Science at Trinity

Faculty of Engineering, Mathematics and Science

TR060
Biological & Biomedical Sciences
Senior Freshman Programme 2019 - 2020
This handbook applies to all students taking TR060: Biological and Biomedical Science. It provides a guide to what is expected of you on this programme, and the academic and personal support available to you. Please retain for future reference.

The information provided in this handbook is accurate at time of preparation. Any necessary revisions will be notified to students via email and the Science Course Office website (http://www.tcd.ie/Science). Please note that, in the event of any conflict or inconsistency between the General Regulations published in the University Calendar and information contained in the course handbooks, the provisions of the General Regulations will apply.

Produced by:  
The Science Course Office  
Trinity College  
The University of Dublin  
Dublin 2

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Edited by: Ms Anne O’Reilly and Ms Ann Marie Brady
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TR060: Biological and Biomedical Sciences introduction

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

In the Biological and Biomedical Stream, students will study the core concepts that are fundamental to all biological systems. These will be presented in core modules during the first two years and will include: cell structure and composition, genetics, heredity and biological information, evolution, molecular biology, metabolism, structure, physiology and development of bacteria, fungi plants and animals, ecosystems and environmental biology. Students will study core concepts in chemistry with a focus on aspects that are essential for an understanding of how biological systems function and those that underpin biomedical science. Students will acquire mathematical, statistical and computational skills that are relevant for the analysis of biological systems. Furthermore, students will study the history of science, philosophical considerations about knowledge, the scientific method and discuss the application of ethical theories in science.

In addition, students have the opportunity to expand their scientific knowledge and pursue their individual interests by choosing approved modules from a cohort on topics such as foundation physics, geoscience, science education and communication, agriculture and biotechnology, infection and immunity, and behavior.

In the third year, students specialize in one of the 11 moderatorships offered in this stream: Biochemistry; Botany; Environmental Science; Genetics; Human Genetics; Immunology; Microbiology; Molecular Medicine; Neuroscience; Physiology; Zoology. The fundamental concepts of that discipline will be presented in core modules while students will also select from a cohort of approved modules from allied disciplines that enhance understanding of their chosen discipline and encourage interdisciplinary thinking and research. Students can also experience the wide range of knowledge and investigation available throughout the university by choosing a Trinity Elective module (https://www.tcd.ie/trinity-electives) from a cohort that highlights major research themes from across all faculties.

In the fourth year students choose from a selection of modules on advanced topics within their chosen discipline. They will also undertake a capstone project in Trinity College or in a research laboratory in another university, research institute or hospital. Throughout this program, students will also acquire skills in problem solving and data handling and in oral and written communication.

This program of science education is designed to foster and develop a student’s capability for independent thought and effective communication, an ability to continue their education independently and to act in a responsible manner. These attributes are a preparation for a career in science and medicine (e.g. in research, biotechnology, pharmaceutical industry, further medical training); for a career in related areas where a scientific education is beneficial (e.g. patent law, forensic science, journalism) and for careers in areas such as education, management, business, industry, communication and policy making.

Professor Kevin Devine
Director, TR060 Biological and Biomedical Sciences Course
TR060 Biological and Biomedical Sciences overview and module selection

The Senior Freshman year will build on and expand on topics presented in the Junior Freshman year. The Senior Freshman year is divided into Semester 1 (Michaelmas term) and Semester 2 (Hilary term). Students must select modules to the value of 60 credits for the year with no more than 30 credits from Semester 1 and 30 credits from Semester 2.

If you wish to change your mind before term begins in September 2019, you can resubmit the online form with a subject line of "change of module choice" and a note in the form specifying "change of module choice".

MODULE SELECTION

Students must take 40 core credit modules (20 per semester) as follows:

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYU22201</td>
<td>From Molecules to Cells</td>
<td>Semester 1</td>
<td>10</td>
</tr>
<tr>
<td>BYU22202</td>
<td>From Cells to Organisms</td>
<td>Semester 2</td>
<td>10</td>
</tr>
<tr>
<td>BYU22203</td>
<td>From Organisms to Ecosystems</td>
<td>Semester 2</td>
<td>10</td>
</tr>
<tr>
<td>BYU22S01</td>
<td>Statistics and Computation</td>
<td>Semester 1</td>
<td>5</td>
</tr>
<tr>
<td>PIU22991</td>
<td>History, Philosophy and Ethics of Science</td>
<td>Semester 1</td>
<td>5</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYU22204</td>
<td>Sustainable Production: Food, Drink and Drugs</td>
<td>Semester 1</td>
<td>5</td>
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<tr>
<td>BYU22205</td>
<td>Influences on Animal Behaviour</td>
<td>Semester 1</td>
<td>5</td>
</tr>
<tr>
<td>BYU22206</td>
<td>Microbes, Immune Systems and their Interaction</td>
<td>Semester 2</td>
<td>5</td>
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<tr>
<td>BYU22207</td>
<td>Genomes, Disease and Diversity</td>
<td>Semester 2</td>
<td>5</td>
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<tr>
<td>CHU22205</td>
<td>Chemistry for Biologists</td>
<td>Semester 2</td>
<td>5</td>
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<tr>
<td>GSU22001</td>
<td>Geochemical Cycles: From Geo to Biogeochemistry</td>
<td>Semester 1</td>
<td>10</td>
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<tr>
<td>GSU22005</td>
<td>Sedimentary Processes &amp; Environments</td>
<td>Semester 2</td>
<td>10</td>
</tr>
<tr>
<td>MAU23302</td>
<td>Euclidian and Non Euclidian Geometry</td>
<td>Semester 2</td>
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</tbody>
</table>
Semester structure

TR060: BIOLOGICAL AND BIOMEDICAL SCIENCES

CORE MODULES (mandatory) – 20 credits per semester

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>BYU22201: From Molecules to Cells (10 credits)</td>
<td>BYU22202: From Cells to Organisms (10 credits)</td>
</tr>
<tr>
<td>BYU22SC01: Statistics and Computation (5 credits)</td>
<td>BYU22203: From Organisms to Ecosystems (10 credits)</td>
</tr>
<tr>
<td>PIU22991: History, Philosophy and Ethics of Science (5 Credits)</td>
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</tbody>
</table>

APPROVED MODULES (optional): Students choose 10 credits from each semester

<table>
<thead>
<tr>
<th>BYU22204: Sustainable Production: Food, Drink and Drugs (5 Credits)</th>
<th>BYU22207: Genomes, Disease and Diversity (5 credits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYU22205: Influences on Animal Behaviour (5 Credits)</td>
<td>BYU22206: Microbes, Immune Systems and their Interaction (5 credits)</td>
</tr>
<tr>
<td>GSU22001: Geochemical Cycles: From Geo- to Biogeochemistry (10 credits)</td>
<td>GSU22005: Sedimentary Processes &amp; Environments (10 credits)</td>
</tr>
<tr>
<td>CHU22005: Chemistry for Biologists (5 Credits)</td>
<td>MAU223302: Euclidian and Non Euclidian Geometry (5 credits)</td>
</tr>
</tbody>
</table>

Moderatorships
In the Junior and Senior Freshman years TR060 students complete a course of study which will qualify them to compete for a place in one of the following Moderatorships after the Senior Freshman year:
• * Biochemistry
• Botany
• Environmental Sciences
• * Genetics
• * Human Genetics
• * Immunology
• * Microbiology
• * Molecular Medicine
• * Neuroscience
• Physiology
• Zoology

* Students intending to apply for moderatorships marked with an asterisk are very strongly advised to take ‘Chemistry for Biologists’ as an approved module in semester 2. This is a new module specifically designed and tailored to provide the foundational chemistry that supports these moderatorships in the molecular biological sciences.
### Faculty of Engineering Mathematics and Science
### TR060: Biological and Biomedical Sciences
### Senior Freshman module choice form

**BLOCK CAPITALS PLEASE**

Name: ____________________________  E-mail: ____________________________

Date: ____________________________  Student No: ____________________________

### SENIOR FRESHMAN MODULES 2019/20

<table>
<thead>
<tr>
<th>Module Code</th>
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<th>Credits</th>
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<td><strong>Core modules – 20 credits per semester</strong></td>
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<tr>
<td>BYU22201:</td>
<td>From Molecules to Cells</td>
<td>Semester 1</td>
<td>10</td>
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<tr>
<td>BYU22202:</td>
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<td>BYU22203:</td>
<td>From Organisms to Ecosystems</td>
<td>Semester 2</td>
<td>10</td>
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<tr>
<td>BYU22501:</td>
<td>Statistics and Computation</td>
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<td>5</td>
<td></td>
</tr>
<tr>
<td>PIU22991:</td>
<td>History, Philosophy and Ethics of Science</td>
<td>Semester 1</td>
<td>5</td>
<td></td>
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<tr>
<td><strong>Approved modules – 10 per semester</strong></td>
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<tr>
<td>Please tick appropriate box</td>
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<tr>
<td><strong>Semester 1</strong></td>
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<tr>
<td>BYU22204:</td>
<td>Sustainable Production: Food, Drink and Drugs</td>
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<td>5</td>
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</tr>
<tr>
<td>BYU22205:</td>
<td>Influences on Animal Behaviour</td>
<td>Semester 1</td>
<td>5</td>
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<td>or</td>
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<td></td>
</tr>
<tr>
<td>GSU22001:</td>
<td>Geochemical Cycles: From Geo to Biogeochemistry</td>
<td>Semester 1</td>
<td>10</td>
<td></td>
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<tr>
<td><strong>Semester 2</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>BYU22206:</td>
<td>Microbes, Immune Systems and their Interaction</td>
<td>Semester 2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>BYU22207:</td>
<td>Genomes, Disease and Diversity</td>
<td>Semester 2</td>
<td>5</td>
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<td>or</td>
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<tr>
<td>BYU22206:</td>
<td>Microbes, Immune Systems and their Interaction</td>
<td>Semester 2</td>
<td>5</td>
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<tr>
<td>CHU22205:</td>
<td>Chemistry for Biologists</td>
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<td>or</td>
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<tr>
<td>BYU22207:</td>
<td>Genomes, Disease and Diversity</td>
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<td>MAU23302:</td>
<td>Euclidian and Non Euclidian Geometry</td>
<td>Semester 2</td>
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PTO
Change of APPROVED modules
If, after a couple of weeks, a student feels that they have perhaps made the wrong choice of approved module combination, they should seek advice immediately from a Tutor, Course Director or the Science Course Office. It may be possible to change from one module to another within your course, subject to permission from the Associate Dean of Undergraduate Science Education. Once a decision has been made to change modules, it should be done quickly - it can be difficult to try to catch up with work in a new module when more than two or three weeks of lectures have been missed.

Change of modules forms are available from the Science Course Office. All change of module request must be submitted to the Science Course Office. Module change requests made via any other office will not be processed.

College registration
The Academic Registry issue an ‘Invite to Register’ email to all continuing students eligible to register for the forthcoming academic year. This communication is issued via the my.tcd.ie portal and your institutional (TCD issued) email address.

On receipt of the emailed invitation, you should log in to the my.tcd.ie to complete the registration steps.

All information regarding College registration is available at the following links:
https://www.tcd.ie/academicregistry/
https://www.tcd.ie/academicregistry/student-registration/
The European Credit Transfer Accumulation System (ECTS)

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

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

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

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

TR060 Biological and Biomedical Sciences - CORE MODULES

BYU22201: From Molecules to Cells
Semester 1, 10 credits

Contact Hours:
39 lectures. 8 x 3hr Practicals.

Module Personnel:

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

Module content: Programme of lectures and practicals

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture Topic</th>
<th>Lecturer</th>
<th>Practical</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Introduction to Module BYU22201 “from Molecules to Cells”</td>
<td>Prof Creagh</td>
<td>Solutions &amp; Dilutions</td>
</tr>
<tr>
<td>3</td>
<td>Cell structure &amp; intracellular transport</td>
<td>Prof Creagh</td>
<td>Chromatography</td>
</tr>
<tr>
<td>3</td>
<td>Cell cytoskeleton I</td>
<td>Prof Creagh</td>
<td>Enzyme Kinetics</td>
</tr>
<tr>
<td>3</td>
<td>Cell cytoskeleton II</td>
<td>Prof Creagh</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Cellular Proliferation &amp; Death</td>
<td>Prof Creagh</td>
<td></td>
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<tr>
<td>4</td>
<td>Proteins &amp; amino acids</td>
<td>Prof Mok</td>
<td></td>
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<tr>
<td>4</td>
<td>Protein folding and purification</td>
<td>Prof Mok</td>
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</tr>
<tr>
<td>4</td>
<td>Oxygen binding proteins</td>
<td>Prof Mok</td>
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<tr>
<td>5</td>
<td>Enzymes, catalysis and assays</td>
<td>Prof Murray</td>
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<tr>
<td>5</td>
<td>Enzyme kinetics, inhibition &amp; regulation</td>
<td>Prof Murray</td>
<td></td>
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<tr>
<td>5</td>
<td>Lipids - Fatty acids &amp; Phospholipids</td>
<td>Prof Hayes</td>
<td></td>
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<tr>
<td>5</td>
<td>Lipids – beta-oxidation &amp; fatty acid synthesis</td>
<td>Prof Hayes</td>
<td></td>
</tr>
<tr>
<td>Week</td>
<td>Topic</td>
<td>Lecturer</td>
<td>Notes</td>
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<td>--------------------------------------------</td>
</tr>
<tr>
<td>6</td>
<td>Powering Life: Energy transduction &amp; life</td>
<td>Prof Nolan</td>
<td>Spectrophotometry</td>
</tr>
<tr>
<td>6</td>
<td>Bioenergetics 1: Oxidative Phosphorylation</td>
<td>Prof Nolan</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Bioenergetics 2: The university of chemiosmosis</td>
<td>Prof Nolan</td>
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<tr>
<td>6</td>
<td>Harvesting the light: Photosynthesis</td>
<td>Prof Nolan</td>
<td></td>
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<tr>
<td>7</td>
<td>Glycolysis</td>
<td>Prof Porter</td>
<td>Oxidative Phosphorylation (1st half of class)</td>
</tr>
<tr>
<td>7</td>
<td>Gluconeogenesis</td>
<td>Prof Porter</td>
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<tr>
<td>7</td>
<td>TCA cycle</td>
<td>Prof Porter</td>
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<tr>
<td>7</td>
<td>Glycogen biosynthesis &amp; degradation</td>
<td>Prof Porter</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Nitrogen metabolism &amp; Integration of Metabolism</td>
<td>Prof Nolan</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Summary Lecture – Cell Biology &amp; Metabolism</td>
<td>Prof Creagh and Prof Nolan</td>
<td>Oxidative Phosphorylation (2nd half of class)</td>
</tr>
<tr>
<td>8</td>
<td>DNA – Structure, Replication, Repair, Recombination I</td>
<td>Prof Ramaswami</td>
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<tr>
<td>8</td>
<td>DNA – Structure, Replication, Repair, Recombination II</td>
<td>Prof Ramaswami</td>
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<tr>
<td>9</td>
<td>Reading Week</td>
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<td>Open MCQ</td>
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<td>Monday 28th October 2019 – Bank Holiday</td>
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<tr>
<td>10</td>
<td>DNA – Structure, Replication, Repair, Recombination III</td>
<td>Prof Ramaswami</td>
<td>Genetic Variation in Humans PTC test and analysis I</td>
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<tr>
<td>10</td>
<td>Transcription – RNA types, mRNA processing</td>
<td>Prof Ramaswami</td>
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<td>Transcription – RNA types, mRNA processing</td>
<td>Prof Ramaswami</td>
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<tr>
<td>11</td>
<td>Regulation of gene expression: general principles</td>
<td>Prof Martin</td>
<td>Genetic Variation in Humans PTC test and analysis II</td>
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<td>11</td>
<td>Gene expression in prokaryotes and eukaryotes</td>
<td>Prof Martin</td>
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<td>11</td>
<td>Chromatin and epigenetic effects on gene expression</td>
<td>Prof Martin</td>
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<td>11</td>
<td>Alternative splicing and protein translation</td>
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<tr>
<td>12</td>
<td>Mendelian Inheritance</td>
<td>Prof Campbell</td>
<td>Genetic Variation in Humans PTC test and analysis III</td>
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<tr>
<td>12</td>
<td>Mapping Mendelian traits</td>
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<td>12</td>
<td>Quantitative traits and heritability</td>
<td>Prof Campbell</td>
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<tr>
<td>12</td>
<td>Genetics of common diseases</td>
<td>Prof Campbell</td>
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Description of Lecture Content:

Week 3:
- Introduction to to the BYU22201 Module ‘ from Molecules to Cells’
- Revision of Cell structure (Podcast), Membrane structure & Intracellular protein transport mechanisms. (Elements Flipped classroom)
- Cellular cytoskeleton I (Actin filaments, myosin motor protein) (combination of flipped classroom & traditional lectures material) - Principles of cellular movement & the process of muscle contraction.
- Cellular cytoskeleton II – Importance of Microtubules & Intermediate filaments for cellular function (combination of flipped classroom & traditional lectures material). Specialised microtubules involved in the motility of cilia/flagella will be discussed.

Week 4:
- What are proteins? The 20 amino acids and their structures and properties, acid-base equilibria, the isoelectric point. (Combined flipped classroom and traditional lectures) The polypeptide chain and general properties of proteins. The hierarchy of protein structure (primary / secondary / tertiary / quaternary structures).
- Protein folding and protein misfolding diseases / neurodegenerative diseases. Protein purification and protein characterization techniques.

Week 5:
- Enzyme substrate relationship, catalysis and the transition state. Physiochemical parameters of enzyme activities and assays.
- Michaelis-Menten kinetics, limiting velocity, rate/enzyme correlation (in class activity supported by podcasts). Reversible inhibition and allostERIC regulation.
- Lipids-Fatty Acids and Phospholipids. What are lipids? Chemical and functional properties of diverse lipids such as steroid hormones, fat soluble vitamins and ketone bodies. Fatty acids, phospholipids and membranes.
- Lipids- β-oxidation and fatty acid synthesis. Energy production through the mobilisation of fatty acids from triacylglycerols and their oxidation in mitochondria. Energy storage through the synthesis of fatty acids and storage of triacylglycerols in adipocytes.

**Week 6:**
- Powering Life: Energy transduction & life. Introduction to basics: energy transduction in biological systems: concept of displacement from equilibrium, chemical potential, electrochemical potential and redox potentials. ATP and energy coupling: key concepts: Is ATP a high energy compound?
- Bioenergetics 2: The Chemiosmotic view of Life and the universality of the concept.
- Harvesting the light: Photosynthesis. The light reactions of photosynthesis: photophosphorylation, the Z scheme, PSI & II and C1C0-ATPase. A comparison of oxidative and photo phosphorylation.

**Week 7:**
- The necessity for gluconeogenesis. Its control and regulation. Substrate sources. Reciprocal control of gluconeogenesis and glycolysis in liver.
- Pyruvate dehydrogenase and control of regulation of oxidative catabolism of substrates via the tricarboxylic acid (TCA) cycle. The TCA cycle as a source of biogenic amines. The TCA cycle as a source of anabolic substrates. Anapleurotic reactions.

**Week 8:**
- Nitrogen metabolism & Integration of Metabolism
- Summary Lecture of Cell Biology and Metabolism
- DNA – Structure, Replication, Repair, Recombination I. Discovery of DNA as the genetic material; structure, properties and conformation(s) of DNA; mechanism for DNA replication in prokaryotes and eukaryotes: DNA polymerases and the replisome.
- DNA - Structure, Replication, Repair, Recombination II. The role of telomeres in DNA replication in eukaryotes. Spontaneous and induced mutations; mutagens and the effects of mutations.

**Week 9: Reading Week.**

**Week 10:**
- DNA - Structure, Replication, Repair, Recombination III. DNA repair mechanisms; non-homologous end joining and homologous recombination.
- Transcription - RNA types and processing I. Discovery of RNA; properties and classes of RNAs; types of RNA polymerases; transcription in prokaryotes: initiation, elongation and termination.
- Transcription - RNA types and processing II. Types of RNA polymerases; transcription in eukaryotes: initiation, elongation and termination.
Week 11:
- Regulation of gene expression. The general principles of the regulation of gene expression in prokaryotes and eukaryotes.
- Gene expression in prokaryotes and eukaryotes. Mechanisms of the regulation of gene expression in prokaryotes and eukaryotes: promoters. Sigma factors, transcription factors, enhancers, silencers, insulators
- Chromatin and epigenetic effects on gene expression. Introduction to epigenetics; structure and composition of chromatin; histone and DNA modifications and their effects on chromatin and gene expression.

Week 12:
- Mendelian Inheritance. Mendel’s laws (recap from JF) and molecular basis of inheritance patterns; pedigree analysis; gene interactions: dominance, co-dominance, incomplete dominance, recessivity, penetrance, expressivity, and epistasis.
- Mapping Mendelian traits: This lecture outlines the historical methods that were used to identify mutations in genes associated with Mendelian diseases. It highlights the methodology and underlying analysis with a focus on linkage and recombination.
- Quantitative traits and heritability: This lecture focuses on more complex traits, somatic mutations and heritability and how they pertain to human disease. The lecture uses examples of conditions such as breast cancer to describe the identification of genes that ascribe relative risk scores to disease.
- Genetics of common diseases: This lecture focuses on giving a wide range of examples of human disease that show Mendelian and non-mendelian modes of inheritance. It aims to give the student a broad understanding of the complexities of these diseases and the underlying genetic causes.

Week 13:
- Virology: genetic diversity of viruses. The diversity of viral genomes and particle structures will be explored in this lecture.
- Virology: Replication cycle 1 – from entry to transcription. In this lecture we will compare how different viruses enter cells and a range of viral strategies for producing mRNA.
- Virology: Replication cycle 2 – from translation to virion formation and release. In this lecture we will explore how the location within the cell of viral genome replication and assembly of new virions is dependent on the cellular processes a virus needs to utilise during replication.
- Virology: Emerging viruses – mutation, adaptation and transmission. In this lecture we will discuss a range of viruses causing emerging infections and explore how their replication cycles changed to adapt to new hosts or cell types.

Description of Practical Content:

**Practical 1 - Solutions & dilutions** – This numerical skills tutorial will prepare students for numerical calculations relevant for lab work (eg. Calculating molarites, how to make up buffers, dilution factors, etc).

**Practical 2 - Chromatography** – During this practical highlights student’s will perform Gel filtration chromatography: oxidised sheep’s blood is used to observe the colour changes that occur as it is reduced (methaemoglobin-haemoglobin-oxyhaemoglobin); and Ion exchange chromatography: yeast extract is applied to a DEAE column, anionic enzymes Catalase & Glucose oxidase are eluted, collected in fractions and tested for the presence of both enzymes.
Practical 3 – Enzyme Kinetics - Students perform a stopped enzyme assay, using increasing substrate and inhibitor concentrations. They calculate the final concentrations in the assay, calculate Km and Vmax for uninhibited series, use Lineweaver-burk plots to demonstrate competitive inhibition, and determine the Ki.

Practical 4 - Spectrophotometry - Enzyme assays, using increasing Alcohol dehydrogenase (ADH) concentrations, will be performed - measuring the spectrophotometric production of NADH as the readout.

Practical 5 – Oxidative phosphorylation. Students will measure the P:O ratio of succinate and glutamate/malate; measure respiratory control ratios; inhibit Complexes I/III using rotenone/Antimycin A; uncouple mitochondria using DNP and inhibit ATP synthase using oligomycin.

Practicals 6 and 7: Genetic Variation in Humans
Variation in the ability to taste phenylthiocarbamide (PTC) in the population; DNA isolation from human cheek cells; detection of PTC taster and non-taster receptor alleles through PCR, restriction digest and agarose gel electrophoresis. Estimating allele frequencies in a population and Hardy-Weinberg equilibrium.

Practical 8: Assessment of Genetic Variation through Computational Analysis
Introduction to Bioinformatics; accessing and retrieving DNA sequence information from Genbank; comparison of homologous gene sequences using BLAST; identification of polymorphisms.

Learning Outcomes:
On completion of this module students should understand fundamental concepts in the following cellular structures and processes: the structure and function of cells and organelles; structures and functions of nucleic acids, proteins carbohydrates and lipids; the fundamental concepts and regulation of metabolism; the composition, structure synthesis and function of DNA and RNA; regulation of gene expression in prokaryotes and eukaryotes; chromatin structure and epigenetic regulation of gene expression; the principles of genetic inheritance; genetic diseases and fundamental concepts in virology.

Recommended Reading List:
The topics and concepts presented in this module will be found in many general textbooks on Cell Biology. Biochemistry and Genetics. The following are recommended for your guidance:

Assessment Details:
(A) End of semester written examination: 50% total mark
Exam is comprised of:
• 25%: 10 short answer questions, testing understanding of concepts and deduction.
• 25%: 1 essay-type question from a choice of 3 questions on paper

(B) Two MCQ: 15% of total mark
• testing knowledge of subject

(C) Practical write-ups/assessments: 35% total mark.

Module coordinator - BYU22201 From Molecules to Cells
Dr Emma Creagh
Ph: 01 896 2539
E-mail: ecreagh@tcd.ie

Executive Officer
E-mail: BTC.Administrator@tcd.ie
Phone: 01 896 1117
BYU2202: From Cells to Organisms
Semester 2, 10 credits

Contact Hours
39 lectures and 4 x 3 hour practical classes

Module Personnel

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

Module content: Programme of lectures and practicals

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<thead>
<tr>
<th>Week</th>
<th>Lecture Topic</th>
<th>Lecturer</th>
<th>Practical</th>
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<tr>
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<td>Introduction to BYU2202 “from Cells to Organisms”</td>
<td>Prof Cunningham</td>
<td>Bacterial motility</td>
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<td>Sugar utilisation And Cell communication</td>
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<td>22</td>
<td>The bacterial world: diversity &amp; unique extracellular structures</td>
<td>Prof Dorman</td>
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<td>22</td>
<td>Energy, transport and scavenging in bacteria</td>
<td>Prof Dorman</td>
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<td>22</td>
<td>Motility and chemotaxis in bacteria</td>
<td>Prof Dorman</td>
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<td>23</td>
<td>Cell:cell communication &amp; bacterial development</td>
<td>Prof Geoghegan</td>
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<tr>
<td>23</td>
<td>Bacterial interactions with eukaryotic cells</td>
<td>Prof Geoghegan</td>
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<td>23</td>
<td>Fungal world</td>
<td>Prof Bond</td>
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<tr>
<td>23</td>
<td>Autocrine, Juxtacrine, paracrine &amp; endocrine signaling</td>
<td>Prof Cunningham</td>
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<td>24</td>
<td>Cargo packaging for export (peptides vs non protein)</td>
<td>Prof Cunningham</td>
<td>cAMP synthesis</td>
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<td>Calcium-dependent exocytosis</td>
<td>Prof Cunningham</td>
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<td>24</td>
<td>Post-synaptic actions at ionotropic receptors</td>
<td>Prof Cunningham</td>
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<td>24</td>
<td>Conserved components of intracellular signal-transduction</td>
<td>Prof Zisterer</td>
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<td>25</td>
<td>G-protein coupled receptors, cAMP, PKA, integration</td>
<td>Prof Zisterer</td>
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<td>25</td>
<td>Receptor Tyrosine Kinases, MAP kinases</td>
<td>Prof Zisterer</td>
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<td>Crosstalk between pathways, conservation between organisms</td>
<td>Prof Zisterer</td>
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<td>Organising a body plan in multicellular organisms</td>
<td>Prof Rolfe</td>
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<td>Cell signaling/cell communication in the context of development</td>
<td>Prof Rolfe</td>
<td>Practical on</td>
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<td>26</td>
<td>Elaboration of positional information/Progressive specification/cell lineage analysis</td>
<td>Prof Rolfe</td>
<td>Development</td>
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<td>26</td>
<td>How a cell responds to positional information</td>
<td>Prof Rolfe</td>
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<tr>
<td>26</td>
<td>Evolution/Development –body plan changes through evolution</td>
<td>Prof Rolfe</td>
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<td>27</td>
<td>Organogenesis</td>
<td>Prof Rolfe</td>
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<td>27</td>
<td>Revision/integration lecture</td>
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<td>27</td>
<td>Nervous control of physiological function (CVS)</td>
<td>Prof Kelly</td>
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<td>27</td>
<td>Neuropharmacology of autonomic nervous system</td>
<td>Prof Kelly</td>
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<td>28</td>
<td>Reading Week &amp; Open MCQ</td>
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<td>29</td>
<td>Muscle function (cardiac, skeletal, pathophysiology)</td>
<td>Prof Kelly</td>
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<td>29</td>
<td>Endocrine regulation of physiological function</td>
<td>Prof Kelly</td>
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<tr>
<td>29</td>
<td>Fundamentals of cardiovascular &amp; renal (altitude,exercise)</td>
<td>Prof Kelly</td>
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<tr>
<td>29</td>
<td>Fundamentals of cardiovascular &amp; renal (acid/base, BP)</td>
<td>Prof Kelly</td>
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<td>Monday 17th March – St Patrick’s Day</td>
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<tr>
<td>30</td>
<td>Pathophysiology and treatment of hypertension</td>
<td>Prof Kelly</td>
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<td>30</td>
<td>Digestion &amp; metabolism, metabolic syndrome, gut-brain axis.</td>
<td>Prof Kelly</td>
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<td>30</td>
<td>The immune system and its influence on homeostasis</td>
<td>Prof Lynch</td>
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<td>31</td>
<td>Integration of Nervous, endocrine and immune regulation of physiology and pathophysiology of Neurodegenerative disease.</td>
<td>Prof Kelly</td>
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<td>31</td>
<td>Motor coordination and control</td>
<td>Prof Witney</td>
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<td>31</td>
<td>Sensation and perception</td>
<td>Prof Witney</td>
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<td>31</td>
<td>Pain, nociception, and interoception</td>
<td>Prof Witney</td>
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<td>32</td>
<td>Emotion and motivation</td>
<td>Prof Ryan</td>
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<td>32</td>
<td>Learning and Memory</td>
<td>Prof Ryan</td>
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<td>32</td>
<td>Understanding brain function through pathology/disease</td>
<td>Prof Ryan</td>
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<td>Summary - Revision/integration lecture</td>
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<tr>
<td>34</td>
<td>Revision Week Open MCQ</td>
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<td>35</td>
<td>Assessment Week</td>
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Description of Lecture Content:

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

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

Development
- Organising a body plan in multicellular organisms: The concepts of multicellular life and how an organized body plan, composed of different cell types and tissues, is established. Examples of relatively simple (hydra) organisms to the most complex (examples of drosophila, mouse, human and others) will be used. Fundamental similarities and differences in the organisation of animals and plants will be covered. It will deal with molecular and biophysical mechanisms governing cellular behavior.
- **Cell signaling/cell communication in the context of development.** Cell communication is fundamental to building an organized body plan. The main developmental signaling pathways (Wnt, BMP, Hedgehog, FGF, YAP/hippo etc) will be introduced with examples of how they guide development. Pathway conservation and elaboration through evolution related to developmental complexity will be examined.

- **Elaboration of positional information over time.** Exploration of key concepts, moving from the “French flag model” to more sophisticated ways of thinking. The concept of gradients and graded influence across tissues. Progressive specification and how information builds over developmental time. Cell lineage analysis and tracing a cell through time. Stem cells and how stem cell niches are established during development.

- **How a cell responds to positional information.** Transcriptional and post-transcriptional regulation leading to cellular differentiation. The integration of different types of information at the cellular level determining how a cell responds. The importance of the cellular context and epigenetics. Hox genes and how they relate to positional information – the concept of a positional code. Mutations that change the body plan.

- **Evolution & Development:** How body plans can change through evolution. The concept of “the Toolkit” for building an organism and “tinkering with the toolkit” – genetic changes that can lead to major body plan shifts such as loss of limbs or acquisition of specialised structures such as a turtle shell.

- **Organogenesis:** Development of organ and organ systems; e.g. heart, kidney, lung etc. building on the concepts and mechanisms involved in building complex structures, current knowledge on how specific organs are established will be presented and explained.

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

- Motor coordination and control. Students will learn how the complexity of an animal’s movement is constrained by the underlying neural circuitry. Simple behaviours in simpler animals and their underlying neural control (e.g. CPGs) through to complex voluntary action and manipulative tasks.

- Sensation and perception. Students will gain an understanding of how the brain makes sense of sensory input. They will be aware of and able to explain fundamental discoveries (e.g. Hubel & Wiesel). They will be able to describe neuronal circuitry that enables us to distinguish between sensory input from the external world and that which is internally generated (sensory cancellation and efference copy mechanisms).

- Pain, nociception, and interoception. Students will attain and understanding of the internal awareness of the animal body to states such as pain.

- Emotion and motivation. Students will develop an understanding of how we empirically study animal behaviours that can be attributed to motivational drives and emotional states, and will attain knowledge of how environment experience and genetic background can alter these behaviours.

- Learning and memory. Students will be able to describe the basic learning theory models in the context of Pavlovian and operant conditioning, and basic invertebrate and vertebrate experimental models of learning-induced brain plasticity and memory storage.

- Understanding brain function through pathology/disease. Students will gain an understanding of how clinical studies of humans with brain damage and disease, when combined with careful behavioural and psychiatric analysis, and give us new insights into brain function at a systems level. An introduction to the use of animal disease models and a few highlights of how animal models have been used to develop an understanding of disease processes.

Description of Practical Content:

Practical 1
Title: Studying bacterial signalling molecules using a transcriptional fusion reporter gene.

Summary:
Bacteria release and detect signalling molecules to control gene expression as their population grows. This phenomenon is called quorum sensing. This practical will illustrate the principles of quorum sensing in bacteria by studying the effect of quorum sensing molecules on gene expression in real-time. Supernatants from different bacteria grown under a variety of conditions will be examined for their ability to activate the promoter of a gene normally activated in response to a specific-signalling molecule. The promoter has been fused to a gene encoding green fluorescent protein (GFP). The production of GFP protein, which makes the bacteria fluoresce when exposed to light of the appropriate wavelength, will be examined using fluorescence microscope.

Learning Outcomes: Upon successful completion of this practical students will be able to:
- Appreciate the specificity of quorum sensing signalling molecules in bacteria
- Understand the use of transcriptional fusions for studying cell-cell communication in bacteria

Practical 2
Title: Analysis of the Degradation of a Second Messenger by Thin-layer Chromatography
Summary: Cyclic adenosine monophosphate (cAMP) is a second messenger important in many biological processes. cAMP is hydrolysed to 5’ adenosine monophosphate (5’AMP) by the enzyme phosphodiesterase in a reaction inhibited by theophylline. Given that both substrate and product fluoresce when exposed to ultra violet light the degradation and the inhibition of degradation of cAMP can be conveniently analysed by thin-layer chromatography.
Learning Outcomes: Upon successful completion of this practical and the associated exercises, students should be able to:

- Demonstrate that they can evaluate and optimize experimental conditions
- Demonstrate that they can keep complete and reliable records of experiments
- Perform a thin-layer chromatography analysis
- Demonstrate a knowledge of some important second messenger molecules

Practical 3
Title: 3D Imaging and database research of Embryonic Development

Summary: Visualising and interpreting dynamic complex changes that take place during vertebrate embryonic development. Using online 3D databases of developing embryos, students will investigate and describe changes in anatomical features during the formation of a 3D body plan and begin to explore the molecular changes that underpin morphological change.

Learning Outcomes: Upon successful completion of this practical and the associated exercises, students should be able to:

- Utilise online tools and databases to explore specific questions related to embryonic development including an appreciation of the power of using shared data in research

Practical 4
Title: Cardiovascular and respiratory physiology

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

Learning Outcomes: Upon successful completion of this practical and the associated exercises, students should be able to:

- Measure and understand fundamental cardiovascular and respiratory variables in human subjects

Learning Outcomes:
Unicellular to multicellular life:

On successful completion students will be able to:

- Demonstrate an understanding of how bacteria form communities and the role of signalling in bacterial communication.
- Describe the regulatory and physiological adaptations that bacteria undergo to acquire nutrients and respond to stress.
- Appreciate the structure, function and importance of bacterial extracellular structures and their roles in modulating cell-cell interactions
- Describe the mechanisms used by bacteria to interact with eukaryotic cells
- Appreciate the diversity of fungi, their developmental processes and multicellular lifestyles
**Cell signalling:**
After completing the cell-cell communication & cell signalling lectures, students should be able to demonstrate an understanding of how biological signals are prepared for export, are temporally and spatially controlled, are sent, amplified, and received in the cellular context (signal transduction), and provide examples as to how this is achieved in cells. Students should be able to:

- Understand the different mechanisms by which cells communicate with each other and how these shape the spatial extent of signalling.
- Appreciate and be able to articulate the ways in which molecules must be packaged, in order to be released.
- Give an account of how neurotransmitters are released by Calcium-dependent exocytosis, including demonstrating understanding of the ionic and energetic basis of depolarisation and release (Action potential and voltage-dependent calcium channels).
- Understand how neurotransmitters act on post-synaptic ionotropic receptors on muscle cells or neurons, to bring about activation or inhibition.
- Understand the basic principles of signal transduction mechanisms, in particular the concepts of response specificity, signal amplitude and duration, and how signals are integrated within a cell to give a specific functional response.
- Give examples of different types of extracellular signals and receptors, and explain their functional significance.
- Describe the mechanisms by which different receptors may be activated by their respective ligands.
- Describe and give examples of the structure and properties of the major components of signal transduction pathways.
- Understand the importance of signal termination and give examples of how signal transduction pathways can be terminated.
- Understand and give examples of how defects in certain signalling molecules can give rise to disease states.

**Development:**
- Articulate the concepts of how biological complexity is established as the body plan of multicellular organisms emerge.
- Integrate these concepts in the context of how body plans have evolved.

**Human Physiology**
- After completing these lectures students will be able to:
- Describe the contribution of the nervous, endocrine and immune systems to regulation of physiological homeostasis in humans.
- Describe the gross and microscopic structures of the cardiovascular, respiratory, immune, renal and digestive systems.
- Discuss how the functions of physiological systems are integrated to ensure cell, tissue, organ and whole-body homeostasis.
- Describe how alterations in physiological variables as a result of exercise, changes in barometric pressure or pathophysiological processes impact on homeostasis in different organ systems.
Neuroscience & Behaviour

- The students will be able to use examples from invertebrate & vertebrate neurobiology to articulate how the brain achieves basic functions for the animal.
- Students will be encouraged to think integratively about how the fundamental physiology of neural circuits can be used to explain behavioural function in both vertebrates and invertebrates.
- Students will be able to give explanatory accounts of movement and motor control, sensation, and interoception.
- Students will be able to give explanatory accounts of emotion/motivation, memory, and how brain injury in human patients can inform us about brain function.

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


Assessment Details:
(A) **End of semester written examination: 50% total mark**
Exam comprised of:
- 25%: 10 short answer questions, testing understanding of concepts and deduction
- 25%: 1 essay-type question from a choice of 3 questions on paper

(B) **Two MCQ: 15% of total mark**
- testing knowledge of subject

(C) **Practical write-ups/assessments: 35% total mark.**

Contacts:

Module coordinator - BYU22202: From Cells to Organisms
Professor Colm Cunningham E-mail: colm.cunningham@tcd.ie
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Executive Officer E-mail: BTC.Administrator@tcd.ie
Phone: 01 896 1117
**BYU22203: From Organisms to Ecosystems**  
*Semester 2, 10 credits*

**Contact Hours**
38 Lectures, 5 Practicals.

**Module Personnel:**
Professors N. Marples, R. McLaughlin, N. O’Connor, D. Bradley, N. Payne, M. Williams, F. Mitchell, P. Luijckx

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

**Module content:** Programme of lectures and practicals

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<th>Lecture Topic &amp; Lecturer</th>
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<th>Practical</th>
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<tr>
<td>22</td>
<td>Introduction to BYU 22203 “Organisms to Ecosystems”</td>
<td>Prof Marples</td>
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<td>22</td>
<td>Natural selection</td>
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<td>22</td>
<td>Species and speciation</td>
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<td>23</td>
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<td>Evolution of reciprocity</td>
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<td>24</td>
<td>Genetic drift and neutral evolution</td>
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<td>24</td>
<td>Molecular Phylogenetics</td>
<td>Prof McLaughlin</td>
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<td>Human evolution in health and disease</td>
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<td>Diversity of life: Conquering the land</td>
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<td>25</td>
<td>Diversity of life: fungi, lichens, algae, angiosperms</td>
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<td>Diversity of life: animals, phylogeny and early evolution</td>
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<td>Diversity of life: animal feeding strategies</td>
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<td>Diversity of life: tetrapods and evolution of humans</td>
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<td>Diversity of animal life: reproductive behaviour</td>
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<tr>
<td>26</td>
<td>Diversity of plant life: plant reproductive strategies</td>
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<td>27</td>
<td>Life in extreme environments: evolutionary adaptations</td>
<td>Prof Mitchell</td>
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Description of Lecture Content:

- **Module Introduction - Darwin**
  After an introduction to the main topics to be covered in this module, module structure, assessment and general information. The main historical events leading to the evolutionary thinking under a Darwinian view will be discussed. This includes but is not limited to philosophy of organismal transformation, fixing forms, catastrophism and emergence of new life forms. This lecture also covers the stages by which Darwin came to his understanding of Natural Selection, and ends with an overview of the natural selection process.

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

- **Species and speciation**
  The species concept, and 6 approaches to defining what a species is will be explained and their various merits discussed. Examples form current work on speciation on islands in Indonesia being carried out by Prof Marples’ group will be used to illustrate the use of genetic methods. The 3 mechanisms of speciation will be introduced including the concept of hybrid zones.
• **Coevolution**
We explore the concept of animals evolving in response to the evolution of other species using the case study of the warning coloration of insects co-evolving with their predators. This example is used to illustrate the complexity co-evolutionary processes including positive and negative frequency dependence, differing selection pressures and three types of mimicry.

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

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

• **Evolution of reciprocity**
The lecture covers the remaining three reasons for co-operative behaviour, starting with examples of mutualisms, both with immediate and with delayed payoffs. The concept of reciprocal altruism is introduced, the evolution of tit for tat systems and the importance of policing both using theoretical animals and real life examples. Finally human altruism is discussed and experiments described showing a strong inclination towards policing being present in humans. The altruism practical is outlined so they can undertake it in their own time after this lecture. The ethical considerations of working with the public are explained at this point.

• **Molecular genetics**
This lecture provides foundational/refresher content in general principles of molecular genetics: the structure of DNA, heredity, genetic variation and transmission/segregation of alleles. The lecture also provides the required vocabulary for the student to fully understand all terms that are used in the subsequent five lectures and to introduce the core paradigm of molecular evolution: that changes in the characteristics of a population or species over time (evolution) can be directly observed at DNA level, and this serves as the very substrate that is studied in most major branches of evolutionary genetics.

• **Fitness and selection**
The concept of natural selection in revisited in this lecture, but this time from the perspective of molecular genetics and changes in allele and genotype frequencies over evolutionary time. We introduce the concept that alleles and genotypes have relative fitnesses in a given environment and explore how this can lead to differential success of individuals in the struggle for survival. Different mechanisms of selection are explored in reference to the relative fitnesses of genotypes, and real-world examples are provided, representing naturally-occurring human, plant and animal populations as well as long-running artificial selection experiments.
• Genetic drift and neutral evolution
Having explored in detail the basis of molecular evolution and the core principle that allele frequencies change over time, we extend this concept to neutral genetic variation that has no overall effect on phenotype or fitness. The change in frequencies of neutral alleles over evolutionary time by genetic drift is explored in detail, providing the foundational framework for the Neutral Theory of Molecular Evolution. This is a core paradigm in many studies of molecular phylogenetics, which is the topic of the next lecture.

• Molecular phylogenetics
This lecture provides the core theory and technical approach to the construction of phylogenetic trees from molecular data. We explore the topology of different types of phylogenetic trees and establish the appropriate vocabulary to understand their structure and the information they depict. Methods for the construction of phylogenetic trees from multiple sequence alignments are explored. Some real-world examples are provided demonstrating the power of molecular phylogenetics to resolve opaque evolutionary relationships and provide fundamental insights into the evolutionary histories of species.

• Population Genetics
In this lecture we hone our focus from the cross-species comparisons covered in the previous lecture to investigate the evolutionary relationships between individuals of the same species within and between populations. Drawing on real examples from worldwide human populations, we explore the expected statistical relationships between genotype and allele frequencies in model populations and the evolutionary interpretations when observed data deviate from expectation.

• Human evolution in health and disease
This lecture ties together key concepts in molecular genetics, molecular evolution and molecular phylogenetics by focusing on a single case study: the origins and rise of Homo sapiens and our ongoing struggle for survival in the modern world. We explore the fossil evidence that establishes the evolutionary history of the hominin lineage, the phylogenetic evidence for the recent African origin for the worldwide spread of anatomically modern humans and the use of molecular genetic and phylogenetic techniques for the study of transmissible and inherited human diseases.

• Diversity of life: Conquering the land
Conquering the land – the beginning and the winners.

• Diversity of life: fungi, lichens, algae, angiosperms

• Diversity of life: animals, phylogeny and early evolution
This lecture introduces animal body plans, the early invertebrates and the significance of the Cambrian explosion. Student will learn to define an ‘animal’, radial symmetry, bilateral symmetry, ecdysis, lophotrochozoan and where these features fit on the phylogeny of animals. This lectures includes key characteristics of the major invertebrate phyla.

• Diversity of life: animal feeding strategies
This lecture introduced the main feeding types of animals with examples: Suspension/filter feeders, substrate feeders, fluid feeders, bulk feeders vs predators, herbivores, parasites, parasitoids. The great diversity of animals and how this relates to dietary adaptations is discussed including examples of predators and their prey, herbivores and plants, and humans.
- **Diversity of life: tetrapods and evolution of humans**
  This lecture describes the evolution of tetrapods from sea to land, including the major steps in the evolution of tetrapods, suggested reasons why tetrapods may have moved to land including when this may have occurred and how tetrapods are adapted to live on land. In addition, we explore how the many things that make humans “special” are not unique to humans. We will discuss how to tell whether or not a fossil hominid was bipedal and how humans are still evolving with examples.

- **Life in extreme environments: evolutionary adaptations**
  Polar, deep sea, high altitudes, deserts etc. Evolutionary adaptations for survival in plants and animals.

- **Diversity of animal life: reproductive behaviour**
  Reproductive behaviour and evolution of mating systems, sexual selection etc.

- **Diversity of plant life: plant reproductive strategies**
  Dispersal and interactions with animals.

- **Interactions between organisms including mutualisms**
  Includes examples from plants and animals.

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

- **Thermoregulation and Water Stress in Plants**
  Extreme habitats, growth forms, thermoregulation through evapotranspiration and mitochondrial respiration, heat and water loss, structural and metabolic solutions to water loss.

- **Animal Nutrition and Digestion**
  Having been introduced to the energy requirements and feeding strategies of animals (lectures 23 and 17, respectively), this lecture links those concepts by focussing on nutrition. The different types of essential nutrients will be introduced, as will be the various stages of food processing (from ingestion to elimination). We will examine the range of digestive systems seen across taxa, and look in a little more detail at characteristics of the mammalian digestive system. Focussing on vertebrates, examples of digestive system adaptations to deal with specific diets will also be presented.

- **Plant Nutrition and Digestion**
  Nutrient deficiency in plants, serpentine soils and heavy metal accumulation, insectivorous plants.

- **Circulation and Gas Exchange in Animals**
  This lecture explores the immense variation in form and function of circulatory and gas-exchange systems seen in animals. By taking a largely comparative approach, we will examine the different types of respiratory systems (e.g. trachea, gills and lungs), modes of ventilation, and circulatory systems (open and closed) seen across invertebrates, fish, birds and mammals. We will also consider how physical attributes of water present challenges to gas exchange for aquatic animals, and how these can be overcome in groups such as ‘water-breathing’ sharks and deep-diving whales.
- **Circulation and Gas Exchange in Plants**
  Plants are high pressure systems, the three transport pathways, biophysical ‘pumps’ in plants, water potential, gas exchange: CO₂ and O₂.

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

- **Terrestrial ecosystems: forests and grassland**
  Functioning and adaptations in forest and grassland ecosystems at individual, biome and global scales.

- **Terrestrial ecosystems: desert, tundra and peatland**
  Functioning and adaptations in desert, tundra and peatland ecosystems at individual, biome and global scales.

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

- **Freshwater ecosystems: Rivers and lakes**
  This lecture will provide a short broad introduction into these ecosystems followed by two in-depth examples how climate change affects lake and river ecosystems thus providing both breadth and depth. Introduction to rivers and lakes. Formation, ecological importance. The water framework directive. Decrease in water quality in Irish rivers multiple stressors and their interactions. Research example: Exstream system from Prof. Jay Piggott, climate, nutrients and sediment. Take home: Beware of ecological surprises, sediment not nutrients may be the most important stressor. Global warming and the spread of aquatic infectious diseases. Complexity of predicting the effect of global warming on disease. A few short contradictory examples of how climate change impacts disease in aquatic environments. Metabolic theory a potential solution Research example on climate and disease using the Daphnia system. Take home, complexity of temperature on species interactions.

- **Marine ecosystems: Estuaries**
  Classification, biological and environmental characteristics. Biological communities associated with estuaries. Estuarine ecosystem functioning and food webs, disturbance and biodiversity. Dublin Bay.

- **Marine ecosystems: Coastal waters and Open Seas**
  Characteristic features of shelf seas, habitat characteristics, associated biota and functional roles, food webs and human interactions. Characteristic features of the deep sea and associated fauna with examples.

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

- **Genes to ecosystems**
  This lecture will demonstrate that the genetic make-up of a population can have large consequences for ecological and evolutionary processes. This lecture is aimed connecting concepts handled in BY201 - from molecules to cells and BY202 - from cells to organisms to ecosystem function. How genetic diversity can play a role in ecosystem functioning, biodiversity and resilience. Genetic diversity in keystone species can have a large effect on biodiversity. What does that mean for
conservation? Role of genetic diversity in invasions by of non-native species. How a single genetic change can have large consequences for the entire ecosystem. Research example Ian Donohue. Mutation in transmissible cancer Tasmanian devil?

• Module Review

Description of Practical Content:

Practical 1 – Altruism (worth 7% of total mark)
This practical is carried out in the students’ own time, in groups of 3 or 4. They read about altruistic behaviour in humans, then design and carry out their own experiment to test one of the supposed influences of humans on each other’s behaviour. They are provided with a list of possible projects to get them thinking, but are encouraged to design something new. They then fill in a template for their write-up, one for each group, which is marked as part of the CA for this module. Report due 3 weeks later.

Practical 2 Molecular phylogenetics (worth 7% of total mark)
In this practical session students undertake their own genotyping experiments to infer the phylogeny of a set of Mycobacterium tuberculosis strains. Students perform gel electrophoresis of strain-informative DNA sequences amplified by polymerase chain reaction and construct a phylogeny of the various strains using techniques explored in preceding lectures. The practical session will run during week 25 in the Biology Teaching Laboratories. Students are assessed during the practical session via a pro-forma lab report consisting of a series of short answer questions (submitted at the end of the session).

Practical 3 Animal physiology (worth 7% of total mark)
This practical will allow students to make measurements of the metabolic rates of living invertebrate animals, and to quantify the influence of body size or temperature on metabolism. Rates of change in the concentration of respiratory gasses will be measured, and data from different individuals will be combined to estimate metabolic scaling parameters. Assessment: Completion of sections outlined in the practical manual and associated questions on Blackboard (one week after the prac).

Practical 4 Plant physiology (worth 7% of total mark)
Leaf photosynthesis of C3 and C4 plants using IRGAs to monitor changes in concentration of CO2 in air.

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

Assessment: Students are asked to plot two graphs and answer a series of short questions during the practical. In addition, an online MCQ accompanies this practical where students will be questioned on C3 and C4 photosynthesis (one week after the practical).
Practical 5 Computer based ecological modelling (worth 7% of total mark)
This practical uses the interactive Symbio/Ecobeaker package that is loaded on the PAC room computers. It is a self-directed practical which tests the Intermediate Disturbance Hypothesis by modelling forest succession and manipulating fire return time and intensity. Assessment: Completion of the sections outlined the practical manual and completion of associated questions on Blackboard. Deadline: End of the module.

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

Recommended Reading List:
The topics and concepts presented in this module can be found in selected chapters of the following textbooks:
- Introduction to Genetic Analysis, chapter 18 (Griffiths et al, 11th edition).

Assessment Details:

(A) End of semester written examination: 50% total mark
Exam is comprised of:
- 25%: 10 short answer questions, testing understanding of concepts and deduction.
- 25%: 1 essay-type question from a choice of 3 questions on paper.

(B) Two MCQ: 15% of total mark
- testing knowledge of subject

(C) Practical write-ups/assessments: 35% total mark.
- Practical 1 week 23 – report due week 26
- Practical 2 week 25 – report submitted during practical
- Practical 3 week 27 – online quiz within one week (week 28)
- Practical 4 week 29 – report and online quiz (week 30)
- Practical 5 week 31 – report and online quiz (week 34)

Contacts:

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Phone: 896 1640

Executive Officer E-mail: BTC.Administrator@tcd.ie
Phone: 01 896 1117
BYU22S01: Statistics and computation
Semester 1, 5 credits

Contact Hours:
20 Lectures; 5 x 2 hour practicals; 5 x 1 hour drop-in sessions.

Module Personnel
Professors Yvonne Buckley, Jacinta Kong, Dan Bradley, Russel McLaughlin and Dr. Karsten Hokamp.

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

Module content: Programme of lectures and practicals

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<td>Introduction to Statistics &amp; Computation for Biologists</td>
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<td>Drop-in 1: set-up Y. Buckley</td>
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<td>Communicating quantitative biology</td>
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<td>Variables: types, sample distributions, summary statistics</td>
<td>Prof. Buckley</td>
<td>Practical 1: R-Studio Y. Buckley</td>
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<td>4</td>
<td>Principles of probability</td>
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<td>5</td>
<td>Data visualisation, regression, correlation</td>
<td>Prof. Buckley</td>
<td>Drop-in 2 Y. Buckley</td>
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<tr>
<td>5</td>
<td>Normal distribution z score, p values correlation</td>
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<td>6</td>
<td>Type I, type II errors</td>
<td>Prof Bradley</td>
<td>Practical 2: Hypotheses R. McLaughlin</td>
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<td>6</td>
<td>Sample error of the mean</td>
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<td>7</td>
<td>The t distribution and t tests</td>
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<td>Drop-in 3 D. Bradley</td>
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<td>7</td>
<td>The basics of Analysis of variance</td>
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<td>8</td>
<td>Chi squared testing, contingency tables</td>
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<td>Practical 3: Modelling 1 Y. Buckley</td>
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<td>8</td>
<td>Non-parametric tests</td>
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<td>10</td>
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<td>10</td>
<td>Regression &amp; parameter estimation</td>
<td>Prof Buckley</td>
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<td>10</td>
<td>Introduction to Generalised Linear Models: Proportions</td>
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<td>11</td>
<td>Introduction to GLMs: Count data</td>
<td>Prof. Buckley</td>
<td>Practical 4: Modelling 2 Y. Buckley</td>
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<td>11</td>
<td>Implementing an analysis workflow</td>
<td>Prof. Buckley</td>
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Description of Lecture Content:
- Introduction to module & resources, expectations around effort & activities. Workflows in quantitative biology, using R Studio, saving scripts, working with data, good housekeeping. Pseudocode, code and statistics – how elements of the module fit together.
- Communicating quantitative biology – visualisation, writing comprehensible code, reporting on statistics.
- Types of variables, sample distributions and families of summary statistics
- Basic rules of probability
- Data visualization, regression, correlation
- The normal distribution, the Z score and P values
- Type I, type II error
- Sample error of the mean
- The t distribution and t tests
- Analysis of variance (very basic introduction to concept)
- Chi squared testing, contingency tables
- Non-parametric test analogues of normal distribution-based tests
- Regression & parameter estimation (intercept, slope)
- Introduction to GLMs: Proportion data
- Introduction to GLMs: Poisson
- Implementing an analysis workflow [to support the dataset analysis assessment]
- Control Structures: branching and loops
- Reusing code: functions and blocks
- Functional programming in R
- Programming in practise: documentation, debugging, testing, distribution

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

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

Recommended Reading List:

Assessment Details:
• 50% CA Practical reports (10% per practical report/worksheet, handed in & marked in the practicals)
• 25% CA MCQ quiz based on lecture material, marked automatically on BB (3 day window for completion in week 9 reading week)
• 25% CA Take-home problem: Each student is given a data set to analyse with a series of questions. Data sets will be randomised so answers will be unique to each student. Answers will be submitted via Blackboard (assessment instructions given to students in week 10 and submitted in week 14).

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

Module Coordinator: BYU22SC01: Statistics and Computation
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Executive Officer E-mail: BTC.Administrator@tcd.ie
Phone: 01 896 1117
PIU22991: History, Philosophy and Ethics of Science
Semester 1, 5 credits

Contact Hours:
20 hours of lectures + 6 hours of tutorials

Module Personnel: Dr. Keith Begley (Philosophy) & Prof. Linda Hogan (Ecumenics)

Learning Aims *(Drawn from the Trinity Graduate Attributes)*
- **Think independently:** Appreciates knowledge beyond chosen field. Thinks critically and creatively.
- **Communicate effectively:** Listens, persuades, and collaborates. Uses communication tools of discipline.
- **Develop continuously:** Learns and develops through reflection. Adapts to change.
- **Act responsibly:** Is ethically aware. Is effective in teams. Acts responsibly and on the basis of knowledge.

Module content: Programme of Lectures and Practicals

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<td>Tutorial: Justification/Method</td>
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<td>What Makes Something Ethical? Duties and Virtues</td>
<td>Prof Hogan</td>
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<td>From Principle to Practice: Navigating the Ethics Ecosystem</td>
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<td>9</td>
<td>Reading Week <em>(21st Oct -25th Oct 2019)</em></td>
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<td>10</td>
<td>Monday 28th October 2019 – Bank Holiday</td>
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<td>10</td>
<td>Does Science aim at Truth? (Scientific Realism)</td>
<td>Dr Begley</td>
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<td>10</td>
<td>Does Science aim at Truth? (Constructive Empiricism)</td>
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<td>11</td>
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<td>Metaphysical theories (Realism and Nominalism)</td>
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<td>12</td>
<td>Problems of Identity</td>
<td>Dr Begley</td>
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<td>12</td>
<td>Reduction and Emergence</td>
<td>Dr Begley</td>
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<td>12</td>
<td>Tutorial: Truth</td>
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Note: Some tutorials might have to be scheduled in the week following those indicated (excluding revision week).

Description of Lecture Content:
The lectures follow a thematic progression that begins with the early history of science and philosophy and philosophical considerations about knowledge. This provides a context for discussion of scientific justification and method, and of science and truth. The lectures shift focus from epistemological considerations to ethical theories and their applications in science, and then again to metaphysical considerations regarding ontology, identity, emergence, causation and laws of nature.

Introduction and early History
This lecture is an introduction to the module. We will also begin to address the question: Where did our scientific and philosophical traditions come from?

History of Science and Philosophy
This lecture continues with the historical focus, by considering some key episodes in the genesis of science. We will also begin to consider in what way Science and Philosophy are investigations aimed at knowledge and wisdom.

What is Knowledge?
This lecture begins by distinguishing a number of different kinds and sources of knowledge, including the distinction between Knowledge-how and Knowledge-that and the distinction between a priori and empirical knowledge. We will also consider how these kinds manifest themselves in science.

Defining Knowledge
In this lecture we will discuss the philosophical project of defining or analysing knowledge, the traditional distinction between knowledge and mere true belief, and what is known as the ‘classical’ definition of knowledge as Justified True Belief. We will also begin to consider how science is distinguished from other practices aimed at knowledge, primarily by its manner of justification.

What is Scientific Justification?
In this lecture we will elucidate the distinctions between the main forms of inference, namely, deduction and induction/abduction, and the notions of argument, validity, fallacy, and soundness. We will see that induction, whatever else it may be, is not a logically valid form of inference. We will also consider a deeper issue, that of Hume’s problem of induction.

Problems of Induction and Confirmation
This lecture will introduce two further philosophical problems or paradoxes for the justification of inductive inference, which have been important in the philosophy of science, namely, Goodman’s new riddle of induction and Hempel’s paradox of ravens.
What is Scientific Method?
In this lecture we will consider one response to the problems of induction/confirmation, namely, Popper’s deductive scientific method (conjecture and refutation), which claims that science can do without induction and rely instead on deduction. We will also consider Popper’s claim that his criterion of falsification is what distinguishes science from non-science and pseudo-science, and whether or not there is such a thing as ‘scientific proof’ on this view.

Further views on Scientific Method
In this lecture we will consider a problem for naïve falsificationism, namely, the Duhem thesis. Further, we will consider some possible consequences of this for theory revision, such as Holism (Quine), and alternative views of (normal) science as operating within a certain paradigm (Kuhn).

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

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

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

From Principle to Practice: Navigating the Ethics Ecosystem
This lecture examines how institutional cultures affect individual decision-making, whether that be in the context of the university lab or the professional work environment. Topics for consideration will include ethical blind-spots, group-think, ethical fading and the question of whistle-blowing.

Does Science aim at Truth? (Scientific Realism)
In this lecture we will consider a number of views regarding the relation between science and truth, before considering some arguments for Scientific Realism, and the relevance of the (non-)distinction between observables and unobservables.

Does Science aim at Truth? (Constructive Empiricism)
This lecture will consider an anti-realist response to the argument for realism in the previous lecture, namely, and argument for the view known as Constructive Empiricism. This will take account of the relevance of the (vague) distinction between observables and unobservables, and the underdetermination of theory by evidence.

What is Metaphysics?
This lecture is an introduction to the philosophical area known as Metaphysics. We will consider in particular the main distinctions that are made in a main branch of metaphysics called ontology (the study of being): The object / property distinction (substantial / non-substantial) and the universal / particular distinction, and the ontological categories arising from these.

Metaphysical theories
This lecture builds upon the previous one by identifying kinds of metaphysical theory by the ontological categories that they accept. We will consider two such broad kinds of theory, Realism and Nominalism, and how principles and reasons, e.g., Occam’s Razor, might lead one to accept one view over another.
Problems of Identity
Having already prepared some basic notions in metaphysics in previous lectures, in this lecture we will begin to discuss some metaphysical problems. In particular, we will consider applications of metaphysics to problems of identity.

Reduction and Emergence
In this lecture we will consider applications of metaphysics to problems of reduction and emergence, and consider the question of whether and in what way the objects of the special sciences exist or are reducible to the fundamental posits of physics.

What is Causation?
In this lecture we will consider some traditional views of cause and explanation, as answers to why questions. We will then discuss an influential argument against real causation, which was put forward originally by Hume. Consideration will also be given to the notions of correlation and causation.

What is a Law of Nature?
In this lecture we will discuss the two main kinds of view regarding laws of nature. Following on from the previous lecture, we first discuss Regularity or ‘Humean’ views on laws of nature, before turning to Realist views. We will also consider some problems for these views.

Learning Outcomes:
At the end of this module students will be able to:
Think independently:
• demonstrate critical thinking and independence of judgement.
• investigate philosophical problems related to their discipline.
Communicate effectively:
• use valid argumentation and avoid fallacious reasoning.
• collaborate effectively regarding philosophical problems.
Develop continuously:
• appraise theory and practice through philosophical reflection.
• adapt to changing evidence and investigate new possibilities informed by philosophical approaches.
Act responsibly:
• demonstrate ethical awareness and recognise the place of science and philosophy in society.
• operate well both as part of a team and individually, recognising the role of the academic community in upholding standards.

Recommended Reading List:


Further reading: TBC
Assessment Details:

2 Written Essays of 1,000 words (2-3 pages) each (25%)

1. Essay (1,000 words) on scientific practice in light of one of the themes or problems regarding (i) Knowledge, (ii) Scientific Justification, (iii) Method

2. Essay (1,000 words) on an ethical problem in science (one question from three), applying approaches informed by normative ethical theories.

Questions will be published in weeks 3 & 8, respectively. Essays will be due in weeks 10 & 15. A 50–100 word abstract of the focus of each essay will be due two weeks prior to the essay deadline, in weeks 8 & 13.

Written Examination (1.5 hours, 50%) – two questions from five (excluding first essay topic).

Section A: (i) Knowledge, (ii) Scientific Justification, (iii) Method
Section B: (iv) Truth, (v) Metaphysics, (vi) Causation/Laws

- One question from Section A (excluding first essay topic) OR one question from Section B. (25%)
- A question from Section B. (25%)

Module Website

https://www.tcd.ie/Philosophy

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Department of Philosophy
TR060 Biological and Biomedical Sciences - APPROVED MODULES

BYU22204: Sustainable Production: Food, Drink and Drugs
Semester 1, 5 credits

Contact Hours 28 hours (16 lectures and 4 x 3hr practical sessions)

Module Personnel
Professor Mike Williams

Learning Aims:
The aims of this course are to familiarise the student with concepts of sustainable development, ecological farming, green pharma, sustainable diets, novel food and drink products, and how environmental impacts of the food/drink and drug industry are assessed using Life Cycle Analysis (LCA). Practicals will focus on biotechnology (tissue culture), brewing (students will produce their own SMASH beer – *single malt and single hop beer*) and environmental LCA of dietary protein sources (meta-analysis of published data).

Module content: Programme of Lectures and Practicals

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<th>Lecture Topic</th>
<th>Practical</th>
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<td>Introduction to the module: concepts of sustainability and sustainable indicators.</td>
<td>1: SMASH beer production (a) Fermentation</td>
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<tr>
<td>3</td>
<td></td>
<td>2: Tissue Culture (a) Incubating explants in tissue culture medium</td>
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<td>3</td>
<td></td>
<td>3: Environmental Footprint of the European Diet</td>
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<td>6</td>
<td>Environmental footprint of food and beverage production: GHGs.</td>
<td>1. SMASH beer production (b) bottling</td>
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<tr>
<td>6</td>
<td>Environmental footprint of food and beverage production: N and P pollution</td>
<td>2. Tissue Culture: Assessing effect of auxins and cytokinins on growth of explants</td>
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<tr>
<td>7</td>
<td>Environmental Life Cycle Analysis (LCA)</td>
<td>1. SMASH beer production: (c) sugar and alcohol determination using specific gravity</td>
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<td>7</td>
<td>Nutrient Densities and LCAs</td>
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<td>8</td>
<td>Novel Foods</td>
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<td>8</td>
<td>Sustainability and the Drug, Pesticide and Chemical Industry</td>
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</tbody>
</table>
Learning Outcomes:
At completion of course students should be better informed with regard to sustainable food, drink and drug production, be able to make informed decisions with respect to diet and food choice, be familiar with concepts and methodology of life cycle analysis of food production pathways, understand the practical aspects of tissue culture and how important such methodologies are in biotechnology, understand the brewing process and be able to produce acceptable beers at home using a variety of hops and malts.

Recommended Reading List:
Assessment Details:
The course will be assessed both by examination and continual assessment (50:50). The examination paper will consist of one essay question (60%) and five short answer questions (40%). Each of the three practicals will be assessed in class and also by short MCQs at the end of each practical.

Module Coordinator: BYU22204: Sustainable production: Food, Drink and Drugs
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Executive Officer:  E-mail: BTC.Administrator@tcd.ie
Phone: 01 896 1117
BYU22205: Influences on Animal Behaviour
Semester 1, 5 credits

Contact Hours 21

Module Personnel:
Professors Nicola Marples; Elizabeth Nixon, Fiona Newell, Andrew Jackson

Learning Aims
The Influences on Animal Behaviour module comprises a series of lectures, assessments carried out online and practicals. The module is taught jointly by the School of Natural Sciences and the School of Psychology, and covers a wide range of topics, beginning with a brief history of behavioural research. The students are then introduced to various aspects of learning, cultural transmission, cognition and intelligence in animals. Three lectures explore the animal’s behaviour in its environment and why all individuals of a species do not behave in the same ways. The final lectures address the importance of an understanding of behaviour in relation to conservation in the wild and in zoos, and in relation to climate change. These lectures are supported using clicker technology and there is ample opportunity for interaction in class. The module includes student led learning leading to online assessment and fosters a responsible approach by allowing students to complete most aspects of the CA in their own time.

Module content: Programme of lectures and practicals

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<td>Introduction and Historical overview</td>
<td>Prof Marples</td>
<td>Practical 1: Dublin Zoo: introduced in lecture 1 and completed in their own time by end of Week 5</td>
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<tr>
<td>3</td>
<td>Learning</td>
<td>Prof Marples</td>
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<td>Memory</td>
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<td>4</td>
<td>Human sensation and perception</td>
<td>Prof Newell</td>
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<tr>
<td>4</td>
<td>Human perception and attention</td>
<td>Prof Newell</td>
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<td>5</td>
<td>Play in animals</td>
<td>Prof Marples</td>
<td>Practical 2: Videos (introduced in Lecture, completed by start of reading week)</td>
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<td>5</td>
<td>Play in humans</td>
<td>Prof Nixon</td>
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<td>6</td>
<td>Cultural transmission</td>
<td>Prof Marples</td>
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<td>6</td>
<td>Imitation and teaching in animals</td>
<td>Prof Marples</td>
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<td>7</td>
<td>Intentionality in animals</td>
<td>Prof Marples</td>
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<td>7</td>
<td>Intentionality &amp; Agency in Infancy and Childhood</td>
<td>Prof Nixon</td>
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<td>8</td>
<td>Collective behaviour</td>
<td>Prof Jackson</td>
<td>Practical 3: Collective behaviour (2 Scheduled Weds practical slots am and pm. Assessment intro in</td>
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Description of Lecture Content:

Introduction and Historical overview
Course overview; historical context: Gilbert White, Pavlov, Lorenz, von Frisch, Tinbergen, 4 whys of Tinbergen, Skinner, Operant conditioning, Ethology vs behavioural ecology / ultimate vs proximate distinction, lab and field both needed, correlation does not prove causation

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

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

Human Sensation and Perception
What are the basic sensory processes; How do we measure our perceptual abilities; how the brain perceives a constant world; perception and social psychology; how perception changes across the lifecourse; individual differences.
Human Perception and Attention
What is the relationship between perception and attention; visual attention is selective and serial; attending to sounds; attending to multiple sensory stimulation; social attention and the role of eye gaze.

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

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

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

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

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

Intentionality & Agency in Infancy and Childhood
Early signs of intentionality: self-directed activity, means-end-differentiation and the cognitive revolution at 9 months of age; emerging understanding of intentional-states in others; (Meltzoff and the “like me” framework, Tomasello and the simulation account); perspective taking and intersubjectivity; language (personal pronouns) and reflective forms of agency; intentional self-regulation.
Navigation
Simple contortion of path, swarming of bacteria, dead reckoning, piloting by landmarks, Tinbergen’s wasps, bees, mice, food storing birds, wind and current maps, auditory maps, olfactory maps, celestial cues of direction, clock shift experiments, shoreline orientation, sun compass, zugunruhe experiments, magnetic sense, Walcott experiment, combining cues, “true navigation”, shearwaters, monarch butterflies

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

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

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

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

Behaviour and conservation

Behaviour, zoos and reintroductions
Behavioural ecology can help: imprinting problems, migration route learning, cross fostering, predator recognition, hunting skills, movement in the environment, stress, boredom, stereotypies, appetitive behaviours, natural behaviour management, contra-freeloading, inbreeding, mate choice, selection for personality types.
Description of Practical Content:

Practical 1: Zoo animal behaviour: (Nicola Marples)
Worksheet on animal signalling, which students complete in the zoo in their own time. Gain entry through student tickets (reduced price) provided to them by Biology Teaching Centre. On completion of the practical the students do an online quiz in Blackboard.

Practical 2: Trials of Life Videos:
Students watch 4 videos from the BBC series "Trials of Life" by David Attenborough, which they complete in their own time. After each video, they do an online MCQ in blackboard which explores the concepts covered in the video.

Practical 3: Collective Behaviour: (Andrew Jackson, Dept of Zoology)
Timetabled practical carried out in the sports hall. The students experiment with how simple rules of movement cause emergent self-organising behaviours such as movement in a torus in the absence of any leaders. They then experiment with the addition of small proportions of the group as leaders and how this changes the emergent behaviours. Whole practical is filmed for later discussion in the collective behaviour lecture (lecture 13). This is followed by an online exercise.

Requirements for teaching support:
Maintenance of access to the online quizzes and collection of the worksheets for Practical 1

Learning Outcomes:
On successful completion of this module, students will be able to:
• Place the study of behaviour in context related to a historical perspective.
• Describe the range of factors which influence animal behaviour, linking the understanding of behaviour to a number of other biological study areas.
• Outline the basics of learning, both through classical mechanisms and through cultural transmission.
• Discuss the concept of animal intelligence and our understanding of consciousness in non-humans.
• Outline the main reasons for variation in behaviour between individuals.
• Discuss how and why animals play, and how they navigate.
• Outline the importance of animal behaviour studies in the context of conservation.
• Build from a sound basis of understanding of basic behavioural ecological concepts.
• Organise and complete assessed work independently of the course co-ordinator.

Recommended Reading List:
• Barnard C. 2004 Animal Behaviour: Mechanism, Development, Function and Evolution. Springer
• Marian Stamp Dawkins “Through Our Eyes Only?: the search for animal consciousness” 1998 Oxford University Press
Assessment Details:
Exam: 10 short answer questions (70%)

Three CA assessments (each worth 10%) attached to practicals:
Practical 1 assessment: Worksheet from zoo marked pass/fail; online quiz marked electronically.
   i) Presented in week 3 lecture 1
   ii) Hand in by week 5, 4pm Friday
Practical 2 assessment: Online MCQs. The mark goes towards their CA mark for the course.
   i) Presented in week 5 lecture 6
   ii) Closed in week 8, 4pm Friday
Practical 3 assessment: Online quiz for collective behaviour, marked electronically.
   i) Presented in week 8 lecture 13
   ii) Closed in week 13, 4pm Friday

Module Coordinator: BYU22205: Influences on Animal Behaviour
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BYU22206: Microbes, Immune Systems and their Interaction
Semester 2, 5 credits

Contact Hours: 16 lectures; 3 x 3 hour practicals

Module Personnel:

Learning Aims
Overview of the module with aims
The microbial world existed successfully for 1.5 billion years before multicellular organisms began to appear. During that time, microbes evolved multiple defence mechanisms against potential competitors. Even when multicellular organisms evolved, microbes continued to exist successfully, often in harmony. Many of these mechanisms are conserved in multicellular organisms and used in defence against potential pathogens. In this module, students will learn about immune systems that have evolved over billions of years and about the complex interactions between microbes and their hosts which can lead to significant disease but which are also required for health. Students will learn about the molecular and cellular biology of key pathogens (viral, prokaryotic and eukaryotic) which currently threaten human populations; they will learn about immune systems and the diverse mechanisms used by immune molecules and cells to detect and respond to these microbes.

Module content:

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<tr>
<td>23</td>
<td>Introduction: Microbes Immune Systems and their Interaction</td>
<td>Prof O’Farrelly &amp; Prof Kroger</td>
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<td>23</td>
<td>Evolution of Microbial and Multicellular Organisms</td>
<td>Prof Kroger</td>
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<td>24</td>
<td>Microbial Defence Mechanisms:</td>
<td>Prof Kroger</td>
<td>Cells and Organs of the Immune System</td>
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<tr>
<td>24</td>
<td>Introduction to Vertebrate Immune Systems:</td>
<td>Prof O’Farrelly</td>
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<tr>
<td>25</td>
<td>Where and how immunology happens: Molecules, Cells &amp; Organs of the Immune System.</td>
<td>Prof O’Farrelly</td>
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<tr>
<td>25</td>
<td>Innate Immunity:</td>
<td>Prof O’Farrelly</td>
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<tr>
<td>26</td>
<td>Bacterial Pathogens: Mycobacterium tuberculosis:</td>
<td>Prof Geoghegan</td>
<td>Immunological Activity</td>
</tr>
<tr>
<td>26</td>
<td>Microbiomes and Health</td>
<td>Prof Corr</td>
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</tr>
<tr>
<td>27</td>
<td>Inflammation in Health and Disease</td>
<td>Prof O’Farrelly</td>
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</tr>
</tbody>
</table>
### Description of Lecture Content:

**Introduction to Module Microbes, Immune Systems and their Interaction.**
This will be a joint presentation by a microbiologist and an immunologist describing the integrative nature of microbiology and immunology, how the course has been designed to reflect this integration and the relevant expertise of each contributor to the course.

**Evolution: Microbial and Multicellular Organisms**
An introduction to how multicellular organisms evolved ‘around’ the microbial world and how the microbial world continues to exist successfully on the plant

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

**Introduction to vertebrate anti-microbial defence**
An overview of what vertebrate immunology is; how so much of microbial defence has been conserved; how competition for nutrient resources underpins immunometabolism immune activity and immune regulation; immune systems detect altered self as well as foreign and danger – anti-cancer immunity, virally infected cells, Natural Killer cells.
Where Immunology Happens and How: Molecules, Cells & Organs of the Immune System
Overview of the key immune organs, cells and molecules, their location structure and principle functions; introduction to haematopoiesis.

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

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

Inflammation in Health & Disease
Inflammatory cytokines, chemokines, local inflammation systemic inflammation; chronic inflammatory disease, anti-inflammatory therapies.

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

Adaptive Immunity 1: Immunisation:
Global effect of successful vaccines; structure and function of antibodies; primary and secondary responses, B lymphocytes, induction of an effective antibody response; infectious agents without vaccines.

Adaptive Immunity 2 Anti TB immunity:
How T lymphocytes are activated, DCs antigen processing and presentation; 4 populations of T cells; Mtb evasion of adaptive immunity; granuloma formation; role of TNF

Viral Pathogens - influenza:
The influenza virus, pathogenesis of influenza virus infections, anti-virals.

Adaptive Immunity 3: anti-‘flu Immunity
The adaptive immune response against viruses; cytotoxic T cells; flu vaccine.

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

Immune Responses to Malaria:
Innate and adaptive immune responses to natural malarial infection; malarial evasion of immunity; vaccine challenges

Description of Practical Content:
PRACTICAL 1: Microbial offense and defence

Purpose:
To familiarise student with the strategies used by microbes to defend themselves against competing microbes and to cause damage to host cells. To demonstrate two of the major mechanisms by which antibiotic resistance can arise in bacteria.

Completion of this practical will enable you to:
- Demonstrate the lytic effects of bacterial toxins on eukaryotic erythrocytes
- Demonstrate the growth inhibitory activity of antibiotics produced by fungi and bacteria on a culture of Escherichia coli
- Isolate antibiotic resistant mutants of Escherichia coli
- Determine the sensitivity of Escherichia coli to antibiotics
- Enumerate bacterial viruses and animal viruses using a plaque assay

PRACTICAL 2: Cells and Organs of the Immune System

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

Completion of this practical will enable you to:
- Be able to identify the cells and tissues involved in the mammalian immune system
- Have some idea of their dimensions
- Be familiar with the appearance of the neutrophil, macrophage, dendritic cell, and lymphocyte

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

Purpose:
To familiarise students with some immunological functions in particular the specific recognition ability of antibodies and phagocytic potential of macrophage-like cells

Completion of this practical will enable you to:
- carry out an ELISA (enzyme-linked immunosorbent assay)
- generate a standard curve
- Perform blood-typing
- Carry out a phagocytosis assay

Learning Outcomes:
Completion of this practical will enable you to:
1. Demonstrate an understanding of the microbial world
2. Discuss the evolution of multicellular organisms
3. Discuss the evolution of ‘defence’ amongst microbes and multicellular organisms
4. Appreciate the components of and function of prokaryotic and mammalian immune systems
5. Describe how key pathogens cause infection and the immune response to pathogens
6. Describe how vaccines and antimicrobial agents work and their role in the control of infectious disease.
Recommended Reading List:

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

1. Campbell Biology 10th Edition Pearson (especially chapter on Immunology)
2. Prescott’s Microbiology. 10th edition
4. [https://www.youtube.com/watch?v=eUv1jkZshh0&t=629s](https://www.youtube.com/watch?v=eUv1jkZshh0&t=629s) The Future of Immunology  
   Lydia Lynch

Assessment Details:

Types of assessment and allocation of marks for each assessment  
1 x MCQ 10 questions each week

Module Coordinator: Microbes, Immune Systems and their Interaction  
Professor Cliona O’Farrelly  
E-mail: Cliona.ofarrelly@tcd.ie  
Phone: 01 896 3175

Executive Officer:  
E-mail: BTC.Administrator@tcd.ie  
Ms  
Phone: 01 896 1117
BYU22207: Genomes, Disease and Diversity  
Semester 2, 5 credits

Contact Hours
16 lectures, 3 X 3hr Practical

Module Personnel
Professors Dan Bradley, Jane Farrar, Aoife McLysaght, Seamus Martin, Marta Martins, Pepijn Luijckx

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

Module content: Programme of lectures and practicals

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture Topic</th>
<th>Lecturer</th>
<th>Practical</th>
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</thead>
<tbody>
<tr>
<td>22</td>
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<td>22</td>
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<tr>
<td>23</td>
<td>The inherited genome: Introduction to the human genome</td>
<td>Prof Farrar</td>
<td>Genome data analysis (1) A. McLysaght</td>
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<tr>
<td>23</td>
<td>The inherited genome: Human disease and genomics</td>
<td>Prof Farrar</td>
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<td>24</td>
<td>The inherited genome: Complex genomic inheritance</td>
<td>Prof Farrar</td>
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<tr>
<td>24</td>
<td>The inherited genome: Genome wide analysis of human traits</td>
<td>Prof Farrar</td>
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<tr>
<td>25</td>
<td>The non-inherited genome: Cancer, incidence, sources of mutagens, types of mutation</td>
<td>Prof Martin</td>
<td>Functional Genomics A. McLysaght</td>
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<td>25</td>
<td>The non-inherited genome: Oncogenes and tumor suppressor genes</td>
<td>Prof Martin</td>
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<td>26</td>
<td>The non-inherited genome: The process of cellular transformation</td>
<td>Prof Martin</td>
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<td>The non-inherited genome: Cancer genomics, epigenomics and implications for treatment.</td>
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<td>Description of Lecture Content:</td>
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<td>Lectures are grouped in four themes:</td>
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<td></td>
<td><strong>1) The inherited genome with four lectures as follows:</strong></td>
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<td>- Introduction to the human genome</td>
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<td>- From genes to genomics</td>
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<td>- Human disease and genomics</td>
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<td>- Non disease traits and genomics</td>
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<td><strong>2) The non-inherited genome with four lectures:</strong></td>
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<td>- Cancer, incidence, sources of mutagens, types of mutation</td>
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<td>- Oncogenes and tumor suppressor genes</td>
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<td>- Cancer genomics, epigenomics and implications for treatment</td>
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<td><strong>3) The social genome:</strong></td>
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<td>- Ancient Irish ancestry and genomics</td>
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<td>- Genealogy and forensic genomics</td>
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<td><strong>4) The Microbiome</strong></td>
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<td>- Microbiology without culture</td>
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<td>- the human microbiome</td>
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<tr>
<td></td>
<td>- Environmental microbiomics</td>
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<td>- The Ecological genome</td>
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</tbody>
</table>
Description of Practical Content:
3 practicals: two genome analysis sessions and one laboratory practical on functional genomics.

Practical 1
Genome analysis (1): Computation of a genomewide association study of a human trait. This computer-based practical will be carried both in the student’s own time following an introductory directed learning in practical class. The subject will interact with the material given in the “Inherited Genome” portion of the lectures and will presume knowledge and experience gained in the Core Module on statistics and computation for biologists in semester 1. Topics to be addressed will include: the nature of complex trait inheritance; the concept of linkage disequilibrium and marker association; the problem of multiple testing. Assessment is via an online pro-forma report to be completed by the end of week 25. An optional 2-hour drop-in clinic with instructors and demonstrators will run during week 25 in the basement Mac laboratories adjacent to LTEE3 for students experiencing difficulties.

Practical 2
Functional genomics: Differential gene expression. This practical will take place with a short set up session at the end of practical 1 in the biology teaching laboratory but will mainly take place in week 26. In this the students will set up a RTPCR on a range of genes and test their expression patterns in different human tissues using gel electrophoresis. Examination will be through demonstrator marking of laboratory write up.

Practical 3
Genome analysis (2) Computation of Neanderthal admixture within human populations. This computer-based practical will again be completed in the student’s own time following introductory directed learning in class. The task will interact with the material given in the “Social Genome” portion of the lectures and will also presume knowledge and experience gained in the Core Module on statistics and computation for biologists. Population genomics topics addressed will include: Derived alleles; D statistics and detection of introgression; ancient DNA, genetic geography of human populations. Assessment is via an online pro-forma report to be completed by the end of week 30. An optional 2-hour drop-in clinic with instructors and demonstrators will run during week 30 in the basement Mac laboratories adjacent to LTEE3 for students experiencing difficulties.

Learning Outcomes:
On completion of the module students will be able to:
- Understand the core concepts in genomics
- Understand the interaction of genomic investigation and human inherited traits, including complex disease
- Understand the impact of genomics on the study and treatment of cancer
- Understand genomic impact in the study of human evolution
- Understand core concepts in microbial genomics
- Appreciate genomic impacts in ecological research.
- Key analytical skills gained in the statistics and computation for biologists module will be reinforced through application to genomic data.
**Recommended Reading List:**

**Assessment Details:**

Types of assessment and allocation of marks for each assessment
30% for practical assessment, including both online submission (weeks 25, 30) and practical notebook marking (week 26)
70% for end of semester examination, combination of single essay and short answer format questions.

Module Coordinator: BYU22207: Genomes, Disease and Diversity
Professor Dan Bradley
E-mail: dbradley@tcd.ie
Phone: 01 896 1088

Executive Officer: E-mail: BTC/Administrator@tcd.ie
Phone: 01 896 1117
CHU22005: Chemistry for Biologists
Semester 2, 5 credits

Contact Hours:
Contact Hours: 20 hours lectures (Semester 2)
6 hours laboratory (Semester 2)
66 hours self-directed learning
6 hours lab preparation
Delivery: 2 h L/week; 0.5 h P (average)/week; --> 2.5 student contact hrs/week

Module Personnel:
Professor Eoin Scanlan

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

Module content: Programme of lectures and practicals

<table>
<thead>
<tr>
<th>Teaching Week</th>
<th>Topic</th>
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<tbody>
<tr>
<td>1-3 (6 L)</td>
<td>Introduction to the physical chemistry of biomolecules:</td>
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<tr>
<td></td>
<td>• Gibbs free energy and spontaneous reactions: link with metabolism and group transfer.</td>
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<td></td>
<td>• The temperature dependence of equilibria: vant’Hoff</td>
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<td></td>
<td>• Binding reactions in biological systems: the dissociation constant</td>
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<td></td>
<td>• Colligative properties and osmotic pressure (2 L)</td>
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<td></td>
<td>• Kinetics: Rate of a reaction, the rate constant, reaction order, concentration dependence, half life</td>
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<td>• Collision theory</td>
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<td>• Activation energy</td>
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<td>• Catalysis and lowering activation energy</td>
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<td>• Enzymatic catalysis: Michaelis-Menten</td>
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<td>4-12 (14 L)</td>
<td>• Functional groups: O, N and S groups,</td>
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<td>• Isomerism: Isomers/stereoisomers</td>
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<td></td>
<td>• Chirality, Isomers in Biology</td>
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<tr>
<td>Week 7 = study week</td>
<td>Chemical reactions in cells</td>
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<td>• Substitution, addition, elimination, condensation</td>
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<td>• Reaction mechanisms and transition state intermediates</td>
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<td>• Key Functional group chemistry and key/common biochemical reactions</td>
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<td></td>
<td>Chemical reactions of enzymes and metabolism:</td>
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</tbody>
</table>
• Transferring groups by displacement/substitution (transferases, esterases, petidases, hydrolysis, phosphatases, kinases etc)
• Addition across a double bond (e.g. hydratases)
• Elimination: removal to create a double bond: e.g. (decarboxylation).
• Reactions involving enolates and carbocation intermediates
• Addition of R-OH, R-NH₂ and R-SH to polarised double bonds. e.g. carbonic anhydrase, fumase, enolase
• Enolic Intermediates: e.g. aldose-ketoase interconversions: triose phosphate isomerase
• Beta cleavage and condensation, e.g. aldolase and synthases, decarboxylation of α-oxoacids; e.g. aldolase, citrate synthase, Rubisco; PEPCarboxykinase. PEWP carboxylase
• Oxidation-Reduction reactions: Nioctinamide/Flavin linked
• Dehydrogenation of (i) an alcohol; (ii) an amine; (iii) thiol/aldehyde; (iv) acyl-CoA/carboxylic acid

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<tr>
<th>13</th>
<th>Student Revision/Study week</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Student Assessments</td>
</tr>
</tbody>
</table>

**Reading list/ Indicative Resources**
Organic Chemistry, by Jonathan Clayden and Nick Greeves; Publisher: OUP Oxford; 2 ed.
Chemistry & Chemical Reactivity Hardcover by Paul Treichel, John Kotz, John Townsend, David Treichel; Publisher: Brooks Cole; 9 ed.

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

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

**Methods of Assessment**
Exam 80% 4 questions (2 hr exam)
Lab 20%

**Evaluation**
Feedback given by students to DUTL via online poll
**Lecture and Tutorial Contact Hours**

<table>
<thead>
<tr>
<th></th>
<th>Lectures</th>
<th>Tutorials</th>
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<tbody>
<tr>
<td>Physical Chemistry</td>
<td>6</td>
<td>1</td>
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<tr>
<td>Organic Chemistry</td>
<td>14</td>
<td>2</td>
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<td><strong>Overall Total</strong></td>
<td><strong>20</strong></td>
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<tr>
<td>Lab</td>
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**Lab Hours** = 2 x 3 hours = 6 hours  
Lab runs 4 weeks: Students have 1 practical every other week

Module Coordinator: CHU22005 Chemistry for Biologists  
Professor Eoin Scanlan  
E-mail: Eoin.Scanlan@tcd.ie  
Phone: 01 896 2514

Senior Executive Officer:  
E-mail: farrea25@tcd.ie  
Phone: 01 896 1726
GSU22001: Geochemical Cycles – From Geo to Biogeochemistry
Semester 1, 10 credits

**Prerequisites:** GSU11004

Contact hours:
2 x 1 hour / week = 22 hours
3 hour laboratory every other week per student (5 weeks over one semester) = 15 hours
1 day field excursion = 8 hours
Total: 45 hours / student

Module Personnel
Dr. Carlos Rocha (Coordinator)
TBA Lecturer in geochemistry
TAs/Lab assistants

High level Aims: (Drawn from the Trinity Graduate Attributes)
To develop the following skills & graduate attributes:

- The ability to collect qualitative and quantitative data with precision and organization.
- The numeracy to analyse and critically evaluate data using appropriate mathematical, statistical, computational and other relevant methods.
- Competence in discipline specific analytical and technical skills
- A detailed knowledge and understanding of the core principles of a discipline acquired through research centred learning.
- An awareness of current disciplinary knowledge boundaries and of major research efforts to extend them
- The capability to formulate and test hypotheses and to make logical and scientific arguments based on current data

Module learning aim:
To provide a hands-on introductory level knowledge of:

- How chemical principles may be employed in the study of the Earth system
- Common laboratory techniques and unitary operations in (bio)geochemistry
- Classic field techniques and unitary operations in (bio)geochemistry
- How tools such as aqueous geochemistry, trace element geochemistry and isotope geochemistry can be employed to understand the composition, reactivity and age of different earth system reservoirs

Module content:

<table>
<thead>
<tr>
<th>Lecture (1 hour slots)</th>
<th>Topic and Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Cosmic Lego: Introduction.</strong> Course aims, content and expectations. Assessment. Nature of Science and the scientist as a skeptic. Vernadski, Lotka and Lovelock. Fundamental role of biogeochemistry in understanding (building) planets and living systems</td>
</tr>
<tr>
<td>1 a</td>
<td><strong>Origins: Origin of the elements, Solar system and Earth.</strong> Nucleosynthesis, relative abundances of the elements, solar system formation, accretion and differentiation of the Earth. Formation of atmosphere, composition of atmosphere.</td>
</tr>
</tbody>
</table>
2 The Lifeless Wobbler: Abiotic earth and pre-biotic mineral cycles. Evolution of the Earth; Lithosphere, Atmosphere, Hydrosphere compositional change over time. Mineral cycling in prebiotic Earth

2a Life and Lemons: Origin of Life & Citric Acid Cycle. Abiogenesis; Primordial soup hypothesis; Abiogenic organic synthesis; Krebs and prior versions of chemical energy storage and release. Clays and surface reaction (catalysis); RNA world models; Photolysis;

3 Water, water anywhere: Global Water Cycle. Global water Cycle; Models of the hydrological cycle; Water cycle at different climate scenarios


4 A rock and a hard place: The Lithosphere and the Rock cycle. Rock weathering, soil chemical development, weathering rates


5 An Iron Ocean: Formal Concepts of Redox Chemistry. Weathering, Iron speciation and the evolution of ocean composition; Oxidation reactions, stability diagrams; mineralization. BIFs

5a 100% Recycled: Terrestrial Biogeochemical Cycles. The biosphere: the carbon cycling of terrestrial ecosystems; Photosynthesis, respiration, net primary production. Turnover of carbon in terrestrial ecosystems

6 On solid ground: Terrestrial Biogeochemical Cycles (II). Biogeochemical cycling in soil and land plants. Nutrient (N, P) partitioning and allocation; Whole landscape mass balances


7 Race to the bottom: The Ocean Carbon Cycle. Turnover of carbon in the ocean. Open vs Coastal Ocean Carbonate biogeochemistry. Comparison of carbon biogeochemistry in terrestrial and aquatic ecosystems


<table>
<thead>
<tr>
<th>9</th>
<th><strong>No hot air: Global Phosphorus Cycle.</strong> Phosphorus Fluxes, Recycling and Peak P. Regional vs Global perspectives on P cycling. Linking the global cycles of C, N and P.</th>
</tr>
</thead>
<tbody>
<tr>
<td>9a</td>
<td><strong>Cycles within Cycles: Oceans &amp; Climate, Marine Sediments.</strong> Oceans in the Anthropocene. Light isotope geochemistry in the carbon cycle. The pace of life and the modern carbon cycle. Early Diagenesis.</td>
</tr>
<tr>
<td>10</td>
<td><strong>Heartburn: Carbon Cycle and Climate, Carbonate Cycle.</strong> Ocean acidification, future of atmospheric CO₂ and fate of marine CO₂ system</td>
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<tr>
<td>10a</td>
<td><strong>Carbon Cycle and Climate, Biogeochemical Sedimentary Record.</strong> Marine sediments &amp; Global environmental history. Climate history, ocean controls over atmospheric carbon reservoir.</td>
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<thead>
<tr>
<th>Lab</th>
<th>Topic and Content</th>
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<tbody>
<tr>
<td>2</td>
<td>Gravimetry &amp; Electrical conductivity: chlorinity of seawater &amp; relationship with salinity</td>
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<tr>
<td>3</td>
<td>Kinetics (Halite dissolution)</td>
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<tr>
<td>4</td>
<td>Acid Base Titration and Total Alkalinity (Gran Titration)</td>
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<tr>
<td>5</td>
<td>Early diagenesis and sediment core description</td>
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</tbody>
</table>
Module Learning Outcomes
On successful completion of this module students will be able to:

- Demonstrate proficiency in handling and describing geochemical data
- Comprehend the role chemistry plays in describing the function of the Earth system
- Understand the origin of the lithosphere, hydrosphere and atmosphere
- Illustrate how living systems co-evolve with the chemistry and geology of the Earth
- Identify specific clusters of elements and describe their role in natural geo and biogeochemical processes.
- Plan and carry out an examination of common natural geochemical processes through field and laboratory-based exercises

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


Method of Assessment (100% in course)

2 x Next-day lecture tests (MCQs): 30% (mainly summative)
2 x Online Problem sets: 20% (mainly formative)
2 x Online Exams (SAQs): 25% (summative and formative)
1 x Laboratory notebook: 25% (formative and summative)

Module Coordinator: GSU22001: Geochemical Cycles – From Geo to Biogeochemistry
Dr Carlos Rocha E-mail: rochac@tcd.ie

Executive Officer: E-mail: earth@tcd.ie
Ms Sarah Guerin Phone: 01 896 1074
GSU22005: Sedimentary Processes & Environments
Semester 2, 10 credits

Prerequisites: GSU11005

Module Co-ordinator: Micha Ruhl

Contact Hrs:
Lectures 4 / week = 40 hrs
Total student contact = 40 hrs

Module Aims
Develop understanding of:
- Different Earth system environments
- Processes that control and impact on the Earth system environment
- Sediment generation, transport & deposition
- The impact of environmental processes on sediment generation, transport & deposition
- How sedimentary archives can record (changes in) the Earth system and environmental processes

Learning Outcomes
On successful completion of this module students will be able to:
- Classify siliciclastic and carbonate sedimentary rocks
- Describe (changes in) the origin and formation of sediments and sedimentary archives and interpret these in regards to changes in physical and Earth surface processes, and changing environments
- Appraise some of the major current debates around climate and environmental change and Earth surface processes
- Illustrate how physical processes (have) shape(d) Earth’s surface, in the past, present, and future
- Infer past climatic and environmental change from physical, chemical and biological data stored in sedimentary archives
- Explain how the understanding of modern processes is fundamental to our ability to reconstruct the past and predict the future

Method of Assessment: 100% in course
The course-content will be assessed through in-course assessment and online module-testing.

Module Outline:
Earth’s climate has changed on multiple temporal and spatial scales throughout its history, which significantly impacted on physical processes and environments. Information on past climatic and environmental changes are recorded in physical, chemical and biological materials stored in sedimentary archives.

Sedimentary materials storing such information can be found across most of the Earth's crust, both on land and in the oceans, and much of our understanding of Earth history comes from their examination.
This Module will introduce key physical and sedimentary processes, deposits and examples of contemporary and past environmental change that shape(d) Earth’s surface. It will analyze and explain the generation, transport and preservation of sediments, as diagnostic tools to link surface processes with the geological records of Earth history, as well as modern environmental change.

Module Coordinator: GSU22005: Sedimentary Processes & Environments
Dr Micha Ruhl  
E-mail: MICH.A.RUHL@tcd.ie
Phone: 01 896 1165

Executive Officer:
E-mail: earth@tcd.ie
Phone: 01 896 1074

Ms Sarah Guerin  
Phone: 01 896 1074
MAU23302: Euclidian and Non Euclidian Geometry  
Semester 2, 5 credits

Contact Hours
11 weeks, 3 lectures per week

Lecturer 
Professor David Wilkins

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

- justify with reasoned logical argument basic properties of triangles, circles and polygons in the Euclidean plane;
- describe measures of curvature, both extrinsic and intrinsic, applicable to smooth surfaces in three-dimensional Euclidean space;
- identify and justify with reasoned logical argument, significant geometric features and properties of the hyperbolic plane, and the corresponding features and properties of the disk that represent them in the Poincaré disk model of the hyperbolic plane.

Module Content
Aims to introduce complex variable theory and reach the residue theorem, applications of that to integral evaluation.

- Euclidean geometry: an exploration of Euclid's *Elements of Geometry*, based on editions freely available online, with detailed discussion of the definitions, axioms and propositions of Book 1, followed by discussion of a selection of significant results contained in Books 2—6.
- Geometric properties of stereographic projection.
- The hyperbolic plane: the Poincaré disk model of the hyperbolic plane, geodesics and curvature, homogeneity, the representation of isometries as Möbius transformations.

Module Prerequisite
None

Assessment Detail
This module will be examined in a 2 hour examination in Trinity term.

Module Coordinator: MAU23302: Euclidian and Non Euclidian Geometry  
Professor David Wilkins  
E-mail: dwilkins@maths.tcd.ie  
Phone: 01 896 2281

Executive Officer:  
E-mail: clancyem@maths.tcd.ie  
Ms Emma Clancy  
Phone: 01 896 1947
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.
Academic Year Structure 2019/20

Key Dates:

Study/Review Week:
Revision Week Semester 1: Monday 21 to Friday 25 October inclusive

Foundation Scholarship
Applications for Foundation Scholarship Examinations:
Examination Dates: Wednesday 16 October to Wednesday 30 October inclusive
Monday 6 January to Friday 10 January inclusive

Study/Review Week:
Revision Week Semester 2: Monday 13 April to Friday 17 April 2020
Trinity week: Monday 20 April to Friday 24 April 2020
Announcement of Scholarship Monday 20 April 2020 at 10 am outside the Examination Hall, Front Square

Formal Assessment weeks:
Semester 1 examinations: Monday 9 December 2019 to Friday 13 December 2019 inclusive
Semester 2 examinations: Monday 27 April 2020 to Friday 1 May 2020 inclusive

Closing Dates for Course Transfer

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

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

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

Information on progression and awards can be found via the following webpage: https://www.tcd.ie/TEP/assets/Docs/factsheet_students_progression_awards.pdf

Attendance

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

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

The requirements for attendance at lectures and tutorials vary between the different faculties, schools and departments. Attendance is compulsory for Junior Freshman in all subjects. The school, department or course office, whichever is relevant, publishes its requirements for attendance at lectures and tutorials on notice-boards, and/or in handbooks and elsewhere, as appropriate.
Absence from College – Medical and Absence Certificates

Medical Certificates
Where a student misses an assigned laboratory practical class through illness, they should (a) submit a Medical Certificate to the Science Course office on the day of their return to College and (b) inform the laboratory practical supervisor of their absence at the next session.

- Science Medical Certificate Form (use with med cert from doctor) – Available from Science Course Office

For periods of illness of three days or less (but no more than seven days in any year) a student may 'self-certify' their illness on the forms supplied, again to the Science Course Office on the day of their return to College.

- Science Medical Self Certification Form (use for 3 days med not covered by doctor) – Available from the Science Course Office

Other Absences
Students who require to be absent from a laboratory practical classes or tutorials (with or without an associated assessment) for any other reason, such as a sporting or social event, should inform the Science Course Office well in advance of the event (preferably a week beforehand).

- Science Absence from College Form, Sport or Other – Available from the Science Course Office

Where possible they will be assigned to an alternative laboratory practical session, but if that is not possible, and the justification for the absence is considered legitimate, they may be treated in the same manner as students submitting medical certificates (i.e. assigned an alternative assessment for one missed or awarded a pro-rata/pass mark). This is decided by the individual Disciplines concerned (i.e. Biology, Chemistry, Physics etc.) not the Science Course Office.

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

Non-satisfactory attendance and course work
All students must fulfil the 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. Further information on non-satisfactory attendance and course work may be found via the following webpage:

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

Plagiarism is interpreted by the University as the act of presenting the work of others as one’s own work, without acknowledgement.

Plagiarism is considered as academically fraudulent, and an offence against University discipline. The University considers plagiarism to be a major offence, and subject to the disciplinary procedures of the University.

A general set of guidelines for students on avoiding plagiarism is available on:  
https://libguides.tcd.ie/friendly.php?s=plagiarism

The Calendar entry outlines the process through which a suspected case of plagiarism should be dealt with:  

Trinity Tutorial Service

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

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

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

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

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

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

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

Further information on the support available may be found via the following link:
https://www.tcd.ie/disability/services/

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

Student Counselling

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

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

- Phone: (01) 8961407
- Email: student-counselling@tcd.ie

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

Useful College Websites:

Orientation – Student Life
Student life offers information on Supports and Services, Clubs and Societies, Student Unions etc.,
https://www.tcd.ie/students/

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

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

Student Accommodation
The Accommodation Office is open Monday to Friday from 8.30am to 1pm and 2pm-5pm each day. Queries can be emailed to residences@tcd.ie, or you can telephone 8961177 during office hours.
https://www.tcd.ie/accommodation
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<td>BYU2201: From Molecules to Cells 2 (GOLDHALL)</td>
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**SEMESTER ONE TIMETABLE**

**Monday 9 September 2019 - Friday 29 November 2019**

**Reading week: 21-25 October 2019**

**Bank Holiday: 28 October 2019**

**SENIOR FRESHMAN**

**TR060: Biological and Biomedical Sciences**

**SAMPLE**

**TR060: Biological and Biomedical Sciences 21.03.19**
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TR060: Biological and Biomedical Sciences

Contact details:

Course Director TR060: Biological and Biomedical Sciences
Professor Kevin Devine  E-mail: kdevine@tcd.ie
Phone: 01 896 1872

Executive Officer:  E-mail: BTC.Administrator@tcd.ie
Ph: 01 896 1117

Science Course Office
Professor Áine Kelly  Ph: 01 896 2025
Associate Dean of Undergraduate Science
Education

Ms Anne O’Reilly  E-mail: science@tcd.ie
Science Course Administrator  Ph: 01 896 2023

Ms Ann Marie Brady  E-mail: sfesco@tcd.ie
Senior Executive Officer  Ph: 01 896 2829

Ms Lucy Martin  E-mail: martlnl@tcd.ie
Executive Officer  Ph: 01 0896 1970

Ms Eva Page  E-mail: eva.page@tcd.ie
Global Officer, Life and Geosciences  Ph: 01 896 2799
## Teaching Term Dates 2019-2020

<table>
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<tr>
<th>Michaelmas Term</th>
<th>Monday 09 Sept 2019 - Friday 29 Nov 2019</th>
<th>Hilary Term</th>
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<td>09 Sept - 13 Sept</td>
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<td>Week 04</td>
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<td>07 Oct - 11 Oct</td>
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<td>17 Feb - 21 Feb</td>
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<td>Week 08</td>
<td>Teaching wk 6</td>
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<td>21 Oct - 25 Oct</td>
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<td>Week 10</td>
<td>Teaching wk 8</td>
<td>Week 29</td>
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<td>Week 11</td>
<td>Teaching wk 9</td>
<td>Week 30</td>
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<td>04 Nov - 08 Nov</td>
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<td>* 16 Mar - 20 Mar</td>
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<tr>
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<td>Week 12</td>
<td>Teaching wk 10</td>
<td>Week 31</td>
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<td>Week 33</td>
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<td>25 Nov - 29 Nov</td>
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<td>06 Apr - 10 Apr</td>
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* Monday 28th October 2019 Bank Holiday - College closed
* Tuesday 17th March 2020 St Patricks Day - College closed

Updated: 01/04/19
## Appendix 1: General Information

<table>
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<tr>
<th>ITEM</th>
<th>REFERENCE/Source</th>
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| General Regulations   | Calendar, Part II - General Regulations and Information, Section II, Item 12: https://www.tcd.ie/calendar/undergraduate-studies/general-regulations-and-information.pdf  
                          Calendar, Part III, General Regulations, Section 1.20  
                          https://www.tcd.ie/calendar/graduate-studies-higher-degrees/complete-part-III.pdf  
                          Attendance Requirements:  
                          Calendar, Part II, General Regulations and Information, Section II, Items 17-23  
                          Calendar, Part III, General Regulations and Information, Sections 1.23; 2.11; and 3.2  
                          Absence from Examinations  
                          Calendar, Part II, General Regulations and Information, Section II, Item 35  
                          Calendar, Part III, Section 3.5  
                          Calendar – General Regulations:  
                          Plagiarism Policy and information:  
                          https://www.tcd.ie/teaching-learning/UG_regulations/Plagiarism.php  
                          https://libguides.tcd.ie/friendly.php?s=plagiarism  |
| General Information   | Timetable are available via my.tcd.ie portal:  
                          https://my.tcd.ie/urd/sits.urd/run/siw_lgn  
                          Blackboard:  
                          https://tcd.blackboard.com/webapps/login/  
                          Academic Registry:  
                          https://www.tcd.ie/academicregistry/  
                          Data Protection:  
                          Dignity & Respect Policy  
                          https://www.tcd.ie/equality/policy/dignity-respect-policy/  |
| Foundation Scholarship| Foundation and Non Foundation Scholarship: Calendar, Part II  
                          Science Foundation Scholarship information sheet:  
<table>
<thead>
<tr>
<th>Teaching and Learning</th>
<th>Academic Policies: <a href="https://www.tcd.ie/teaching-learning/academic-policies/">https://www.tcd.ie/teaching-learning/academic-policies/</a></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Student Learning and Development: <a href="https://www.tcd.ie/Student_Counselling/student-learning/">https://www.tcd.ie/Student_Counselling/student-learning/</a></td>
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<td>Student Complaints Procedure: <a href="https://www.tcd.ie/about/policies/160722_Student%20Complaints%20Procedure_PUB.pdf">https://www.tcd.ie/about/policies/160722_Student%20Complaints%20Procedure_PUB.pdf</a></td>
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<td>Avoiding Plagiarism: <a href="https://libguides.tcd.ie/friendly.php?s=plagiarism/about">https://libguides.tcd.ie/friendly.php?s=plagiarism/about</a></td>
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<tr>
<td>Student support</td>
<td>Student Support Services: <a href="https://www.tcd.ie/students/supports-services/">https://www.tcd.ie/students/supports-services/</a></td>
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<td>Graduate Studies <a href="https://www.tcd.ie/graduatestudies/">https://www.tcd.ie/graduatestudies/</a></td>
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<td></td>
<td>Mature Student Office <a href="https://www.tcd.ie/maturestudents/">https://www.tcd.ie/maturestudents/</a></td>
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<tr>
<td>Co-curricular activities</td>
<td>Central Societies Committee: <a href="https://www.tcd.ie/calendar/general-information/students-unions-societies-and-clubs.pdf">https://www.tcd.ie/calendar/general-information/students-unions-societies-and-clubs.pdf</a></td>
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<td>DUCAC: <a href="https://www.tcd.ie/Sport/student-sport/ducac/?nodeId=94&amp;title=Sports_Clubs">https://www.tcd.ie/Sport/student-sport/ducac/?nodeId=94&amp;title=Sports_Clubs</a></td>
</tr>
<tr>
<td>Information on TCDSU and GSU, Including student</td>
<td>TCDSU <a href="https://www.tcdsu.org/">https://www.tcdsu.org/</a></td>
</tr>
<tr>
<td></td>
<td>TCDSU Student Representation Overview</td>
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<tr>
<td>Emergency Procedure</td>
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<td>In the event of an emergency, <strong>dial Security Services on extension 1999</strong> 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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</tr>
</tbody>
</table>

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