Dear SS Biochemistry students,

Welcome to Senior Sophister year, the culmination of your Biochemistry degree. It is a chance to really engage with Biochemistry as a subject and to graduate as well rounded scientists with the ability to follow a wide range of career paths.

This Handbook has been prepared as a guide to the Sophister year and contains information regarding the course content, course assessment and criteria, plagiarism and health & safety information etc. The Handbook is published on the school website but a number of hard copies are also available in the school office. Personal hard copies can be made available to students on request. In addition to learning within the context of formal lecture and laboratory sessions, I encourage co-operation with your fellow students so as you can learn from each other along the way.

If you have any problems during the year which affect your academic studies, please come and speak to me in confidence. I am here to help. Looking forward to working with you over the coming year.

Danny Zisterer: SS Course Co-ordinator: dzister@tcd.ie Direct line: 8961628
BIU44190  RESEARCH PROJECT IN BIOCHEMISTRY (S1) (20 credits)
The module comprises of an original research project in biochemistry and a research thesis.

BIU44010  ADVANCED RESEARCH SKILLS (S1) (10 credits)
This purpose of this module is to further develop research, critical analysis and communication skills that are essential for a graduate biochemist. Students will be trained in data handling as well as solving quantitative problems in biochemistry. In addition, this module will introduce students to a wide array of cutting edge techniques and strategies used in biochemistry.

BIU44110  BIOCHEMISTRY IN HEALTH & DISEASE II (S2) (10 credits)
This module covers the structure, function and pharmacology of neurotransmitters, neuron-glial interactions, intraneuronal signalling and the neurobiology of behaviour and neurodegenerative disorders. This module also covers the biochemistry of genetic deficiency diseases and metabolic diseases.

BIU44120  IMMUNOLOGY & MICROBIOLOGY (S2) (10 credits)
This module covers pathogen recognition by and signal transduction in immune cells. Bacterial pathogens of medical importance will also be covered in detail. It will provide an introduction to parasitic protozoa such as trypanosomes and helminths. Finally, the biochemical and genetic mechanisms by which bacteria, viruses and parasites evade the host immune responses will be covered.

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

NOTE: Learning outcomes for each of the modules can be found below (from page 28).
Biochemistry Personnel and Contact Details:
The Senior Sophister Course Co-ordinator is Danny Zisterer (phone extension 1628, email dzister@tcd.ie). The Head of School is Ed Lavelle (phone extension 2488, email lavellee@tcd.ie) and the School Administrator is Conor Spillane (phone extension 1604, email CSPILLAN@tcd.ie). Sara Geoghegan (sageoghe@tcd.ie) is the point of contact in the School office on Level 3 TBSI. Remember that you also have a college tutor that you can contact at any time. A complete list of the Biochemistry Staff can be found at http://www.tcd.ie/Biochemistry/staff/

Attendance:
All students are expected to attend lectures, workshops, practical classes, in-course assessments and examinations. Scheduled classes play an important role in supporting progress through the academic year in particular course assignment work. Students are therefore expected to keep up a consistent rate of good attendance so that performance later in the year will not be adversely affected. In the event of not being able to attend classes due to illness, please inform the Course Advisor. Medical certificates are required for absences of more than a few days OR if the absence means a deadline or an assessment will be missed. Details of medical certificates and other personal information will be treated confidentially. Students who miss classes are responsible for updating themselves on any information provided during those classes.

The Department operates the College procedure in relation to ‘Non-satisfactory attendance and course work’ (Calendar). That is, any student who misses more than a third of a course in any term or fails to complete assignments may be declared ‘non-satisfactory’. Non-satisfactory returns are made to the Senior Lecturer; such students may be refused permission to take the annual examination and may be required by the Senior Lecturer to repeat the year.


Non-satisfactory attendance and course work

§24 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.

§25 At the end of the teaching term, students who have not satisfied the school or department requirements, as set out in §§18, 22 and 23 above, may be reported as non-satisfactory for that term. Students reported as non-satisfactory for the Michaelmas and Hilary terms of a given year may be refused permission to take their annual examinations and may be required by the Senior Lecturer to repeat their year.’
Please see https://www.tcd.ie/undergraduate-studies/academic-progress/attendance-course-work.php for regulations regarding student attendance.

Explanation of 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. The Trinity College Dublin, University of Dublin academic year is 40 weeks from the start of Michaelmas Term to the end of the annual examination period. 1 ECTS 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 and assessments.

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.

For additional details see: http://www.tcd.ie/vp-cao/bd/vpdb3college_ects.php

Annual Year Structure:
Students should note that the annual year structure has changed this year. Information is available at https://www.tcd.ie/calendar/academic-year-structure/

Examinations/Assessments and Breakdown of Marks:

<table>
<thead>
<tr>
<th>Senior Sophister Module Name</th>
<th>ECTS Weighting</th>
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<tbody>
<tr>
<td>1) Research Project in Biochemistry</td>
<td>BIU44190 20 ECTS</td>
</tr>
<tr>
<td>2) Advanced Research Skills</td>
<td>BIU44010 10 ECTS</td>
</tr>
</tbody>
</table>
SS year is broken down into a total of 60 credits.

Research Project in Biochemistry (BIU44190) Value: 20 ECTS
An 11-week research project and thesis. Project laboratory work will start on September 10th and terminate on the 23rd November. After the completion of laboratory work, you will be required to submit a draft of your project thesis to your supervisor. The absolute deadline for submission of thesis 1st draft is Monday 21st January 2019. We would recommend that you submit your first draft at an earlier date in January in order to give you time to incorporate suggested revisions. A deadline for handing in final revised project thesis will operate. It is 4.00 pm on Friday 8th February. For every working day that your thesis is late 2% will be deducted from your mark. Following submission of your project thesis you will give a 15 min oral presentation that explains your project, its aims, your experimental approach, your results and conclusions (Monday 4th March). Your presentation and your ability to answer questions will be assessed by a panel of three members of academic staff. It is advisable to arrange at least one practise session with your project supervisor. This oral presentation will account for 15% of the project mark.

You will also present a Project Poster to the School at a poster session (Friday 8th March). Your poster will be judged by 2 members of staff. This poster presentation will account for 5% of the project mark.

Ms Roisin Cleere and Dr Audrey Carroll (Preparation Room) will advise you about the presentation of your poster and print it for you. Further details on Project write-ups and poster presentations will be given at the end of semester 1.

Project Marking Scheme:
Lab performance: 15% (awarded by supervisor)
Thesis: 65% (awarded by supervisor & 1 other staff member)
Oral presentation: 15% (awarded by panel of 3 staff members)
Poster presentation: 5% (awarded by 2 staff members)

Copy of mark sheets and criteria for SS project and thesis can be found below (pages 19-23)
- Lab performance report (supervisor only; 15%)
- Project thesis (supervisor’s report – made available without mark to 2nd marker)
- Project thesis (2nd marker) – marks independently, meets and agrees mark with supervisor (65% of the project mark)

Note: if the supervisor and the 2nd markers are more than 10% apart, the thesis will be given to a third marker before a final mark is agreed.
Advanced Research Skills (BIU44010)  Value: 10 ECTS
This module covers quantitative biochemical problems, bioinformatics (sequence analysis), comparative medicine and a series of group presentations by students on various biochemical techniques. A series of 18 lectures will also introduce students to a wide array of cutting edge techniques and strategies used in biochemistry. Marks (100) for this module are awarded through continual assessment and in-course exams as follows:

- Quantitative Problems (4 in total, assessed by two 1hour in-course exams of equal weighting-one compulsory question on each exam) (30 marks in total)
- Bioinformatics-Sequence Analysis (3 in total, assessed by assignments submitted online of equal weighting) (10 marks in total)
- Group BioTechniques (assessed by one 1hour in-course MCQ exam (15 marks), oral presentation (5 marks) and summary report (5 marks) (25 marks in total)
- Comparative Medicine (assessed by one 1 hour in-course exam) (5 marks)
- BioTechniques Lectures (material assessed by one 1hour in-course exam, answer 2 out of 3 essay style questions) (30 marks in total)

Quantitative Problem Sessions:
All Quantitative Problems will be given out at introductory sessions by various staff members (e.g. Prb 1 Intro on the timetable), at the times indicated. You will attempt the problem in your own time and must bring the problem with you to a timetabled tutorial session (e.g. Prb 1 Tutorial). You must be able to demonstrate that you have attempted the problem to the staff member and failure to do so will result in being returned as non-satisfactory. In the tutorial session, the staff member will go through the solution with you and answer any queries you may have. There will be 4 quantitative problems in total and these will be assessed by two 1 hour in-course exams of equal weighting-one compulsory question on each exam.

Sequence Analysis Sessions:
There will be three Sequence Analysis Sessions (Dr Jerrard Hayes). The session will begin with a brief introduction in FRED. You will then move to the East End Public Access Mac Room for the practical session. Submission dates for the Sequence Analysis Exercises are indicated on the timetable. Dr Hayes will advise you as to how and where you submit the exercises.

Annual Examination Papers  Value: 30 ECTS
There are three exam papers at the end of the SS year, each with equal weighting as follows:

Paper 1 (BIU44110) Biochemistry in Health & Disease II Value: 10 ECTS
Exam paper (100 marks) divided into 4 sections of equal weighting as follows:
Section 1: Neurobiology (Answer 1 out of 2 questions) 25marks
Section 2: Metabolic Diseases (Answer 1 out of 2 questions) 25marks
Section 3: General (Integrative/philosophical) (Answer 1 out of 3 questions) 25marks
Section 4: General (Quickie questions)  
(Answer 4 out of 7 questions)  25marks

**Paper 2 (BIU44120) Immunology & Microbiology**  
Value: 10 ECTS
Exam paper (100 marks) divided into 4 sections of equal weighting as follows:
Section 1: Immunology (Answer 1 out of 2 questions)  25marks
Section 2: Microbiology (Answer 1 out of 2 questions)  25marks
Section 3: General (Integrative/philosophical)  
(Answer 1 out of 3 questions)  25marks
Section 4: General (Quickie questions)  
(Answer 4 out of 7 questions)  25marks

**Paper 3 (BIU44130) Cancer Biology & Cell Signalling**  
Value: 10 ECTS
Exam paper (100 marks) divided into 4 sections of equal weighting as follows:
Section 1: Cancer Biology (Answer 1 out of 2 questions)  25marks
Section 2: Cell Signalling (Answer 1 out of 2 questions)  25marks
Section 3: General (Integrative/philosophical)  
(Answer 1 out of 3 questions)  25marks
Section 4: General (Quickie questions)  
(Answer 4 out of 7 questions)  25marks

All answers from the above exam papers are double-marked.

The overall degree mark is comprised of 80% of SS year and 20% of JS year.

On completion of their annual examinations, some students sit a viva voce examination with the External Examiner (Prof. Simon Morley, University of Sussex). Students are considered ‘borderline’ if they are 2.5% or less off a grade and following the viva voce examination the External Examiner may recommend at the Examiners’ meeting that the students’ degree mark be brought up to the next grade. Note: not all students called for viva are borderline and additional students may be included as controls. You will not be told which category you are in.

**Practise Vivas:**
Vivas (oral exams) are held approximately two weeks following the completion of your three exam papers. The maximum percentage marks that you can be brought up by is 2.5%. You cannot be marked down by a viva. You will not know your mark before sitting the viva.

**How can you prepare for the viva?**
Practise vivas will be held during the year. You will be assigned to a pair of academic staff members. The vivas take approximately 20 minutes and you will be asked a variety of questions. There are no marks assigned to this exercise. Please regard these vivas not as a test of your knowledge but as useful practise. They are also good interview experience. When you are called for a viva in the summer, you should read over your project thesis as the Extern often starts off by asking you about your project. He/she will want to relax you and will
generally start you off on a topic you know a lot about. The Extern will probably cover about 4-6 topics during the viva and it is impossible to second guess what they will ask. However, if you feel you did badly in one particular exam question, it is a good idea to revise this topic. The Extern has access to all your marks and if he/she sees a poor mark in an otherwise very consistent good set of marks they may wish to follow this up. The Extern may also ask you if there is a topic in Biochemistry that you find particularly interesting and that you wish to talk about. It is therefore a good idea to have something prepared but ensure that it is a specific topic. Do not be too general and say that you’re interested in protein structure! The Extern may also ask you on your views of the course; was there a part of the course you really enjoyed or not as the case may be. The role of the Extern is not only to assess your performance but also to assess our teaching capabilities and to identify strengths/weaknesses and even omissions in the course so that they can make recommendations for the following year.

**Tutorials:**
Tutors have been chosen randomly. Please contact your tutor during the first week of the first semester. You are expected to attend a tutorial every fortnight. Times and dates of tutorials given on timetable are a rough guide only. Your tutor will set various exercises and these should help you in your final examinations.

**Course Feedback:**
A Feedback Form for each course will be given out at the beginning of the term. These (anonymous) forms are a mechanism whereby students can make comments and suggestions that will help us to maintain and indeed improve the quality of the teaching offered by the School of Biochemistry & Immunology. Please fill out the form upon completing each course, do not wait until the end of term (you will forget!). Put the forms into the box provided in the school office.

**Addresses and Phone No's:**
Please enter your College based address, e-mail address and telephone number (if any) on the sheet provided at the Introductory Briefing Session. Please also include a home (or other contact) address and telephone number. This will enable us to contact you in an emergency or with important changes in such details as timetables, exam venues, etc. If you do not enter these details you may not be informed of any changes.

**Prizes & Medals:** A prize for the best poster in Biochemistry will be awarded to the student who attains the highest marks in their poster presentation. Poster prizes will also be given out to students in the Molecular Medicine and Immunology classes. The **Margaret Ciotti Medal** is awarded each year to a Senior Sophister student in one of the three classes for excellence in undergraduate research. It will be awarded to the student who attains the highest marks overall in their research project. This award was initiated by Bruno Orsi to honour his wife’s achievements in biochemistry and will now be a memorial to her. It is traditionally presented by Bruno on a date between the end of the exams and the vivas. This year the award ceremony and reception will take place on the afternoon of the 10th May.
Health and Safety Matters:

1) Registration with Safety Officer
Preliminary safety registration takes place during one of the mandatory health and safety briefing sessions timetabled in the first week of Semester 1 (see timetable). You must also register, in person, with the Safety Officer once you commence your project. This is necessary in order to record your next-of-kin details in the unlikely event of an accident, to record where you will be working, to ascertain whether or not you have to work with major hazards during your project work (carcinogens, mutagens, cyto-toxics, biological agents, GMOs, radioactivity, etc), and to ensure that you and your supervisor understand that you have to conduct a HIRAC review (hazard identification, risk assessment and risk control) of the proposed work. (see below).

2) Formal Health and Safety Briefings
Mr Liam McCarthy (Chief Technical Officer) will describe the general management and security features of the building on the first day of term. Dr Nóirín Nic a’ Bháird, the School Safety Officer will give you two formal Health and Safety briefings on Monday 10th & Tuesday 11th September. ATTENDANCE AT THESE BRIEFINGS AND ANY ADDITIONAL TRAINING SESSIONS (e.g. Radiological Protection Workshop, viewing safety videos, etc.) IS MANDATORY. Some of these actions are legal, license or College's insurer's requirements that have to be complied with.

3) Safety Lab Coat & Spectacles
You must have at least one Howie-style laboratory safety coat, conforming to the NISO 1993, or better, standard, along with a pair of safety spectacles with you at all stages during active laboratory work.

4) Specific Aspects of Health and Safety Associated with Project Work
You are required to complete a ‘Personnel Training Form’ to ensure that you have been trained in all techniques/equipment that you will be using during your project, that you understand any risks associated with your project and that you understand how to minimize them. Any hazardous materials, steps or procedures (including off-site work connected with your research such as collecting samples from other laboratories, etc.) involved in your project will have been identified by, and discussed with you by your project supervisor. He/she is required, by law, to perform this hazard identification, risk assessment and risk control (HIRAC) on every experiment undertaken by you, but you have a role to play as well in making sure that you record the conclusions of this procedure in your notebook. The control measures necessary to reduce or eliminate risk must be written in your notebook for each hazardous step or procedure. The law requires this to be done. You are still in training so you cannot be classed as a competent biochemist and thus able to do this yourself to ensure your safety. If in doubt about the proper procedures for any experiment, do not perform that experiment.
Senior Sophisters must make themselves aware of the College's and School’s Safety Statement which is displayed prominently in every laboratory in the School. [It can be downloaded from the School’s Local Home-Page at this URL: www.tcd.ie/biochemistry/]. You are still bound by the 'Science Faculty's Health and Safety Guidance Manual' and the associated Health Questionnaire which you completed at the start of JF year. If your health status has changed since then in terms of the categories listed (including pregnancy or lactation) you have to complete a new Health Questionnaire. If your health status again changes during the year you must consult, in confidence, with the Safety Officer. [This particularly applies in the case of pregnancy.]

You are not permitted to work with unsealed radionuclide sources unless you have attended and satisfactorily completed a Radiological Protection Workshop. This is normally held sometime in January. Please see following link for further details and dates http://www.tcd.ie/Buildings/Safety/biosafety_website/

Any student working with human materials (blood, buffy coats, semen, CSF, dialysis fluid, primary explants, etc.) must be vaccinated against Hepatitis B prior to commencing your project. You are not permitted to work with any risk group 3 or class 3 biological agents such as HIV, Hepatitis B and C, etc. or to culture Category 3 (or higher) pathogens.

You must request or otherwise obtain Material Safety Data Sheets (MSDS) for any toxic or dangerous chemicals or preparations that you are using in your project. These MSDS's have to be requested at the point of ordering any material. The MSDS must be stuck into your laboratory notebook. The guidance must be followed.

After 6:00 pm on working days, and at all times on weekends and public holidays, no Senior Sophister may work in any laboratory without the close presence of a member of the academic staff. It is the Senior Sophister's responsibility to ask that staff member if he/she will consent to act in a supervisory capacity for the time the student is working. During normal working hours no student may work alone in any laboratory.

Failure to observe these rules/procedures will cause the offenders to be officially warned, and be reported to the Head of School, school safety officer and project supervisor. Normal College disciplinary procedures can be invoked (including fines being levied as well as withdrawal of student i.d. card, etc.) Persistent failure to observe these rules may result in that student being banned from laboratory work with loss of those marks available for project work. All the necessary forms are available to download on the local safety pages at https://www.tcd.ie/Biochemistry/local/safety.php

Once you have completed all the forms and safety briefings, bring them along in person to the Safety officer, Nóirín Nic a’ Bháird in Room 5.08.

5) Emergency Procedure
In the event of an emergency, dial Security Services on extension 1999. Security Services provide a 24-hour service to the college community, 365 days a year. They are the liaison to the Fire, Garda and Ambulance services and all staff and students are advised to always
telephone extension 1999 (+353 1 8961999) 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).

**Students with Disabilities:** The University Policy Relating to students with disabilities is available at www.tcd.ie/disability. The Student Disability Service is located in Room 2054 Arts Building, phone = 8963111, email = disab@tcd.ie. The Student Disability Services Committee provides the formal channel for raising issues affecting students with disabilities. Martha Motherway (motherm@tcd.ie) is the liaison officer for the disability services in our school.
An online service that you can use to:

- Apply for opportunities which match your preferences - vacancies including research options
- Search opportunities- postgraduate courses and funding
- View and book onto employer and CAS events
- Submit your career queries to the CAS team
- Book an appointment with your Careers Consultant
Simply login to MyCareer using your Trinity username and password and personalise your profile.

Careers Advisory Service
Trinity College Dublin, 7-9 South Leinster Street, Dublin 2
01 896 1705/1721  |  Submit a career query through MyCareer

[Icons and links]

Opening Hours
During term: 9.30am - 5.00pm, Monday - Friday
Out of Term: 9.30am - 12.30pm & 2.15 - 5.00pm, Monday - Friday

Careers Talk:
Karina Septore will give a Careers Talk tailored for Life Sciences students, on Thursday 27th September at 9am in B2.36/37/38.

Plagiarism:
The full statement of College’s policy on plagiarism (see Calendar, General Regulations and Information, §82-§91 at http://tcd-ie.libguides.com/plagiarism are reproduced below. In addition members of staff of the School of Biochemistry & Immunology may scan your written assignments using plagiarism-detecting software such as Turnitin (additional information for which can be found at: http://turnitin.com/static/index.html). During your final year you will be expected to prepare material for the Biochemical Techniques course and to write a report on the research findings of your fourth year project. You will be provided with guidance notes for the completion of these exercises. In the first semester, Prof. Kingston Mills will give a tutorial class on how to prepare and write a report for your research project.

It is a college requirement that all students must complete an online tutorial on avoiding plagiarism ‘Ready, Steady, Write’, located at http://tcd-ie.libguides.com/plagiarism/ready-steady-write.

In addition, students must complete cover sheets or include text containing the following declaration when submitting assessed work in hard or soft copy or via Blackboard:

I have read and I understand the plagiarism provisions in the General Regulations of the University Calendar for the current year, found at: http://www.tcd.ie/calendar
§82 General
It is clearly understood that all members of the academic community use and build on the work and ideas of others. It is commonly accepted also, however, that we build on the work and ideas of others in an open and explicit manner, and with due acknowledgement.

Plagiarism is the act of presenting the work or ideas of others as one’s own, without due acknowledgement.

Plagiarism can arise from deliberate actions and also through careless thinking and/or methodology. The offence lies not in the attitude or intention of the perpetrator, but in the action and in its consequences.

It is the responsibility of the author of any work to ensure that he/she does not commit plagiarism.

Plagiarism is considered to be academically fraudulent, and an offence against academic integrity that is subject to the disciplinary procedures of the University.

§83 Examples of Plagiarism

Plagiarism can arise from actions such as:
(a) copying another student’s work;
(b) enlisting another person or persons to complete an assignment on the student’s behalf;
(c) procuring, whether with payment or otherwise, the work or ideas of another;
(d) quoting directly, without acknowledgement, from books, articles or other sources, either in printed, recorded or electronic format, including websites and social media;
(e) paraphrasing, without acknowledgement, the writings of other authors.

Examples (d) and (e) in particular can arise through careless thinking and/or methodology where students:
(i) fail to distinguish between their own ideas and those of others;
(ii) fail to take proper notes during preliminary research and therefore lose track of the sources from which the notes were drawn;
(iii) fail to distinguish between information which needs no acknowledgement because it is firmly in the public domain, and information which might be widely known, but which nevertheless requires some sort of acknowledgement;
(iv) come across a distinctive methodology or idea and fail to record its source.

All the above serve only as examples and are not exhaustive.
§84 Plagiarism in the context of group work
Students should normally submit work done in co-operation with other students only when it is done with the full knowledge and permission of the lecturer concerned. Without this, submitting work which is the product of collusion with other students may be considered to be plagiarism. When work is submitted as the result of a group project, it is the responsibility of all students in the group to ensure, so far as is possible, that no work submitted by the group is plagiarised.

§85 Self plagiarism
No work can normally be submitted for more than one assessment for credit. Resubmitting the same work for more than one assessment for credit is normally considered self-plagiarism.

§86 Avoiding plagiarism
Students should ensure the integrity of their work by seeking advice from their lecturers, tutor or supervisor on avoiding plagiarism. All schools and departments must include, in their handbooks or other literature given to students, guidelines on the appropriate methodology for the kind of work that students will be expected to undertake. In addition, a general set of guidelines for students on avoiding plagiarism is available on http://tcd-ie.libguides.com/plagiarism.

§87 If plagiarism as referred to in §82 above is suspected, in the first instance, the Director of Teaching and Learning (Undergraduate), or their designate, will write to the student, and the student’s tutor advising them of the concerns raised. The student and tutor (as an alternative to the tutor, students may nominate a representative from the Students’ Union) will be invited to attend an informal meeting with the Director of Teaching and Learning (Undergraduate), or their designate, and the lecturer concerned, in order to put their suspicions to the student and give the student the opportunity to respond. The student will be requested to respond in writing stating his/her agreement to attend such a meeting and confirming on which of the suggested dates and times it will be possible for them to attend. If the student does not in this manner agree to attend such a meeting, the Director of Teaching and Learning (Undergraduate), or designate, may refer the case directly to the Junior Dean, who will interview the student and may implement the procedures as referred to under conduct and college regulations.

§88 If the Director of Teaching and Learning (Undergraduate), or designate, forms the view that plagiarism has taken place, he/she must decide if the offence can be dealt with under the summary procedure set out below. In order for this summary procedure to be followed, all parties attending the informal meeting as noted in §87 above must state their agreement in writing to the Director of Teaching and Learning (Undergraduate), or designate. If the facts of the case are in dispute, or if the Director of Teaching and Learning (Undergraduate), or designate, feels that the penalties provided for under the summary procedure below are inappropriate given the circumstances of the case, he/she will refer the case directly to the Junior Dean, who will interview the student and may implement the procedures as referred to under conduct and college regulations.

§89 If the offence can be dealt with under the summary procedure, the Director of Teaching and Learning (Undergraduate), or designate, will recommend one of the following penalties:
(a) Level 1: Student receives an informal verbal warning. The piece of work in question is inadmissible. The student is required to rephrase and correctly reference all plagiarised elements. Other content should not be altered. The resubmitted work will be assessed and marked without penalty;
(b) Level 2: Student receives a formal written warning. The piece of work in question is inadmissible. The student is required to rephrase and correctly reference all plagiarised elements. Other content should not be altered. The resubmitted work will receive a reduced or capped mark depending on the seriousness/extent of plagiarism;
(c) Level 3: Student receives a formal written warning. The piece of work in question is inadmissible. There is no opportunity for resubmission.

§90 Provided that the appropriate procedure has been followed and all parties in §87 above are in agreement with the proposed penalty, the Director of Teaching and Learning (Undergraduate) should in the case of a Level 1 offence, inform the course director and where appropriate the course office. In the case of a Level 2 or Level 3 offence, the Senior Lecturer must be notified and requested to approve the recommended penalty. The Senior Lecturer will inform the Junior Dean accordingly. The Junior Dean may nevertheless implement the procedures as referred to under conduct and college regulations.

§91 If the case cannot normally be dealt with under the summary procedures, it is deemed to be a Level 4 offence and will be referred directly to the Junior Dean. Nothing provided for under the summary procedure diminishes or prejudices the disciplinary powers of the Junior Dean under the 2010 Consolidated Statutes.
**Class Descriptors:** These Science Faculty Descriptors are given as a guide to the qualities that assessors are seeking in relation to the grades usually awarded. A grade is the anticipated degree class based on the consistent performance at the level indicated by an individual answer. In addition to the criteria listed, the Department’s examiners will also give credit for evidence of critical discussion of the facts or evidence.

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<th>Class</th>
<th>Range</th>
<th>Criteria</th>
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<tr>
<td>I</td>
<td>90 - 100</td>
<td>IDEAL ANSWER; showing insight and originality and wide knowledge. Logical, accurate and concise presentation. Evidence of reading and thought beyond course content. Contains particularly apt examples. Links materials from lectures, practicals and seminars where appropriate.</td>
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<td></td>
<td>80 - 89</td>
<td>OUTSTANDING ANSWER; falls short of the ‘Ideal’ answer either on aspects of presentation or on evidence of reading and thought beyond the course. Examples, layout and details are all sound.</td>
</tr>
<tr>
<td></td>
<td>70 - 79</td>
<td>MAINLY OUTSTANDING ANSWER; falls short on presentation and reading or thought beyond the course, but retains insight and originality typical of the first class work.</td>
</tr>
<tr>
<td>II - 1</td>
<td>65 - 69</td>
<td>VERY COMPREHENSIVE ANSWER; good understanding of concepts supported by broad knowledge of subject. Notable for synthesis of information rather than originality. Sometimes with evidence of outside reading. Mostly accurate and logical with appropriate examples. Occasionally a lapse in detail.</td>
</tr>
<tr>
<td></td>
<td>60 - 64</td>
<td>LESS COMPREHENSIVE ANSWER; mostly confined to good recall of coursework. Some synthesis of information or ideas. Accurate and logical within a limited scope. Some lapses in detail tolerated.</td>
</tr>
<tr>
<td>II – 2</td>
<td>55 - 59</td>
<td>SOUND BUT INCOMPLETE ANSWER; based on coursework alone but suffers from a significant omission, error or misunderstanding. Usually lacks synthesis of information or ideas. Mainly logical and accurate within its limited scope and with lapses in detail.</td>
</tr>
<tr>
<td></td>
<td>50 - 54</td>
<td>INCOMPLETE ANSWER; suffers from significant omissions, errors and misunderstanding, but still with understanding of main concepts and showing sound knowledge. Several lapses in detail.</td>
</tr>
<tr>
<td>III</td>
<td>45 - 49</td>
<td>WEAK ANSWER; limited understanding and knowledge of subject. Serious omissions, errors and misunderstandings, so that answer is no more than adequate.</td>
</tr>
<tr>
<td></td>
<td>40 - 44</td>
<td>VERY WEAK ANSWER; a poor answer, lacking substance but giving some relevant information. Information given may not be in context or well explained, but will contain passages and words which indicate a marginally adequate understanding.</td>
</tr>
<tr>
<td>F - 1</td>
<td>35 - 39</td>
<td>MARGINAL FAIL; inadequate answer, with no substance or understanding, but with a vague knowledge relevant to the question.</td>
</tr>
<tr>
<td>F - 2</td>
<td>30 - 34</td>
<td>CLEAR FAILURE; some attempt made to write something relevant to the question. Errors serious but not absurd. Could also be sound answer to the misinterpretation of the question.</td>
</tr>
<tr>
<td>F - 3</td>
<td>0 - 29</td>
<td>UTTER FAILURE; with little hint of knowledge. Errors serious and absurd. Could also be a trivial response to the misinterpretation of the question.</td>
</tr>
</tbody>
</table>
**Scheme for marking of projects:**
The project mark is comprised of the Supervisor’s mark and one other Examiner’s marks for the project thesis. The Supervisor’s mark will be based on the student’s performance within the laboratory (technical ability, understanding of the project and literature pertaining to it, critical evaluation of results, demonstration of initiative and independent thought) and on the content and presentation of the project thesis. The supervisor will also make the other Examiner of the project thesis aware of any unforeseen difficulties that arose during the course of the project.

<table>
<thead>
<tr>
<th>Class</th>
<th>Mark Range</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>85-100</td>
<td>Exceptional project report showing broad understanding of the project area and excellent knowledge of the relevant literature. Exemplary presentation and analysis of results, logical organisation and ability to critically evaluate and discuss results coupled with insight and originality.</td>
</tr>
<tr>
<td></td>
<td>70-84</td>
<td>A very good project report showing evidence of wide reading, with clear presentation and thorough analysis of results and an ability to critically evaluate and discuss research findings. Clear indication of some insight and originality. A very competent and well presented report overall but falling short of excellence in each and every aspect.</td>
</tr>
<tr>
<td>II-1</td>
<td>60-69</td>
<td>A good project report which shows a reasonably good understanding of the problem and some knowledge of the relevant literature. Mostly sound presentation and analysis of results but with occasional lapses. Some relevant interpretation and critical evaluation of results, though somewhat limited in scope. General standard of presentation and organisation adequate to good.</td>
</tr>
<tr>
<td>II-2</td>
<td>50-59</td>
<td>A moderately good project report which shows some understanding of the problem but limited knowledge and appreciation of the relevant literature. Presentation, analysis and interpretation of the results at a basic level and showing little or no originality or critical evaluation. Insufficient attention to organization and presentation of the report.</td>
</tr>
<tr>
<td>III</td>
<td>40-49</td>
<td>A weak project report showing only limited understanding of the problem and superficial knowledge of the relevant literature. Results presented in a confused or inappropriate manner and incomplete or erroneous analysis. Discussion and interpretation of result severely limited, including some basic misapprehensions, and lacking any originality or critical evaluation. General standard of presentation poor.</td>
</tr>
<tr>
<td>Fail</td>
<td>20-39</td>
<td>An unsatisfactory project containing substantial errors and omissions. Very limited understanding, or in some cases misunderstanding of the problem and very restricted and superficial appreciation of the relevant literature. Very poor, confused and, in some cases, incomplete presentation of the results and limited analysis of the results including some serious errors. Severely limited discussion and interpretation of the results revealing little or no ability to relate experimental results to the existing literature. Very poor overall standard of presentation.</td>
</tr>
<tr>
<td></td>
<td>0-19</td>
<td>A very poor project report containing every conceivable error and fault. Showing virtually no real understanding or appreciation of the problem and of the literature pertaining to it. Chaotic presentation of results, and in some cases incompletely presented and virtually non-existent or inappropriate or plainly wrong analysis. Discussion and interpretation seriously confused or wholly erroneous revealing basic misapprehensions.</td>
</tr>
</tbody>
</table>
**Senior Sophister Lab Performance Report**

This mark contributes 15% to the overall project mark. It is designed to assess lab performance, independent of the thesis and based on criteria listed below.

<table>
<thead>
<tr>
<th>Student Name:</th>
<th>Supervisor Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attendance</td>
<td>Poor ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>How diligently did the student work?</td>
<td>Well below expectation ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>How well did the student plan the experiments?</td>
<td>Slapdash ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>How well were the experimental methods and results documented (e.g. in lab book)?</td>
<td>Slapdash ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>How well did the student observe the relevant safety procedures (e.g. wear lab coat)?</td>
<td>Never ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>How accurate was the student’s experimental technique?</td>
<td>Slapdash ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Quantity of work done</td>
<td>Very little ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Ability to trouble shoot in lab</td>
<td>Poor ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Level of help in lab available</td>
<td>Very little ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Ability to work independently</td>
<td>Poor ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Attitude to work</td>
<td>Poor ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Ability to work with others</td>
<td>Poor ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Ability to respond to criticism</td>
<td>Poor ☐ ☐ ☐ ☐</td>
</tr>
</tbody>
</table>

**Comments:**

**Particular difficulties if any:**
Senior Sophister Project Thesis - Supervisor’s report

This mark is independent of the lab performance. The research project thesis mark is to be agreed with the second examiner (and third examiner if first/second marks are greater than 10% apart). This agreed mark contributes 65% to the overall project mark. It is designed to capture the abilities of a student to engage in an academic research project, plan experiments, critically analyse data and communicate research findings and their implications.

<table>
<thead>
<tr>
<th>Student name</th>
<th>Project Title</th>
<th>Supervisor name</th>
<th>Date</th>
</tr>
</thead>
</table>

| 1st Draft submission on time | Yes ☐ | No ☐ |

<table>
<thead>
<tr>
<th>Presentation</th>
<th>Messy, poor English</th>
<th>Publication standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Wholly inadequate</td>
<td>Publication standard</td>
</tr>
<tr>
<td>Introduction</td>
<td>Trivial</td>
<td>Publishable</td>
</tr>
<tr>
<td>Literature coverage</td>
<td>Poor</td>
<td>Extensive and deep</td>
</tr>
<tr>
<td>Description of aims</td>
<td>Wholly inadequate</td>
<td>Perfectly clear</td>
</tr>
<tr>
<td>Materials and methods</td>
<td>Wholly inadequate</td>
<td>Perfectly clear</td>
</tr>
<tr>
<td>Description of results</td>
<td>Wholly inadequate</td>
<td>Perfectly clear</td>
</tr>
<tr>
<td>Figures/ legends/ tables</td>
<td>Wholly inadequate</td>
<td>Perfectly clear, complete</td>
</tr>
<tr>
<td>References</td>
<td>Wholly inadequate</td>
<td>Fully accurate</td>
</tr>
<tr>
<td>Quality of data</td>
<td>Poor</td>
<td>Exemplary</td>
</tr>
<tr>
<td>Analysis of data</td>
<td>Poor</td>
<td>Comprehensive analysis</td>
</tr>
<tr>
<td>Appropriate statistical analysis</td>
<td>Poor</td>
<td>Strict</td>
</tr>
<tr>
<td>Discussion</td>
<td>Poor</td>
<td>Publication standard</td>
</tr>
<tr>
<td>Scientific rigour e.g. use of controls</td>
<td>Weak</td>
<td>Strict</td>
</tr>
<tr>
<td>Understanding/ insight</td>
<td>Very little</td>
<td>Research level</td>
</tr>
<tr>
<td>Capacity for self-direction</td>
<td>Poor</td>
<td>Outstanding</td>
</tr>
<tr>
<td>Quality of first draft</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

Comments:
Particular difficulties if any:

Mark out of 100%:

---

**Senior Sophister Project Thesis - Second Examiner’s report**

This mark is independent of the lab performance. The research project thesis mark is to be agreed with the project supervisor (and third examiner if first/second marks are greater than 10% apart). This agreed mark contributes 65% to the overall project mark. It is designed to capture the abilities of a student to engage in an academic research project, plan experiments, critically analyse data and communicate research findings and their implications.

<table>
<thead>
<tr>
<th>Student name</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Project Title</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>Examiner’s name</td>
<td></td>
</tr>
</tbody>
</table>

**Agreed mark (out of 100%):**

<table>
<thead>
<tr>
<th>Thesis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Presentation</strong></td>
</tr>
<tr>
<td><em>Messy, poor English</em></td>
</tr>
<tr>
<td>☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
</tr>
<tr>
<td><em>Wholly inadequate</em></td>
</tr>
<tr>
<td>☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td><strong>Introduction</strong></td>
</tr>
<tr>
<td><em>Trivial</em></td>
</tr>
<tr>
<td>☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td><strong>Literature coverage</strong></td>
</tr>
<tr>
<td><em>Poor</em></td>
</tr>
<tr>
<td>☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td><strong>Description of aims</strong></td>
</tr>
<tr>
<td><em>Wholly inadequate</em></td>
</tr>
<tr>
<td>☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td><strong>Materials and methods</strong></td>
</tr>
<tr>
<td><em>Wholly inadequate</em></td>
</tr>
<tr>
<td>☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Description of results</td>
</tr>
<tr>
<td>----------------------------</td>
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<tr>
<td>Figures/ legends/ tables</td>
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<tr>
<td>References</td>
</tr>
<tr>
<td>Quality of data</td>
</tr>
<tr>
<td>Analysis of data</td>
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<tr>
<td>Appropriate statistical analysis</td>
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<tr>
<td>Discussion</td>
</tr>
<tr>
<td>Scientific rigour e.g. use of controls</td>
</tr>
<tr>
<td>Understanding/ insight</td>
</tr>
</tbody>
</table>

**Comments:**

**Mark out of 100%:**
Biochemistry
Breakdown of SS Papers 1, 2 and 3
2018-2019

Paper 1– BIU44110 Biochemistry in Health & Disease II

Section 1: ‘Neurobiology’
Answer 1 of 2 questions

Neurochemistry (GD)
Neurobiology (JH)
Neurodegenerative disorders (GD)

Section 2: ‘Metabolic Diseases’
Answer 1 of 2 questions
Genetic Diseases (AM)
Metabolic Diseases (RP)
Metabolic Control Mechanisms (RP)

Section 3: ‘General’
Answer 1 of 3 questions
Trans-subject integrative/philosophical questions

Section 4: ‘General’
Answer 4 of 7 questions
Quickie questions

Paper 2– BIU44120 Immunology & Microbiology

Section 1: ‘Immunology’
Answer 1 of 2 questions

Cytokine Signalling (LON)
Immunotherapies (AD/DF/FS)
Viral Evasion (AB, RMcL)

Section 2: ‘Microbial Diseases’
Answer 1 of 2 questions
Trypanosomiases (DN)
Prokaryotic pathogens (HW)
Helminths (PF)

Section 3: ‘General’
Answer 1 of 3 questions
Trans-subject integrative/philosophical questions

Section 4: ‘General’ Answer 4 of 7 questions

Quickie questions

Paper 3– BIU44130 Cancer Biology & Cell Signalling

Section 1: ‘Cancer Biology’ Answer 1 of 2 questions
Initiation & Progression (VK)
Metastasis & Treatment (VK/KM)
Haematological malignancies (TMcE)

Section 2: ‘Cell Signalling’ Answer 1 of 2 questions
Cell cycle (VK/PV)
Stem cells (VK)
Apoptosis & Autophagy (DZ/JM)

Section 3: ‘General’ Answer 1 of 3 questions
Trans-subject integrative/philosophical questions

Section 4: ‘General’ Answer 4 of 7 questions
Quickie questions
Practise Viva Groups 2018-2019

Please find below the students assigned to pairs of Staff Members. Would the first Staff Member in each group please arrange a time (afternoons are best) and venue agreed with their Staff partner and email these arrangements to the students concerned.

<table>
<thead>
<tr>
<th>Staff</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>D. Nolan &amp; D. Zisterer:</td>
<td>Adeniyi, Eniola</td>
</tr>
<tr>
<td></td>
<td>Bakour, Noor</td>
</tr>
<tr>
<td></td>
<td>Bryan, Conor</td>
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<tr>
<td></td>
<td>Casey, Alva</td>
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<tr>
<td></td>
<td>Claffey, Naomi</td>
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<tr>
<td></td>
<td>Clarke, Allan</td>
</tr>
<tr>
<td>R. Porter &amp; D. Finlay:</td>
<td>Duggan, Niamh</td>
</tr>
<tr>
<td></td>
<td>Dunne, Joseph</td>
</tr>
<tr>
<td></td>
<td>Esezobor, Melanie</td>
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<tr>
<td></td>
<td>Gaynor, Dean</td>
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<td></td>
<td>Haidurovs, Aleksandrs</td>
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<tr>
<td></td>
<td>Maunsell, Morrigan</td>
</tr>
<tr>
<td>Ken H Mok &amp; A.Khan</td>
<td>Mc Cabe, Aine</td>
</tr>
<tr>
<td></td>
<td>Moloney, Sophie</td>
</tr>
<tr>
<td></td>
<td>O Callaghan, Casey</td>
</tr>
<tr>
<td></td>
<td>O Maolcheire, Ciaran</td>
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<tr>
<td></td>
<td>O Sullivan, Sarah</td>
</tr>
<tr>
<td></td>
<td>Peng, Yue</td>
</tr>
<tr>
<td>J. Murray &amp; A. Budanov:</td>
<td>Rezk, Hasnaa</td>
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<tr>
<td></td>
<td>Sharif, Ahmed</td>
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<tr>
<td></td>
<td>Skelly, Marcus</td>
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<td></td>
<td>Sutcliffe, John</td>
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<tr>
<td></td>
<td>Teeling, Sean</td>
</tr>
<tr>
<td></td>
<td>Wade, Kevin</td>
</tr>
</tbody>
</table>
Prof. Kenneth Hun Mok  mok1@tcd.ie
Adeniyi, Eniola
Bakour, Noor
Bryan, Conor
Prof. Andrei Budanov  budanova@tcd.ie
Casey, Alva
Claffey, Naomi
Clarke, Allan
Prof. Derek Nolan  denolan@tcd.ie
Duggan, Niamh
Dunne, Joseph
Esezobor, Melanie
Prof. Richard Porter  rkporter@tcd.ie
Haidurovs, Aleksandrs
Sharif, Ahmed
Maunsell, Morrigan
Prof. Emma Creagh  ecreagh@tcd.ie
Mc Cabe, Aine
Moloney, Sophie
O Callaghan, Casey
Prof. Danny Zisterer  dzisterer@tcd.ie
O Maoilcheire, Ciaran
O Sullivan, Sarah
Peng, Yue
Prof. Amir Khan  amirrafk@tcd.ie
Rezk, Hasnaa
Gaynor, Dean
Skelly, Marcus
Prof. James Murray  James.Murray@tcd.ie
Sutcliffe, John
Teeling, Sean
Wade, Kevin
SS Module Codes, Learning Outcomes, Course Descriptions & Key Reading

2018-2019
Learning outcomes:

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

- Pursue with a degree of independence an original research project in Biochemistry. Design and implement a wide range of experimental procedures, critically analyse and interpret experimental data, synthesise hypotheses from a wide range of information sources, critically evaluate research literature and write a research dissertation.

- Demonstrate a comprehensive understanding of the theory behind the techniques used in the research project and show a critical awareness of how these techniques can be applied to biological problems.

- Discuss a specialised research area of Biochemistry in depth.

- Work effectively as an individual and in a team and exercise initiative and personal responsibility.

- Display computer literacy and use advanced computer skills to aid in conducting scientific research.

- Communicate results of research project effectively with the scientific community.

- Show that they have acquired the learning skills to undertake further research with a high degree of autonomy.
BIU44010 Advanced Research Skills (S1)
(10 credits)

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

Learning outcomes:

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

- Apply appropriate statistical tests to experimental data and evaluate the results of these tests.
- Demonstrate proficiency in the application of sequence analysis algorithms
- Solve numerical biochemical problems
- Demonstrate proficiency in the application of molecular modelling software
- Display a solid foundation in the ethics of and use of animals for experimentation
- Describe the principles behind and applications of current techniques in scientific research

Sequence Analysis Jerard Hayes

The course will provide an introduction into Bioinformatics. Topics covered include:

- DNA (including genomic) and protein databases
- Accessing sequence information from databases using the Internet
- Sequence similarity searches (i.e. BLAST, FASTA)
- Identification of homologous proteins
- Multiple sequence alignments (i.e. Clustal W)
- Searches for protein motifs, domain, patterns
Students will carry out three exercises:

**Exercise 1:** Accessing databases from the Internet, retrieval of sequences (DNA and protein), extracting relevant sequence information, presentation and annotation of a chosen sequence

**Exercise 2:** Sequence similarity search (BLAST), identification of homologous proteins, multiple sequence alignment (Clustal W)

**Exercise 3:** Sequence analysis of membrane proteins, hydrophobicity plots, identification of transmembrane helices and signal peptides

**Reading list:**

*essential reading

# recommended


*Rost, B. et al. 1995. Transmembrane helices predicted at 95% accuracy. Protein Science, 4: 521-533.
X-ray crystallography (2 lectures) Amir Khan

These two lectures will provide an introduction to X-ray crystallography and will include the following:
• overview of modern X-ray and cryo-EM techniques to visualize macromolecules (proteins, DNA, RNA) and larger assemblies at atomic resolution
• concept of resolution in imaging and its relationship to X-ray and cryo-EM hardware for data collection
• principles of X-ray diffraction and cryo-EM structure determination, advantages of the techniques and their limitations

Recommended reading:
Crystallography Made Crystal Clear
Gale Rhodes

Protein Crystallography: A concise guide
Eaton Lattman and Patrick Loll

Metabolomics research (2 lectures) Richard Porter & David Finlay

• Metabolic flux analysis (1 lecture) Richard Porter

Analysis of cellular oxygen consumption together with extracellular acidity rate are an excellent way to get an overview of metabolic flux in a cell. Furthermore, the use of selective inhibitors can allow a researcher to shed light on the bioenergetics and biochemical pathways that contribute to that flux. The Seahorse Flux Analyser and the Oroboros Respirometer are excellent apparati for determining such metabolic flux. The lecture will cover the principles behind the use of these apparati and will give examples of their use to researchers.
• Proteomics and metabolomics (1 lecture) David Finlay

Various approaches to proteomic and metabolomic analysis will be discussed. The types of experimental question that can be addressed using these techniques will be reviewed.

Protein engineering (2 lectures) Jerard Hayes

Protein engineering is the process of developing valuable proteins, mainly for the biopharmaceutical market with a value of approximately $170 billion annually. This 2 lecture course will cover the production of recombinant proteins through genetic engineering and cell biology techniques for bioprocessing and biopharmaceutical manufacturing. Included in the course is upstream processing of proteins in bacterial, mammalian and insect cell lines, downstream processing in bioreactors and production of purified products, and optimisation of the bioprocess for the generation of desired post translational modifications, such as glycosylation.

Flow cytometry & cell sorting (2 lectures) Barry Moran

Flow cytometry is a key technology underpinning almost all biomedical research. Using fluorescent probes to tag molecules in or on the cell, it allows high-speed, high-parameter analysis of single cells as they flow through a fluid stream. Cell sorting extends the technology, enabling any identifiable cell population to be enriched to a very high purity. These lectures will cover the fundamentals of flow cytometry and cell sorting, including novel techniques and applications.

NMR spectroscopy for biomedical scientists (2 lectures) Ken Hun Mok

Lecture 1. Brief overview of the theories and practices; How NMR is used in structural biology and in probing the dynamics of biomolecules.

Lecture 2. Application of NMR to metabolomics; How mass spectrometry and NMR are complementary in identifying metabolites.

Reading / Viewing Materials:
(2) Knowbee Tutoring, "Introduction to NMR Spectroscopy" Parts 1 and 2, [https://www.youtube.com/watch?v=TJhVotrZt9I](https://www.youtube.com/watch?v=TJhVotrZt9I), 2015.
(4) Wong F, “NMR Made Easy!” Parts 1-6, [https://www.youtube.com/watch?v=9orcRVfKcS0&list=PLP0TLbeMObSy4izIklMIC2QOpJCzNjpc17](https://www.youtube.com/watch?v=9orcRVfKcS0&list=PLP0TLbeMObSy4izIklMIC2QOpJCzNjpc17), 2012.

Cellular Imaging (3 lectures) Derek Nolan

Lecture 1: Introduction to imaging and the concept of resolution. Application of electron microscopy in cell imaging. EM tomography and specialized techniques. Introduction to light microscopy.

Lecture 2: Advanced light microscopy: wide field and confocal microscopy.

Lecture 3: Application of fluorescent proteins and probes in multidimensional imaging in fixed and live cells.

Suggested reading and references.

http://www.nature.com/milestones/milelight/index.html
An excellent resource available on line. This series highlights the most influential developments in light microscopy in a series of short articles, each describing a major achievement. Almost a one stop shop

http://www.olympusmicro.com/
The Olympus Microscopy Resource Center.
This site covers a wide range of topics in light microscopy: basic to advanced topics with primers and interactive tutorials in some sections.


Correlative cryo-light microscopy and cryo-electron tomography: from cellular territories to molecular landscapes. Current Opinion in Biotechnology, Volume 20, 2009, Pages 83-89 From nano to micometre scale in cells.

Transgenics (5 lectures) Vincent Kelly & Derek Nolan

Lecture 1. Mutagenic, transgenic & cloning technology (VK): The concept of forward and reverse genetics in understanding gene function will be considered and how these mutations are physically introduced into the genome through random mutagenesis, viral mutagenesis, gene replacement and gene-targeting strategies. The process of microinjection to create transgenic animals, gene knockouts and cloned animal will be covered and the generation and use of induced pluripotent stem cells (iPS) in biomedical research applications.

Lecture 2. Design and development of transgenic constructs (VK): The design of targeting vectors relies on a detailed structural/functional understanding of the gene under study. Various strategies for controlling the activity of the gene are available including the creation of knock-outs, knock-ins,
conditional knockout and reporter systems. Gene-trap technology has, in recent times, gained significantly in popularity and the methodology will be examined in some detail.

**Lecture 3. Zinc Finger Nucleases and Talen Nucleases (VK):** These state-of-the-art technologies have the potential to revolutionise the manipulation of the eukaryotic genome, from cells in culture to mice, rats, rabbits, pigs etc. This lecture will cover the principles of this technology and how it is being currently exploited in research.

**Lectures 4 & 5. RNA interference (DN):** The discovery of the classical RNA interference pathway involving siRNA will be described. The lectures will consider the concept of regulation of expression through siRNA and microRNAs along with the use and design of RNAi based approaches in functional genomics. The advantages and limitation of such approaches will investigated through the use of specific examples. The potential use of RNAi in therapeutic approaches will be outlined.

**Reading List:**
**Lectures 1-3:**
** Highly relevant material

# Papers relate to the endothelin B receptor and conditional mouse. These papers are discussed in the lectures and are given as an example of the power of inducible transgenics.


**Bockamp et al. 2002. Of mice and models: improved animal models for biomedical research. Physiol. Genomics. 11:115-132 *Very good overview of mouse transgenics, covers the endothelin receptor B example described in lectures*


#Lee et al. 2003. The endothelin receptor-B is required for the migration of neural crest-derived melanocyte and enteric neuron precursors. Developmental Biology 259; 162–175

**Lectures 4-5**


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**Comparative Medicine**  Peter Nowlan

The purpose of this lecture course is to introduce students to the basic requirements for working with animals. This is necessary if a full appreciation of animal related work is to be got from the projects. It is also a legal requirement that anybody involved in the use of animals for scientific purposes has appropriate training (*EC directive 86/609*).

This module is not intended to be a comprehensive training course. To do this would require a much more detailed and extensive series of talks. Most of the training which will be required by students will be obtained by working in close contact with a technician and with experienced supervisors.

The golden rule should be always 'if you don't know ask somebody'.

The welfare of the animal and often the success of your Project will depend on using a correct approach to animals involved in your project.

Even if you are not undertaking a SS project which involves live animals you may do so in your future career.

**Introduction to Laboratory Animal Science**

**The Law and Application for a licence**

**Animal House Design; Its effect on Research**
Characteristics of Individual species

Experimental design Choice of species

Injections and tissue sampling

Health Considerations

Alternatives to live animal experimentation

Handling Video, Safety, Local arrangements

Video and discussion 'Ethics of Animal research'

The Scientists Viewpoint

Assessment

Reading List:

Laboratory animals an introduction for new experimenters
A. A. Tuffery
Handbook of laboratory animal management and care
S. Wolefensohn,
M. Lloyd
Introduction to laboratory animal science and technology
J. Inglis
Humane experimental technique
W. Russell, R. Burch
Experimental and surgical technique in the rat
H. Wayneforth,
P. Flecknell
Animals and alternatives in toxicology; present and future prospects
M. Balls, J. Bridges, J. Southee
In vitro toxicology
S. Cox Gad
UFAW handbook on the care & management of laboratory animals
T. Poole
Laboratory animals anaesthesia P. Flecknell
Handbook of rodent and rabbit medicine K Laber-Laird,
M. Swindle, P. Flecknell
The biology and medicine of rabbits and rodents J. Harkness J. Wagner
The laboratory animals, principles and practice W. Lane-Petter,
BIU44110 BIOCHEMISTRY IN HEALTH & DISEASE II (S2) (10 credits)

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

**Learning outcomes:**

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

- Recall and integrate key knowledge on structure of cell types in the brain and how they control neurotransmission and critically evaluate how various chemicals (biogenic amines, amino acids, peptides & labile gases) in the brain fulfill the criteria for characterisation as neurotransmitters.

- Demonstrate an understanding of the molecular mechanisms that control neurotransmitter release, the kinetics that describe how neurotransmitters bind to receptors and how defects in neurotransmitter signalling can affect behaviour.

- Employ an understanding of the molecular mechanisms that are involved in the major neurodegenerative disorders and the medical advances that are in development.

- Demonstrate an understanding of the biochemical pathways involved in one-carbon metabolism.

- Evaluate the contribution of inheritable mutations to disease outcome and appraise the relationship of gene-nutrient interactions to disease outcome.
• Compare and contrast bottom-up metabolic control analysis and top-down elasticity analysis and propose how they can be used to define control and regulation in biochemical pathways

• Demonstrate an understanding of the diagnosis, aetiology, complications and treatment associated with diabetes and obesity

**Neurochemistry: Brain Biochemistry & CNS Acting Drugs (5 lectures) Gavin Davey**

**Lecture 1:**
- Energy substrates for the brain
- Glucose/lactate transporters
- What uses ATP in the brain?
- Astrocytes-neuron lactate shuttle hypothesis
- Glucose sensing neurons
- What controls blood flow in the brain?

**Lecture 2:**
- Energy thresholds in the brain
- Mitochondria control glutamate release
- Mitochondrial fusion/fission dynamics
- Complex I activity & mitochondrial fusion

**Lecture 3:**
- In vivo techniques for measuring neurotransmitter release and actions
- Microdialysis & HPLC
- Classical neurotransmitters
- Atypical neurotransmitters
- Nitric oxide

**Lecture 4:**
- GABA metabolism & GHB
- Polyamine NTs
- Glial cells and NT release (D-serine, taurine, NAAG & neuropeptides)

**Lecture 5:**
- Melatonin as a NT
- Aspartate & pheromones

*References: to be supplied closer to lectures*
Neurobiology (5 lectures) Jerrard Hayes

Lecture 1:
- SNARE hypothesis of exocytosis:
- experimental approaches leading to this theory (pharmacology, electrophysiology)
- neurotoxins which affect exocytosis.

Lecture 2:
- Cholinergic signalling:
  - Voltage-gated ion channels vs. ligand-gated ion channels
  - Nicotinic vs. muscarinic Acetylcholine receptors
  - Prerequisites to obtain information on structure and function of receptor proteins (as an example)

Lecture 3:
- Inhibitory neurotransmission
- Glycinergic neurotransmission (receptors, mechanisms and pharmacology)
- GABA-ergic neurotransmission (receptors, mechanisms and pharmacology)

Lecture 4:
- Glutamatergic neurotransmission (receptors, mechanisms and pharmacology)
- Involvement of glutamatergic signalling in learning and memory formation
- Cannabinoid signalling (involvement of cannabinoid receptors in extinction and PTSD)

Lecture 5:
- Neurotransmitter transporter proteins as drug targets
- Serotonergic neurotransmission
- Neurobiology of depression
- Animal models of depression
- Molecular mechanisms of antidepressant treatment
- Non-synaptic neurotransmission and somatodendritic neurotransmitter release

References: to be supplied closer to lectures

Neurodegenerative disorders: An interdisciplinary approach (6 lectures) Gavin Davey

**Lectures 2-3:** Parkinson’s disease—pathology, anatomy, protein aggregation, dopaminergic neuron destruction, mitochondria, ROS production, genetics, epidemiology, MPTP + neurotoxins, alpha-synuclein, prevention in animal models. Treatments – new therapies.

**Lectures 3-4:** Alzheimer’s disease – pathology, PET scans, neurofibrillary tangles, tau protein, tangles, beta-amyloid, presenilin, apolipoprotein E. Treatments.


References: to be supplied closer to lectures

Reading/Learning Resources:

- *Proteins, Transmitters and Synapses* by D.G. Nicholls (1994) Blackwell, Oxford – The best on synaptic bioenergetics (out of print but there is a copy in the library).
- The Biochemical basis of neuropharmacology by JF Cooper, FE Bloom and RH Roth Oxford University Press, Eighth Edition

**Gene-nutrient interactions (5 lectures) Anne Molloy**

**Lecture 1: Genome responses to nutritional exposures:** Nutrition is the most persistent and variable environmental exposure to apply evolutionary pressure to the human genome. This lecture will consider the idea of how sub-optimal – or even unbalanced - micronutrient status might alter genomic responses and conversely how genetic variability might affect nutritional responses. The idea of the fetal origins of adult disease is introduced and how long-term risk of chronic disease might be influenced by variability in genes involved in nutrient availability, metabolism or function.
Lecture 2: **One-carbon metabolism in intermediary metabolism:** One-carbon units (methyl, methylene and formyl groups) are required both for synthesis and maintenance of DNA and to provide the methyl group (−CH₃) for all biological methylation reactions, which control many important epigenetic and signaling events. In lecture 2, the biochemical pathways involved in one-carbon metabolism will be described. It will be shown that four vitamins - folate, riboflavin (B₂), pyridoxal phosphate (B₆) and cobalamin (B₁₂) - are required as cofactors of enzymes in these pathways and that cell proliferation and gene expression systems link in with availability of these nutrients.

Lecture 3: **The 677C>T polymorphism in the folate dependent enzyme MTHFR:** This lecture will consider an example of a common functional polymorphism that has important nutritional, functional and disease implications. Through studying the metabolic effects of this polymorphism, the lecture will explore the common disease-common variant hypothesis whereby complex disease conditions are driven in part by polymorphisms that confer a relatively minor risk at the individual level but may have a significant effect on the burden of disease at the population level.

Lecture 4: **Nutrigenomics; a tapestry of Nature and Nurture.** The specific example of one-carbon metabolism will be discussed in relation to the known metabolic links between low B vitamin status and medical conditions such as neural tube defects, cardiovascular disease, cancer and cognitive dysfunction. The lecture will consider how nutrient dependent methylations of DNA and histones, through the one-carbon network, exert epigenetic control over cellular protein synthesis. The lecture will expand on the hypothesis that maternal nutritional factors can influence epigenetic imprinting in foetal tissues and this may be associated with changes in postnatal development and long-term susceptibility to disease.

Lecture 5: **The broader concept of genes and nutrients:** This final lecture will round off the topic by discussing other types of gene-nutrient interactions. As examples, the role of vitamin D as a transcriptional regulator will be discussed and how cellular iron balance is controlled by an integrated transcriptional system. The module will close on a discussion of how exploration of bio-bank data from large population cohorts can lead towards a better understanding of biological function, using an unusual example from cholesterol metabolism.

**References:**


**Metabolic Control Analysis (4 lectures) Richard K. Porter**


**References:**
Fell, D. (1997) 'Understanding the Control of Metabolism'
(K. Snell ed.) Portland Press


MCA website: [http://bip.cnrs-mrs.fr/bip10/mcafaq.htm](http://bip.cnrs-mrs.fr/bip10/mcafaq.htm)
[https://en.wikipedia.org/wiki/Metabolic_control_analysis](https://en.wikipedia.org/wiki/Metabolic_control_analysis)
**Obesity & Diabetes (5 lectures) Richard K Porter**

**Lecture 1. Control of appetite**

**Lecture 2. Obesity**

**Lecture 3. Physiology and biochemistry of insulin action**

**Lecture 4. Type I diabetes**

**Lecture 5. Type II diabetes**
BIU44120 Immunology & Microbiology (S2)  
(10 credits)

This module covers pathogen recognition by and signal transduction in immune cells. Bacterial pathogens of medical importance will also be covered in detail. It will provide an introduction to parasitic protozoa such as trypanosomes and helminths. Finally, the biochemical and genetic mechanisms by which bacteria, viruses and parasites evade the host immune responses will be covered.

**Learning outcomes:**

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

- Recall and integrate key knowledge and concepts about innate immune molecules and the signalling pathways they activate.
- Demonstrate an understanding of technologies underpinning the discovery of immune molecules and the signalling pathways they activate.
- Define bacterial and viral mechanisms that evade and subvert the anti-bacterial and anti-viral innate and adaptive response.
- Describe how agents that target signal transduction pathways in immune cells can modulate immune responses and provide therapy for immunological disorders.
- Define the molecular basis of pathogenesis of various prokaryotic pathogens of medical importance including *Helicobacter pylori*.
- Relate how African trypanosomes avoid the immune response and innate immunity of their human hosts.
Compare the strategies to control helminth infections, using specific species as examples and evaluate the global impact of helminth infections on endemic countries.

**Cytokine Signalling (5 lectures) Luke O'Neill**

**Lecture 1:** Cytokine families: interleukins, interferons, tumour necrosis factors, chemokines, colony stimulating factors. Properties and functions: inflammation, hemopoiesis, immune cell activation, anti-inflammatory cytokines. Class I cytokine receptors: JAKs and STATs. Specificity in signalling. WWS motif. gp130 as second chain. Common and unique receptor chains. Complexity of IL2 signalling: PI3 kinase, IRS-1.

**Lecture 2:** Type II cytokine receptors: Interferon receptor signalling: discovery of ISGFs and Tyk. Use of JAK and STAT nomenclature. JAK and STAT knock-out mice: key features. Interferon responsive genes and anti-viral effects. IL10 signalling. Suppresors of Cytokine signalling.

**Lecture 3:** Type III cytokine receptor family: TNF receptors. Homology between TNFR, NGFR, Fas and CD40. TNF signalling: TRADD, RIP, FADD and caspases. TRAFs. Pathways to NFkB and apoptosis. Mechanism of activation of NFkB. IKK complex. CARD-containing proteins.

**Lecture 4:** Type IV cytokine receptors: IL1 family. IL1 receptor signalling: IL1 pathway as prototypical 'stress' response in plants and animals. The TIR domain: structure and function. Toll-like receptors in mammals and innate immunity. LPS and IL18 receptors/ MyD88 as key adaptor. Roles of TLR-1 to TLR-10: recognition of PAMPs by PRRs. Primacy of TLRs in innate immunity.

**Lecture 5:** Signal transduction pathways activated by the TIR domain. MyD88, IRAK1 – IRAK-4. TAB1/TAK-1. Traf-6 and ubiquitination. Regulation Stress activated protein kinases: p38 MAP kinase and JNK. Comparison to classical MAP kinases. IKK activation by TAK-1. Lessons from knock-out mice: Specific adapters for different TLRs? The role of Mal in LPS signalling. NALPs and NODs. Regulation of caspase-1

**Reading List:**


**Immunotherapies  (5 lectures) Aisling Dunne (AD), Fred Sheedy & David Finlay (DKF)**

**Lecture 1: Immunotherapy – Striking a balance (DKF)** This lecture provides an introduction to immunotherapeutic strategies and the potential adverse effects of long-term immune-modulation.

**Lecture 2: Immunosuppression to prevent organ transplant rejection (DKF)** Detailing the current strategies for preventing organ transplant rejection, focusing on the mechanism of action of the potent immunosuppressant’s rapamycin and cyclosporin A.

**Lectures 3: Infectious disease vaccines and adjuvants - innate immune activators (AD)** Current vaccination strategies, vaccine subtypes, adjuvant requirements, vaccine benefits versus risks, safety.

**Lecture 4-5: Immunotherapeutics for metabolic disease (FS).** Pancreatic inflammation and diabetes and cytokine therapies. Atherosclerosis pathogenesis and targeting plaque inflammation.

**Bacterial and Viral Evasion  (5 lectures) Rachel McLoughlin and Andrew Bowie**

**Lecture 1: Immune response to bacterial infection (RMcL)**
Characterise a pathogen, introduce the concept of virulence and virulence factors, discuss extracellular vs. intracellular bacterial infections, Mechanisms of host immunity to different types of bacterial infection: Anti-microbial peptides, complement, phagocytes, antibodies, T-helper cells, cytotoxic T-cells.
**Lecture 2: Immune evasion by bacteria (RMcL)**

**Lecture 3: Innate immune detection and viral evasion I (AB)**
Key concepts in viral detection and evasion. Overview of viral life cycle. Viral pathogen associated molecular patterns (PAMPs) and antiviral pattern recognition receptors (PRRs).

**Lecture 4: Innate immune detection and viral evasion II (AB)**
Innate immune sensing of viral nucleic acids (RNA and DNA) and self:non-self discrimination.

**Lecture 5: Innate immune detection and viral evasion III (AB)**
Viral evasion of PRRs, and downstream transcription factors. Poxviral mechanisms of innate immune evasion, specific examples of manipulation of innate immune signalling by vaccinia virus proteins with a Bcl-2-like fold.

**Reading list for lectures 1-2:**
Finlay B et al. Anti-Immunology: Evasion of the Host Immune System by Bacterial and Viral Pathogens. 2006 Cell 124, 767-782

Krzyszof G et al. Friendly fire against neutrophils: Proteolytic enzymes confuse the recognition of apoptotic cells by macrophages. 2008 Biochimie 90, 405-415


Faherty C.S et al. Staying alive: bacterial inhibition of apoptosis during infection. 2008 Trends in Microbiology Vol 16 No.4


**Reading list for lectures 3-5:**

**General**

**Pattern Recognition Receptors:**
- Carty and Bowie. 2010. Recent Insights into the role of Toll-like receptors in viral infection. *Clinical & Experimental Immunology* 161, 397-406.

**Poxviruses (e.g. Vaccinia Virus):**
The aim of these lectures is to provide an introduction to African trypanosomes, parasitic protozoans that cause sleeping sickness in humans and a related disease, Nagana, in cattle. These parasites are a major problem for human and veterinary health throughout sub Saharan Africa and serious barrier to economic development of the region. Perhaps the most striking feature of these parasites is that they are exclusively extracellular. They grow and divide in the mammalian vasculature and consequently exposed the adaptive and innate defence responses of their mammalian hosts. In addition, for a variety of reasons, African trypanosomes have been come a favourite model organism for molecular and cell biologists and many discoveries of broad significance have emerged from studies on these model unicellular eukaryotes. Areas where such discoveries have been reported will be illustrated in the lectures where appropriate. The course is organized into two parts.

**Trypanosomes Part 1:** Stealth strategies of an elusive parasite
1. How are trypanosomes, such as *Trypanosoma brucei*, able to evade the host humoral immune response given that they are constantly exposed to this arm of the immune response?
2. What other strategies do trypanosomes employ to circumvent the innate immune responses?
3. How are these parasites able to acquire essential macromolecular growth factors from their hosts without attracting a response?

**Trypanosomes Part 2:** What is the molecular basis of human sleeping sickness?
The focus in part II is on the innate immunity that humans and other primates have to infection by all but a few trypanosomes. In effect in this part we will consider the molecular basis of African human sleeping sickness. We will consider the nature of the trypanolytic toxin present in human serum and how this toxin kills these parasites. We will see an amazing link between the toxin and an unsuspected programmed cell death pathway. Finally, we will see how two strains of trypanosomes have responded by developing independent mechanisms to resist this toxin and how in turn certain human populations are able to overcome this resistance and the price they pay for this capacity.

**Reading List:**
Additional specific references for key experiments will be provided within the lectures which are available on the school website.

**Trypanosomes Part I**
Nuclear architecture underlying gene expression in Trypanosoma brucei

**Trypanosomes Part II**
(6) Vanwalleghem G. et al. (2015) NATURE COMMUNICATIONS | 6:8078 | DOI: 10.1038/ncomms9078 Coupling of lysosomal and mitochondrial membrane permeabilization in trypanolysis by APOL1

**Helminths of Human Importance (4 lectures)** Padraic Fallon

A third of the world’s population is infected with parasitic worms. These lectures will address the major parasitic worms that are of medical importance.

**Lecture 1-2:**
Introduction to the major helminth parasites that infect man. Medical and economic impact of helminth parasites on society.

**Lecture 3-5:**
helminth parasites: implications for designing vaccines. Molecular and biochemical targets for current and future drugs to treat helminth infections.

A reading list will be given out during the course

Prokaryotic pathogens (3 lectures) Henry Windle

Lecture 1: Bacterial pathogens as a paradigm for chronic infection I. Molecular mechanisms of bacterial induced disease - modulation of host cell signalling responses and pathogenesis. Pro-carcinogenic microorganisms.

Lecture 2: Bacterial pathogens as a paradigm for chronic infection II. Infection and cancer – the Helicobacter pylori connection: molecular basis of pathogenesis.

Lecture 3: Mixed microbial populations and disease. The microbiome in health and disease.

General Reading:


*Human gut microbiome: hopes, threats and promises* (Review article). Cani PD

Gut. 2018;67(9):1716-1725. PMID: 29934437
This module covers the cellular and regulatory mechanisms that control the cell cycle. It also covers the molecular basis of a stem cell and its potential use in therapies. Furthermore it covers the molecular basis of cancer, the progression of the disease and the therapeutic treatment strategies.

**Learning outcomes:**

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

- Explain the processes of growth, proliferation, and cellular division and outline the cellular changes and regulatory mechanisms that define the stages of the cell cycle

- Describe the biochemical and genetic principles that define a stem cell, how these cells may be used in future therapies and explain the principles of the stem cell niche

- Critically discuss the environmental and hereditary causes of cancer and relate how alterations to the cell cycle impact on cancer development

- Describe the genetic, metabolic and cellular alterations in cancer and outline the process of metastasis

- Demonstrate an understanding of the stem cell theory of cancer

- Evaluate the contribution of the immune system to cancer

- Describe the therapeutic strategies for the control of cancer such as dietary mechanisms for reducing initiation, targeting oncogenes, overcoming drug resistance and immunotherapy

- Demonstrate an understanding of the molecular mechanisms of various modes of cell death including apoptosis and autophagy and outline the mechanisms used by cancer cells to evade cell death
Cancer Initiation & Progression (4 Lectures) Vincent Kelly

Lecture 1. Underlying causes of cancer (VK): The characteristics that are used to classify cancers and their stage of development will be described. A number of examples will be given of how environmental factors, i.e. xenobiotics, radiation and oxidative damage contribute to multistep carcinogenesis. The means by which cancer is limited by DNA damage sensing, DNA repair and cellular adaptation to oxygen/radical damage will be covered.

Lecture 2. Oncogenes and tumour suppressor genes (VK): Many of the original discoveries on oncogenes were derived from work on viruses. The concepts of onocgenes and proto-oncogenes will discussed such as src and the Rous sarcoma virus and there will be an in dept examination of the ras oncoprotein pathway an the function of other oncogenes including abl, sis, c-myc and how they influence cellular proliferation. Suppressor genes play an important role in limiting cancer formation and a number of models were put forward from original studies including Knodson’s two-hit model and haploinsufficiency. The mode of action of tumour suppressors such as APC, MSH2, MLH1, BRCA1, p53 will be examined with particular focus on p53, Rb and APC.

Lecture 3. Cancer epigenetics (VK): Changes in the genetic code is but one means to arrive at a pre-malignant crossroads. Epigenetics changes in gene expression have been found to alter tumor suppressor gene activity through. These epigenetic changes may occur as a consequence of altered DNA methylation status at CpG promoter regions of aberrant histone modification. In fact, cooperative suppression by both mechanisms has recently become the focus of new anti-cancer therapies through the development of DNMT and histone deacetylase inhibitors.

Lecture 4. Cancer metabolism & the tumor microenvironment (VK): Many of the control points of cancer, oncogenes, tumor suppressor genes (including mTOR, PI3K, Akt, p53, AMPK) are intimately linked to metabolism, especially glycolysis, which provides the cancer with the building blocks for growth. The tumor cell microenvironment is invariably acidic and hypoxic causing the transcription factor HIF1a to set in place protective responses including unregulating the production of monocarboxylate transporters, VEGF, matrix metalloproteinases and angiogenic factors.

Metastasis and Cancer Treatments (7 Lectures) Vincent Kelly & Kingston Mills

Lecture 1. Angiogenesis and metastasis (VK): The process by which cancer cells develop new blood supplies (angiogenesis) is reliant on being able to remodel the tumor environment and the extracellular matrix. A discussion of how this remodelling occurs through matrix metalloproteinases and plasminogen will be given along with the cause and consequences of breaking cell-cell interactions. The means used by cancer cells to physically move from the primary tumor (e.g. epithelial-mesenchymal transition) and how the immune system promotes this process
will be described. Breast cancer will be used as a model of how cancer cells choose secondary sites for proliferation, especially the bone marrow; ‘the vicious cycle’.

Lecture 2. Colon cancer, genetics and epigenetics (VK): Arguably, colon cancer is one of the best studied cancers in terms of its formation and progression. This lecture will discuss the contribution of chromosomal instability in terms of changes to APC, COX2 and Smad4 and microsatellite instability caused by epigenetic suppression of mis-match repair enzymes including MSH2 & MLH1. The contribution of inflammation to colon cancer will be considered and how NSAIDS and IL-10 mediate polyp formation.

Lecture 3. Stem cell theory of cancer, focusing on colon cancer (VK): The intestinal crypt stem cells are maintained in a specialized compartment of the intestinal crypt through the Ephrin receptors. The maintenance and proliferation of these stems cells will be covered including the various signals used to control their proliferation, such as hedgehog, WNT, PDGF, Eph, NOTCH and BMP. The importance of the intestinal stems cells to cancer development and treatment will be considered.

Lecture 4. Cancer treatment (VK): Classical anti-cancer drugs such as antimetabolites, alkylating agents and antimytotic agents are still widely used in therapy today despite severe side-effects. Newer ‘magic bullets, hold promise of more specific cancer treatment strategies such as lmatinab in the treatment of CML. However, drug resistance is a problem and has revealed the phenomenon of oncogene addition. Recent drug strategies have begun to focus on targeting tumor cell metabolism, its environment and the cancer initiating cells (cancer stem cells) that perpetuate proliferation even after treatment.

Lecture 5. Cellular and humoral Immune responses to tumors (KM): These lectures include the role of antibody, cytotoxic T lymphocytes, macrophages, NK cells and Th1 cells; Evasion and subversion of immune responses by tumors - anti-inflammatory cytokine production and regulatory T cell induction; Tumor-specific antigens and breaking tolerance to self antigens

Lectures 6-7. Tumor immunotherapy (KM): Antibodies, Toll-like receptor agonists and cell-based therapies; Tumor vaccines - killed tumor cells, tumor specific peptides and antigens, heat shock proteins and dendritic cell vaccines

Cancer References:
12. Immunobiology by Janeway and Travers
13. Cellular and Molecular Immunology by Abbas, Lichtman and Pober

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**Haematology and haematological malignancies: Tony McElligott**

**(2 Lectures), IMM**

**Introduction to Haematology and haematological malignancies:** Haematological malignancies are a group of neoplasms that arise through malignant transformation of bone marrow derived cells. The great diversity seen in this group of malignancies reflects the complexity of normal haematopoiesis and the immune system. The primary basis of classification is the distinction between tumours of lymphocytes and those of myeloid lineage. Haematological malignancies include leukaemias, lymphomas and multiple myeloma, and are defined and distinguished from one another according to clinical features, microscopic morphology, immunophenotype and molecular/genetic features.

**Molecular biology of haematological malignancies and leukaemia:** Many molecular genetic markers have been described in haematological malignancies including chromosomal translocations and rearrangements of the immunoglobulin and T-cell receptor genes. These prognostic or predictive markers can be useful in guiding clinical management of patients and permit the development of very sensitive and specific assays for the detection of neoplastic cells. In addition, these molecular markers have provided important clues in elucidating the biological mechanisms by which haematological malignancies develop and persist. More recently, it has been recognised that epigenetic changes and aberrant expression of miRNAs are common features of some haematological malignancies and may play an important role in carcinogenesis.
Cell Cycle (6 lectures) Vincent Kelly & Paul Voorheis

Lecture 1. The cell cycle & growth (VK): This lecture will cover some of the seminal discoveries of the cell cycle, discussing the experiments performed on frog oocytes, sea urchins and yeast. Key regulators of cell cycle progression, as determined by these early studies, MPF, Cdc2/cdc28, wee1 and Cdc25, will be covered. Components of the mammalian cell cycle, which have been discovered principally via bio-informatic approaches, will be discussed including mammalian cyclin dependant kinases (CDKs) and cyclin-dependant kinase inhibitors (CKI).

Lecture 2. Start of the cell cycle, G1 (VK): Signals for a cell to start proliferation are essential for initiation of the cell cycle. Examples will be provided of how growth signals through PI3K, AKT, mTOR and myc are co-ordinated to the uptake of amino-acids and glucose. In addition, we will discuss how cell-cell and cell-matrix contacts must be altered to permit cell cycle progression.

Lecture 3. S-phase, DNA replication & DNA repair checkpoints (VK): The control of DNA replication is a major decision point of the cell cycle. This lecture will describe the replication licensing process, the selection of the origin(s) of replication and the proteins that make up the origin replication complex, e.g. Mcm, Cdc6. If the DNA to be replicated is not properly loaded or is damaged the cell initiates various checkpoints, i.e G1- and S-phase checkpoint. This lecture will cover the various protein complexes such as 911, the MRE11-Rad50-NBS1/γH2AX complex and the kinase pathways used to tell the cell to stop the cell cycle process including ATM & ATR, BRCA1, Chk1 Chk2 and P53.

Lecture 4. Mitosis (VK): Mitosis is a huge undertaking for the cell and requires the co-ordinated disassembly/assembly of numerous cellular macromolecules and membranes. A selection of these processes will be discussed including chromosome cohesion and separation of sister chromatids. An overview of the ubiquitin/ubiquitin ligases that control the cell cycle, the SCF complex in G1 to M phase transitions and the APC complex at anaphase entry will be covered.

Lecture 5. Mechanics of chromosomal partition (HPV): A. Dissolution of the nuclear envelope and role of the nuclear scaffold proteins in prometaphase
1. Laminin A & laminin B
2. Role of cyclin-dependent kinase
B. Role of cohesins, condensins and the cohesin-specific protease during metaphase & anaphase
   1. Regulation of expression
   2. Condensed phase chromosomes
   3. Cohesin attachment & pairing of sister chromatids
   4. Spindle attachment checkpoint
   5. Destruction of cohesins at the beginning of anaphase
C. Structure of the mitotic spindle and polarity of the spindle microtubules
   1. Centrosomes & the centrosomal cycle
   2. Bipolar spindles without centrosomal involvement
   3. Kinetocore & astral microtubules
4. Microtubule growth from centrosomes
5. Kinetocore capture
6. Metaphase plate

D. Molecular motors on the spindle and force-generation for chromosomal partition
1. Kinesins
2. Dyneins
3. Orientation of the spindle
4. Role of MAPS
5. Role of catastrophins
6. Chromosomal sliding & chromosomal oscillations
7. Anaphase A & anaphase B

E. Reformation of the nuclear envelope during telophase
1. Location of the laminins during mitosis
2. Dephosphorylation of the laminins

3. Mechanics of nuclear membrane fusion & reformation of the envelope
4. Schizogony: nuclear division without cytokinesis followed by cytoplasmic condensation & plasma membrane vesiculation

**Lecture 6. Establishing the plane of cytokinesis & the separation of daughter cells (HPV):**

A. Role of the spindle
   1. The cleavage furrow
   2. Septins
   3. Symmetric & asymmetric partition of total cell contents

B. Role of actin and Myosin II
   1. Structure of the contractile ring in animal cells
   2. The pre-prophase band, phragmoplast & cell plate in plants
   3. Cells without myosin II
   4. Polo-like family of protein kinases

5. Contractile mechanism of the contractile ring & mid-body formation

**References:**


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**Stem cells (5 lectures) Vincent Kelly**

**Lecture 1. The embryonic stem cell:**
Early studies on stem cells; Development of the fertilised egg; Pre-implantation embryonic cell lineages; The embryonic epiblast; teratocarcinomas; Chimeric animals; Embryonic stem (ES) cells; Culture of ES cells; Essential signalling pathways in stem cell maintenance LIF, BMP4, Smad, TGFβ, FGF2, sonic hedgehog. Transcription factors Oct4, Sox2 and Nanog. Wnt, β-Catenin and the determination of cell fate; primordial germ cells.

**Lecture 2. Histone & DNA modifications affecting pluripotency**
Cloning of animals; Re-programming by somatic nuclear transfer; Differentiation versus pluripotency; Histone modifications; Heterochromatin & euchromatin; DNA methylation; Transcriptional inactivation; X-inactivation; XIST RNA; Polycomb group proteins

**Lecture 3. Imprinting & epigenetic regulation of pluripotency**
Imprinted genes; parthenogenesis; Studies on primordial germ cells; Epigenetics and differentiation; Induced pluripotent stem cells; Oct4, Myc, Sox3 and Klf4 and their role in iPS.
Lecture 4. The stem cell niche

Lecture 5. Stem cells in medicine
The clinical potential of adult stem cells; Leukaemia and bone marrow transfer; Pluripotency and plasticity of adult stem cells; Reprogramming adult somatic cells; Stem cell therapy with iPS cells; Treating sickle cell anaemia with iPS; The cancer stem cell; Discussion on the ethics of stem cell therapy.

Reading List:


Molecular Mechanisms of Cell Death
(5 lectures) Danny Zisterer

Lecture 1: Historical Classification of Modes of Cell Death - Type I Cell Death or Apoptosis; Type II Cell Death or Autophagy; Type III Cell Death or Necrosis. 2018 Updated Classification of Cell Death Subroutines: Multiple Cell Death Pathways including apoptosis, necroptosis, pyroptosis & ferroptosis. Role of apoptosis in development, maturation of the immune system and in cell turnover. Biochemical methods used for examination of apoptosis e.g. Annexin V staining. Aberrations in apoptosis: implicated in cancer and neurodegenerative diseases e.g. Alzheimer's. Genetic studies into nematode C. elegans provides key insights into molecular mechanisms regulating apoptosis.


**Reading List:**

**General cell death mechanisms:**

**Necroptosis and Pyroptosis:**

**Caspases:**

**IAPs:**
- Kocab AJ and Duckett CS (2016) Inhibitor of apoptosis proteins as intracellular signalling intermediates. FEBS J 221-231

**Intrinsic apoptotic pathway:**

**Extrinsic apoptotic pathway:**

**Cancer:**
• Ni Chonghaile T and Letai A (2009) Mimicking the BH3 domain to kill cancer cells Oncogene 27, S149-S157

p53:

Autophagy (2 lectures)  James Murray

Lecture 1: The mechanics of autophagy
• Early signalling events in autophagy
• Omegasomes: PI3P platforms that manufacture autophagosomes
• Sources of the autophagosome membrane
• Ubiquitin-like conjugation systems that mediate membrane formation
• Autophagosome maturation and lysosomal fusion

Lecture 2: Selective autophagy & disease
• Chaperone-mediated autophagy, macro/microautophagy & mitophagy
• Autophagy and cell death
• Autophagy and ageing: age-related neurodegenerative diseases
• Autophagy in cancer prevention, development and therapy
• Autophagy as a defence against intracellular pathogens

Reading list:
“Autophagy: molecules and mechanisms” by Jon Lane.

A list of suitable reviews will be given out during the lecture course