRY (S1)**

20 credits

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

The module comprises of 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, A Molloy & R Porter.

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


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
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.
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 Mike Williams willism@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, physiology 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 20 credits in residential field trip modules, including trips to Gran Canaria, and Africa.
## Module Structure

### Botany

<table>
<thead>
<tr>
<th>Core Modules</th>
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<tbody>
<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>BOU33XXX: Diversity and Systematics of Land Plants (5 credits)</td>
</tr>
<tr>
<td>BOU33109: General Botanical Science 5 Credits</td>
<td>BOU33121: Field Skills in Plant and Environmental Sciences (5 Credits)</td>
</tr>
</tbody>
</table>

### Open Modules Scenario I

In addition to the 5 credits of Trinity Electives, choose **ONE** module from the following three:

- BOUXXXX Mycology
- GSU33003: Ice Age Earth (5 credits)
- BOU33105: Global Environmental Change (5 credits)

Trinity Elective (5 credits)

Students will automatically be enrolled on both modules below in semester 2:

- BOU33123: Soil Science (5 credits)
- BOU33122: Entomology (5 credits)

### Open Modules Scenario II

Choose two modules from the following three:

- BOUXXXX Mycology
- GSU33003: Ice Age Earth (5 credits)
- BOU33105: Global Environmental Change (5 credits)

In addition to the 5 credits of Trinity Electives, choose **ONE** module from the following two:

- BOU33123: Soil Science (5 credits)
- BOU33122: Entomology (5 credits)

Trinity Elective (5 credits)

### Open Modules Scenario III

In addition to the 5 credits of Trinity Electives, choose **ONE** module from the following three:

- BOUXXXX Mycology
- GSU33003: Ice Age Earth (5 credits)
- BOU33105: Global Environmental Change (5 Credits)

In addition to the 5 credits of Trinity Electives, choose **ONE** module from the following two:

- BOU33123: Soil Science (5 credits)
- BOU33122: Entomology (5 credits)

Trinity Elective (5 credits)
BOU33100 Plant Physiology (S1) Prof M Williams
5 credits
This module covers major biochemical and physiological aspects of photosynthesis, respiration, resource capture and growth at both the cell and whole plant level. Supporting practical’s are designed to examine both the light and stromal reactions of photosynthesis and to investigate the role of light in seed germination and plant development. Continual assessment will be through a programme of practical’s, tutorials, and student presentations.

ZOU33010 Fundamentals of Ecology (S1) Prof I Donohue and Prof F Mitchell
5 credits
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) Profs F Mitchell, I Donohue, T Hodkinson, J McElwain, M Saunders, J Stout & M Williams
5 credits
This module combines an introduction to the Botany and Environmental Sciences moderatorships with a series of field-based activities including a residential fieldtrip during the first week of the teaching term. There will also be a lecture given during the field trip and three following it on specific aspects of the Irish flora.

BOU33XXX Frontiers in Botany (S1) Prof M Saunders
5 credits
The aim of this module is to introduce undergraduate students to current research topics in the field of Botany and to explore how the research undertaken in the Botany department is at the frontier of addressing the key challenges that society faces. These topics will be discussed through interactive tutorials and students will have the opportunity to write an extended desk study around the research topics of the staff members. The module is also aligned with the Ecology, Evolution and the Environment seminar series where invited international speakers will discuss their research and is further divided into a series of interactive tutorials and workshops with themes such as, essay writing, problem solving, presentation skills, graphics, thesis writing, journal article analysis and scientific communication.

BOU33107 Plant Molecular Biology (S2) Prof T Hodkinson
5 credits
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 C Holland
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 module consists of two parts. 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 and the use of spreadsheets for data entry. 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 aim of the second part of the module is to address, in more detail, the fundamentals of experimental design and to explore how previous projects were conducted. In addition, students will learn how to write a moderatorship project proposal.

BOU33XXX Diversity and Systematics of Land Plants (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 allies), 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
Prof J Stout (coordinator), T Hodkinson, S Waldren, M Saunders & M Williams
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.
Open Modules
BOU33XXX Mycology (S1) Prof C Harper 5 credits
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.

GSU33003: Ice Age Earth (S1) 5 credits
Prof Robin Edwards & Prof 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.

BOU33105 Global Environmental Change (S1) Prof M Williams 5 credits
The global environment is changing more rapidly at present than at any time during the human occupancy of the planet. This module reviews the existence of the changing environment and the predictions for the future. Continual assessment consists of a mini desk study on the environmental pressures faced by a given country, and also a soil respiration practical where climate change is linked to increases in heterotrophic soil respiration.

BOU33123 Soil Science (S2) Prof M Saunders 5 credits
Soils are important for plants as they provide the key resources required for growth and 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) Prof J Stout 5 credits
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 practical’s will provide students with the skills for sampling and identification of insects, which will be further enhanced through an individual project.
# Module Structure

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<td><strong>Core Modules</strong></td>
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<tr>
<td>ZOU44030</td>
<td>Data Handling (5 credits)</td>
<td>BOU44XXX Plants and the Planet (5 credits)</td>
</tr>
<tr>
<td>BOU44108</td>
<td>Plant Environment Interactions (5 credits)</td>
<td>BOU44110 The Evolution of Plants and Plant Atmosphere Interactions (5 credits)</td>
</tr>
<tr>
<td>BOU44109:</td>
<td>Vegetation Description and Analysis (5 credits)</td>
<td>BOU44103: Plant Conservation and Biodiversity (5 credits)</td>
</tr>
<tr>
<td>BOU44107:</td>
<td>Plant-Animal Interactions (5 credits)</td>
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<tr>
<td>FBU44060:</td>
<td>Plant Breeding and Biotechnology (5 credits)</td>
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<tr>
<td>BOU44111:</td>
<td>Restoration Ecology and Re-Wilding (5 credits)</td>
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<tr>
<td>ZOU44XXX Tropical Ecology and Conservation (5 credits – field trip)</td>
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**Module Description**

**ZOU44030 Data Handling (S1) 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 skillset 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 conceptualizing 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.
BOU44108 Plant Environment Interactions (S1)  
Prof M Saunders  
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. 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.

BOU44109 Vegetation Description and Analysis (S1)  
Profs S Waldren  
This module will describe how to sample, record and lead up to detailed multivariate analyses to help define vegetation communities. Though some theoretical and historical framework will be given in lectures, the emphasis will be on practical collection, analysis and interpretation of vegetation data. Various data sets will be utilised in computer-based sessions, and field work will be used to generate a novel data set, the analysis and interpretation of which will form part of the continuous assessment for this module.

BOU44XXX Plants and the Planet (S2)  
Prof M Saunders  
The aim of this module is to further explore how plants influence our planet through the research undertaken in the Botany department and the wider world. The module is divided into a series of interactive tutorials with staff and also invited speakers on the Ecology, Evolution and the Environment seminar series which will explore the frontiers of botanical research and how this work addresses the key environmental challenges faced by society. This module will also help to develop skills in communication, the analysis of scientific information, essay writing, problem solving, graphics, thesis writing, journal article analysis.

BOU44110 The Evolution of Plants and Plant Atmosphere Interactions (S2)  
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.
BOU44103 Plant Conservation and Biodiversity (S2) 5 credits
Profs S Waldren & 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.

FBU44000: Research Project (S2) 20 credits
Prof I Donohue (module co-ordinator) 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. They will submit a research proposal before the practical work begins as part of the Junior Sophister ZOU33070 Experimental Design & Analysis module, submit a thesis and present a poster on the results. For the project, they 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, all the time recording progress in a notebook, which must be made available to the project supervisor together with original data. Detailed guidance notes on writing and submitting the thesis and poster may be found on the FBU44000 Blackboard site.

Open Modules
BOU44107 Plant-Animal Interactions (S1) Prof J Stout 5 credits
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 plant-pollinator interactions, including pollinator-mediated evolution of floral traits, community level interactions, pollinator decline and conservation. The second part 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. Practical’s will investigate floral characteristics and adaptations for pollination, pollinator networks and plant and animal adaptations to herbivory.

FBU44060 Plant-Breeding Biotechnology (S1) 5 credits
Prof T Hodkinson & Dr B Murphy
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, and case studies in breeding and biotechnology. Practicals cover crop diversity, polyploid estimation and at least one site visit to a Teagasc Research Centre (e.g. Ashtown Dublin).
BOU44111 Restoration Ecology and Re-Wilding (S1)  5 credits
Dr Marcus 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. 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.

ZOU44XXX Tropical Ecology and Conservation (S1)  5 credits
Prof I Donohue
The module comprises a short series of lectures followed by a nine-day residential field course in East Africa that will run at the end of October (encompassing the reading week) though, depending upon national and international travel restrictions, may be moved to January 2022 or, if necessary, to later in Semester 2 2022. The module will focus on the ecology and biodiversity of a range of ecosystems and habitats (including aquatic ecosystems [freshwater rivers and lakes, wetlands and saline lakes], tropical montaine forest 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 module. The module will focus particularly on the following three topics:

- Quantifying biodiversity and the factors that underpin biodiversity in the tropics
- Economics of wildlife management
- Behaviour on the savannah
- Sustainable development of tropical ecosystems
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 sciences 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 critically evaluate 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, using spreadsheets and other software.
  • Collaborate effectively in teams and work independently.
  • Communicate accurately, clearly, persuasively and imaginatively, in both oral and written form.
Environmental Science

Junior Sophister    Course Advisor: Prof M Saunders saundem@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.
# Module Structure

## Environmental Sciences

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<thead>
<tr>
<th>Core Modules</th>
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<tr>
<td>BOU33108 Plants in the Irish Environment (5 credits)</td>
<td>BOU33123 Soil Science (5 credits)</td>
</tr>
<tr>
<td>ZOU33010 Fundamentals of Ecology (5 credits)</td>
<td>GGU33930 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>BOU33105 Global Environmental Change (5 credits)</td>
<td>ESU33003 Desk Study: Key challenges in Environmental Science (5 credits)</td>
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### Open Modules Scenario I

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<tr>
<th>GSU33003 Ice Age Earth (5 credits)</th>
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*This module has a quota of 15 students*
BOU33108 PLANTS AND THE IRISH ENVIRONMENT (S1) 5 credits
Coordinator: Prof F Mitchell
This module combines an introduction to the Plant Sciences and Environmental Sciences moderatorships with a series of field-based activities including a residential fieldtrip during the first week of term (Week 3). There will also be a lecture given during the field trip and three following it on specific aspects of the Irish flora.

ZOU33010 FUNDAMENTALS OF ECOLOGY (S1) 5 credits
Coordinator: Prof I Donohue
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
Coordinator: Profs J Piggott & M Penk
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 a field trip and in subsequent laboratory sessions. The field trip will conclude with a written report, detailing student’s findings in a scientific format.

BOU33105 GLOBAL ENVIRONMENTAL CHANGE (S1) 5 credits
Coordinator: Prof M Williams
The global environment is changing more rapidly at present than at any time during the human occupancy of the planet. This module reviews the existence of the changing environment and the predictions for the future and focusses on aspects of sustainability and how this is assessed for various production systems.

BOU33123 SOIL SCIENCE (S2) 5 credits
Coordinator: 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.
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.

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 module consists of two parts. 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 and the use of spreadsheets for data entry. 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 aim of the second part of the module is to address, in more detail, the fundamentals of experimental design and to explore how previous projects were conducted. In addition, students will learn how to write a moderatorship project proposal.
ESU33003: DESK STUDY: KEY CHALLENGES IN ENVIRONMENTAL SCIENCE (S2)  5 credits
Coordinator: Prof C Harper
Scientific writing is a new language for everyone. The aim of this module is to introduce students to the scientific writing process. Throughout the duration of the semester, students will be presented with a brief overview of the steps involved in reading, publishing, organising, and disseminating research findings; with sufficient experience, this will become easier over time. The goal is to address individual challenges in that process and provide a foundation for success. 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. The finished assessment will be a general-format scientific review article.

GSU33003: ICE AGE EARTH (S1)                         5 credits
Coordinator: Prof 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.

BOU33100 PLANT PHYSIOLOGY (S1)       5 credits
Coordinator: Prof M Williams
This module covers major biochemical and physiological aspects of photosynthesis, respiration, resource capture and growth at both the cell and whole plant level. 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 where raw data from a growth study of plants maintained at different light intensities will be supplied.
GSU33002: BLUE EARTH: UNDERSTANDING THE FUNCTION OF MARINE ECOSYSTEMS (S1)
5 credits
Coordinator: Prof C Rocha

Countless exchanges of chemicals happen every millisecond in this reaction vessel that we happen to call Earth. These constrain and receive feedback from the biosphere, controlling the composition of the hydrosphere, the atmosphere and the lithosphere, and set our environmental futures - our ability to survive, develop and evolve as a species. Even though we call it ‘Earth’, it is the ocean that plays the central role in our planet’s climate system, and marine biogeochemical processes regulate the impact of human activity on the global environment. In addition, the sea supplies a range of ecosystem services without which humanity in its current form could not exist. These include food, energy, transport and trade routes, nutrient and carbon cycling and between 50 and 85% of the oxygen we breathe. Studying marine biogeochemistry provides a working knowledge of how the earth system functions and reacts to human activity, giving a multi-disciplinary view of how life formed, evolved, is sustained and is endangered on Earth. This knowledge provides working insights on how to adapt to climate and environmental change, enhance food production, manage fisheries and aquaculture, mitigate pollution, and innovate by developing new products including drugs and decarbonation technologies. This module will concentrate on the key processes that regulate the climate and marine biology, from ecosystems to cells. The course will cover the biogeochemistry of marine and coastal systems, including coral reefs, estuaries and wetlands, processes regulating the formation and fate of organic matter in the marine environment, and introduce analytical and modelling techniques in marine biogeochemistry. This course will prepare students for related courses field and lab work in Geography, Environmental Sciences and Oceanography.

BOUXXXX Mycology (S1) 5 credits
Coordinator: 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. This module will be delivered through a combination of weekly lectures and several hands-on laboratory practical exercises, i.e., prepared microscope slides, student-prepared wet-mount and whole organism examination. There will be a fungal foray field trip for students to collect and identify specimens in the laboratory. Moreover, there will be class project to document Irish fungal biodiversity, where students will individually and accurately document, record, and report a given number of fungi to national Irish biodiversity data centres.
GLU33009 HYDROLOGY AND GROUNDWATER QUALITY (S2)  5 credits
Coordinator: Prof C Coxon
This module aims to provide students with an understanding of hydrological processes, following the different pathways of water through the terrestrial part of the hydrological cycle. It also aims to familiarise students with the factors affecting groundwater quality, and to develop an understanding of groundwater quality issues in the context of integrated catchment management. The hydrology component of this module includes the following topics: the hydrological cycle and catchment water balances; rainfall and evapotranspiration; soil water and hillslope hydrology; river flow; hydrogeology; groundwater – surface water interaction. The groundwater quality component includes groundwater chemistry and natural groundwater quality problems; groundwater quality issues in rural and industrial settings; groundwater vulnerability and protection. The interaction of groundwater and surface water quality is also considered.

BOU33121 FIELD SKILLS IN PLANT AND ENVIRONMENTAL SCIENCE (S2)  5 credits
Coordinator: Prof J Stout
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.

ZOU330XX Terrestrial Wildlife and Field Ecology (S2)  5 credits
Coordinator: Prof Y Buckley
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 37, 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
Coordinator: Prof J Stout
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.
## Module Structure

### Environmental Sciences

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<tr>
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<tr>
<td>ZOU44030 Data Handling (5 credits)</td>
<td>BOU44103 Plant Conservation and Biodiversity (5 Credits)</td>
</tr>
<tr>
<td>ZOU44092 Environmental Impact Assessment (5 credits)</td>
<td>ESU44054 Spatial Analysis using GIS (5 Credits)</td>
</tr>
<tr>
<td>BOU44111 Restoration Ecology and re-wilding (5 credits)</td>
<td>GGU44927 Environmental Governance 2 (5 Credits)**</td>
</tr>
<tr>
<td>ZOU44060 Research Comprehension (5 credits)</td>
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<tr>
<td>ESU44052 General Environmental Sciences (5 credits)</td>
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**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 skillset 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 conceptualizing 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
Coordinator: Prof I DONOHUE
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 is also briefly covered. In addition to the lectures, students carry out a scoping exercise for a proposed development and conduct a quality review of an actual EIA.

ZOU44060 RESEARCH COMPREHENSION (S1 & S2) 5 credits
Coordinator: Prof P Luijckx
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
Coordinator: 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. 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
Coordinator: Prof M Saunders
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. Guest lectures also form a core part of this module and will be given by practitioners 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
Coordinator: Prof I Donohue
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. They will submit a research proposal before the practical work begins as part of the Junior Sophister ZOU33070 Experimental Design & Analysis module. As part of FBU44000 they will submit a thesis and present a poster on the results. For the project, they 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.

ZOU44XXX TROPICAL ECOLOGY AND CONSERVATION (S1) 5 credits
Coordinator: Prof I Donohue
The module comprises a short series of lectures followed by a nine-day residential field course in East Africa that will run at the end of October (encompassing the reading week). The module will focus on the ecology and biodiversity of a range of ecosystems and habitats (including aquatic ecosystems [freshwater rivers and lakes, wetlands and saline lakes], tropical montaine forest and grasslands) and the connectivity’s 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 module. The module will focus particularly on the following three topics:

- Quantifying biodiversity and the factors that underpin biodiversity in the tropics
- Economics of wildlife management
- Behaviour on the savannah
- Sustainable development of tropical ecosystems

BOU44109 VEGETATION DESCRIPTION AND ANALYSIS (S1) 5 credits
Coordinator: Prof S Waldren
This module will describe how to sample, record and lead up to detailed multivariate analyses to help define vegetation communities. Though some theoretical and historical framework will be given in lectures, the emphasis will be on practical collection, analysis and interpretation of vegetation data. Various data sets will be utilised in computer-based sessions, and field work will be used to generate a novel data set, the analysis and interpretation of which will form part of the continuous assessment for this module.
BOU44107: PLANT ANIMAL INTERACTIONS (S1) 5 credits
Coordinator: Prof J Stout
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 plant-pollinator interactions, including pollinator-mediated evolution of floral traits, community level interactions, pollinator decline and conservation. The second part 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. Practical’s will investigate floral characteristics and adaptations for pollination, pollinator networks and plant and animal adaptations to herbivory.

ZOU44013: CONSERVATION AND WILDLIFE MANAGEMENT (S1) 5 credits
Coordinator: Prof I Donohue
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.

BOU44103: PLANT CONSERVATION AND BIODIVERSITY (S2) 5 credits
Coordinator: Prof S Waldren
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.
ESU44054: SPATIAL ANALYSIS USING GIS (S2)  
Coordinator: Prof N Harty  
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 the Geographic Information Systems (GIS) platform ArcGIS.

GGU44927 ENVIRONMENTAL GOVERNANCE 2 (S2)  
Coordinator: 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.
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.
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 rapidly sequence genomes. A few examples of remarkable advances in knowledge include:
- 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.
## Module Structure

### Genetics

<table>
<thead>
<tr>
<th>Core Modules</th>
<th>Semester 2</th>
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<tbody>
<tr>
<td>GEU33015 Molecular Genetics (5 credits)</td>
<td>GEU33065 Plant and Microbial Genetics (5 credits)</td>
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<tr>
<td>GEU33007 Molecular Genetics Laboratory (5 credits)</td>
<td>GEU33085 Science Structure, Discussion and Presentation for Genetics (5 credits)</td>
</tr>
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<td>GEU33075 Evolutionary and Population Genetics (5 credits)</td>
<td>GEU33035 Genetic Analysis of Nervous Systems (5 credits)</td>
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<td>GEU33025 Data Handling and Bioinformatics (5 credits)</td>
<td>GEU33008 Analytical Genetics Laboratory (5 credits)</td>
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### Open Modules Scenario I

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<tr>
<th>GEU33045 Genomics and Systems Biology (5 credits)</th>
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<tr>
<td>Trinity Elective (5 credits)</td>
<td>GEU33215 Medical Genetics (5 credits)</td>
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<td>OR</td>
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<td>BIU33250 Introduction to Immunology and Immunometabolism (5 credits)</td>
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<td>BIU33475 Basic Neurobiology (5 credits)</td>
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### Open Modules Scenario II

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<tbody>
<tr>
<td>BIU33150 Biochemistry for Biosciences (5 credits)</td>
<td>Trinity Elective (5 credits)</td>
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</table>
GEU33015 Eukaryotic Molecular Genetics (S1)  5 credits
Instructors: Adrian Bracken, Tony Kavanagh, Mani Ramaswami, Seamus Martin
Module Description: The aim of this module is to introduce students to advanced concepts in the molecular genetics of eukaryotes. A major focus will be on the complexities of gene expression and its regulation. This will include transcription by RNA polymerase II, the role of the Mediator complex, and the processing steps involved in the maturation of pre-mRNAs: capping, polyadenylation and splicing. The regulation of gene expression and its critical importance in differentiation and development will be explored at the level of chromatin and nucleosome modifications, and in relation to the combinatorial interactions between transcription factors and cis-acting upstream regulatory elements such as enhancers. Approximately one-third of the course will explore recombinant DNA techniques used in gene expression and genome analysis.
Assessment: 100% end of semester examination.

GEU33007 Molecular Genetics Laboratory (S1)  5 credits
Instructor: Tony Kavanagh
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: 100% end of semester examination.
**GEU33045 Genomics and Systems Biology (S1) 5 credits**

**Instructors:** Frank Wellmer, Ken Mok, Adrian Bracken, Carsten Kröger

**Module Description:** 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.

**Assessment:** 100% end of semester examination.

**GEU33065 Plant and Microbial Genetics (S1) 5 credits**

**Instructors:** Kevin Devine, Tony Kavanagh

**Module Description:** The aim of this module is to introduce students to advanced concepts in plant and microbial genetics, and 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). The evolutionary origins of plant cell organelles (chloroplasts and mitochondria) via endosymbiosis involving ancestral microbes will also be explored, with a focus on their similar gene expression systems. 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 the model plant *Arabidopsis thaliana*, light-regulated gene expression, hormone receptors and signal transduction systems, and the genetics of plant-microbial interactions.

**Assessment:** 100% end of semester examination.
GEU33085 Science Structure Discussion and Presentation for Genetics (S1)  5 credits
Instructors: Juan Pablo Labrador, Kevin Devine, Frank Wellmer, Seamus Martin, Matthew Campbell, Dan Bradley, Aoife Mc Lysaght, Adrian Bracken, Tony Kavanagh, Mani Ramaswami, Lara Cassidy, Russell McLaughlin, Jane Farrar
Module Description: In this module students meet in small groups with lecturers for discussion and problem-solving in an informal setting. Topics include genetic 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 topic can be chosen by the student or suggested by staff. The objective of the review is to bring the reader up-to-date on the subject under review.
Assessment: 100% continuous assessment.

GEU33035 Genetic Analysis of Nervous Systems (S1)  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 (S1)  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 (involving weekly quizzes and a final lab report).
GEU33055 Developmental Genetics (S1) 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 (S1) 5 credits

**Instructors:** Jane Farrar, Russell McLaughlin

**Module Description:** 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).

**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 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*
BIU33475 Basics of Neurobiology (S2)  
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.
# Module Structure

## Genetics

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<thead>
<tr>
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<tbody>
<tr>
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<tr>
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<tr>
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<tr>
<td><strong>Capstone Project</strong></td>
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### GEU4400X Molecular and Cellular Genetics (S 1 & 2)  
10 credits

**Instructors:** Adrian Bracken, Jane Farrar, Mani Ramaswami, Seamus Martin, Matthew Campbell

**Module Description:** The module covers different aspects of cellular genetics and molecular genetics and includes the following areas: Genetic and Non-Genetic Mechanisms in Cancer, Transgenic Animals and Gene Therapy, Genetics & Immunology of Neural Diseases, Functions, Mechanisms and Genetics of Prion-Domain Proteins and Programmed Cell Death.

**Assessment:** 100% end of year examination.

### GEU4400X Evolutionary, Population and Developmental Genetics (S 1 & 2)  
10 credits

**Instructors:** Seamus Martin, Frank Wellmer, Kevin Mitchell, Juan Pablo Labrador, Dan Bradley

**Module Description:** The aim of this module is to expand the knowledge acquired in the previous year on genetic analysis and developmental genetics. Areas covered in the module are Human Evolutionary Genetics, Molecular Evolution, Developmental Genetics of Drosophila, Genetics of Neural Development, Behavioural Genetics

**Assessment:** 100% end of year examination.

### GEU4400X Human Genetics and Genomics (S1 & 2)  
10 credits

**Instructors:** Aoife Mc Lysaght, Adrian Bracken, Tony Kavanagh, and Kevin Devine

**Module Description:** This module expands general and molecular genetics subjects already introduced in the previous year with a general course on Principles of Genetics and specific ones on Genetics and Genomics.

**Assessment:** 100% end of year examination

### GEU4400X Genetics of Model Organisms (S 1 & 2)  
10 credits

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

Module Description: This module will include lectures on prokaryotic, fungal and plant genetics, as well as lectures on selected animal models such as Caenorhabditis elegans.

Assessment: 100% end of year examination

GEU4400X Capstone Project and Review (S 1 & 2)  20 credits

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

Module Description:
In this module the student will undertake a capstone project divided into three components: a) a 10-week research project to be conducted on a topic within the full breadth of the Genetics discipline; b) a computational and data analysis practical where students will process and analyze data relevant to their field of study; c) tutorials for problem solving in the field of Genetics.

Assessment: 100% continuous assessment
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 J Farrar jane.farrar@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.
### Module Structure

#### Human Genetics

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</table>
GEU33015 Eukaryotic Molecular Genetics (S1)  5 credits
Instructors: Adrian Bracken, Tony Kavanagh, Mani Ramaswami
Module Description: The aim of this module is to introduce students to advanced concepts in the molecular genetics of eukaryotes. A major focus will be on the complexities of gene expression and its regulation. This will include transcription by RNA polymerase II, the role of the Mediator complex, and the processing steps involved in the maturation of pre-mRNAs: capping, polyadenylation and splicing. The regulation of gene expression and its critical importance in differentiation and development will be explored at the level of chromatin and nucleosome modifications, and in relation to the combinatorial interactions between transcription factors and cis-acting upstream regulatory elements such as enhancers. Approximately one-third of the course will explore recombinant DNA techniques used in gene expression and genome analysis.
Assessment: 100% end of semester examination.

GEU33007 Molecular Genetics Laboratory (S1)  5 credits
Instructor: Tony Kavanagh
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: 100% end of semester examination.
GEU33025 Data Handling and Bioinformatics (S1)  5 credits
Instructors: Karsten Hokamp, Fiona Roche, Dan Bradley
Module Description: This is a practical module, which will introduce students to the field of bioinformatics and the handling and analysis of data. It is made up of three parts: Bioinformatics, Programming and NGS data analysis. The bioinformatics component will introduce students to the following topics: biological sequence databases, sequence alignment and phylogenetic trees, sequence similarity searching, genetic variation and personal genomics, and genome browsing. The programming part introduces students to the Python programming language, with emphasis on applications to bioinformatics and DNA sequence analysis. Students learn to write programs to handle DNA sequence data, for example translate DNA into protein and to use regular expressions to search for motifs in sequences. During the NGS data analysis part students will carry out a short project relating to the analysis of a ChIP-Seq data set. They will gain hands-on experience using software tools including FastQC, Bowtie2, samtools, GEM and IGV, and learn about topics, such as quality control, trimming, mapping, peak finding, and motif detection.
Assessment: 30% end of semester examination, 70% continuous assessment.

GEU33045 Genomics and Systems Biology (S1)  5 credits
Instructors: Frank Wellmer, Ken Mok, Adrian Bracken, Russell McLaughlin, Carsten Kröger
Module Description: 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 analyze the proteome of an organism.
Assessment: 100% end of semester examination.

GEU33215 Medical Genetics (S1)  5 credits
Instructors: Jane Farrar, Peter Humphries, Russell McLaughlin
Module Description: 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 2021 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).
Assessment: 100% end of semester examination.
GEU33285 Science Structure Discussion and Presentation for Human Genetics (S1)  
5 credits  
Instructors: Juan Pablo Labrador, Kevin Devine, Frank Wellmer, Seamus Martin, Matthew Campbell, Dan Bradley, Aoife Mc Lysaght, Adrian Bracken, Tony Kavanagh  
Module Description: In this module students meet in small groups with lecturers for discussion and problem-solving in an informal setting. Topics include genetic techniques and analysis, mathematical genetics, medical genetics, bioethics and many other rapidly growing areas in Human Genetics. 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 topic can be chosen by the student or suggested by staff. The objective of the review is to bring the reader up to date on the subject under review.  
Assessment: 100% continuous assessment.

GEU33035 Genetic Analysis of Nervous Systems (S1)  
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% end of semester examination

GEU33008 Analytical Genetics Laboratory (S1)  
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 (involving weekly quizzes and a final report).
GEU33055 Developmental Genetics (S1)  5 credits

Instructors: Seamus Martin, Frank Wellmer, Adrian Bracken

Module Description: This module aims to introduce students to fundamental concepts in developmental genetics and to the experimental approaches 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

Profs F Sheedy, J Fletcher, M Carty, E Lavelle, R Porter & 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 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

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.

BIU33150 Biochemistry for Biosciences (S1)  5 credits

Profs A Kahn, K Mok, M Caffery, D Nolan, E Creagh & A Dunne.

This module follows on from the biochemistry/cell biology component of the “Molecules to Cells” BIU22201 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.
**Module Structure**

### Human Genetics

<table>
<thead>
<tr>
<th>Core Modules</th>
<th>Semester 1 (S1)</th>
<th>Semester 2 (S2)</th>
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<tbody>
<tr>
<td><strong>GEU4400X Molecular and Cellular Genetics (10 credits)</strong></td>
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<tr>
<td><strong>GEU4400X Evolutionary, Population and Developmental Genetics (10 credits)</strong></td>
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<tr>
<td><strong>GEU4400X Human Genetics and Genomics (10 credits)</strong></td>
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<tr>
<td><strong>GEU4400X Medical Genetics (10 credits)</strong></td>
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<tr>
<td><strong>Capstone Project</strong></td>
<td>(20 credits)</td>
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**GEU4400X Molecular and Cellular Genetics (S1 & S2) 10 credits**

**Instructors:** Adrian Bracken, Jane Farrar, Mani Ramaswami, Seamus Martin, Matthew Campbell

**Module Description:** The module covers different aspects of cellular genetics and molecular genetics and includes the following areas: Genetic and Non-Genetic Mechanisms in Cancer, Transgenic Animals and Gene Therapy, Genetics and Immunology of Neural Diseases, Functions, Mechanisms and Genetics of Prion-Domain Proteins and Programmed Cell Death.

**Assessment:** 100% end of year examination.

**GEU4400X Evolutionary, Population and Developmental Genetics (S1 & S2) 10 credits**

**Instructors:** Seamus Martin, Frank Wellmer, Kevin Mitchell, Juan Pablo Labrador, Dan Bradley

**Module Description:** The aim of this module is to expand the knowledge acquired in the previous year on genetic analysis and developmental genetics. Areas covered in the module are Human Evolutionary Genetics, Molecular Evolution, Developmental Genetics of Drosophila, Genetics of Neural Development, Behavioural Genetics

**Assessment:** 100% end of year examination.

**GEU4400X Human Genetics and Genomics (S1 & S2) 10 credits**

**Instructors:** Aoife Mc Lysaght, Adrian Bracken, Tony Kavanagh, and Kevin Devine

**Module Description:** This module expands general and molecular genetics subjects already introduced in the previous year with a general course on Principles of Genetics and specific ones on Genetics and Genomics.

**Assessment:** 100% end of year examination.
GEU4400X Medical Genetics (S1 & S2) 10 credits

Instructors: Jane Farrar, Aoife Mc Lysaght, Russell Mc Laughlin, Juan Pablo Labrador, Kevin Devine, Frank Wellmer, Seamus Martin, Matthew Campbell, Dan Bradley, Adrian Bracken, Tony Kavanagh, Mani Ramaswami, Kevin Mitchell

Module Description: This module will expand on the previous year’s module on Medical Genetics, highlighting the power and utility of genetic information to understand the molecular basis of human disorders, and to greatly aid in disease diagnosis, prognosis and development of novel treatments.

Assessment: 100% end of year examination

GEU4400X Capstone Project and Review (S1 & S2) 20 credits

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

Module Description:
In this module the student will undertake a capstone project divided into three components: a) a 10-week research project to be conducted on a topic directly related to Human Biology or medical research; b) a computational and data analysis practical where students will process and analyze data relevant to their field of study; c) tutorials for problem solving in the field of Human Genetics.

Assessment: 100% continuous assessment
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 practical’s 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 Parasitology/Zoology 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/.
### Module Structure

#### Immunology

<table>
<thead>
<tr>
<th>Semester 1 (S1)</th>
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<tbody>
<tr>
<td><strong>Core Modules</strong></td>
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<tr>
<td>BIU33220 Core Concepts in Immunology (10 credits)</td>
<td>BIU33230 Gene Regulation (10 credits)</td>
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<tr>
<td>BIU33270 Immunity &amp; Disease (10 credits)</td>
<td>BIU33260 Research Skills in Immunology (10 credits)</td>
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#### Open Modules Scenario I

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<tr>
<td>BIU33150 Biochemistry for Biosciences (5 credits)</td>
<td>MIU33012 Microbial Pathogenesis (5 credits)</td>
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<tr>
<td>Trinity Elective (5 credits)</td>
<td>ZOU33030 Introduction to Parasitology (5 credits)*</td>
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#### Open Modules Scenario II

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<tr>
<td>GEU33045 Genomics and Systems Biology (5 credits)</td>
<td>Trinity Elective (5 credits)</td>
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*Subject to availability

**BIU33220 Core Concepts in Immunology (S1)**


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 practicals will introduce students to basic immunology techniques including cell culture, flow cytometry and bacterial killing assays.
BIU33270 Immunity & Disease (S1)  10 credits
R McLoughlin K Mills, E Lavelle C O’Farrelly, D Finlay, J Fletcher, F Sheedy, D Zisterer, N NicBhaird & D Nolan
This module will consider the basics covered in BIU33220 & apply this knowledge to the specificity of immune responses to infection covering anti-viral, bacterial and helminth 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, metabolic disease and cancer. Associated practical classes will give students an introduction to basic biochemical lab skills, metabolism and enzyme kinetics and binding/signalling 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 hand-on experience with recombinant DNA technology, quantitative PCR and genome-wide association studies (GWAS).

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 practical’s will give students advanced skills in immunological techniques including ELISA, immuno-blotting, tissue extraction and flow cytometry.

Open Modules:

BIU33150 Biochemistry for Biosciences (S1)  5 credits
Profs A Kahn, K Mok, M Caffery, D Nolan, E Creagh & A Dunne.
This module follows on from the biochemistry/cell biology component of the “Molecules to Cells” BIU22201 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)**  
*Profs S Corr & 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)**  
*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 analyze the proteome of an organism.

**ZOU33030 Introduction to Parasitology (S2) ***  
*Prof C Holland*

The significance of the host-parasite relationship and the processes associated with the definition of parasitism are discussed in this module. Examples from important parasite phyla are reviewed with a focus upon life cycle strategies, ecology, pathology and control. The epidemiology of parasitic diseases including important differences between microparasites and macroparasites are defined. The significance of parasite distributions within host populations is highlighted. External and internal factors, which influence parasite populations, are outlined and particular attention is paid to host behaviour, genetics and immunity. The concept of a parasite community at the infracommunity and component community level is developed. The challenges associated with parasite control are explored. The practical work provides access to a wide range of parasitic material and gives emphasis to the diversity of parasitic lifestyles and forms. A number of the sessions are experimental in nature and explore parasitic adaptations for infection, the significance of parasite distributions in infected hosts, behavioural changes in parasitised hosts and the nature of parasite communities.

*Entry into this module is subject to quota*
Module Structure

<table>
<thead>
<tr>
<th>Immunology</th>
<th>Sem</th>
<th>Core Modules</th>
<th>Capstone Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semester 1 (S1)</td>
<td>Semester 2 (S2)</td>
<td>BIU44210: General Immunology 10 credits</td>
<td>BIU44290: Research Project in Immunology (20 Credits)</td>
</tr>
<tr>
<td>BIU44220: Infection &amp; Immunity 10 credits</td>
<td>BIU44010: Advanced Research Skills 10 credits</td>
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<tr>
<td>BIU44230: Immunological diseases &amp; immunotherapy 10 credits</td>
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**BIU44290 Research Project in Immunology (S1)** 20 credits

Each research project is supervised by a member of staff in the School of Biochemistry & Immunology.

The module comprises of 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 signaling 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


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, L Lynch, 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.
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 the Immunology impacts on society.
Microbiology

Junior Sophister  Course Advisor: Prof Ursula Bond ubond@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 practicals, tutorials and a research essay.

Module Structure

<table>
<thead>
<tr>
<th>Microbiology</th>
<th>Semester 1 (S1)</th>
<th>Semester 2 (S2)</th>
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<td><strong>Core Modules</strong></td>
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<tr>
<td>MIU33011 Microbial Physiology (5 credits)</td>
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<td>MIU33012 Microbiology Pathogenesis (5 credits)</td>
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<tr>
<td>MIU33016 Applied Microbiology &amp; Antimicrobial Agents (5 credits)</td>
<td>MIU33003 Research Essay (5 credits)</td>
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<tr>
<td>MIU33017 Eukaryotic Microbial &amp; Molecular Genetics (5 credits)</td>
<td>MIU33018 Prokaryotic Microbial &amp; Molecular Genetics (5 credits)</td>
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<tr>
<td>MIU33019 Experimental Microbiology I (5 credits)</td>
<td>MIU33020 Experimental Microbiology II (5 credits)</td>
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<tr>
<td><strong>Open Modules Scenario I</strong></td>
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<tr>
<td>BIU33150 Biochemistry for Biosciences (5 credits)</td>
<td>*BIU33250 Introduction to Immunology and Immunometabolism (5 credits)</td>
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<td>**ZOU33030 Introduction to Parasitology (5 credits)</td>
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<td><strong>Open Modules Scenario II</strong></td>
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<td><strong>Open Modules Scenario III</strong></td>
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<td>Trinity Elective (5 credits)</td>
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MIU33011 Microbial Physiology (S1) 5 credits
Profs A Fleming & TBA
This module covers various aspects of microbial physiology including cell surface structure and function, cell membranes, nutrient uptake and metabolism, as well as mechanisms by which cells respond to nutrient depletion. Biosynthesis, post-translational modification and secretion of protein and polysaccharide structures in microbes are described. This module is examined during the examination period at the end of Semester 1.

MIU33017 Eukaryotic Microbial & Molecular Genetics (S1) 5 credits
Prof. Ursula Bond.
The module will introduce students to the molecular processes of RNA biogenesis in eukaryotic cells including transcription, transcript processing and export from the nucleus using the yeast, *Saccharomyces cerevisiae*, as a model system. The mechanisms of producing and degrading proteins and the regulation of these processes are explored. Using the pedagogical approach of exploring seminal discoveries in molecular biology, students will learn how the components of the transcription and translation machines were characterised. Finally, students will explore how the knowledge of the cellular processes are applied by the Biotechnology Industry to address current problems in Industry, Agriculture and Medicine. The laboratory component of this module allows students to put the information learned in lectures into practice. This module is examined during the examination period at the end of Semester 1.

MIU33016 Applied Microbiology and Antimicrobial Agents (S1) 5 credits
Profs C Kroger & M Martins
This module covers applications in Applied Microbiology, discussing essential features of microbiology relevant to the environment, food, pharmaceutical industries and clinical settings. While food and medicinal applications constitute a big portion of applied microbiology, the study of microorganisms has led to commercial industries, which are involved with, and affect, almost all aspects of human life. This module will cover areas such as (i) Environmental microbiology and water quality; (ii) Food microbiology; (iii) Biotechnology; and (iv) Clinical microbiology and Public Health. This module also includes lectures on Antimicrobial Agents, namely: (i) the general properties of the major antimicrobial agents in use and under investigation, (ii) targets/mechanisms of action of current and potential drugs, and (iii) mechanisms of drug resistance in microbial pathogens. This module is examined during the examination period at the end of Semester 1.

MIU33019 Experimental Microbiology (S1) 5 credits
This module offers students an opportunity to explore concepts described in 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. Laboratory-based sessions are closely linked to the content of the modules running concurrently. 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 is assessed ‘in-course’ using a variety of assessment modes including written exams, take-home assignments, lab reports, data handling and interpretation exercises and student presentations.
MIU33003 Research Essay (S2)  
Prof Ursula Bond  
Students will conduct a literature review and compose an essay on a current topic in Microbiology. The students will meet with their academic supervisor to discuss the background of the topic and are provided with a set of selected references as a starting point for the literature review. Tutorials are provided on bibliography generation, Pubmed searches, essay writing and plagiarism.

MIU33018 Microbial & Molecular Genetics (S2)  
Prof. Charles Dorman  
Part A: The student will learn about the bacterial cell cycle, chromosome replication, nucleoid structure and the pioneering experiments and methodologies that have led to our current understanding of the nucleoid are reviewed. Part B: Lectures will describe the forces that act to disrupt the bacterial genome and those that conserve it. The student will learn about various types of mutation and about DNA repair. There is an emphasis on Horizontal gene transfer (HGT) pathways as a force in genome evolution. Part C, places all the molecular processes in the context of cellular physiology. This will be achieved using the osmotic stress response, model regulatory systems (e.g. the lac operon and its control by LacI and cAMP-CRP), signal transduction, the roles of 2-component systems in gene control and other processes such as motility and chemotaxis to illustrate the main principles. Part D integrates all of the material from Parts A to C in the context of pathogen evolution and bacterial virulence. The model pathogens Salmonella enterica and Vibrio cholerae are used to illustrate the key points. The laboratory component of this module allows students to put the information learned in lectures into practice. This module is examined during the examination period at the end of Semester 2

MIU33012 Microbial Pathogenesis (S2)  
Profs S Corr & 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

MIU33020 Experimental Microbiology 2 (S2)  
This module allows students to build on the key skills developed during semester 1 and to further their knowledge of important experimental approaches. Laboratory-based sessions are closely linked to the content of the modules running concurrently. 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.
Open Modules

BIU33150 Biochemistry for Biosciences (S1) 5 credits
Profs A Kahn, K Mok, J Murray, M Caffery, P Voorheis, D Nolan and A Dunne.
This module follows on from the biochemistry/cell biology component of the “Molecules to Cells” BIU22201 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
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 analyze the proteome of an organism.

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 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
ZOU33030 Introduction to Parasitology (S2)  5 credits
Prof C Holland
The significance of the host-parasite relationship and the processes associated with the
definition of parasitism are discussed in this module. Examples from important parasite
phyla are reviewed with a focus upon life cycle strategies, ecology, pathology and control.
The epidemiology of parasitic diseases including important differences between
microparasites and macroparasites are defined. The significance of parasite distributions
within host populations is highlighted. External and internal factors, which influence parasite
populations, are outlined and particular attention is paid to host behaviour, genetics and
immunity. The concept of a parasite community at the infracommunity and component
community level is developed. The challenges associated with parasite control are explored.
The practical work provides access to a wide range of parasitic material and gives emphasis
to the diversity of parasitic lifestyles and forms. A number of the sessions are experimental
in nature and explore parasitic adaptations for infection, the significance of parasite
distributions in infected hosts, behavioural changes in parasitised hosts and the nature of
parasite communities.
* This module is subject to a maximum quota of 38 students owing to limitations around
the delivery of the practical’s. Students who apply for this module will be randomly
allocated up to the quota. Students who fall outside the quota will be directed to their
moderation’s teaching office to select an alternative
Module Structure

Microbiology

<table>
<thead>
<tr>
<th>Core Modules</th>
<th>Semester 1 (S1)</th>
<th>Semester 2 (S2)</th>
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<tbody>
<tr>
<td>MIU44002: Microbial Molecular &amp; Cellular Biology (10 credits)</td>
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<td>MIU44003: Microbial Pathogenicity (10 credits)</td>
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<tr>
<td>MIU44004: Advanced Topics in Microbiology (10 credits)</td>
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<tr>
<td>MIU44005: Data Handling (10 credits)</td>
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Capstone Project

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<tr>
<th>Capstone Project</th>
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<tbody>
<tr>
<td>MIU44001: Research in Microbiology</td>
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<tr>
<td>Research Project, Literature Review (20 Credits)</td>
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</table>

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 handling, data interpretation and problem solving to complement the lectures in the core themes.
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
  o the nature and diversity of microorganisms and the methods of studying them
  o the genetic, biochemical and physiological processes occurring in some of the best-characterised microorganisms
  o the interactions between some of the best-characterised pathogenic microorganisms and their hosts
  o the roles, uses and manipulation of microorganisms in health and disease, agriculture, biotechnology and the environment
  o the roles of microorganisms as model systems in related fields
  o 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 practical’s and laboratory placements in the final year. The modules are designed to integrate together 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 (e.g. University of Massachusetts, Boston) 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.
### Module Structure

#### Molecular Medicine

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<thead>
<tr>
<th>Semester 1 (S1)</th>
<th>Semester 2 (S2)</th>
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<tbody>
<tr>
<td><strong>Core Modules</strong></td>
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<tr>
<td>BIU33370 Proteins to Cells (10 credits)</td>
<td>BIU33390 Nucleic Acids (Molecular Medicine) (10 credits)</td>
</tr>
<tr>
<td>BIU33380 Disease Mechanisms and Drug Discovery (10 credits)</td>
<td>BIU33360 Research skills in Molecular Medicine (10 credits)</td>
</tr>
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</table>

**Open Module Scenario 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 Scenario 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 Scenario 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.

**BIU33370 Proteins to Cells (S1)**  
**10 credits**

*Profs K H Mok, D Finlay, J Murray, A Budanov, P Voorheis, 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, J Murray, K Gately, M Barr, McElligot, F Sheedy & C Cunningham.
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, the programme of drug discovery and ADME/ADMET and its relationship to treatment of human disease. Practical’s 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 practical’s.

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.

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 analyze the proteome of an organism.
PGU33905 Cell Physiology and Pharmacology (S1) 5 credits
Profs T Boto & M-V Guillot Sestier
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 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

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).
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.
Module Structure

### Molecular Medicine

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<th>Semester 1 (S1)</th>
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<td><strong>Core Modules</strong></td>
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<tr>
<td>BIU44010 Advanced Research Skills (10 credits)</td>
<td>BIU44310 Neurobiology &amp; Immunology (10 credits)</td>
</tr>
<tr>
<td>BIU44320 Microbial Diseases &amp; Immune System Disorders (10 credits)</td>
<td>BIU44330 Cell Cycle, Cancer Biology and Therapeutics (10 credits)</td>
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<tr>
<td><strong>Capstone Project</strong></td>
<td><strong>Capstone Project</strong></td>
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<tr>
<td>BIU44390 Research Project in Molecular Medicine (20 credits)</td>
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**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 of 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**


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**


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.
This module covers the cellular and regulatory mechanisms that control the cell cycle. It furthermore it covers the molecular basis of cancer, the progression of the disease and the therapeutic treatment strategies.
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 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 Molecular Medicine impacts on society.
Neuroscience

Junior Sophister Course Advisor: Prof E Jimenez-Mateos jimeneze@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 courses 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 underpinning 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.

For all international visiting student queries please email Prof E Jimenez-Mateos at jimeneze@tcd.ie or Prof C Cunningham at colm.cunningham@tcd.ie
## Module Structure

**Neuroscience**

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<tr>
<td>BIU33455 Research Skills (5 credits)</td>
<td>ANU33001 Neuroanatomy (5 credits)</td>
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<tr>
<td>BIU33465 Integrative Neuroscience (5 credits)</td>
<td>BIU33445 Neurochemistry I (5 credits)</td>
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<td></td>
<td>GEU33004 Genetic analysis of Nervous System (5 credits)</td>
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<tr>
<td>NSU33PH1 General Principles of Pharmacology (5 credits)</td>
<td>Neurophysiology I (5 credits)</td>
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<tr>
<td></td>
<td>BIU33495 Nucleic Acids &amp; Molecular Biology Techniques (5 credits)</td>
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<tr>
<td><strong>Open Modules Scenario I</strong></td>
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<tr>
<td>PGU33905 Cell Physiology and Pharmacology (5 credits)</td>
<td>Human Neuropsychology* (5 credits)</td>
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<tr>
<td>BIU33150 Biochemistry for Biosciences (5 credits)</td>
<td>PSU34580 Preclinical and Clinical Models of Neuropsychiatric and Neurological Disorders</td>
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<td>Trinity Elective (5 credits)</td>
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<tr>
<td><strong>Open Modules Scenario II</strong></td>
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<tr>
<td>PGU33905 Cell Physiology and Pharmacology (5 credits)</td>
<td>Trinity Elective (5 credits)</td>
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<td>BIU33150 Biochemistry for Biosciences (5 credits)</td>
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<tr>
<td>GEU33045 Genomics and Systems Biology (5 credits)</td>
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<tr>
<td><strong>Open Modules Scenario III</strong></td>
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<tr>
<td>PGU33905 Cell Physiology and Pharmacology (5 credits)</td>
<td>Trinity Elective (5 credits)</td>
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<td>BIU33150 Biochemistry for Biosciences (5 credits)</td>
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<td>Trinity Elective (5 credits)</td>
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* The human neuropsychology module is subject to change on a yearly basis but will always run in the second semester
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.

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 E. Jimenez-Mateos
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 lipids, gangliosides and lipid
mediators, intracellular trafficking and signalling before finishing on neurodegenerative and
metabolic disorders of the brain. Practical classes will be devoted to the following topics:
subcellular fractionation of brain tissue, assessment of protein expression in brain tissue,
assessment of enzyme markers, measurement of neurotransmitters, analysis of brain lipids,
neurotransmitter receptor binding.

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:
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).
Open Modules

PGU33905 Cell Physiology and Pharmacology. Credit Value (S1)  5 credits
Profs T Boto & M-V Guillot Sestier
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.

BIU33150 Biochemistry for Biosciences (S1)  5 credits
Profs A Kahn, K Mok, M Caffery, P Voorheis, D Nolan and A Dunne.
This module follows on from the biochemistry/cell biology component of the “Molecules to Cells” BIU22201 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.
PSU34580 Preclinical & clinical models of neuropsychiatric and neurological disorders (S2)  
5 credits  
Prof. Shane O’Mara  
Neuropsychiatric and neurological disorders are widespread and disabling conditions in society, compromising individual quality of life and diminishing productive potential while placing a great strain on health-care systems and care-givers. This course examines a number of these disorders, and places a particular focus on the translation of basic neuroscience to clinical disorders, and vice versa. This module provides students with an understanding of neuropsychiatric and neurological disorders, particularly in terms of their interrelatedness with neurocognitive function and their modelling by preclinical animal models. A particular focus will be on current and developing neurotherapeutic strategies (from molecular to behavioural to assistive/invasive technology approaches). Advances in technologies to model, probe and support nervous system function will be a key feature too, whether from a behavioural, pharmacological and/or neural prosthetic perspective.

1. Basics: Neural Plasticity, Imaging, Preclinical & Clinical Models; Translational Neuroscience  
2. Brain Ageing and Alzheimer’s Disease  
3. Amnestic Disorders (organic disorders of memory; disconnection syndromes)  
4. Parkinson’s Disease and Brain Stimulation  
5. Affective Disorders: Depression, Stress, Fear and Anxiety  
6. Addiction  
7. Control of Appetite: Anorexia and Obesity

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.
Module Structure

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<td>PSU4540* Neuropsychology: Social Neuroscience (5 Credits)</td>
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<td>BIU44415 Research Literature skills** (5 credits)</td>
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* The psychology-led module is subject to change on a yearly basis
** The research literature skills are designed to take place entirely in semester 1 or split between semester 1 and 2 to allow the flexibility for us to choose the most appropriate Neuropsychology modules.
This module is designed to explore the neurobiology of 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 scenarios.

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)  
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  
10. Narcotic analgesics and other CNS acting analgesics  
11. Parkinson’s disease and anti-Parkinsonian drugs  
13. Brain 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.
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 neuroscience, social neuroscience seeks to broaden our understanding of human brain function beyond motor, perceptual and cognitive processes by elucidating the brain’s fundamental role in governing interpersonal relations. This effort has the potential to greatly improve our understanding of how the brain works and, at the same time, to refine theories of social processes. The course outlines 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 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 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.

1. The Emergence of Social Neuroscience
2. The Brain Imaging Revolution
3. Reward and Motivation
4. Disorders of Reward
5. Emotion
6. Faces
7. Mirror Neurons
8. Thinking about the self and others
9. Identity, prejudice and stereotypes
10. Neuroethics
11. Neuroeconomics.

Students will have to comprehend, present and critically analyse research articles from high impact Neuroscience Journals. Each 2.5 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.

This course will also prepare students for an assignment that is focused on the comprehension and dissection of a journal article. This 3-hour assignment will take place near 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, glycineric) 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 degenerative processes in the brain, leading with a
focus on deficits in energy metabolism and their role in neuronal demise. A central example
of this is provided by stroke, but the course will go on to examine the pathogenesis of
neurodegenerative diseases including Parkinson’s, Alzheimer’s and Huntington’s disease,
with a focus on proteostasis, protein aggregation and reactive oxygen species and novel
therapeutic approaches to combat these diseases.

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
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.

BIU4445 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 an 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 contributing to 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 diverse options there are many different types of ‘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 simply 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 finally the written report (dissertation) of the project.
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 central nervous system.
- Understand methodological approaches in modern neuroscience research and apply the data arising from these to explain the integrative functioning of the nervous system across functions including movement, perception, emotion and motivation, learning and memory, decision-making, homeostasis, circadian rhythmicity, sleep and consciousness.
- Describe the major neurodegenerative and neuropsychiatric conditions affecting the brain and articulate key cellular and 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.
### Module Structure

#### Physiology

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#### Open Modules Scenario I

| BIU33350 Molecular Basis of Disease (5 credits)       | PGU33009 Neurophysiology (5 credits)                 |
| ZOU33050 Introduction to Developmental Biology (5 credits) | Trinity Elective (5 credits)                        |
| OR                                                   |                                                      |
| BIU33150 Biochemistry for Biosciences (5 credits)     |                                                      |

#### Open Modules Scenario II

| BIU33350 Molecular Basis of Disease (5 credits)       | PGU33009 Neurophysiology (5 credits)                 |
| Trinity Elective (5 credits)                          | BIU33475 Basic Neurobiology (5 credits)              |
|                                                      | OR                                                   |
|                                                      | GEU33215 Medical Genetics (5 credits)                |

#### Open Modules Scenario III

| BIU33350 Molecular Basis of Disease (5 credits)       | PGU33009 Neurophysiology (5 credits)                 |
| Trinity Elective (5 credits)                          | Trinity Elective (5 credits)                         |
PGU33950 Cell Physiology and Pharmacology. Credit Value (S1)  5 credits
Profs T Boto and M-V Guillot-Sestier
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 Cell and Tissue Structure (S1)  5 credits
Prof M Caldwell
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 & T Boto.
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 W Williamson.
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 scenarios 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.

PGU33111 Gut, Kidney and Hormones (HOR) (S2)  5 credits
Profs M Caldwell, E Downer & M-V Guillot-Sestier
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.
Open Modules

BIU33350 Molecular basis of Disease (S1) 5 credits
Profs E Creagh, A Dunne, J Murray, T McElligot, K Gately, & M Barr.
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, P Voorheis, D Nolan & A Dunne.
This module follows on from the biochemistry/cell biology component of the “Molecules to Cells” BIU22201 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.

PGU33009 Neurophysiology I (S1 & 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.
BIU33475 Basics of Neurobiology (S2)  
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.

GEU33215 Medical Genetics (S2)  
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  Course Advisor: Prof A Witney awitney@tcd.ie

Module Structure

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<td>PGU44006 Biomechanics and Neural Control of Movement (5 credits)</td>
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<td>PGU44801 General Physiology 5 Credits</td>
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<td>PGU44001 Synaptic Properties (5 credits)</td>
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<td>PGU44007 Glial Physiology (5 credits)</td>
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<td>PGU44009 Techniques in Cell Physiology (5 credits)</td>
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<td>PGU44002 Journal Club 5 Credits</td>
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<td><strong>S1 and S2</strong></td>
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<td>PGU44802 Integrative Physiology 10 Credits</td>
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<td><strong>Capstone Project (S2)</strong></td>
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<td>PGU44020 Capstone Project (20 credits)</td>
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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. 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)  
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 scenarios.

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.

PGU44002 Journal Club (S1)  
Prof M Lynch

The most important and primary source of scientific knowledge is published work and therefore it is essential that students learn the skills required to critically assess published papers. This 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 10 scientific papers. The papers will be chosen to complement the lecture module in Glial physiology (PGU44007).

PGU44001 Neurophysiology (S1)  
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
Prof M-V Guillot-Sestier
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.

PGU44801 General Physiology (GP) (S2) 5 credits
Prof Á Kelly
These 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. It emphasises the integration of molecular, cellular, systems and whole-body function as the factor that distinguishes physiology from the other life sciences.

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 the project. It incorporates the following elements: ELEMENT ONE: This element is an extensive review of the literature relevant to the proposed final year research project. Lecture based sessions are also designed to ensure students are familiar with correct handling of data and use of appropriate statistical tests before undertaking their final year research project.

ELEMENT TWO: This component of the module represents perhaps 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.
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 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 of the Zoology Department at TCD. 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
## Module Structure

<table>
<thead>
<tr>
<th>Core Modules</th>
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<tbody>
<tr>
<td>ZOU33000: Marine Biology (5 credits)</td>
<td>ZOU33005: Evolutionary Biology (5 credits)</td>
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<tr>
<td>ZOU33003: Animal Diversity 1 (5 credits)</td>
<td>ZOU33070: Experimental Design and Analysis (5 credits)</td>
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<td>ZOU33004: Animal Diversity 2 (5 credits)</td>
<td>ZOU330XX: Terrestrial Field Ecology (5 credits)</td>
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<tr>
<td>ZOU33010: Fundamentals of Ecology (5 credits)</td>
<td>ZOU33090: Desk Study: Zoology and Society (5 credits)</td>
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### Open Modules Scenario I

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<tr>
<th>Choose 2 Modules</th>
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<tr>
<td>ZOU33050: Introduction to Developmental Biology (5 credits) OR BOU33120: Environmental Dynamics (5 credits) OR GSU33003: Ice Age Earth (5 credits)</td>
<td>Choose 2 Modules</td>
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<tr>
<td>Trinity Elective (5 credits)</td>
<td>ZOU33030: Introduction to Parasitology (5 credits) OR BOU33120: Entomology (5 credits) OR BIU33250: Introduction to Immunology and Immunometabolism (5 credits) OR PGU33009 Neuropsychology (5 credits)</td>
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### Open Modules Scenario II

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<tr>
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<tr>
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### Open Modules Scenario III

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<tr>
<td>ZOU33050: Introduction to Developmental Biology (5 credits) OR BOU33120: Environmental Dynamics (5 credits) OR GSU33003: Ice Age Earth (5 credits)</td>
<td>ZOU33030: Introduction to Parasitology (5 credits) OR BOU33122: Entomology (5 credits) OR BIU33250: Introduction to Immunology and Immunometabolism (5 credits) OR PGU33009 Neurophysiology (5 credits)</td>
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<tr>
<td>Trinity Elective (5 credits)</td>
<td>Trinity Elective (5 credits)</td>
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</table>
ZOU33000 Marine Biology (S1) 5 credits
Dr Nessa O'Connor, Dr Nicholas Payne, Prof. Jim Wilson (Field Course only), Dr Conor Nolan (Field Course only)
Typically, this course commences with a 5-day residential field course at a marine research station. This year owing to the COVID-19 pandemic there may not be a residential field course away from Dublin. If travel restrictions are in place, this course will commence with an intense schedule for 5-days during week 6 that includes pre-recorded lectures followed by live questions and answers tutorials, a site visit to a rocky shore near Dublin to collect species for identification at home with live online support and live guest lectures and tutorial support. During this week students will create their own field notebook that must be submitted for assessment and your field identification skills will be assessed. This fully immersive week is followed by a series of weekly lectures that commence later in the semester. This module 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.
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
Profs N Payne, N O’Connor & Dr J Kong
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 with a focus on the Chordata. The module will open by charting the diversification of marine Porifera, Cnidaria and chordates and conclude 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
Profs A Jackson, & Dr Jacinta Kong
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, practical’s 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. The module will conclude by taking a macro-ecological perspective on the diversity of animal life in order to identify the main drivers of diversity at global, long term scales.

ZOU33010 Fundamental of Ecology (S1) 5 credits
Profs I Donohue & Fraser 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
Profs P Luijckx & N Marples
“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)  
**Prof C Holland**

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 module consists of two parts. 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 and the use of spreadsheets for data entry. 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 aim of the second part of the module is to address, in more detail, the fundamentals of experimental design and to explore how previous projects were conducted. In addition, students will learn how to write a moderatorship project proposal.

ZOU330XX Terrestrial Ecology (S2)  
**Prof. Yvonne Buckley, Dr John Rochford, Prof. Nicola Marples, Dr Pepijn Luijckx**

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 37, 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.

In the event of continuing restrictions related to Covid-19 this module will be delivered as either 1) a series of day trips to sites in the Dublin area OR 2) a combination of online teaching and day-trips in the Dublin area OR 3) a combination of online teaching with field activities local to your own location. In all cases you will need to be available for teaching activities during the scheduled week and we will let you know as far in advance as possible which teaching modes will be used.
ZOU33090 Desk Study: Zoology and Society (S2) 5 credits
Profs P Luijckx & Carla Harper
Students will research, the scientific literature, synthesise and write an extended essay on a selected topic of current interest concerning Zoology and Society (sociological, ethical, medical, or environmental). The finished product will conform to the general format of a scientific review article.

Open Modules
ZOU33050 Introduction to Developmental Biology (S1) 5 credits
Prof Paula Murphy
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 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. Other topics include limb development, organogenesis, and evolutionary developmental biology.

BOU33120: Environmental Dynamics (S1 part 1) 5 credits
Prof 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.

GSU33003: ICE AGE EARTH (S1) 5 credits
Coordinator: Prof 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.
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.

ZOU33030 Introduction to Parasitology (S2)* 5 credits
Prof C Holland
The significance of the host-parasite relationship and the processes associated with the definition of parasitism are discussed in this module. Examples from important parasite phyla are reviewed with a focus upon life cycle strategies, ecology, pathology and control. The epidemiology of parasitic diseases including important differences between microparasites and macroparasites are defined. The significance of parasite distributions within host populations is highlighted. External and internal factors, which influence parasite populations, are outlined and particular attention is paid to host behavior, genetics, and immunity. The concept of a parasite community at the infracommunity and component community level is developed. The challenges associated with parasite control are explored. The practical work provides access to a wide range of parasitic material and gives emphasis to the diversity of parasitic lifestyles and forms. A number of the sessions are experimental in nature and explore parasitic adaptations for infection, the significance of parasite distributions in infected hosts, behavioural changes in parasitised hosts and the nature of parasite communities.
* This module is subject to a maximum quota of 38 students owing to limitations around the delivery of the practicals. Students who apply for this module will be randomly allocated up to the quota. Students who fall outside the quota will be directed to their moderatorship’s teaching office to select an alternative

BOU33122 Entomology (S2 part 2) Prof J Stout 5 credits
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
Profs F Sheedy, J Fletcher, M Carty, E Lavelle, R Porter & 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 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
## Module Structure

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<td><strong>Core Modules</strong></td>
<td>ZOU44030: Data Handling, (5 credits)</td>
<td>ZOU44060: Research Comprehension (5 credits)</td>
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<td>ZOU44020 General Zoology (5 credits)</td>
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<tr>
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<td>FBU44000: Research Project (20 credits)</td>
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<td>ZOU44012: Advances in Parasitology</td>
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<td>ZOU44013: Conservation and Wildlife Management</td>
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<td>ZOU44092: Environmental Impact Assessment</td>
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<td>ZOU44019: Behavioural Ecology</td>
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<td>BOU44111: Restoration Ecology and Re-Wilding</td>
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<td>ZOU440XX: Tropical Ecology &amp; Conservation (field course)</td>
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<td>BOU44107: Plant Animal Interactions</td>
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<td>BOU44110: Evolution of plants and plant environment interactions (N.B. runs semester 2)</td>
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### ZOU44030 Data Handling (S1)

**Prof A Jackson & Y Buckley**

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 conceptualizing and analyzing 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)  
Prof P Luijckx  
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)  
Profs A Jackson & all zoology staff  
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)  
Prof I Donohue & all staff across Zoology & Botany  
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. They will submit a research proposal before the practical work begins as part of the Junior Sophister ZOU33070 Experimental Design & Analysis module. As part of FBU44000 they will submit a thesis and present a poster on the results. For the project, they 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.
ZOU44012 Advances in Parasitology (S1)  
Prof C Holland  
This module consists of two parts. The first part (A) explores the significance and impact of parasitism upon humans. Some of the topics discussed during the module illuminate the practical challenges of designing and undertaking parasitological research in human subjects. In contrast, other topics highlight the relative merits of using animal model systems under experimental conditions as compared to field-based studies in human subjects. The topics are as follows - the impact of parasitism upon cognitive development in growing children; co-infection: challenges and solutions; epidemiology of helminths: aggregation and predisposition; the ultimate challenge - parasite control.  
The second part (B) focuses upon more ecological aspects of Parasitology with a particular emphasis upon the impact of parasites at the level of the ecosystem and within wild animal hosts. The topics include parasites as ecosystem engineers, parasites and introduced species and the use of wild mammal host-parasite systems to model human parasitism.

ZOU44013 Conservation and Wildlife Management (S1)  
Profs J Rochford & I Donohue  
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.

ZOU44019 Behavioural Ecology (S1)  
Prof N Marples  
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 signaling. 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 fully flipped classroom format of worksheets leading to recorded lectures and independent reading followed by structured discussions. The continuous assessment will be in two parts. The first will involve the students undertaking group research into the evidence for empathy in animals 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.
ZOU440XX Tropical Ecology & Conservation (S1)  5 credits  
**Dr Ian Donohue, teaching staff from Botany, Environmental Sciences and Zoology**  
The module comprises a short series of lectures followed by a nine-day residential field course in East Africa that will run at the end of October (encompassing the reading week) though, depending upon national and international travel restrictions, may be moved to January 2022 or, if necessary, to later in Semester 2 2022. The module will focus on the ecology and biodiversity of a range of ecosystems and habitats (including aquatic ecosystems [freshwater rivers and lakes, wetlands, and saline lakes], tropical montane forest 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 module. The module will focus particularly on the following three topics:  
- Quantifying biodiversity and the factors that underpin biodiversity in the tropics  
- Economics of wildlife management  
- Behaviour on the savannah  
- Sustainable development of tropical ecosystems

ZOU44092 Environmental Impact Assessment (S1)  5 credits  
**Profs J Rochford & I Donohue**  
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)  Prof J Stout  5 credits  
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 plant-pollinator interactions, including pollinator-mediated evolution of floral traits, community level interactions, pollinator decline and conservation. The second part 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. Practical’s will investigate floral characteristics and adaptations for pollination, pollinator networks and plant and animal adaptations to herbivory.
BOU44110: The Evolution of Plants and Plant-Atmosphere Interaction (S)  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
Dr 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. 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.
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 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.
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

<table>
<thead>
<tr>
<th>Item</th>
<th>Reference/Source</th>
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<tbody>
<tr>
<td>Statement on General Regulations</td>
<td>Calendar, Part II, General Regulations and Information, Section II, Item 12</td>
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<td>Calendar, Part III, General Regulations, Section I</td>
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<td>Student Supports Co-curricular activities</td>
<td>Student Supports</td>
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<td>TCDSU, GSU &amp; student representation</td>
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<td>Emergency Procedure</td>
<td>Standard Text: In the event of an emergency, dial Security Services on extension 1999</td>
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<td>Security Services provide a 24-hour service to the college community, 365 days a year. They are the liaison to the Fire, Garda and Ambulance services and all staff and students are advised to always telephone extension 1999 (+353 1 896 1999) in case of an emergency. Should you require any emergency or rescue services on campus, you must contact Security Services. This includes chemical spills, personal injury or first aid assistance. It is recommended that all students save at least one emergency contact in their phone under ICE (In Case of Emergency).</td>
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<td>Data Protection</td>
<td>Data Protection for Student Data</td>
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<td>Research Ethics</td>
<td>Policy on Good Research Practice</td>
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<td>Key Locations for students: Include</td>
<td>Blackboard</td>
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<td>Programme Offices, Laboratories,</td>
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<td>Online Learning Environments,</td>
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<td>Libraries, Academic Registry, Places of</td>
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<td>Faith/Prayer Rooms, Photocopiers and</td>
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<td>Plagiarism &amp; Referencing Guidance</td>
<td>Calendar, Part II, General Regulations and Information, Section II, Items 95-102</td>
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<td>Calendar, Part III, General Regulations &amp; Information, Section I 'Plagiarism'</td>
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<td>Plagiarism Policy</td>
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<td>Library Guides - Avoiding Plagiarism</td>
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<td>Plagiarism Declaration</td>
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<td>Explanation of ECTS Weighting</td>
<td>ECTS Weighting</td>
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<td>Health and Safety Statements</td>
<td>Faculty of Science Engineering, Mathematics and Science website - <a href="https://www.tcd.ie/stem/undergraduate/health-safety.php">https://www.tcd.ie/stem/undergraduate/health-safety.php</a></td>
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<td>COVID-19 Information</td>
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<td>Calendar, Part II, Foundation and Non-Foundation Scholarships</td>
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<td>Absence from Examinations</td>
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<td>Dignity &amp; Respect Policy</td>
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<td>assessment etc. May include Programme</td>
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<td>Progression Regulations</td>
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<td>Provide by School/Discipline Handbooks</td>
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<td>Careers Information &amp; events</td>
<td><a href="https://www.tcd.ie/Science/careers/">https://www.tcd.ie/Science/careers/</a></td>
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<td></td>
<td>For further information refer to School/Discipline Handbooks.</td>
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<td>External Examiner</td>
<td><a href="https://www.tcd.ie/Science/careers/">Procedure for the transfer of students assessed work to external examiners</a></td>
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<td>Learning Outcomes</td>
<td>Provided in JF, SF &amp; JS Handbooks on the Science Course Website <a href="https://www.tcd.ie/Science/#menu">https://www.tcd.ie/Science/#menu</a>. Also available in School/Discipline Handbooks.</td>
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<td>Registration (UG only)</td>
<td>Students in TR060, TR061, TR062 &amp; TR063 will find handbooks and information on the Science Course website <a href="https://www.tcd.ie/Science/#menu">https://www.tcd.ie/Science/#menu</a> and in School/Discipline Handbook.</td>
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