



Trinity College Dublin

Coláiste na Tríonóide, Baile Átha Cliath

The University of Dublin

School of Biochemistry and
Immunology

SS Immunology 2022–2023



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Welcome

Dear SS Immunology students

Welcome to Senior Sophister year, the culmination of your Immunology degree. The SS year is an opportunity to really engage with Immunology as a subject in greater depth, including in particular the capstone research project.

Covid-19 had an impact on how last year operated, particularly with respect to the semester one examinations (which were run on-line) and the layout of the semester two examination papers, but the hope is that we will be able to return fully to our normal pre-Covid schedule this year. If this has to change for any reason, we have contingency plans in place and you will be updated with any changes.

We do however need to continue to exercise caution with respect to Covid-19 and while mask wearing is not currently mandatory, we recommend wearing them in lecture settings, library and other venues where people may be in close quarters. We know this mitigation is effective in limiting transmission.

If you cannot attend lectures in person due to being positive for Covid-19, you will be offered access to the learning resources and opportunities necessary to fulfil the learning outcomes, for example access to pre-recorded lectures, supplementary reading resources or detailed notes. As was the case last year, it will be sufficient for students to self-certify that they have Covid-19 through provision of a screen shot of a positive PCR or Antigen test.

For now, please take your time going through the booklet and the information therein. It has a lot of important information including deadlines for various activities. A copy of the booklet is on Blackboard under Module BIU44290.

If you have any problems during the year which affect your academic studies, please speak to me in confidence. I am here to help.

I look forward to working with you over the following year.

Andrew Bowie

SS Course co-ordinator: agbowie@tcd.ie Direct line: 8962435

SENIOR SOPHISTER MODULES

60 Credits

BIU44290 CAPSTONE PROJECT IN IMMUNOLOGY (S1) (20 credits)

The module comprises of an original research project in Immunology 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 scientist. Students will be trained in data handling as well as solving quantitative problems in Immunology. In addition, this module will introduce students to a wide array of cutting edge techniques and strategies used in scientific research.

BIU44210 GENERAL IMMUNOLOGY (S2) (10 credits)

This module covers key aspects of systemic and mucosal Immunology including NK cells, B cells and also organ specific Immunology: reproductive, liver, GI and Immunology. There is also a series of lectures on Immune signalling which includes cell death pathways, cytokine signalling, cytokine processing and immunometabolism.

BIU44220 INFECTION AND IMMUNITY (S2) (10 credits)

This module focuses on specific aspects of the immune response against a range of pathogens including viruses, bacteria (extracellular and intracellular), helminths and trypanosomes. Biochemical and genetic mechanisms by which bacteria, viruses and parasites evade the host immune responses will be covered. Finally, there is a series of advanced lectures on vaccines and adjuvants.

BIU44230 IMMUNOLOGICAL DISEASES AND IMMUNOTHERAPY (S2) (10 credits)

This module covers diseases in which the immune system is known to play a role, either in pathology of disease or in potential treatment of the disease. Diseases covered include rheumatoid arthritis, autoinflammatory diseases and obesity. Lectures also cover some neuroimmunology and associated diseases e.g. multiple sclerosis. Finally, given the importance of the immune system in cancer, there are a series of lectures on cancer initiation, progression and conventional treatment along with key immunological aspects including the immune response to cancer, cancer immune evasion and the exploitation of the immune system in a range of cancer immunotherapies.

NOTE: Learning outcomes for each of the modules can be found in the detailed module descriptors later in the booklet (pg 21).

Staff contact details

The SS course coordinator is Prof Andrew Bowie (extension 2435; agbowie@tcd.ie). The Head of School is Prof. Derek Nolan (extension 2455; denolan@tcd.ie) and Prof. Vincent Kelly is the Director of Undergraduate Teaching and Learning (kellyvp@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. The names of small group tutorial tutors are provided below. A complete list of the Biochemistry and Immunology Staff can be found at <https://www.tcd.ie/Biochemistry/people/>

SS Immunology Staff Tutorial groups 2022-2023

STUDENT	ASSIGNED TUTOR
Andreea Atanasescu	Prof. Ed Lavelle (lavellee@tcd.ie)
Josephine Douglas	
Orlaith Henry	
Hollie Austen-Byrne	Prof. Clair Gardiner (gardinec@tcd.ie)
Maegen Fleming	
Adam Keely	
Emma Byrne	Prof. Cliona O'Farrelly (ofarrecl@tcd.ie)
Emily Grace	
Sarah Lawler	
Kieran Byrne	Prof. Kingston Mills (Kingston.mills@tcd.ie) (TBC)
Siofra O'Brien	
Connor Corrigan	Prof. Andrew Bowie (agbowie@tcd.ie)
Craig Murphy	
Evan Lynch	
Shane Cox	Prof. Rachel McLoughlin (mcloughrm@tcd.ie)
Anna Swirk	
Jordan Page	
Megan Healy	Prof. Luke O'Neill (laoneill@tcd.ie)
Clare Jones	
Oscar Vallejo	

Tutors have been chosen randomly. Please **contact your tutor during the first week of the first semester**. You are **expected to attend a tutorial approximately every two weeks**. Your tutor will set various exercises and these should help you in your final examinations.

Addresses and Phone Numbers:

Please send your College based address, e-mail address and telephone number (if any) 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.

Academic Matters

Timetable, face-to-face and remote learning

As you know, CMIS is the official college timetable but we are likely to rely on locally produced information for Semester One. 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, practical classes, in-course assessments and examinations, either on-line or face to face. 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 term or fails to complete assignments may be declared 'non-satisfactory'. Non-satisfactory returns are made to the Senior Lecturer; such students may be refused permission to take the annual examination and may be required by the Senior Lecturer to repeat the year.

From College Calendar General Regulations: 2022-23

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 academic year is 40 weeks from the start of Semester one 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 Immunology	BIU44290	20 ECTS
2) Advanced Research Skills	BIU44010	10 ECTS
3) General Immunology	BIU44210	10 ECTS
4) Infection and Immunity	BIU44220	10 ECTS
5) Immunological diseases and immunotherapy	BIU44230	10 ECTS

SS year is broken down into a total of 60 credits (600 marks).

Capstone Project in Immunology (BIU44290) Value: 20 ECTS

Research Project in Immunology (BIU44290) Value: 20 ECTS

An 11-week research project and thesis. **Project laboratory work will start on Monday September 12th and terminate on Friday 25th 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 25th 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 23rd January 2023.** 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 3000 words for the introduction and a total of 10,000 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 Monday 6th February. For every working day that your thesis is late 2% will be deducted from your mark.** Please submit your thesis to Blackboard under module BIU44290. More detail 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 6th 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 10th 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 Dr Audrey Carroll (Preparation Room) will advise you about the presentation of your poster and print it for you. Further details on Project write-ups and poster presentations will be given at the end of semester 1.

Project Marking Scheme:

Lab performance: 15% (awarded by supervisor)

Thesis: 65% (awarded by supervisor & 1 other staff member)

Oral presentation: 15% (awarded by panel of 3 staff members)

Poster presentation: 5% (awarded by 2 staff members)

Copy of mark sheets and criteria for SS project, thesis and poster can be found below (from page 46)

- Lab performance report (supervisor only; 15%)
- Project thesis (supervisor's report – made available without mark to 2nd marker)
- Project thesis (2nd marker) – marks independently, meets and agrees mark with supervisor (65% of the project mark)

Note: if the supervisor and the 2nd markers are more than 10% apart, the thesis will be given to a third marker before a final mark is agreed.

Advanced Research Skills (BIU44010)

Value: 10 ECTS

This module covers quantitative biochemical problems, bioinformatics (sequence analysis), comparative medicine and a series of group presentations by students on various biochemical techniques. A series of 18 lectures will also introduce students to a wide array of cutting edge techniques and strategies used in biochemistry. Marks (**100**) for this module are awarded through continual assessment and 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 21st October and Problem Exam 2 – Monday 12th 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 13th 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 26th and 27th 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 14th December; answer 3 out of 4 essay style questions. (**45 marks** in total).

Quantitative Problem Tutorials:

An online 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). Tutorials will be delivered by Dr Hayes on Blackboard. 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 (BIU44210) General Immunology

Value: 10 ECTS

Exam paper (100 marks) divided into 4 sections of equal weighting as follows:

Section 1: Systemic and mucosal Immunology (Answer 1 out of 2 questions)	25marks
Section 2: Immune signalling and immunometabolism (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)	25 marks

Paper 2 (BIU44220) Infection and Immunity

Value: 10 ECTS

Exam paper (100 marks) divided into 4 sections of equal weighting as follows:

Section 1: Immune response to pathogen (Answer 1 out of 2 questions)	25marks
Section 2: Antimicrobial resistance and immune evasion (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)	25 marks

Paper 3 (BIU44230) Immunological diseases and Immunotherapy

Value: 10 ECTS

Exam paper (100 marks) divided into 4 sections of equal weighting as follows:

Section 1: Immunological diseases (Answer 1 out of 2 questions)	25marks
Section 2: Cancer and Immunotherapies (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)	25 marks

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

Vivas

On completion of their semester 2 examinations, **some students may be required to sit an in-person *viva voce* examination with the External Examiner** (Prof. Kevin Maloy, University of Glasgow, UK). 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.

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 blip in an otherwise very consistent set of marks they may wish to follow this up. The Extern may also ask you if there is a topic 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 e.g. 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.

Prizes & Medals

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 given 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.

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 12th. You must register, by E-mail or if required in person, with the Safety Officer (Dr. Darren Fayne) once you commence your project. This is necessary in order to record your next-of-kin details in the unlikely event of an accident, to record where you will be working, to ascertain whether or not you have to work with major hazards during your project work (carcinogens, mutagens, cyto-toxics, biological agents, GMOs, radioactivity, etc), and to ensure that you and your supervisor understand that you have to conduct a HIRAC review (hazard identification, risk assessment and risk control) of the proposed work. (see below).

2) Formal Health and Safety Briefings

Mr Liam McCarthy (Chief Technical Officer) will describe the general management and security features of the building at an introductory briefing. Dr Darren Fayne, the School Safety Officer will give you two formal Health and Safety briefings. **ATTENDANCE OF 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.

If you intend working with radioactivity during your project you must first contact the School Radiological Protection Supervisor, Dr Darren Fayne (fayned@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, Darren Fayne (fayned@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).

6) Students with Disabilities

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

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.

Plagiarism

NB – READ THIS SECTION PROPERLY

While plagiarism has always been a serious offense (as detailed in the College Calendar), 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.

Take care when studying and pre-preparing essays as you may plagiarise in your notes and accidentally reproduce that in exams.

Sanctions for plagiarism depend on the activity and the severity and will be discussed with the DUGTL. These include deeming the work inadmissible, requiring to repeat as a second attempt; requiring to repeat exam with a capped mark and/or an official mark on your college transcript.

Note: We fully appreciate it is not always possible to avoid similarities related to scientific terminology and this is always taken into account in these assessments.

The full statement of College's policy on plagiarism (see Calendar, General Regulations and Information, at <http://tcd-ie.libguides.com/plagiarism>) 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 what exactly constitutes plagiarism. Ignorance is not an acceptable defence.**

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

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

I have read and I understand the plagiarism provisions in the General Regulations of the University Calendar for the current year, found at: <http://www.tcd.ie/calendar>

I have also completed the Online Tutorial on avoiding plagiarism 'Ready, Steady, Write', located at <http://tcd-ie.libguides.com/plagiarism/ready-steady-write>

Calendar regulations on plagiarism 2022/23

95 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.

96 Examples of Plagiarism Plagiarism can arise from actions such as: (a) copying another student's work; (b) enlisting another person or persons to complete an assignment on the student's behalf; (c) procuring, whether with payment or otherwise, the work or ideas of another; (d) quoting directly, without acknowledgement, from books, articles or other sources, either in printed, recorded or electronic format, including websites and social media; (e) paraphrasing, without acknowledgement, the writings of other authors. Examples (d) and (e) in particular can arise through careless thinking and/or methodology where students: (i) fail to distinguish between their own ideas and those of others; (ii) fail to take proper notes during preliminary research and therefore lose track of the sources from which the notes were drawn; 48 Calendar 2020-21 (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.

97 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.

98 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.

99 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>.

100 If plagiarism as referred to in §95 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.

101 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 §100 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.

102 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 Calendar 2020-21 49 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.

103 Provided that the appropriate procedure has been followed and all parties in §100 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.

104 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 2022-2023

Progression regulations: Bachelor programmes³

58 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. 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 3See individual entries for applicable certificate and diploma course progression regulations. 38 Calendar 2020-21 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.

59 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.

60 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 failed components of all modules for which they obtained a fail and/or a qualified pass.

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

62 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.

63 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).

64 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.

65 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.

Class Descriptors: These Science Faculty Descriptors are given as a guide to the qualities that assessors are seeking in relation to the grades usually awarded. A grade is the anticipated degree class based on consistent performance at the level indicated by an individual answer. In addition to the criteria, listed the Department's examiners will also give credit for evidence of critical discussion of 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 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 misunderstandings, 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 a sound answer to the misinterpretation of a 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 a question.

Paper 1– BIU44210 General Immunology**Section 1: Regional Immunology****Answer 1 of 2 questions**

ILC including NK cells (CG)
B cells & their contribution to disease. (MC)
Reproductive immunology (COF)
Liver immunology (COF)
Gastrointestinal tract (EL)
Respiratory immunology (RMcL)
The brain and immune privilege (CC)

Section 2: Immune signalling**Answer 1 of 2 questions**

Cell death pathways (DZ)
Cytokine signalling (LON)
Immunometabolism (DF/LON)

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

General/philosophical questions

Section 4: 'Quickie/Short questions'**Answer 4 out of 7 questions****Paper 2– BIU44220 Infection and Immunity****Section 1: Immune response to prokaryotic pathogens****Answer 1 of 2 questions**

T cell differentiation and regulation (KM)
T cell immunity to bacterial and viral infections (KM)
Immune response to TB (FS/JK)
Prokaryotic pathogens (HW)
Microbiome (SC)
Viral immune evasion (AB)
Antimicrobial resistance (RMcL)

Section 2: Immune response to eukaryotic pathogens/vaccines**Answer 1 of 2 questions**

Helminths of human importance (PF)
Trypanosomes (DN)
Viruses and disease (GB)
Vaccines, adjuvants and the hygiene hypothesis (EL)

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

General/philosophical questions

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

Paper 3– BIU44230 Immunological diseases and immunotherapy

Section 1:

Answer 1 of 2 questions

Rheumatoid arthritis (LON)
Autoinflammatory diseases (EC)
Obesity and inflammation (LL)
Genetics of inflammatory diseases (RMcM)
Neuroimmunology (CC/AD)
MS&EAE (KM/JF)

Section 2: Cancer

Answer 1 of 2 questions

Initiation & Progression (VK)
Metastasis, cancer stem cells & Treatment (VK/KM)
Immune response to cancer (KM/CG)
Immunotherapy (LL/CG)

Section 3: General

Answer 1 of 3 questions

General/philosophical questions

Section 4: 'Quickie/Short questions'

Answer 4 out of 7 questions

SS Lecture Course Summaries and Learning Outcomes for modules

2022-2023

BIU44290 CAPSTONE PROJECT IN IMMUNOLOGY (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 Immunology. Design and implement a wide range of experimental procedures, critically analyse and interpret experimental data, synthesise hypotheses from a wide range of information sources, critically evaluate research literature and write a research 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
- Write about a specialised research area of Immunology in depth
- Work effectively as an individual and in a team and exercise initiative and personal responsibility
- Display computer literacy and use advanced computer skills to aid in conducting scientific research
- Communicate results of research project effectively with the scientific community
- Show that they have acquired the learning skills to undertake further research with a high degree of autonomy

Learning outcomes:

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

- Describe the cells and molecules involved in the induction and regulation of innate and adaptive immune responses
- Demonstrate an understanding of the complexities and unique aspects of systemic and local organ immunology including organs such as the uterus, liver, GI tract, respiratory system and brain
- Recall and integrate key knowledge and concepts about important cell signalling pathways including cell death, cytokine signalling and cytokine processing pathways
- Integrate biochemistry and immunology analyses to critically understand the impact of immunometabolism on the immune response

Systemic and mucosal Immunology**B cells and contribution to disease (2 lectures) Michael Carty**

Lecture 1: Discovery and history of B cells will be given as will a detailed description on the activation of B cells. B cell subtypes and regulation will also be described in detail.

Lecture 2: A detailed description of antibody production will be given. Dysregulation of this system will be described in disease processes. Therapeutic manipulation of B cells and humoral immunity will also be provided in inflammatory diseases and other conditions.

ILC including Natural Killer Cells (3 lectures) Clair Gardiner

Lecture 1: Main ILC populations and key characteristics

Lecture 2: NK cell functions and how these are regulated

Lecture 3: Clinical importance and emerging concepts including trained immunity.

Reproductive Immunology (1 lecture) Cliona O'Farrelly

This will introduce students to the basics of reproductive immunology. Against a background of some basic anatomy, physiology and endocrinology of the human male and female reproductive tracts, current understanding of local immune mechanisms and their regulation will be presented. The effects of immunoregulatory abnormalities on related pathologies will be introduced, in particular endometriosis, infertility, sexually transmitted infection and cervical cancer. In this context, the potential for immunotherapeutic interventions will be explored. Students will have the opportunity to visit the National Maternity Hospital at Holles St where the Director of the Merrion Fertility Clinic will give some insight into current major clinical challenges.

Liver Immunology (1 lecture) **Cliona O'Farrelly**

This will introduce students to the fundamentals of liver immunology. Against a background of some basic anatomy and physiology of human liver, current understanding of local immune mechanisms and their regulation will be presented. The effects of immunoregulatory abnormalities on related pathologies will be introduced, in particular liver metastasis, transplant rejection and HCV infection. In this context, current immunotherapeutic interventions and the potential for new developments will be explored. Students will have the opportunity to visit the National Liver Transplant Centre at St.Vincent's University Hospital, where one of the hepatobiliary surgeons or pathologists will give some insight into current major clinical challenges facing hepatology.

Gastrointestinal tract (3 lectures) **Ed Lavelle**

Lecture 1: Overview of gut associated lymphoid tissue, Peyer's patches, inductive and effector sites. Uptake of antigens across epithelial surfaces.

Lecture 2: Dendritic cells and T cells in the gastrointestinal tract. Homing of gut T cells

Lecture 3: Mucosal humoral immunity. IgA responses and their regulation.

Respiratory tract (3 lectures) **Rachel McLoughlin**

Lecture 1: Introduction to the basic biology of the respiratory tract: conducting airways, mucosal surface, lung parenchyma and organization of the lung immune system. Understanding the concept that the lung is continually exposed to foreign antigens and must discriminate between recognition of innocuous environmental antigens and pathogenic antigens.

Lecture 2: Roles played by individual cells in regulating immune response in the lung: airway epithelial cells, alveolar macrophages, regulatory T-cells, T-cell homing to lung, innate lymphoid cells

Lecture 3: Immunological challenges faced by the lungs: Infection, Allergic disease (Asthma), inflammatory disease (COPD), toxin exposure (Cigarette smoke)

Brain (1 lecture) **Colm Cunningham**

This lecture will outline the status of the brain as an immune privileged organ, including historical perspectives on how this view emerged and recent studies that illustrate the relative nature of privilege and the propensity of tolerance to CNS antigens to be overcome in diseases such as multiple sclerosis.

- **Galea I**, Bechmann I, Perry VH. (2006) *What is immune privilege (not)*, TRENDS in Immunology 28(1)
- **Louveau A**, Harris, TJ, **Kipnis J** (2015) Revisiting the mechanisms of CNS Immune Privilege. Trends in Immunology 36(10) 569-577
- **Engelhardt** et al., (2017) The movers and shapers in immune privilege of the CNS. Nat Immunol. 2017 Feb;18(2):123-131. doi: 10.1038/ni.3666.
- **Sospedra M**, Martin R. (2005) Immunology of multiple sclerosis. Annu Rev Immunol. 2005;23:683-747.
- **Yednock TA**, Cannon C, Fritz LC, Sanchez-Madrid F, Steinman L, Karin N (1992) Prevention of EAE by antibodies against a4b1 integrin. Nature, vol 356
- **Ransohoff, R.** Natalizumab for multiple sclerosis. New England Journal of Medicine 356 (25), 2622-2629

Immune signalling lectures

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:

- Galuzzi 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. & Llampi, 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 Opin 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.

Cytokine Signalling (5 lectures) Luke O'Neill

Lecture 1: Cytokine families: interleukins, interferons, tumour necrosis factors, chemokines, colony stimulating factors. Properties and functions: inflammation, hemopoiesis, immune cell activation, anti-inflammatory cytokines. Class I cytokine receptors: JAKs and STATs. Specificity in signalling. 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. Suppressors 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 NF- κ B and apoptosis. Mechanism of activation of NF- κ B. 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.

Cytokine processing (2 lectures) Seamus Martin

Lecture 1. IL-1 family cytokines, structure, function, signaling and secretion. The role of IL-1 family cytokines as canonical damage-associated molecular patterns (DAMPs).

Lecture 2. Processing and activation of IL-1 family cytokines by endogenous proteases (caspases, neutrophil proteases) and allergen and pathogen-derived proteases.

Immunometabolism (5 lectures) David Finlay and Luke O'Neill

Lecture 1. **Cellular metabolism + immune cells (David Finlay)** Overview of metabolic pathways. Discuss why cells adopt different metabolic configurations. Outline the metabolic configurations used by different immune subsets.

Lecture 2. **Macrophage immunometabolism (Luke O'Neill)**

Metabolic changes during macrophage polarization, roles of key metabolites in M1 and M2 macrophages. Role of mitochondria as signal generator in macrophages.

Lecture 3. **Lymphocyte immunometabolism (David Finlay)**

Central role for metabolism in the control of lymphocyte activation, differentiation and function; Effector, regulatory and memory T cells, NK cells and B cells.

Lecture 4. **Nutrients and the tumour microenvironment (David Finlay)** Discuss nutrient availability to immune cells and nutrients as fuels and key regulators of immune signalling. Focus on how the tumour

microenvironment can alter immune function through altering nutrient levels. Potential for improved anti-cancer immunotherapy through manipulation of metabolism and nutrient levels.

Lecture 5. Targeting metabolism to treat inflammatory and infectious disease (Luke O'Neill)

Prospects of targeting metabolism to treat inflammatory and infectious diseases. Current therapies that target metabolism: metformin, rapamycin and methotrexate. Solute carriers, PKM2, SDH and GAPDH as examples.

BIU44220 Infection and Immunity (S2) (10 credits)

Learning outcomes:

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

- Integrate knowledge about how the innate and adaptive immune systems work together to eliminate bacterial and viral pathogens.
- Demonstrate understanding of how different immune responses are required depending on the type of pathogen e.g. intracellular bacteria, helminths, viruses and trypanosomes
- Critically evaluate how pathogens subvert both innate and adaptive immune responses
- Evaluate how our current understanding of vaccines informs requirements for development of new safe and effective injectable and mucosal vaccines

T cell differentiation and regulation (2 lectures) Kingston Mills

Lecture 1. T cell subtypes, antigen presentation and T cell differentiation'.

Lecture 2. Natural and induced regulatory T cells. Regulatory T cells in infectious diseases. Role of anti-inflammatory cytokines produced by innate cells and T cells in subversion of immunity to infection.

T cell immunity to bacterial and viral infection (2 lectures) Kingston Mills

Lecture 1: The bridge between innate and adaptive immunity. Pathogen activation of macrophages and dendritic cells through pattern recognition receptors. Role of dendritic cells in directing T cell subtypes.

Lecture 2: Role of Th1/Th2 cells in immunity to infection, including HIV, hepatitis C virus and *Bordetella pertussis*.

Viral Evasion of innate and adaptive immunity (4 lectures) Andrew Bowie

Lecture 1: 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 2: Innate immune sensing of viral nucleic acids (RNA and DNA) and self:non-self discrimination.

Lecture 3: 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.

Lecture 4: Viral interference with Interferon induction and function. What poxviral proteins have taught us about innate immune signalling.

Reading list:

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

Antimicrobial resistance and the host response to bacterial infection (2 lectures) Rachel McLoughlin

Lecture 1: Mechanisms of antimicrobial resistance in bacteria. Epidemiology of antimicrobial resistant bacterial infections. The limitations of antibiotics as therapeutic strategies.

Lecture 2: Targeting the host immune response for the development of vaccines and immunomodulatory therapies to treat bacterial infection. Case study *Staphylococcus aureus* (MRSA) infections.

The immune response to tuberculosis (3 lectures) Frederick Sheedy & Joe Keane

Lecture 1 (FJS): The innate immune response to tuberculosis; a model for pathogen evasion of the human host response. The alveolar macrophage and recruited inflammatory cells. First contact – Phagocytosis & Pattern Recognition.

Lecture 2 (FJS): The adaptive immune response to TB – the TB granuloma; prison for the live bug. T-cells, IFN γ and TNF orchestrating the granulomatous response.

Lecture 3 (JK): Clinical aspects of TB & the emergence of multi-drug resistance. TNF blockers and reactivation of tuberculosis. The efficacy of BCG vaccination.

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:

Insights into host responses against pathogens from transcriptional profiling. Jenner et al. *Nat Rev Microbiol* (2005)3 (4), 281-94

The impact of the microbiota on the pathogenesis of IBD: lessons from mouse infection models S *Nell, S Suerbaum & C Josenhans* *NAT REV MICROBIOL* (2010) 8 (8) 564-77.

What are the consequences of the disappearing human microbiota? *MJ. Blaser & S Falkow* *NAT REV MICROBIOL* (2009) 7 (12) 887-94.

Helicobacter pylori: gastric cancer and beyond. [Polk DB](#), [Peek RM](#) *Nat Rev Cancer*. (2010)10(6):403-14.

Microbiome in health and disease (2 lectures) Sinead Corr

In these two lectures we will discuss the influence of our microbial inhabitants, termed the Microbiome, on development of normal host physiology and nearly all aspects of human health

and wellbeing. We will discuss what happens when this Microbiome becomes disturbed and the inflammatory, autoimmune and metabolic conditions which arise. We will also discuss the current strategies which have been developed to manipulate the Microbiome and restore health.

African trypanosomes (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 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 become 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 allelic 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
doi:10.1016/j.tim.2007.04.004
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**: 985-989
Mutual 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.

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

Lecture 3: 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.

Viruses and 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

Vaccines, adjuvants and the danger hypothesis (5 lectures) Prof. Ed Lavelle

Lecture 1: Basic concepts in vaccine development. Traditional approaches to vaccination. Nature and mode of action of vaccines in current use.

Lecture 2: Vaccine adjuvants. Inert particulate and live bacterial and viral delivery systems. Toxin/lectin and toll like receptor-based adjuvants.

Lecture 3: Mucosal vaccines. Distinctive features of the mucosal immune system and implications for vaccination. Mucosal vaccine adjuvants and delivery systems.

Lecture 4: Vaccines for neonatal immunisation. Therapeutic vaccines.

Lecture 5: Danger theory. Endogenous danger signals in innate immune activation, role of danger signals in efficacy of vaccine adjuvants.

BIU44230 Immunological diseases and Immunotherapy (S2) **(10 credits)**

Learning outcomes:

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

- Critically evaluate the contribution of immunology to a range of important human diseases including autoimmunity (rheumatoid arthritis), autoinflammatory diseases, obesity and neurological diseases
- Describe the genetic, metabolic and cellular alterations in cancer and outline the process of metastasis
- Integrate knowledge of Immunology and cancer to understand how the immune system fights cancer and how cancer impacts on it
- Discuss the potential and limitations of targeting the immune system during immunotherapy against cancer.

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.

Autoinflammatory 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 (CAMP5) and early onset inflammatory bowel diseases (EO-IBD).

Obesity and Inflammation (3 lectures) Lydia Lynch

Lecture 1: Obesity and co-morbidities: In addition to heart disease and diabetes, obesity is associated with many immune related disorders, including infection, vaccination failure, cancer. Several mechanisms underlie these risks including changes in lipids, hormones etc. having a direct

effect on the tumor. Immune defects in obese humans are also found. Mouse models of obesity to be introduced.

Lecture 2: The adipose tissue immune system: Adipose resident immune cells, including ILCs, iNKT, gd T cells, NK cells, macrophages and adaptive immune cells. Parabiosis studies. Regulatory cytokine production Their unique functions in adipose tissue compared to elsewhere.

Lecture 3: The role of the adipose immune system in health and disease: The function of the adipose resident immune system for homeostasis in the lean healthy state, and how it responds to external stimuli like cold, and to diet and obesity. How inflammation starts in adipose tissue and the role adipose immune cells play in controlling systemic metabolism.

Multiple Sclerosis and EAE (3 lectures) Jean Fletcher, Kingston Mills

Lecture 1: Breakdown of tolerance in autoimmunity. Risk factors, pathogenesis, diagnosis and monitoring of MS

Lecture 2. MS therapies: Mechanisms of action, efficacy, side effects.

Lecture 3: EAE. Role of innate and adaptive immunity in pathogenesis of autoimmune diseases. Role of regulatory T cells in preventing autoimmune diseases.

Inherited traits in health and disease (2 lectures) Ross McManus

Part 1: Genetics of disease: why is this approach useful?

Part 2: What is Genomics and how are such studies carried out?

Part 3: Genomics of 2 examples of inflammatory diseases: Inflammatory Bowel Disease (IBD) and Celiac Disease

Neuroimmunology (5 lectures) Colm Cunningham and Aisling Dunne

Lecture 1 (CC): This lecture will focus on innate immune responses during acute insults such as brain infection, stroke and traumatic brain injury, chiefly mediated by the brain resident macrophage population, the microglia, and will outline special regulatory features of the brain that modulate such responses.

Lecture 2 (AD): This lecture will cover the response of glia to infection and sterile inflammatory insults. Aspects of Pattern recognition Signaling, pathogen-associated molecular patterns (PAMPs) and damage- associated molecular patterns (DAMPs) will be discussed as will the pathways involved in regulation of microglial activation.

Lectures 3&4 (CC):These two lectures will then examine the role of the immune system (and immunotherapy) in chronic neurodegenerative disease states such as Alzheimer's disease.

Lecture 5 (CC): The final lecture examines how systemic inflammatory responses impact on brain function and behaviour (Sickness Behaviour, metabolic changes) and how these produce deleterious effects when superimposed on chronic brain disease (delirium and progression of disease).

Microglial activation states, DAMPs, PAMPS, regulators.

Ransohoff, R.M. & Perry, H.V. Microglial Physiology: Unique Stimuli, Specialized responses. Annual Review Immunology (2009) 27: 119-145.

Carty, M. & Bowie, A.G Evaluating the role of Toll-like receptors in diseases of the central nervous system. (2011) 81: 825-837.

Lucin and Wyss-Coray (2009) Immune activation in brain aging and neurodegeneration: too much or too little? Neuron 64(1):110-22.

Alzheimer's disease and Immunotherapy

Van Dyck, C (2018) Anti-Amyloid- β Monoclonal antibodies for Alzheimer's Disease: pitfalls and promise. Biological Psychiatry.

Karran & De Strooper (2016) The amyloid cascade hypothesis: are we poised for success or failure. J. Neurochem. Oct;139 Suppl 2:237-252. doi: 10.1111/jnc.13632.

Inflammatory mediator actions in the brain/sickness behaviour

Konsman JP, Parnet P, Dantzer R. (2002) Cytokine-induced sickness behaviour: mechanisms and implications. Trends Neurosci. 25: 154-159.

Saper CB, Romanovsky AA, Scammell TE. (2012). Neural circuitry engaged by prostaglandins during the sickness syndrome. Nature Neuroscience 15; 1088-1095

Cunningham C. (2013) Microglia and Neurodegeneration, the role of systemic inflammation. Glia. Jan;61(1):71- 90. doi: 10.1002/glia.22350.

Cancer Initiation & Progression (4 Lectures) Vincent Kelly

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

Lecture 2. Oncogenes and tumour suppressor genes (VK): Many of the original discoveries on oncogenes were derived from work on viruses. The concepts of oncogenes and proto-oncogenes will be discussed such as *src* and the Rous sarcoma virus and there will be an in depth examination of the ras oncoprotein pathway and 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 Knudson's two-hit model and haploinsufficiency. The mode of action of tumour suppressors such as APC, MSH2, MLH1, BRCA1, p53 will be examined with particular focus on p53, Rb and APC.

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

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

Metastasis and Cancer Treatments (4 Lectures) Vincent Kelly

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

Lecture 2. Colon cancer, genetics and epigenetics: 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: 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 stem 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 stem cells to cancer development and treatment will be considered.

Lecture 4. Cancer treatment: Classical anti-cancer drugs such as antimetabolites, alkylating agents and antimetabolic 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 Imatinib 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.

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

Cancer Immunology & Immunotherapy (7 lectures) Kingston Mills, Clair Gardiner, Lydia Lynch

Lecture 1. Normal immune response to tumors (KM). Adaptive immune response, including CTL, Th1, Treg cells, IFN- γ , IL-17. Innate immune response, including dendritic cells, macrophages, myeloid derived suppressor cells, $\gamma\delta$ T cells, NK cells.

Lecture 2: Cancer Immune evasion (CG) Selection of cells that facilitate immune evasion. Soluble factor secretion e.g. TGF β , IL10; secretion of receptor ligands e.g. MICA/B for down regulation of NKG2D; dysregulation of signalling networks e.g. CD155 axis; platelet coating of circulating tumour cells etc.; deletion of MHC region and regulation of its expression – impact on CTL and NK cells; impact of cancer microenvironment on immune cell metabolism; challenges of immunosuppressive environment to therapies.

Lecture 3: Immunotherapeutic antibodies in cancer treatment (CG). Ehrlich's concept of 'magic bullet' - successful antibody therapies and their MOA including rituximab, herceptin etc. Cytotoxic conjugates; bispecific antibodies; anti-cytokine antibodies; positive and negative regulation of receptors - concept of immune check point inhibitors (e.g. Anti-KIR).

Lectures 4 & 5: (KM) Specific and non-specific therapies that target innate and adaptive immune response. This will include whole tumor and peptide vaccines, dendritic cell vaccines, TLR agonists, BCG, immune checkpoint inhibitors, inhibitors of Pi3 kinase, depletion/inhibition of Treg cells.

Lectures 6 & 7: (LL) These lectures will cover adoptive cellular immune therapies. This includes allogeneic use of immune cells including primary $\gamma\delta$ T cells, NK cells and 'off the shelf' type products. Autologous cell therapies will also be discussed. Finally, the contribution and potential of CAR-T and CAR- NK cells for cancer immunotherapy will be covered.

BIU44010 Advanced Research Skills (S1) **(10 credits)**

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

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

There are 5 components in this module

1. Technique lectures
2. Group techniques
3. Quantitative problems
4. Sequence analysis
5. Comparative Medicine

1. Technique lectures (18 hours)

- Flow Cytometry & Cell Sorting (2 hr): 2 hr; BMoran.
- Advanced Imaging Techniques (3 hr): Confocal microscopy, SEM etc. DN/GMcM
- Metabolomics Research (2 hr): Seahorse Analysis (1 hr; R Porter), Proteomics and metabolomics (1 hr; D. Finlay)
- Cellular Imaging at atomic resolution (2 hr): 1 hr XRay Crystallography and 1hr on cryo-EM (2 hr; KMok),
- Protein Engineering (2 hr): (2 hr Jer Hayes)
- NMR (2 hr; KMok)
- Gene Knockout and Transgenic Technology (5 hr): Transgenics: (3 hr VK), RNAi etc (2 hr; DNolan)

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.

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 micrometre scale in cells.

Metabolomics Research (2 lectures) Richard Porter & David Finlay

Lecture 1: Seahorse analysis 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 apparatus for determining such metabolic flux. In the lecture, I will cover the principles behind the use of these apparatus and give examples of their use to researchers.

Lecture 2: Proteomics and metabolomics 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.

X-ray crystallography (2 lectures) Amir Khan

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

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.

NMR spectroscopy (2 lectures) Ken Hun Mok

A rapid review of the principles of optical spectroscopy + How do they compare with the principles of NMR spectroscopy; Why Heisenberg's Uncertainty Principle is, "in no uncertain terms", crucially important for NMR. Magnetic resonance; Listening to radio waves; Chemical shifts; Coupling. Relaxation times; Two-dimensional NMR – why NMR likes to be "NOESY" and "COSY". Applications to biological molecules and biological systems, MRI (Magnetic Resonance Imaging) NMR in structural genomics; metabolomics and metabonomics

Reading List:

- (1) Hornak JP, Web book: "The Basics of NMR", <http://www.cis.rit.edu/htbooks/nmr/>, 1997.
- (2) Hore PJ, Jones JA, Wimperis S, "NMR: The Toolkit", Oxford Chemistry Primers 92, Oxford University Press, 2000.
- (3) Keeler J, "Understanding NMR Spectroscopy", Wiley, 2005.
- (4) Hore PJ, "Nuclear Magnetic Resonance", Oxford Chemistry Primers 32, Oxford University Press, 1995.

Transgenics (3 lectures) Vincent Kelly

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

Lecture 2. Design and development of transgenic constructs: 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 knockouts, 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: 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.

Reading List:

** 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

RNAi (2 lectures) Derek Nolan

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 be investigated through the use of specific examples. The potential use of RNAi in therapeutic approaches will be outlined.

(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

2. Group techniques

Groups of 4 students working together. Students will give 15 minute presentation in Semester 1 and provide a summary document.

Student summary and presentations to include all the following:

- a. Theoretical basis for the technique
- b. How the technique is performed
- c. How it can be applied to address a clearly defined scientific question
- d. How one of the other techniques can also be used to further address scientific question

3. Quantitative problems

Information given at start of handbook

4. Sequence Analysis (Jerrard Hayes)

The course will provide an introduction into Bioinformatics. Part I of the course consists of three lectures and three exercise sessions. 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 (marked as problems):

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 Doolittle, 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.

5. Comparative Medicine Peter Nowlan

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

This 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 do not intend choosing a 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 perspective - R. Rupke

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	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>As expected</i>
How diligently did the student work?	<i>Well below expectation</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Intensively</i>
How well did the student plan the experiments?	<i>Well below expectation</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Research level</i>
How well were the experimental methods and results documented (e.g. in lab book)?	<i>Well below expectation</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Research level</i>
How well did the student observe the relevant safety procedures (e.g. wear lab coat)?	<i>Never</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Always</i>
How accurate was the student's experimental technique?	<i>Well below expectation</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Research level</i>
Quantity of work done	<i>Very little</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>A great deal</i>
Ability to trouble shoot in lab	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Excellent</i>
Level of help in lab available	<i>Very little</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>A great deal</i>
Ability to work independently	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Excellent</i>
Attitude to work	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Highly motivated</i>
Ability to work with others	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Excellent</i>
Ability to respond to criticism	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Excellent</i>
Comments:			
Particular difficulties if any:			
Mark out of 100%:			

Senior Sophister Project Thesis - Supervisor's report

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

Student name			
Project Title			
Supervisor name			
Date			
1 st Draft submission on time		Yes <input type="checkbox"/>	No <input type="checkbox"/>
Thesis			
Presentation	<i>Messy, poor English</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Publication standard</i>
Abstract	<i>Wholly inadequate</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Publication standard</i>
Introduction	<i>Trivial</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Publishable</i>
Literature coverage	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Extensive and deep</i>
Description of aims	<i>Wholly inadequate</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Perfectly clear</i>
Materials and methods	<i>Wholly inadequate</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Perfectly clear</i>
Description of results	<i>Wholly inadequate</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Perfectly clear</i>
Figures/ legends/ tables	<i>Wholly inadequate</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Perfectly clear, complete</i>
References	<i>Wholly inadequate</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Fully accurate</i>
Quality of data	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Exemplary</i>
Analysis of data	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Comprehensive analysis</i>
Appropriate statistical analysis	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Strict</i>
Discussion	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Publication standard</i>
Scientific rigour e.g. use of controls	<i>Weak</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Strict</i>
Understanding/ insight	<i>Very little</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Research level</i>
Capacity for self-direction	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Outstanding</i>
Quality of first draft	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Excellent</i>
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	<i>Messy, poor English</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Publication standard</i>
Abstract	<i>Wholly inadequate</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Publication standard</i>
Introduction	<i>Trivial</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Publishable</i>
Literature coverage	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Extensive and deep</i>
Description of aims	<i>Wholly inadequate</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Perfectly clear</i>
Materials and methods	<i>Wholly inadequate</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Perfectly clear</i>
Description of results	<i>Wholly inadequate</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Perfectly clear</i>
Figures/ legends/ tables	<i>Wholly inadequate</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Perfectly clear, complete</i>
References	<i>Wholly inadequate</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Fully accurate</i>
Quality of data	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Exemplary</i>
Analysis of data	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Comprehensive analysis</i>
Appropriate statistical analysis	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Strict</i>
Discussion	<i>Poor</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Publication standard</i>
Scientific rigour e.g. use of controls	<i>Weak</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Strict</i>
Understanding/ insight	<i>Very little</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<i>Research level</i>

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	<i>Strongly Disagree</i>	□ □ □ □ □	<i>Strongly Agree</i>
Information is accurate, no significant errors	<i>Strongly Disagree</i>	□ □ □ □ □	<i>Strongly Agree</i>
Poster is logically laid-out and easy to follow	<i>Strongly Disagree</i>	□ □ □ □ □	<i>Strongly Agree</i>
Poster is eye-catching and visually appealing	<i>Strongly Disagree</i>	□ □ □ □ □	<i>Strongly Agree</i>
Exhibits analytical and critical thinking	<i>Strongly Disagree</i>	□ □ □ □ □	<i>Strongly Agree</i>
Poster and presenter shows understanding of the topic	<i>Strongly Disagree</i>	□ □ □ □ □	<i>Strongly Agree</i>
Presenter explained the poster well	<i>Strongly Disagree</i>	□ □ □ □ □	<i>Strongly Agree</i>
Presenter answered questions fully	<i>Strongly Disagree</i>	□ □ □ □ □	<i>Strongly Agree</i>

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



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