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

School of Biochemistry and Immunology

SS Biochemistry 2024–2025

Table of Contents:

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.
Please take your time going through the booklet and the information therein. It contains important information including deadlines for various activities. Please note that S2 exams are provisionally scheduled for the week beginning Monday 21 April 2025, and vivas will take place on Tuesday 20 May 2025 (more information below). A copy of the booklet can also be found on Blackboard under Module BIU44190.
If you have any problems during the year which affect your academic studies, please 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: dzistrer@tcd.ie Direct line: 8961628

SENIOR SOPHISTER MODULES 60 Credits

BIU44190 CAPSTONE 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 (S2) (10 credits)
This module covers the structure, function and pharmacology of neurotransmitters, neuron-glia interactions, intraneuronal signalling and the neurobiology of behaviour and neurodegenerative disorders. This module also covers the biochemistry of genetic deficiency diseases, metabolic and inflammatory 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 29).

Biochemistry Personnel and Contact Details:
The Senior Sophister Course Co-ordinator is **Danny Zisterer (phone extension 1628, email** dzistrer@tcd.ie). The Head of School is Prof. Andrew Bowie (agbowie@tcd.ie) and Prof. Jean Fletcher is the Director of Undergraduate Teaching and Learning (fletchj@tcd.ie). Please use biochem@tcd.ie to contact 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 and Immunology Staff can be found at https://www.tcd.ie/Biochemistry/people/

Timetable, face-to-face and remote learning:
CMIS is the official college timetable. Small group tutorials may be face to face or remote via Teams or zoom. It is important this year that students actively engage with academic staff to enrich your education experience.

Attendance:
All students are expected to attend lectures, workshops, in-course assessments and examinations. Tutorials, lectures, and workshops 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 participation so that performance later in the year will not be adversely affected. In the event of not being able to participate in classes due to illness, **please inform the Course Co-ordinator.** 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.
The School 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 semester 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 end of semester examinations and may be required by the Senior Lecturer to repeat the year.

From College Calendar General Regulations: 2024-25

Non-satisfactory attendance

24 All students must fulfil the course requirements of the school or department, as appropriate, with regard to attendance. Where specific requirements are not stated, students may be deemed non-satisfactory if they miss more than a third of their course of study 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 §§19 and 24 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 semester two assessment/examinations and may be required by the Senior Lecturer to repeat their year. Further details of procedures for reporting a student as non-satisfactory are given on the College website at www.tcd.ie/academic registry/studentcases.

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 Semester 1 to the end of semester 2. 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.

Annual Year Structure:
Information is available at https://www.tcd.ie/calendar/academic-year-structure/

Examinations/Assessments and Breakdown of Marks:

Senior Sophister Module Name		**ECTS Weighting**
1) Capstone Project in Biochemistry	BIU44190	20 ECTS
2) Advanced Research Skills	BIU44010	10 ECTS
3) Biochemistry in Health & Disease	BIU44110	10 ECTS
4) Immunology & Microbiology	BIU44120	10 ECTS
5) Cancer Biology & Cell Signalling	BIU44130	10 ECTS

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 Monday September 9th** and **terminate** on **Friday 22nd November**. In general, students will finish in the laboratory by 6pm each day. Occasionally, experiments may run longer but this should not be the norm – please contact

your supervisor if you need further information. In order to be fair to other students, no student is allowed to work in the laboratory after the 22nd November (even to finish one last experiment). Please contact your course coordinator if you need further information.

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 20th January 2025.** We would strongly recommend that you submit your first draft at an earlier date in January in order to give you time to incorporate suggested revisions. Your supervisor should only see one or possibly two drafts of the thesis prior to submission. Listen carefully to their feedback and incorporate it. **There is a word limit of 1500 words for the introduction and a total of 8500 words for the entire thesis (excluding bibliography and legends).**

A deadline for handing in final revised project thesis will operate. **It is 4.00 pm on Tuesday 4th February. For every working day that your thesis is late 2% will be deducted from your mark (until you reach a pass mark of 40%.)** Please submit your thesis to Blackboard under module BIU44190. More details will follow.

Following submission of your project thesis you will give a 15 min oral presentation (10 min plus 5 min for questions) that explains your project, its aims, your experimental approach, your results and conclusions (**Monday 3rd March**). Your presentation and your ability to answer questions will be assessed by a panel of three members of academic staff. Your classmates will also be present at this session. 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 7th March**). All members of the School, both staff and students, are invited to attend and they may ask you questions about your research project. Your poster will be judged by 2 members of staff and you will be asked questions by these judges. This **poster presentation will account for 5% of the project mark.**

Ms Roisin Cleere and Ms Martha Motherway (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 later on in the year.

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 lab performance, thesis, oral and poster presentations can be found below *(from page 24)*

- Lab performance report (supervisor only; 15%)
- Project thesis (supervisor's report – made available without mark to 2nd examiner)

- Project thesis (2nd examiner) – marks independently, meets and agrees mark with supervisor (65% of the project mark)

Note: if the supervisor and the 2nd examiners' marks 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 exams as follows:

- Quantitative Problems: (4 in total, assessed by two 1 hour in-person exams of equal weighting; - one compulsory question, from one of two problems, on each exam. Problem Exam 1 – Friday 18th October and Problem Exam 2 – Monday 9th December. (**30 marks** in total).
- Bioinformatics-Sequence Analysis (3 in total of equal weighting, assessed by assignments submitted on-line). (**10 marks** in total).
- Comparative Medicine (assessed by a 1 hour in-person exam on 10th December; answer one compulsory essay style question). (**5 marks**)
- Group BioTechniques assessed in part by oral presentation (5 marks) and a summary report (5 marks) (**10 marks** in total). Presentations will take place on 23rd and 24th October.
- BioTechniques Exam. Both the material delivered in lectures and material covered in the group BioTechniques will be assessed by a 2.5h in-person exam on 11th December; answer 3 out of 4 essay style questions. (**45 marks** in total).

Quantitative Problem Tutorials:

An introductory session to each of the **four** Quantitative Problems will be delivered by four assigned staff members (*e.g.* **Prb 1 Intro** on timetable). Following the introductory session, you will be asked to attempt a quantitative problem circulated by that staff member before the next tutorial session (*e.g.* **Prb 1 Tutorial**). In this session, the staff member will go through the solution to the problem.

There will be two exams of equal weighting with one compulsory question on each exam. Problem Exam 1 will cover material from Problem 1 or Problem 2, and Problem Exam 2 will cover material from Problem 3 or Problem 4.

Sequence Analysis Sessions:

There will be three Sequence Analysis Exercises (Dr Jerrard Hayes). A tutorial will be delivered by Dr Hayes. He will show you how to use the required software and provide you with some worked

examples. He will also advise you how and where to submit the exercises and of their submission deadlines.

Semester 2 Examination Papers Value: 30 ECTS

There are three exam papers at the end of semester 2, each with equal weighting as follows:

Paper 1 (**BIU44110) Biochemistry in Health & Disease Value: 10 ECTS**
Exam paper (100 marks) divided into 4 sections of equal weighting.

Section 1: Neurobiology (Answer 1 out of 2 questions)	25marks
Section 2: Metabolic & Inflammatory Diseases (Answer 1 out of 2 questions)	25marks
Section 3: General (Integrative/philosophical) (Answer 1 out of 3 questions)	25marks
Section 4: Quickie/Short 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.

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: Quickie/Short 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.

You must answer a total four questions, at least one from each section 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: Quickie/Short questions (Answer 4 out of 7 questions)	25marks

The overall degree mark is comprised of 70% of SS year and 30% of JS year.

Vivas:
On completion of their semester two examinations, **some students sit an in-person viva voce examination with the External Examiner** (Prof. Anne Ridley, University of Bristol, UK). Please be aware

the vivas take place outside of term time once all exam results have been collated- **PROVISIONAL DATE: 20th May 2025.** Students are considered **'borderline' if they are 1% 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. You cannot be marked down by a viva. You will not know your mark before sitting the viva. Finally, vivas will be held **in-person only (including for international students)** so please ensure you are in the country and available if called. **Requests for remote online vivas will not be granted**.

How can you prepare for the viva?

If 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 see list below). Please **contact your tutor during the first week of the first semester**. You are **expected to attend a tutorial every fortnight**. Your tutor will set various exercises and these should help you in your final examinations.

Addresses and Phone No's:

Please send your College based address and telephone number (if any) by email to biochem@tcd.ie. 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. If you do not enter these details you may not be informed of any changes.

Prizes:

The **Ciotti Orsi Prize:** This prize was founded in 1996 by the late Dr. Bruno A. Orsi in honour of his wife, Margaret Ciotti, and, from 1999 as a memorial to her. It is awarded each year by an annual gift to a final year biochemistry, immunology or molecular medicine student who has shown excellence in research during their project and, in this way, reflects Margaret's scientific career in the U.S. Since the passing of Dr. Bruno A. Orsi in May 2020, the prize is now being awarded in memory of them both, reflecting their joint contributions to the world of Biochemistry. Dr. Bruno A. Orsi was professor emeritus and will be particularly remembered for his exuberant and enthusiastic teaching style. Value, €400 and a commemorative bronze medal. **Provisional date: 15th May 2025**

Gold Medal: Gold Medals are awarded on the basis of the final, overall degree award mark (which will be calculated on a 30/70 basis over the final two years). If you achieve an overall degree mark of 75% or above you will be awarded a Gold Medal at graduation.

Health and Safety Matters:

1) Registration with Safety Officer

Preliminary safety registration takes place during two mandatory health and safety briefing sessions scheduled on the first day of term September 9th. You must register, by E-mail or if required 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 Cross (Chief Technical Officer) will describe the general management and security features of the building at an introductory briefing. Dr Joyce Rubotham, the School Safety Officer, will give you two formal Health and Safety briefings. **ATTENDANCE AT THESE BRIEFINGS 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 scientist 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.]

If you intend working with radioactivity during your project you must first contact the School Radiological Protection Supervisor, Dr Joyce Rubotham (rubothj@tcd.ie) (You are not permitted to work with unsealed radionuclide sources).

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, COVID-19, *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 ID 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_info.php

Once you have completed all the forms and safety briefings, E-mail them to the Safety officer, Joyce Rubotham (rubothj@tcd.ie).

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 rescues 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 Printing House Square, phone = 8963111, email = askds@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.

Support Provision for Students with Disabilities: Trinity has adopted a Reasonable Accommodation Policy that outlines how supports are implemented in Trinity. Student seeking reasonable accommodation while studying in Trinity must apply for reasonable accommodations online with the Disability Service in their student portal my.tcd.ie. Based on appropriate evidence of a disability and information obtained from the student on the impact of their disability and their academic course requirements, the Disability Staff member will identify supports designed to meet the student's disability support needs. Following the Needs Assessment, the student's Disability Officer prepares an Individual Learning Educational Needs Summary (**LENS**) detailing the Reasonable Accommodations to be implemented. The information outlined in the LENS is communicated to the relevant School via the student record in SITS.

Student responsibilities for departmental assessments/course tests: Students are required to initiate contact with the School/Department and request reasonable accommodations **as per their LENS report, or email received following their needs assessment** for particular assessments for School/ Department administered assessment. Students are advised to make contact **at least two weeks prior** to the assessment date to enable adjustments to be implemented.

Need support? Reach out to Student Counselling Service

Student Counselling Service (SCS) provides a compassionate, inclusive and student-centred service, embedding high quality social integration, academic development and mental health services.

What does SCS actually do? SCS offer free, confidential and non-judgemental support to registered students of Trinity who are experiencing personal and/or academic concerns. The SCS team of qualified counsellors and learning strategists are committed to promoting and protecting wellbeing and success throughout a diverse student body. No matter who you are, no matter what your situation is, the Student Counselling Service is here to support you through your difficulties. The SCS strive to help all Trinity students irrespective of age, disability, sexual orientation, socioeconomic background, gender identity and expression, marital or family status, religion, ethnicity or culture.

SNAP (Support & Needs Assessment Planning)
A SNAP session is a student's first meeting with SCS. During a SNAP appointment you will meet with one of our clinicians for a conversation about what you are experiencing and to identify what resources might be helpful to meet your current needs. The goal of this appointment is to get you connected with the most effective and least time/energy intensive option to get your needs met. You can get assigned an individual counsellor after a SNAP session.

Sign up for a SNAP session at student-counselling@tcd.ie

Workshops
SCS offer workshops free of charge on topics relevant to student mental health and wellbeing.

- Minding our Mental Health in College
- Managing Stress and Anxiety
- Shyness and Social Anxiety
- Self-Esteem and the Inner Critic
- How to Support a Friend Who is Struggling
- Cultivating Mindfulness and Compassion
- Building Empathy Skills
- Suicide Awareness Skills

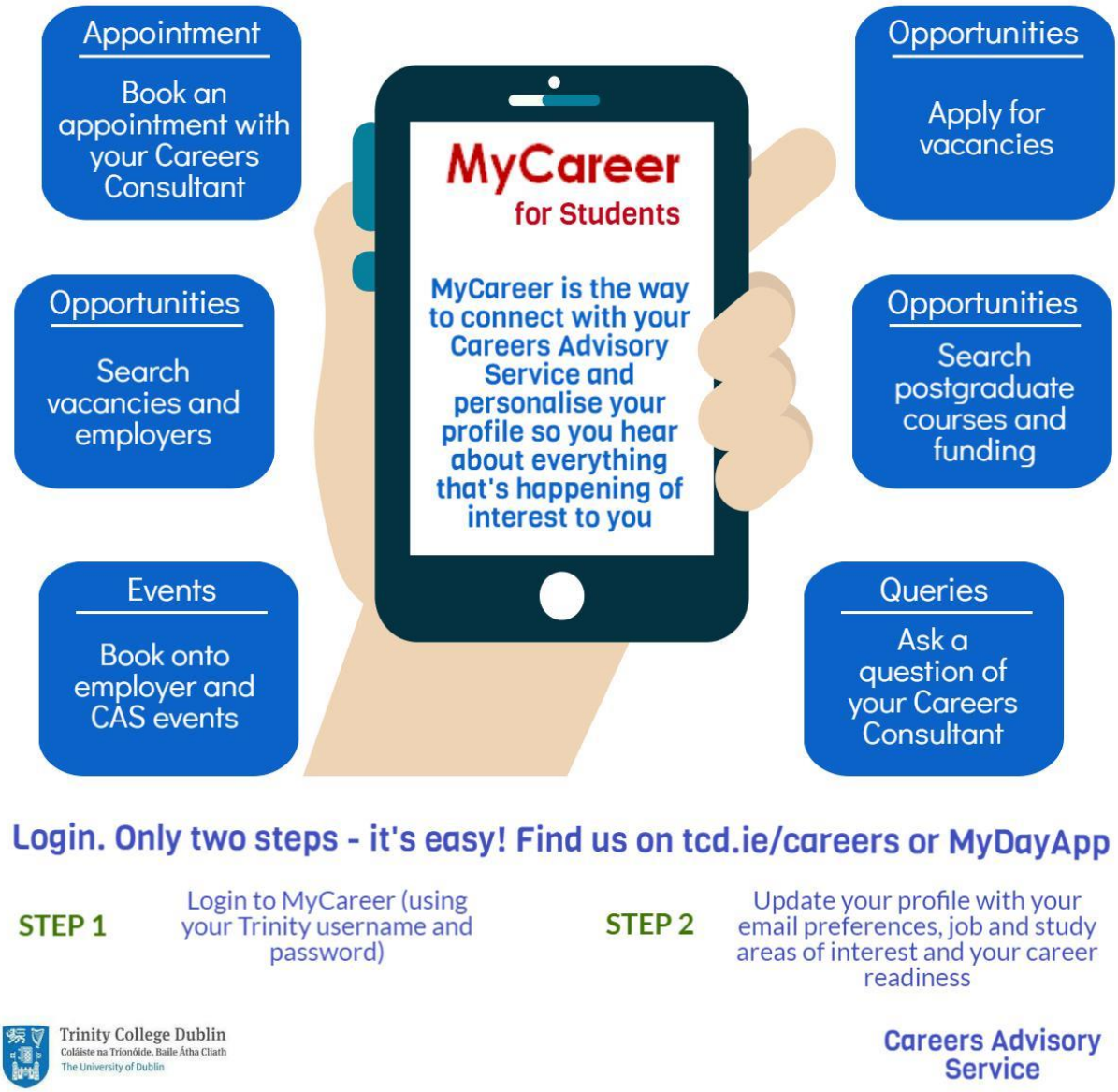
Please email student-counselling@tcd.ie to request a workshop or talk.

Need Urgent Support?
In the event of an emergency that cannot wait, the Student Counselling Service has emergency appointments available every weekday. Email at student-counselling@tcd.ie to book in with the duty counsellor. You can also reach ***Niteline***, which is run by students at:

https://www.tcd.ie/Student_Counselling/support-services/niteline/

Additional off-campus support is available at Samaritans (www.dublinsamaritans.ie) and Peita House (http://www.pieta.ie/).

As a reminder, you can always contact your **College Tutor** for personal support.



MyCareer from Careers Advisory Service

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

MyCareer: mycareerconnect.tcd.ie

www.tcd.ie/Careers/students/postgraduate/

TCD.Careers.Service

@TCDCareers

TCDCareers

tinyurl.com/LinkedIn-TCD-Connecting

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

Plagiarism: NB – READ THIS SECTION PROPERLY

While plagiarism has always been a serious offense (as detailed in the College Calendar-see excerpt below), the incidence of plagiarism has increased, in part due to remote and electronic submissions. It is your responsibility to understand what plagiarism is and avoid it. It can include the following:

Substantial or direct duplication of text/content:

- from material previously submitted during your degree.
- from published online sources without appropriate quotation and citation.
- from lecture slides.

Self-plagiarism (using materials prepared by you and previously submitted) is still plagiarism.
Care needs to be taken when paraphrasing from an article/source. Paraphrasing does not indicate that you understand the material and depending on the scale, can be considered plagiarism. For you to demonstrate understanding (and get better marks), you need to use your own words.

Please see the link to a series of webpages designed to help you to understand what plagiarism is and to employ the principles of academic integrity to avoid plagiarism:

https://libguides.tcd.ie/academic-integrity

The full statement of College's policy on plagiarism (see Calendar, General Regulations and Information, at general-regulations-and-information.pdf (tcd.ie) are reproduced below. Your capstone project thesis **will be submitted through plagiarism-detecting software** such as Turnitin (additional information for which can be found at: http://turnitin.com/static/index.html). **It is your responsibility to educate yourself about academic integrity and what exactly constitutes plagiarism. Ignorance is not an acceptable defence.**

It is a college requirement that all students must complete an online tutorial on academic integrity 'Ready, Steady, Write', located at https://libguides.tcd.ie/academic-integrity/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

I have also completed the Online Tutorial on avoiding plagiarism 'Ready, Steady, Write', located at https://libguides.tcd.ie/academic-integrity/ready-steady-write

Calendar regulations on plagiarism

96 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.
97 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; (f) using another person's form of words without quotation marks (this constitutes plagiarism even if the student provides a reference to that person or their work). 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

98 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 collaboration 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. In order to avoid plagiarism in the context of collaboration and group work, it is particularly important to ensure that each student appropriately attributes work that is not their own.

99 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.

100 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://libguides.tcd.ie/plagiarism.

101 If plagiarism as referred to in §96 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 §2.

102 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 §101 above must state their agreement in writing to the Director of Teaching and Learning (Undergraduate) or designate. If one of the parties to the informal meeting withholds his/her written agreement to the application of the summary procedure, or 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 §2.

103 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 with corrections. Instead, the student is required to submit a new piece of work as a reassessment during the next available session. Provided the work is of a passing standard, both the assessment mark and the overall module mark will be capped at the pass mark. Discretion lies with the Senior Lecturer in cases where there is no standard opportunity for a reassessment under applicable course regulations.

104 Provided that the appropriate procedure has been followed and all parties in §101 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 may approve, reject, or vary the recommended penalty, or seek further information before making a decision. If the Senior Lecturer considers that the penalties provided for under the summary procedure are inappropriate given the circumstances of the case, he/she may also refer the matter directly to the Junior Dean who will interview the student and may implement the procedures as referred to under CONDUCT AND COLLEGE REGULATIONS §2. Notwithstanding his/her decision, the Senior Lecturer will inform the Junior Dean of all notified cases of Level 2 and Level 3 offences accordingly. The Junior Dean may nevertheless implement the procedures as referred to under CONDUCT AND COLLEGE REGULATIONS §2.

105 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.

College regulations on Academic Progress and Progression 2024-2025

Progression regulations: Bachelor programmes

59 Some programmes with professional accreditation have received a derogation from specific regulations on progression by the University Council. The relevant programme entry provides these details. See www.tcd.ie/teaching-learning/academic-affairs/ug-prog-award-regs/derogations /by-school.php.

In order to rise with their class, students must obtain credit for the academic year by satisfactory attendance at lectures and tutorials and by carrying out, submitting and sitting the required assessment components. In addition, students must pass the year by achieving, at a minimum, an overall credit-weighted average pass mark for the year (40 per cent or 50 per cent, as per programme regulations) and either:

- *(a) accumulate 60 credits by achieving at least the pass mark in all modules*
  or
- *(b) pass by compensation. All modules and components within modules are compensatable (except in particular professional programmes where compensation does not apply).*

To pass a year by compensation, in programmes that locate the pass mark at 40 per cent, a student must achieve the pass mark in modules carrying a minimum of 50 credits and obtain a module mark of at least 35 per cent in any remaining module(s). A student may accumulate a maximum of 10 credits at qualified pass where the mark lies between 35-39 per cent. To pass a year by compensation, in programmes that locate the pass mark at 50 per cent, a student must achieve the

pass mark in modules carrying a minimum of 50 credits and obtain a module mark of at least 45 per cent in any remaining module(s). A student may accumulate a maximum of 10 credits at qualified pass where the mark lies between 45-49 per cent.

60 Progression is on an annual basis. Within a year students may carry failed modules from one semester to the next but not from one academic year to another; that is, they will not be able to rise to the next year of their programme until they have successfully completed the preceding year(s). Students who have not passed their year are required to present for reassessment when:

(a) they obtain in excess of 10 credits at qualified pass (i.e. marks between 35-39 per cent where the pass mark is 40 per cent; or 45-49 per cent where the pass mark is 50 per cent);

(b) they fail any module (i.e. achieving marks below 35 per cent where the pass mark is 40 per cent; or below 45 per cent where the pass mark is 50 per cent);

(c) they do not obtain an overall pass mark for the year;

(d) any combination of (a) - (c) occurs.

61 If a student has achieved both fail and qualified pass grades at the first sitting or has exceeded the 10-credit limit allowed for compensation and is not permitted to rise with their year, they must present for reassessment in all modules for which they obtained a fail and/or a qualified pass.

62 Different modalities of assessment to the first sitting are permitted in the reassessment session, as determined by the programme.

63 The same progression and compensation regulations as outlined above apply at the reassessment session. The overall credit-weighted average for the academic year will be calculated using the most recent marks achieved.

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

65 Students are permitted to repeat any year of an undergraduate programme subject to not repeating the same year more than once and not repeating more than two academic years within a degree course, except by special permission of the University Council.

66 The maximum number of years to complete an undergraduate degree is six years for a standard four-year programme and seven years for a five-year programme.

67 Access to scripts and other assessed work and discussion of performance

(i) All students have a right to discuss their examination and assessment performance with the appropriate members of staff. This right is basic to the educational process. Students are entitled to view their scripts and other assessments in person when discussing their performance. For work completed during semester one, students should note that all results are provisional until moderated by the court of examiners in Trinity term. In Trinity term, students' performance cannot be discussed with them until after the publication of the end-year results.

(ii) Written assessment components and assessment components which are recorded by various means (e.g. video, audio) are retained by schools and departments for thirteen months from the date of the meeting of the court of examiners which moderates the results in question and may not be available for consultation after this time period.

68 Re-check/re-mark of examination scripts and other assessed work

(i) Having received information about their final results at the court of examiners in Trinity term and having discussed these and their performance with the Director of Teaching and Learning (Undergraduate) or the head of discipline and/or the appropriate staff, students may ask that their results be reconsidered if they have reason to believe: (a) that the grade is incorrect because of an error in calculation of results; (b) that the examination paper or other assessment specific to the student's course contained questions on subjects which were not part of the course prescribed for the examination or other assessment; or (c) that bias was shown by an examiner in marking.

(ii) In the case of (a) above, the request should be made through the student's tutor to the Director of Teaching and Learning (Undergraduate) or course director as appropriate.

(iii) In the case of (b) and/or (c) above, the request should be made through the student's tutor to the Senior Lecturer. In submitting such a case for reconsideration of results, students should state under which of (b) and/or (c) the request is being made.

(iv) Requests for re-check or re-mark should be made as soon as possible after discussion of results and performance and no later than twelve months from the date of the meeting of the court of examiners which moderated the marks in question.

(v) Once a result has been formally published following the court of examiners it cannot be amended without the permission of the Senior Lecturer.

(vi) Any student who makes a request for re-check or re-mark that could have implications for their degree result is advised not to proceed with degree conferral until the outcome of the request has been confirmed.

Class Descriptors: These 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 School's examiners will also give credit for evidence of critical discussion of the facts or evidence.

Guidelines on Grades for Sophisters' Essays and Examination Answers

Class	Range	Criteria
I	90 - 100	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.
	80 - 89	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.
	70 - 79	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.
II - 1	65 - 69	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.
	60 - 64	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.
II – 2	55 - 59	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.
	50 - 54	INCOMPLETE ANSWER; suffers from significant omissions, errors and misunderstanding, but still with understanding of main concepts and showing sound knowledge. Several lapses in detail.
III	45 - 49	WEAK ANSWER; limited understanding and knowledge of subject. Serious omissions, errors and misunderstandings, so that answer is no more than adequate.
	40 - 44	VERY WEAK ANSWER; a poor answer, lacking substance but giving some relevant information. Information given may not be in context or well explained, but will contain passages and words which indicate a marginally adequate understanding.
F - 1	35 - 39	MARGINAL FAIL; inadequate answer, with no substance or understanding, but with a vague knowledge relevant to the question.
F - 2	30 - 34	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.
F - 3	0 -29	UTTER FAILURE; with little hint of knowledge. Errors serious and absurd. Could also be a trivial response to the misinterpretation of the question.

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.

Student Name:	**Supervisor Name:**		
Attendance	*Poor*	☐ ☐ ☐ ☐ ☐	*As expected*
How diligently did the student work?	*Well below expectation*	☐ ☐ ☐ ☐ ☐	*Intensively*
How well did the student plan the experiments?	*Well below expectation*	☐ ☐ ☐ ☐ ☐	*Research level*
How well were the experimental methods and results documented (e.g. in lab book)?	*Well below expectation*	☐ ☐ ☐ ☐ ☐	*Research level*
How well did the student observe the relevant safety procedures (e.g. wear lab coat)?	*Never*	☐ ☐ ☐ ☐ ☐	*Always*
How accurate was the student's experimental technique?	*Well below expectation*	☐ ☐ ☐ ☐ ☐	*Research level*
Quantity of work done	*Very little*	☐ ☐ ☐ ☐ ☐	*A great deal*
Ability to trouble shoot in lab	*Poor*	☐ ☐ ☐ ☐ ☐	*Excellent*
Level of help in lab available	*Very little*	☐ ☐ ☐ ☐ ☐	*A great deal*
Ability to work independently	*Poor*	☐ ☐ ☐ ☐ ☐	*Excellent*
Attitude to work	*Poor*	☐ ☐ ☐ ☐ ☐	*Highly motivated*
Ability to work with others	*Poor*	☐ ☐ ☐ ☐ ☐	*Excellent*
Ability to respond to criticism	*Poor*	☐ ☐ ☐ ☐ ☐	*Excellent*

Comments:

Particular difficulties if any:

Mark out of 100%:

Senior Sophister Project Thesis - <u>Supervisor's report</u>

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.

Student name			
Project Title			
Supervisor name			
Date			
1st Draft submission on time		Yes ☐	No ☐

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

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.

Student name	
Project Title	
Date	
Examiner's name	
Agreed mark (out of 100%):	

Thesis			
Presentation	*Messy, poor English*	☐ ☐ ☐ ☐ ☐	*Publication standard*
Abstract	*Wholly inadequate*	☐ ☐ ☐ ☐ ☐	*Publication standard*
Introduction	*Trivial*	☐ ☐ ☐ ☐ ☐	*Publishable*
Literature coverage	*Poor*	☐ ☐ ☐ ☐ ☐	*Extensive and deep*
Description of aims	*Wholly inadequate*	☐ ☐ ☐ ☐ ☐	*Perfectly clear*
Materials and methods	*Wholly inadequate*	☐ ☐ ☐ ☐ ☐	*Perfectly clear*
Description of results	*Wholly inadequate*	☐ ☐ ☐ ☐ ☐	*Perfectly clear*
Figures/ legends/ tables	*Wholly inadequate*	☐ ☐ ☐ ☐ ☐	*Perfectly clear, complete*

References	*Wholly inadequate*	☐ ☐ ☐ ☐ ☐	*Fully accurate*
Quality of data	*Poor*	☐ ☐ ☐ ☐ ☐	*Exemplary*
Analysis of data	*Poor*	☐ ☐ ☐ ☐ ☐	*Comprehensive analysis*
Appropriate statistical analysis	*Poor*	☐ ☐ ☐ ☐ ☐	*Strict*
Discussion	*Poor*	☐ ☐ ☐ ☐ ☐	*Publication standard*
Scientific rigour e.g. use of controls	*Weak*	☐ ☐ ☐ ☐ ☐	*Strict*
Understanding/ insight	*Very little*	☐ ☐ ☐ ☐ ☐	*Research level*
Comments:			
Mark out of 100%:			

Senior Sophister Poster Mark Sheet

This mark contributes **5%** to the overall project mark.

Student Name:	**Degree:**
Examiners:	**Overall Mark:**

Poster clearly communicates all key scientific information	*Strongly Disagree*	☐ ☐ ☐ ☐ ☐	*Strongly Agree*
Information is accurate, no significant errors	*Strongly Disagree*	☐ ☐ ☐ ☐ ☐	*Strongly Agree*
Poster is logically laid-out and easy to follow	*Strongly Disagree*	☐ ☐ ☐ ☐ ☐	*Strongly Agree*
Poster is eye-catching and visually appealing	*Strongly Disagree*	☐ ☐ ☐ ☐ ☐	*Strongly Agree*
Exhibits analytical and critical thinking	*Strongly Disagree*	☐ ☐ ☐ ☐ ☐	*Strongly Agree*
Poster and presenter shows understanding of the topic	*Strongly Disagree*	☐ ☐ ☐ ☐ ☐	*Strongly Agree*
Presenter explained the poster well	*Strongly Disagree*	☐ ☐ ☐ ☐ ☐	*Strongly Agree*
Presenter answered questions fully	*Strongly Disagree*	☐ ☐ ☐ ☐ ☐	*Strongly Agree*

Any Specific Comments:

Senior Sophister Research Project Oral Presentation

This presentation is to be marked independently by three examiners who will then discuss and agree a mark. This agreed mark contributes **15%** to the overall capstone project mark. It is designed to capture the abilities of a student to communicate their research findings, the importance of the research and plans for future work..

Student Name	
Degree Programme	
1st Examiner's Name	
2nd Examiner's Name	
3rd Examiner's Name	
Date	

Broad Understanding of the Subject Area	Shallow	□□□□□	Extensive
Statement of Aims	Incoherent	□□□□□	Very Clear
Structure of presentation	Badly Disorganised	□□□□□	Logical and Well Organised
Amount of material	Too Little, Too Superficial	□□□□□	Appropriate
Diagrams and Images	Irrelevant/Poor Quality	□□□□□	Highly Relevant/Excellent Quality
Understanding of Methods	Shallow	□□□□□	Extensive
Understanding of Results	Shallow	□□□□□	Extensive
Summary/Conclusion	Absent	□□□□□	Concise and Appropriate
Ideas for Further Research	None	□□□□□	Plenty
Timekeeping	Poor	□□□□□	Excellent
Audibility	Too Quiet, Monotone	□□□□□	Clear and Lively and Varied Tone
Rapport with audience	Poor	□□□□□	Lively and Good Eye Contact

Biochemistry
Breakdown of SS Papers 1, 2 and 3
2024-2025

Paper 1– BIU44110 Biochemistry in Health & Disease

Section 1: 'Neurobiology' **Answer 1 of 2 questions**

Molecular Neurobiology (GD)
Neurometabolism and atypical NTs (GD)
Neurodegenerative disorders (DL)

Section 2: 'Metabolic & Inflammatory Diseases' **Answer 1 of 2 questions**

Genetic Diseases (SO'R)
Metabolic Diseases (MH)
Inflammatory Diseases (EC/LON/SC)

Section 3: 'General' **Answer 1 of 3 questions**

Trans-subject integrative/philosophical questions

Section 4: 'Quickie/Short questions' **Answer 4 of 7 questions**

Paper 2– BIU44120 Immunology & Microbiology

Section 1: 'Immunology' **Answer 1 of 2 questions**

Cytokine Signalling (LON)
Immunotherapies (AD/DF/FS)
Viruses & Disease (GB)
Bacterial & 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: 'Quickie/Short questions' **Answer 4 of 7 questions**

Paper 3– BIU44130 Cancer Biology & Cell Signalling

Section 1: 'Cancer Biology' **Answer 1 of 2 questions**

Initiation & Progression (ABv)
Metastasis & Treatment (ABv/KM)
Haematological malignancies (TMcE)

Section 2: 'Cell Signalling' **Answer 1 of 2 questions**

Cell cycle (VK)
Stem cells (CF)
Apoptosis & Autophagy (DZ/AB)

Section 3: 'General' **Answer 1 of 3 questions**

Trans-subject integrative/philosophical questions

Section 4: 'Quickie/Short questions' **Answer 4 of 7 questions**

SS Biochemistry
Tutorial groups 2024-2025

Prof Emma Creagh
Rebecca Conneely
Eimear Donohoe
Oluwanifemi, Fagbemiro
Prof Derek Nolan
Cherry Gao
Hugo Fitzmaurice
Olamide Iyanda
Prof Amir Khan
Eoghan Leonard
Claire Lin
Shauna Maycock
Prof Andrei Budanov
Raea Michie
Mirela Mucenic
Eimear Ní Chaoilte
Prof Gavin Davey
Abigail O'Leary
Lydia Politi
Prof Aisling Dunne
Caoimhe Ryan
Oisin Ryan
Prof Jer Hayes
Sarah Sheridan
Tea Stapar
Prof Kenneth Hun Mok
Molly Tiernan
Sai Vasudevan
Prof Danny Zisterer
Jay Walsh
Jiaxun Wang
Prof Mohamed Hankir
Aidan Ward
Linjie Yang

SS Module Codes, Learning Outcomes, Course Descriptions & Key Reading

2024-2025

BIU44190 CAPSTONE PROJECT IN BIOCHEMISTRY (S1) (20 credits)

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 paper
- Demonstrate a comprehensive understanding of the theory behind the research project and show a critical awareness of how to develop the a future work proposal
- 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

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 Jerrard 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

*Bioinformatics: Sequence, structure, and databanks. A practical approach. D. Higgins and W. Taylor (eds.) Oxford University Press, 2000.

*Trends guide to bioinformatics. Elsevier Science, 1998

#Benson, D. A. et al. 1999. GenBank. Nucleic Acid Research, 27: 12-17

#Bairoch, A. and R. Apweiler. 2000. The SWISS-PROT protein sequence database and its supplement TrEMBL in 2000. Nucleic Acid Research, 28: 45-48.

#Altschul et al. 1990. Basic local alignment search tool. J. Mol. Biol. 215:403-410.

#Needleman, S. B. and Wunsch, C. D. 1970. A general method applicable to the search for similarities in the amino acid sequence of two proteins. J. Mol. Biol., 48: 443-453.

#Smith, T. F. and Waterman, M. S. 1981. Identification of common molecular subsequences. J. Mol. Biol., 147: 195-197.

#Kyte, J. and Doolttle, R. F. 1982. A simple method for displaying the hydropathic character of a protein. J. Mol. Biol., 157: 105-132.

#Persson, B. and Argos, P. 1994. Prediction of transmembrane segments in proteins utilising multiple sequence alignments. J. Mol. Biol., 237: 182-192.

#Rost, B. et al. 1995. Transmembrane helices predicted at 95% accuracy. Protein Science, 4: 521-533.

#Von Heijne, G. 1992. Membrane protein structure prediction. Hydrophobicity analysis and the positive-inside rule. J. Mol. Biol., 225:487-494.

#Sonnhammer, E. L. L. et al. 1998. A hidden Markov model for predicting transmembrane helices in protein sequences. In J. Glasgow et al. (eds.) Proc. Sixth Int. Conf. On Intelligent Systems for Molecular Biology, 175-182. AAAI Press.

#Von Heijne, G. 1986. A new method for predicting signal sequence cleavage sites. Nucleic Acid Research, 14: 4683-90.

#Nielsen, H. et al. 1997. Identification of prokaryotic and eukaryotic signal peptides and prediction of their cleavage sites. Protein Engineering, 10:1-6.

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 apparti 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) Jerrard 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:
(1) Hornak JP, Web book: "The Basics of NMR", http://www.cis.rit.edu/htbooks/nmr/, 1997.
(2) Knowbee Tutoring, "Introduction to NMR Spectroscopy" Parts 1 and 2, https://www.youtube.com/watch?v=TJhVotrZt9I, 2015.
(3) Hore PJ, Jones JA, Wimperis S, "NMR: The Toolkit", Oxford Chemistry Primers 92, Oxford University Press, 2000.
(4) Wong F, “NMR Made Easy!” Parts 1-6, https://www.youtube.com/watch?v=9orcRVTKcS0&list=PLP0TLbeMObSy4izIkMlC2QOpJCzNJpC17, 2012.
(5) Larive CK, Barding Jr GA, Dinges MM, “NMR Spectroscopy for Metabolomics and Metabolic Profiling”, *Anal. Chem 87* (1): 133–146, 2015.
(6) Markley JL et al, ”The future of NMR-based metabolomics”, *Curr Opin Biotech* 43: 34-40, 2017.
(7) Jang C, Chen L, Rabinowitz JD, “Metabolomics and Isotope Tracing”, *Cell* 173(4): 822-837, 2018.

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.
Principles and Techniques of Biochemistry and Molecular Biology. 7th Edition. Wilson K & Walker J Eds. Chapter 4 Microscopy. Brief overview of field.
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) Claire Fergus & Derek Nolan

Lecture 1. Mutagenic, transgenic & cloning technology (CF): 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 pluripotant stem cells (iPS) in biomedical research applications.

Lecture 2. Design and development of transgenic constructs (CF): 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 (CF): 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.

** Molecular Cell Biology, Lodish et al., Sixth Edition. W. H. FREEMAN, New York. (*Good general overview of genetic techniques)*

*Baneyx F (1999) Recombinant protein expression in E. coli. Current opinion in Biotechnology 10:411-421. (*Detailed review of the plasmid/E.coli features that direct recombinant expression*)

**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*)

Fields, S. and Sternglanz. 1994. The yeast two-hybrid system: an assay for protein-protein interactions. Trends in Genetics 10: 286-292

**Vidan S, Snyder M. (2001) Large-scale mutagenesis: yeast genetics in the genome era. Curr Opin Biotechnol. 12:28-34.

Beutler B, Poltorak A. (2000) The search for Lps: 1993-1998.
J Endotoxin Res. 6:269-93. (*An amusing and personal account of Bruce Beutlers discovery of TLR4 by positional cloning*)

*Wang B. and Zhou J. 2003. Specific genetic modifications of domestic animals by gene targeting and animal cloning. Reproductive Biology and Endocrinology, 1:103

#Masaki T. (2004) Historical review: Endothelin. Trends Pharmacol Sci. 25(4):219-24.

#Shin et al. 1999. The temporal requirement for endothelinreceptor-B signalling during neural crest development. Nature. 402: 496-501

#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

(1) Cogoni C, and Macino G. (2000) Post-transcriptional gene silencing across kingdoms. *Genes Dev* **10**: 638-643.
(2) Guru T. (2000). A silence that speaks volumes. *Nature* **404**, 804-808.
(3) Sharp PA. RNA Interference-2001. (2001) *Genes Dev* **15**: 485-490.
(4) Ullu E., Tschudi C. and Chakraborty T. (2004) RNA interference in protozoan parasites *Cellular Microbiol.* **6**: 509-519

Comparative Medicine Dr Kimberly Jardine

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, A. Pearson
Man and mouse, animals in medical research W. Paton
Lives in the balance; J. Smith,K. Boyd
The ethics of using animals in biomedical research Vivisection in historical prospective
R. Rupke

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

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

- Critically evaluate the contribution of immunology to a range of important human diseases including autoimmunity (rheumatoid arthritis) and autoinflammatory diseases

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

Molecular Neurobiology (6 lectures) Gavin Davey

Lecture 1: Neurotransmission & molecular mechanisms of exocytosis
Lecture 2: Molecular mechanisms in excitatory neurotransmission
Lecture 3: Molecular mechanisms in inhibitory neurotransmission
Lecture 4: Cholinergic signalling & neurotoxins
Lecture 5: Dopamine signalling and molecular neurobiology
Lecture 6: Serotonin and molecular neurobiology underlying depression

References: to be supplied closer to lectures

Neurometabolism and atypical neurotransmitters (5 lectures) Gavin Davey

Lecture 1: Neurovascular structure and cerebral blood flow
Lecture 2: Energy producing systems in the brain
Lecture 3: Energy thresholds and mitochondrial dynamics
Lecture 4: Atypical neurotransmitters
Lecture 5: Melatonin and aspartate neurotransmission

References: to be supplied closer to lectures

Neurodegenerative disorders: An interdisciplinary approach (6 lectures) David Loane

Lecture 1: Common mechanisms of neurodegeneration
Lecture 2: Alzheimer's disease
Lecture 3: Parkinson's disease
Lecture 4: Huntington's disease
Lecture 5: ALS (motor neuron disease)
Lecture 6: Stroke

References: to be supplied closer to lectures

Reading/Learning Resources:

- *Basic Neurochemistry: Molecular, Cellular, and Medical Aspects* by G.J. Siegel *et al.*(1999). 7th Edition - excellent; 6th edition freely available online through Pubmed website (https://www.ncbi.nlm.nih.gov/books/NBK20385/).
- *Principles of Neural Science* (5th. Edition) by E.R. Kandel *et al.* (2000) McGraw-Hill- A monster textbook >1600 pages but very good.
- *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).
- *Stahl's Essential Psychopharmacology: Neuroscientific Basis and Practical Applications* by

S.S. Stahl (2000). Cambridge Univ. Press. Idiosyncratic but fun.

- The Biochemical basis of neuropharmacology by JF Cooper, FE Bloom and RH Roth Oxford University Press, Eighth Edition
- Molecules and mental illness by Samuel H. Barondes Paperback - 216 pages (June 1999) W H Freeman & Co.; ISBN: 0716760339- Drugs and the brain by Solomon Snyder

Gene-nutrient interactions (5 lectures) Sinead O'Rourke

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 ($-CH_3$) 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 (B_2), pyridoxal phosphate (B_6) and cobalamin (B_{12}) - 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:

1. Stover PJ. Polymorphisms in 1-carbon metabolism, epigenetics and folate-related pathologies J Nutrigenet Nutrigenomics. 2011;4(5):293-305.

2. Martín-Subero JI, Esteller M. Profiling epigenetic alterations in disease. Adv Exp Med Biol. 2011;711:162-77.

3. Manolio TA, Collins FS, Cox NJ, Goldstein DB, Hindorff LA, Hunter DJ, McCarthy MI, Ramos EM, Cardon LR, Chakravarti A, Cho JH, Guttmacher AE, Kong A, Kruglyak L, Mardis E, Rotimi CN, Slatkin M, Valle D, Whittemore AS, Boehnke M, Clark AG, Eichler EE, Gibson G, Haines JL, Mackay TF, McCarroll SA, Visscher PM. Finding the missing heritability of complex diseases. Nature. 2009 Oct 8;461(7265):747-53.

4. Burdge GC, Hoile SP, Lillycrop KA. Epigenetics: are there implications for personalised nutrition? Curr Opin Clin Nutr Metab Care. 2012 Sep;15(5):442-7.

5. Zinck JW, MacFarlane AJ. Approaches for the identification of genetic modifiers of nutrient dependent phenotypes: examples from folate. Front Nutr. 2014 Jul 14;1:8.

Rheumatoid Arthritis (2 lectures) Luke O'Neill

Lecture 1: What is rheumatoid arthritis? Clinical, molecular and cellular definitions. Early concepts: connective tissue structure and degradation. Rheumatoid Factor. And B cells. HLA associations and the genetic component. Autoantigens. Role of inflammation – prostaglandins and tissue degrading enzymes.

Lecture 2: Key role of cytokines –IL-1, TNF, IL6. Current therapies –NSAIDs, steroids, biologic therapies (anti-TNF, anti-IL-1, anti-IL-6, anti-CD20 and CTLA-4 Ig). Prospect for future therapies.

Autoinflammmatory diseases (2 lectures) Emma Creagh

Lecture 1: Key features of systemic autoinflammatory disorders. Classic hereditary 'Periodic Fever Syndromes' -FMF (Familial Mediterranean Fever), TRAPS (TNF Receptor Associated Periodic Syndrome) and HIDS (Hyperimmunoglobulinemia-D with periodic fever syndrome).
Lecture 2: NLRP3/Cryopyrin-associated periodic syndromes (CAPS): Familial Cold Inflammatory Syndrome (FCAS); Muckle-Wells Syndrome (MWS) and Neonatal onset multisystem inflammatory disease (NOMID). Autoinflammatory disorders associated with skin pustules, such as DIRA (deficiency of IL-1R antagonist), CARD14 mediated psoriasis (CAMPS) and early onset inflammatory bowel diseases (EO-IBD).

Biochemistry of the Respiratory System and Respiratory Disorders (3 lectures) Suzanne Cloonan

Lecture 1: Respiratory biochemistry, the basics. The microscopic anatomy of the lung from airways to alveoli. The mucociliary escalator, the surfactant system, gaseous exchange, airspace defence systems, the extracellular matrix and the pulmonary vasculature.

Lecture 2. Understanding common lung diseases; Chronic Obstructive Pulmonary Disease (COPD), Cystic Fibrosis, Idiopathic Pulmonary Fibrosis, and Lung Cancer.

Lecture 3. Uncontrolled inflammation in the lung; Asthma, Pneumonia and Acute Respiratory Distress Syndrome.

Obesity & Diabetes (5 lectures) Mohamed Hankir

Lecture 1. Obesity & Appetite Control

Lecture 2. Insulin Signalling

Lecture 3. Type 1 Diabetes Pathogenesis

Lecture 4. Type 2 Diabetes Pathogenesis

Lecture 5. Obesity-associated Disorders

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, hemopoeisis, immune cell activation, anti-inflammatory cytokines. Class I cytokine receptors: JAKs and STATs. Specificity in signalling. WSWS 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:

Fijimoto M and Naka T Regulation of cytokine signaling by SOCS family molecules. Trends Immunol. 2003 Dec;24(12):659-66. Review

Horvath CM STAT proteins and transcriptional responses to extracellular signals. Trends Biochem Sci. 2000 Oct;25(10):496-502. Review.

O'Shea JJ et al A new modality for immunosuppression: targeting the JAK/STAT pathway. Nat Rev Drug Discov. 2004 Jul;3(7):555-64. Review.

Baud V and Karin M Signal transduction by tumor necrosis factor and its relatives. Trends Cell Biol. 2001 Sep;11(9):372-7.

Beutler B Inferences, questions and possibilities in Toll-like receptor signalling. Nature. 2004 Jul 8;430(6996):257-63.

Akira, S and Takeda, K Toll-like receptor signalling.
Nat Rev Immunol. 2004 Jul;4(7):499-511.

O'Neill LA After the toll rush.
Science. 2004 Mar 5;303(5663):1481-2.

Inohara N and Nunez G NODs: intracellular proteins involved in inflammation and apoptosis. Nat Rev Immunol. 2003 May;3(5):371-82.

Immunotherapies (5 lectures) Ed Lavelle, 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 (EL) 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.

Viruses & Disease (3 lectures) Gareth Brady

Lecture 1: Viral infections and Anti-Viral Immunity

- Introduction
- Overview of anti-viral immunity and clearance
- Virus-induced inflammation and disease

Lecture 2: Adaptation and Disease

- Host adaptation and species barriers
- Epstein Barr Virus and B cells
- Molluscum Contagiosum Virus and Human Skin

Lecture 3: Emerging Viruses and Pandemics

- Influenza Virus: from seasonal infections to deadly emergent strains
- Coronaviruses: from the common cold to SARS, MERS and COVID-19
- Methods of virus detection and detection of anti-viral immunity

Reading list:

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

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 extra-cellular 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)
Mechanisms of immune evasion employed by bacteria to circumvent host immune responses: inhibition of complement cascade, inhibition of anti-microbial peptides. Mechanisms employed by intra-cellular and extra-cellular bacteria to manipulate phagocytic responses i.e. Inhibition of phagosome maturation, inhibition of intra-cellular killing mechanisms, modulation of apoptosis. Circumvention of adaptive immunity by antigenic variation.

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

Nizet V et al. Understanding how leading bacterial pathogens subvert innate immunity to reveal novel therapeutic targets. J Allergy Clin Immunol. 2007 Jul;120(1):13-22

Flannagan R et al. Antimicrobial mechanisms of phagocytes and bacterial evasion strategies. 2009 Nat Reviews Microbiology 7, 355-366

Harding C.V et al. Regulation of antigen presentation by *Mycobacterium tuberculosis*: a role for Toll-like receptors. 2010 Nat Rev Micro 8(4): 296

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

Underhill D et al. Phagocytosis of microbes: Complexity in action. 2002 Annu Rev Immunol 825-52

El Kebir G et al. The Scientific World Journal 2010 10:1731-1748. Role of Neutrophil apoptosis in the resolution of inflammation

van der Does AM et al. J Leukoc Biol. 2012 Oct;92(4):735-42.Induction of the human cathelicidin LL-37 as a novel treatment against bacterial infections.

Reading list for lectures 3-5:

General

*Bowie and Unterholzner. 2008. Viral evasion and subversion of pattern-recognition receptor signalling. *Nat. Reviews Immunol.* 8, 911-922.
*Gale and Foy. 2005. Evasion of intracellular host defence by hepatitis C virus. *Nature* 413, 939-945.
Santoro et al. 2003. NFκB and virus infection: who controls whom. *EMBO J* 22, 2552-2560.
Katze, He and Gale. 2002. Viruses and Interferon: a fight for supremacy. *Nature Reviews Immunol.* 2, 675-687.
Alcami. 2003. Viral mimicry of cytokines, chemokines and their receptors. *Nature Reviews Immunol.*3, 36-50.

Pattern Recognition Receptors:

*Goubau, Deddouche, Reis e Sousa. 2013. Cytosolic Sensing of Viruses. *Immunity* 38, 855-869.
*Paludan & Bowie. 2013. Immune Sensing of DNA. *Immunity* 38, 870-880.
Carty and Bowie. 2010. Recent Insights into the role of Toll-like receptors in viral infection. *Clinical & Experimental Immunology* 161, 397-406.
*Unterholzner et al. 2010. IFI16 is an innate immune sensor for intracellular DNA. *Nat. Immunol.* 11, 997-1005.
Yoneyama et al. 2004. The RNA helicase RIG-I has an essential function in double-stranded RNA-induced innate antiviral responses. *Nature Immunol.* 5, 730-737.

Poxviruses (e.g. Vaccinia Virus):

Seet et al. 2003. Poxviruses and immune evasion. *Ann. Rev. Immunol.* 21, 377-423.
*Alcami and Smith. 1992. A soluble receptor for IL-1β encoded by vaccinia virus: a novel mechanism of virus modulation of the host response to infection. *Cell* 71, 153-167.
*Symons, Alcami and Smith. 1995. Vaccinia virus encodes a soluble type I interferon receptor of novel structure and broad species specificity. *Cell* 81, 551-560.
Harte et al. 2003. The poxvirus protein A52R targets toll-like receptor signalling complexes to suppress host defense. *J. Exp. Med.* 197, 343-351.
*Stack et al. 2005. Vaccinia virus protein A46R targets multiple Toll-like-interleukin-1 receptor adaptors and contributes to virulence. *J. Exp. Med.* 201, 1007-1018.

*Schröder, Baran & Bowie. 2008. Viral targeting of DEAD box protein 3 reveals its role in TBK1/IKKε-mediated IRF activation. *EMBO J.* 27, 2147–2157.
*Unterholzner et al. 2011. Vaccinia Virus Protein C6 is a Virulence Factor that Binds TBK-1 Adaptor Proteins and Inhibits Activation of IRF3 and IRF7. 2011. ***PLoS Pathogens*** 7, e1002247.

*essential reading, specifically referred to in lecture course.

African trypansomes (8 lectures) Derek Nolan

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 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

(1) Cross, G.A.M. (2001) African trypanosomes in the 21st century: what is their future in science and health*? Int. J. Parasitol.* **31**: 427-433
(2) Borst, P. (2002) Antigenic variation and alleleic exclusion *Cell* **109**: -8.
(3) Pays, E. (2005) Regulation of antigen gene expression in *Trypanosoma brucei Trends Parasitol*. **21**: 517-520.
(4) Pays E. (2006) The variant surface glycoprotein as a tool for adaptation in African trypanosomes. *Microbes and infection* **8**: 30-937.
(5) Field, MC & Carrington, M. (2004) Intracellular membrane transport systems in *Trypanosoma brucei. Traffic* **5**:1-9
(6) Nolan, DP, Garcia-Salcedo, J.A., Geuskens, M., Salmon, D., Paturiaux-Hanocq, F., Pays,A., Tebabi, P. and Pays, E. (2001)
Endocytosis of macromolecules by African trypanosomes. pp127-141 In "World Class Parasites Volume 1: The African Trypanosomes" Eds. Seed, R. & Black, S.J. (Kluwer Academic Publishers)
(7) Stockdale C. et al (2008) PLoS biology Vol6 issue 7 e185 "Antigenic Variation in Trypanosoma brucei: Joining the DOTs"
(8) Navarro M. et al (2007)TRENDS in Microbiology Vol.15 No.6
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Nuclear architecture underlying gene expression in Trypanosoma brucei

Trypanosomes Part II

(1) Pays, E. Vanhamme, L., Vanhollebeke, B**.,** Nolan, D. P.. and Perez-Morga, D. (2006)
The trypanolytic factor of human serum. *Nat Rev Microbiol.* **6**: 477-86.
(2) Vanhollebeke B & Pays E (2010) Mol. Microbiol. **76**: 806-814 The trypanolytic factor of human serum, many ways to enter the parasites, a single way to kill it.
(3) Pays E & Vanhollebeke B (2008) Microbes Infect **10**: 985-989Mutual self-defence: the trypanolytic story
(4) Genovese et al. (2010) Science **329**: 841-845.
Association of trypanolytic ApoL1 variants with kidney disease in African Americans
(5) Pays E. et al. (2014) The molecular arms race between African trypanosomes and humans
Nature Reviews Microbiology VOLUME 12 575-584.
(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 (3 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.

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Lecture 1: Introduction to the major helminth parasites that infect man. Medical and

economic impact of helminth parasites on society.

Lecture 2: Explore key concepts of biology of helminth infections. Wormy people: genetic predisposition to helminth infection. Co-evolution of man and parasitic worms: molecular and biochemical adaptation. The Helminth proteome and genome projects.

Lecture 3: Gastro-intestinal versus systemic (tissue or blood dwelling) worm infections. Modulation of immunity by 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:

***Helicobacter pylori:* A Paradigm Pathogen for Subverting Host Cell Signal Transmission**.(Review article) Naumann M et al (2017) Trends in Microbiology 24 (4) 316-328 PMID:28057411

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

Gut. 2018;67(9):1716-1725. PMID: 29934437

BIU44130 Cancer Biology & Cell Signalling (S2)
(10 credits)

This module covers the cellular and regulatory mechanisms that control the cell cycle. It also covers the molecular basis of a stem cell and its potential use in therapies. Furthermore, it covers the molecular basis of cancer, the progression of the disease and the therapeutic treatment strategies.

Learning outcomes:

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) Andrei Budanov

Lecture 1. Underlying causes of cancer (ABv): 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 (ABv): Many of the original discoveries on oncogenes were derived from work on viruses. The concepts of onocgenes and proto-ocogenes 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 (ABv): 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 suppessor 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 (ABv): 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) Andrei Budanov& Kingston Mills

Lecture 1. Angiogenesis and metastasis (ABv): The process by which cancer cells develop new blood supplies (angiogensis) 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 (ABv): 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 (ABv): 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 (ABv): 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 Imatinab 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:

1. Weinberg RA. (1996) How cancer arises. *Sci. Am*. 275:62-70
2. Gibbs WW. (2003) Untangling the roots of cancer. *Sci. Am*. 289:56-65

3. Hanahan D, Weinberg RA. (2000) The hallmarks of cancer. *Cell*. 100(1):57-70 4. Payne SR, Kemp CJ. (2005) Tumor suppressor genetics. *Carcinogenesis*. 6:2031-45.
5. Prochownik EV. (2005) Functional and physical communication between oncoproteins and tumor suppressors. *Cell Mol Life Sci*. 62:2438-59.
6. Jeggo PA, Lobrich M. (2006) Contribution of DNA repair and cell cycle checkpoint arrest to the maintenance of genomic stability. *DNA Repair (Amst)*. 5:1192-8.
7. Webb CP, Vande Woude GF. (2000) Genes that regulate metastasis and angiogenesis. *J Neurooncol.* 50(1-2):71-87.
8. Fodde R, Smits R, Clevers H. (2001) APC, signal transduction and genetic instability in colorectal cancer. *Nat Rev Cancer*. 1(1):55-67.
9. de Visser KE, Eichten A, Coussens LM. (2006) Paradoxical roles of the immune system during cancer development. *Nat Rev Cancer*. 6:24-37.
10. Crosnier C, Stamataki D, Lewis J. (2006) Organizing cell renewal in the intestine: stem cells, signals and combinatorial control. *Nat Rev Genet.* 7(5):349-59. 11. McDonald SA, Preston SL, Lovell MJ, Wright NA, Jankowski JA. (2006) Mechanisms of disease: from stem cells to colorectal cancer. *Nat Clin Pract Gastroenterol Hepatol*. 3(5):267-74.
12. Immunobiology by Janeway and Travers
13. Cellular and Molecular Immunology by Abbas, Lichtman and Pober

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 of the complexity of normal haematopoeisis 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

Lecture 1. The cell cycle & growth: 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: 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: 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/□H2AX 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: 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: 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 involvment
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
3. Role of MAPS
4. Role of catastrophins
5. Chromosomal sliding & chromosomal oscillations
6. 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:

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:

The Cell Cycle: An Introduction. (1993) Andrew Murray, Tim Hunt Oxford ISBN 0-19-509529-4

Nurse P, Masui Y, Hartwell L. (1998) Understanding the cell cycle. *Nat Med.* 4(10):1103-6

Malumbres M, Barbacid M. (2005) Mammalian cyclin-dependent kinases. *Trends Biochem Sci*. **30**(11):630-41.

Sarbassov DD, Ali SM, Sabatini DM. (2005) Growing roles for the mTOR pathway. *Curr Opin Cell Biol.* **17**(6):596-603.

Prober DA, Edgar BA. (2001) Growth regulation by oncogenes--new insights from model organisms. *Curr Opin Genet Dev.* **11**(1):19-26.

Blow JJ, Dutta A. (2005) Preventing re-replication of chromosomal DNA. *Nat Rev Mol Cell Biol*. **6**(6):476-86.

Niida H, Nakanishi M. (2006) DNA damage checkpoints in mammals. *Mutagenesis.* **21**:3-9.

Bartek J, Lukas J. (2001) Mammalian G1- and S-phase checkpoints in response to DNA damage. *Curr Opin Cell Biol*. **13**(6):738-47.

Nakayama KI, Nakayama K. (2006) Ubiquitin ligases: cell-cycle control and cancer. *Nat Rev Cancer.* **6**(5):369-81.

Loffler H, Lukas J, Bartek J, Kramer A. (2006) Structure meets function-centrosomes, genome maintenance and the DNA damage response. *Exp Cell Res*. **312**(14):2633-40

Ethel Queralt & Frank Uhlmann (2005) More than a separase *Nature Cell Biology* **7**: 930 - 932

Stem cells (5 lectures) Claire Fergus

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
The drosophilia ovary-original study. Establishing the haemopoietic stem cell niche during embryogeneis. Osteoblastic niche and the vascular niche. Relationship between HSC and osteoblasts and endothelial cells during development. Mesodermal dorsal aorta and mesenchymal cells and hemangioblasts. Asymmetric/symmetric division. Cytokines, growth factors, cell-surface molecules and niche activity. The nervous system in HSC-niche regulation.

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:

Welling M, Geijsen N. (2013)Uncovering the true identity of naïve pluripotent stem cells.

Shafa M, Krawetz R, Rancourt DE. (2010) Returning to the stem state: epigenetics of recapitulating pre-differentiation chromatin structure. Bioessays. 32(9):791-9

Ema H, Suda T. (2012) Two anatomically distinct niches regulate stem cell activity. Blood 120(11):2174-81

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.

Lecture 2: Caspases: family of cysteine proteases: 'death executioners' in apoptosis; inflammatory caspases. Activation of caspases. Experimental evidence that caspases are important in apoptosis. Caspase substrates. Caspase Activation via the Intrinsic and Extrinsic Pathways of Apoptosis. Formation of apoptosome. IAPs (inhibitor of apoptosis proteins). Smac/DIABLO which binds to and neutralises IAPs inhibitory activity.

Lecture 3: The Bcl-2 protein family. Primary structure. Subdivided into 'pro-survival' and 'pro-apoptotic' proteins. Regulation of mitochondrial outer membrane integrity by the Bcl2 protein family. BH3 mimetics and cancer therapy. Post-translational modification of Bcl-2 family.

Lecture 4: Death Receptors: signalling and modulation. Examples of death receptors and signalling mechanisms involved: Fas, TNFR1, DR4 and DR5. TNF-R1 induced necroptosis. Mechanisms of RIPK3-mediated necroptosis. Physiological role of necroptosis? TRAIL signalling and modulation of apoptosis by decoy receptors. Induction of apoptosis by cancer chemotherapy. Mechanisms of evasion of apoptosis by tumour cells.

Lecture 5: Role for the tumour suppressor protein p53 in apoptosis. The mitochondrial p53 programme of apoptosis. Exploiting p53 death signalling-implications for cancer therapy. Pyroptosis. Inflammasome Involvement in Pyroptosis. Physiological role of Pyroptosis? Other Modes of Cell Death (Ferroptosis & Parthanatos). Divergent Modes of Cell Death Differ with Respect to DAMP Release.

Reading List:

General cell death mechanisms:

- Galuuzi Let al., Molecular mechanisms of cell death:recommendations of the Nomenclature committee on cell death 2018 Cell Death & Diff. 25, 486-541.
- Green D.R. & Llambi, F. (2015) Cell death signalling Cold Spring Harb Perspect Biol, 7, 1-24

Necroptosis and Pyroptosis:

- Kearney CJ and Martin SJ. (2017) An inflammatory perspective on necroptosis Molecular Cell 65, 965-973
- Tait SWG et al (2014) Die another way-non-apoptotic mechanisms of cells death J. Cell science 127, 2135-2144
- Awad et al., (2018) Inflammasome biology, molecular pathology and therapeutic implications Pharmacol & Ther 187, 133-149

Caspases:

- Shalini S et al (2015) Old, new and emerging functions of caspases Cell Death & Diff.22, 526-539

IAPs:

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

Intrinsic apoptotic pathway:

- Schafer, ZT and Kornbluth S. (2006) The Apoptosome: Physiological, Developmental, and Pathological Modes of Regulation Dev Cell 10, 549-561.
- Donovan M. & Cotter T.G. (2004) Control of mitochondrial integrity by Bcl-2 family members and caspase-independent cell death. *Biochim. Biophys. Acta.* 1644, 133-147.

Extrinsic apoptotic pathway:

- Guicciardi, ME and Gores, GJ (2009) Life and death by death receptors. The FASEB Journal 23, 1625-1637

Cancer:

- Fulda, S. (2008) Tumour resistance to apoptosis. Int. J. Cancer 124, 511-515
- Fernald K & Kurokawa (2013) Evading apoptosis in cancer. Trend in Cell Biol. 23, 620-633.

- Houston A. and O'Connell, J. (2004) The Fas signalling pathway and its role in the pathogenesis of cancer Curr Opinion in Pharmacology 4, 321-326.
- Ni Chonghaile T and Letai A (2009) Mimicking the BH3 domain to kill cancer cells Oncogene 27, S149-S157

p53:

- Vaseva AV and Moll UM. (2009) The mitochondrial p53 pathway Biochim et Biophys Acta 1787, 414-420.
- Yoshida, K. and Miki, Y. (2010) The cell death machinery governed by the p53 tumour suppressor in response to DNA damage Cancer Sci 101, 831-835.

Autophagy (2 lectures) Andrei Budanov

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