The SciSoc Guide to

NST IB

Updated Summer 2024

CAMBRIDGE UNIVERSITY
SCIENTIFIC SOCIETY

Foreword

Congratulations on completing Part IA and your first year at the University of Cambridge! We hope that you had a great time and in moving on to the next stage of your NatSci journey, we understand that choosing your subjects for NST Part IB can be a challenging decision.

To assist you in this process, we've compiled a guide based on insights from our experiences and fellow NatSci students who have recently completed their second year. Our goal is to provide you with more information about each subject to make an informed decision and better prepare for the course. We sincerely hope that this guide will be useful for you!

While we have undertaken all measures to maintain the accuracy of the information here, it is possible that we may have overlooked some things. If there are any corrections or updates to be made, please let us know via email (president@scisoc.com).

Who are we?

SciSoc, the University of Cambridge's largest and most active science society, is here to provide meaningful opportunities for NatScis to socialise and engage with their academic interests. We host a wide range of scientific talks and social events all year-round. To learn more about SciSoc and stay updated on our activities, visit our website at http://scisoc.com/. We look forward to welcoming you to our talks and events!

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Biology of Disease

Lectures:

Although targeted at Medics, Biology of Disease can be taken by NatScis as well, with 40-50 Bio NatScis taking the course every year. Very clinical in nature, BOD is nevertheless useful for students wishing to eventually enter clinical research or understand the causative agents, progression, and treatment of various diseases. BOD focuses on immunology, as well as diseases caused by common pathogens such as bacteria, viruses, parasites, and fungi, followed by vascular pathologies and cancer. As the course is targeted towards medics, expect a different style of instruction during the lectures and practicals as these are shared. There is an increased emphasis on learning a large number of facts and less experimental and research detail, which may not appeal to everyone. While there are discussions to split the teaching of BoD for NatScis and Medics, as of now there is a perceptible difference between BoD and other NatSci-only modules.

Lectures start at 12pm on Mondays, Wednesdays, and Fridays. Each lecture block generally starts with an introduction to the broad category of the pathogen or disease, followed by a deep dive into specific examples of how the pathogen infects its patient or a disease develops, immune evasion techniques employed by the pathogen, and the host immune response against the pathogen or disease which resolves or worsens the pathological condition. Techniques to prevent and treat the infection are also covered. As the immune system is highly complex with many intersecting pathways, do not be surprised that many immune pathways are shared among different pathogens while having their own exceptions and quirks. There is also a series of Natsci Extension Lectures in Lent and Easter intended for Natscis that focus on the immune system in the context of various pathological conditions and serves as an addendum to the core curriculum. Do also consult the lecture and practical timetable because there are some days without lectures or practicals in Michaelmas and Lent.

The lecture synopses are given below:

<u>Michaelmas:</u>

- **Immunology:** The very first lecture topic is on immunology, which is a massive topic spread over 5 weeks. These start with a series of lectures covering the immune system, with a general introduction to the innate immune system, inflammation, the complement system, and the adaptive immune system. These are then applied to pathological phenomena such as immune tolerance, autoimmunity and hypersensitivity, and transplantation. Although this block ends early in the academic year, it is central to the course with the diseases covered subsequently referencing immunological processes.

- **Viruses:** Another big topic which starts off with a general introduction to viral pathogens. Viral transmission, persistence within the host, immune evasion, immune responses against viruses, and prevention and treatment of viral diseases are dealt with in the following lectures. Viruses commonly covered here include Influenza, Hepatitis A, B, and C, HIV, and various Herpesviruses, although knowledge of other viruses which are covered less extensively such as Covid-19 is greatly helpful in the eventual essay exams. Prions are also briefly discussed within this lecture block.

- **Fungi:** Fungal pathogens are discussed here, with Aspergillus and Candida being some classic examples. The block starts off with a general discussion on fungal characteristics, followed by fungal reproduction and diagnosis of fungal infections. Fungi are then grouped into systemic opportunists versus systemic pathogens, with each group having different pathogenesis and affecting different groups of patients. Lastly, treatment and prevention of fungal diseases are discussed. With only 2 lectures, fungal diseases are not a main focus of the course but can supplement other knowledge.

<u>Lent:</u>

- **Parasites:** This block delves into the world of parasites, organisms which make their living off a host. Following an introduction to parasitic lifestyles and life cycles, various parasites are discussed. Plasmodium (causative agent of malaria), Leishmania (causative agent of leishmaniasis) and various worms and helminths are among the totally lovely and not-at-all-nasty creatures you will cover. Similar to previous lecture blocks, emphasis is placed on immune evasion techniques and the host immune response to infection. Techniques to prevent and treat parasitic infections are also covered here.

- **Bacteria:** Yet another major lecture block in BOD, the bacteria block does a deep dive into the structure and function of various pathogenic bacteria. Much like previous lecture blocks, this one covers the initial stages of infection, colonisation, immune evasion, and host immune response to the pathogen. Various Gram-positive and Gram-negative bacteria are discussed, as are measures against bacterial infections such as antibiotics and vaccination. This block concludes with a review lecture of the various immune responses to the pathogens covered so far, such as viruses, parasites, fungi, and bacteria, which is extremely useful in consolidating the various overlapping immune response pathways.

- **Vascular Pathologies:** This block covers conditions such as atherosclerosis, ischaemia, and various types of anaemia. It starts off with an introduction to both proper and dysregulated responses to vascular injury, setting the foundation for vascular pathologies that are covered in subsequent lectures. One lecture is then dedicated each to atherosclerosis, ischaemia and infarction, and anaemia. Throughout the block, risk factors for the various conditions and the role of different cells or components of the immune system in vascular injury and recovery are discussed.

- **Cancer:** The first few lectures act as an introduction to cancer, with discussion on the various mutations of the genes involved in tumorigenesis and the focus of cancer as a multi-stage evolutionary process. Key hallmarks of cancer cells, such as genetic instability and a loss of growth control, are introduced as concepts and the biochemical basis behind these hallmarks discussed in subsequent lectures. Different classes of mutations ranging from point mutations to entire chromosome translocations and the various genes involved in cancer such as tumour suppressors and oncogenes are discussed in detail. Lastly, environmental causes of cancer such as cancer initiators (carcinogens) and cancer promoters as well as hereditary and non-hereditary risk factors of cancer are discussed. As the archetypal genetic disease, a good biochemistry background would be useful in incorporating extracurricular information in the exams.

- **NST Extension Lectures 1 – 3:** The first of the NST lectures, which all tend to focus on the immune system in different contexts. NST1 comes immediately following the parasitology block and focuses on the immune system's role in parasitic infections. NST2 follows the bacteriology block and discusses the interplay between the immune system and bacteria in chronic bacterial infections. NST3 comes after the cancer lectures, focusing on chronic infection and wound repair in cancer formation.

<u>Easter:</u>

- **NST Extension Lectures 4 – 8:** The core curriculum ends in Lent, so in Easter, the only lectures you will attend are extension lectures. NST4 covers early life development of the immune system, followed by NST5, a lecture on immunosuppression and cancer. NST6 recaps viral evasion of the immune system, while NST7 covers cancers of the immune system. The final lecture of the year, NST8 discusses cancer immunotherapy. These lectures recap various topics covered during the core curriculum, as well as adding some new information which complements the core curriculum. These are "big picture" lectures which help to integrate the various modules, such as viruses & cancer or cancer & immunology.

These lectures are more research-focused which is a welcome reprieve from the medic-focused nature of the main curriculum.

Supervisions:

Supervisions mainly consist of discussing essay homework and lecture content, which may vary depending on your supervisor. Because BOD as a subject is so complex and has so many interplaying factors, supervisions are an ideal time to clarify key concepts and pathways. Depending on your supervisor's area of expertise, it can be very helpful to learn more about the research context to supplement the facts taught in lectures.

Practicals:

Unlike most of the biology subjects you may have taken in part IA, BOD has, wait for it… TWO practicals every week! Each practical lasts 2 hours, and depending on your schedule, you may take it on different days of the week. In 2023-2024 NatScis took practicals on Wednesdays and Fridays from 2pm to 4pm every week. At the end of each practical session or block, you may have a wrap up talk summarising the session.

In Michaelmas, practicals mainly consist of histology, which is the practice of staining and inspecting tissue structures under a microscope. You will inspect images relating to the immune system on a moodle browser following the content you cover during the lectures. You will have access to a worksheet which you can fill up with practical content during the lesson; this worksheet is ungraded and is purely for your own reference, but filling it up along the way synthesises the material for eventual revision before the exam. Each practical mostly consists of online modules which you work through with a partner on computers in the lab, with histology pictures online for your reference where you are free to screenshot and fill in the abovementioned worksheet for your own revision. Do clarify with the demonstrators if you are unsure of anything - the demonstrators are excellent guides through the images as well as the thought processes needed to analyse tissue sections. Following the histology sessions in Michaelmas, you have a couple of lab sessions for virology, which involves hands-on work such as growing viruses and applying lab techniques which will come up in the written practical exam.

Lent practicals start off with a few practicals on parasitology to learn wet-lab techniques on parasite assays. You will then go onto bacteriology, forming the bulk of the lent practicals, where you will be introduced to techniques like gram staining to identify bacteria, as well as where each bacterium species can be found in humans, which is relevant for diagnosing bacterial infections. Much like Michaelmas, you will have access to an ungraded worksheet where you can fill in practical content during each practical, with the practical material being predominantly online. You just work through them while asking any questions to the demonstrators in the lab if you have any doubts. Lent practicals also contain histology sessions, mainly on the vascular pathologies and cancer, which come after you have covered the respective topics in the lectures.

In Easter, there are no official practicals in Easter save for optional revision classes for 2 topics: bacteriology and histology. Depending on how comfortable you are with the topics, you can choose to sign up for these revision classes to clarify any questions and understand the lab techniques better.

Revision and Exams:

The BOD exam consists of 2 papers: a 3-hour essay paper where you write 4 essays and a 2-hour written practical where you are NOT required to perform any experiments yourself; instead, it is intended to test your knowledge on practical techniques. 65% of your grade rests on the essay, while 35% of your grade depends on the practical, and both exams are closed book online exams on the Inspera platform.

For the essay paper, there are 2 sections of 4 questions per section, and you choose 2 questions within each section for a total of 4 essays. Past year papers are plentiful, and you will find that questions often repeat from previous years, which simplifies revision somewhat. The structure of the paper means that you may not need to know every part of the course, but it will be advantageous to know the immunology core as well as being able to draw links between immunology and other diseases. That said, there is not a lot of question choice (often only 1 bacteria, 1 parasite, 1 cancer and 1 vascular diseases question for instance), thus you need to be prepared for curveballs and difficult questions. Unfortunately, because this is a biology essay paper, you cannot run away from memorisation. Regularly revisiting past topics after their lecture blocks end to ensure they stick around in your head alongside can help spread out the workload for the eventual exam preparation season. For those aiming higher, incorporating pieces of extracurricular research will help greatly. A nice place to start will be reading research papers and reviews on Google Scholar or PubMed (see useful resources).

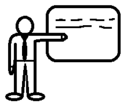
As for the written practical, there are 5 sections: Bacteriology, Analysis of Tissue Sections, Analysis of Information Relating to a Clinical Case, Virology, and Immunology. Unfortunately, there are no past year papers, although there is a sample practical paper in the form of a Moodle quiz and a document outlining the type of questions that will come out. Investing in filling in the Michaelmas and Lent practical worksheets during the practicals will pay dividends during practical revision. In addition, pay close attention to all the various virology, bacteriology (especially the techniques and plates that help you differentiate the species of bacteria), and immunological techniques, as any of these techniques are liable to be tested in sections 1, 4, and 5. As for histology, knowing how to identify different immune cells and structures such as but not limited to fibrin, scar tissue, necrotic tissue, and blood vessels on a tissue stain will go a long way in aiding you in sections 2 and 3.

One final note: it may be tempting to see the nearly 2x weightage of the essay compared to the practical and focus all your energy on the essay. **DO NOT DO THIS**. Your practical content is based on 5 well-defined topics that are at times straight lifts from your practical session slides. Spend some time on the practical to secure these relatively easy-to-get marks, or you will be regretting all your life choices you have made that led you to this point during the practical exam!

Useful resources:

- The course Moodle site, which contains all the practical slides and the recorded wrap up talks
- Sources of papers that will help your essay stand out:
  - PubMed: https://pubmed.ncbi.nlm.nih.gov/
  - Google Scholar: https://scholar.google.com/

Biochemistry and Molecular Biology



Lectures:

Biochemistry and Molecular Biology, or BMB as most call it, is a popular subject choice with those that enjoy learning about molecular processes of the cell. Most topics in BMB can be seen as a more detailed extension of the content learnt in Part IA Biology of Cells such as gene expression, bioenergetics and the cell cycle. The course also places emphasis on experimental techniques which are used to help discover the biological processes that we learn about, contrasting somewhat with Cell and Developmental Biology (CDB) which is more theoretical.

BMB is one of the two subjects that can be taken as a prerequisite to Part II Biochemistry, the other subject being CDB. Many people intending for the Biochemistry route often take both BMB and CDB together, as these two subjects have some content overlap and have great synergy. Topics like immunology and oncogenes are also covered in BMB, which overlaps with the Part IB Biology of Disease (BoD) course.

Lectures are at 10 am on Mondays, Wednesdays and Fridays, and lecturers are generally lovely and happy to answer any questions you might have. However, it is important to note that lecture notes are not provided for all the topics, and that some lecturers will only provide copies of their slides.

The lecture synopses are given below:

<u>Michaelmas:</u>

- **Gene Cloning and Manipulation:** The course starts with covering the experimental tools and methods used in genetic engineering. It starts off with PCR, leading to cloning into vectors and finally experimental techniques to study gene function, such as analysing expression levels, gene localisation, interacting proteins etc.
- **Control of Gene Expression I:** This course extends from Part IA BoC, starting off with the structure of DNA and how it can be specifically recognised despite its regular structure. This is followed by the mechanisms of transcription in eukaryotes and prokaryotes, explained much more in detail.
- **Control of Gene Expression II:** These lectures will explore how gene expression is controlled at the post-transcriptional level along with the translational processes. They complement the previous lectures on gene expression.

- **Protein Structure and Evolution:** This course builds up nicely, starting from the sequence of amino acids and finishing with large macromolecular complexes. It examines how sequence analyses can help us to understand the structure and function of the protein, before discussing how structures are determined, by methods such as X-ray crystallography, cryogenic electron microscopy, and nuclear magnetic resonance spectroscopy. The course also discusses the evolution of proteins such as haemoglobin and immunoglobulins.
- **Enzyme Catalysis and Protein Engineering:** Complementing the previous lecture course, these lectures examine well-defined protein structures such as catalysts and binders in detail. Ideas about enzyme catalysis, kinetics and mechanism are explored, followed by a discussion on immunoglobulins and how their binding to antigens can be understood and exploited. The course also touches on bioengineering methods such as rational design and directed evolution that are relevant in protein engineering.

<u>Lent:</u>

- **Control of Metabolism:** Exploring the different ways in which enzyme activity can be controlled, this course describes the regulation and flux in metabolic pathways, as well as experimental approaches for studying the control of metabolism. These topics will be discussed largely by using examples from glucose metabolism in muscle and liver: i.e., glycolysis, gluconeogenesis, glycogen synthesis and glycogenolysis.
- **Bioenergetics:** This course will first explore the basic concepts of thermodynamics, followed by the diversity of electron transfer systems and their similarities. Building upon IA BoC, the lectures will go through the processes of electron transfer along biological membranes and the evolution of the organelles containing them.
- **Trans-Membrane Signalling:** The aim of this course is to understand the essential properties of signalling pathways and the components that make them up, such as the receptors and second messengers, and how these are controlled in situations such as infection and drug treatments.
- **Regulation of Cell Cycle:** Yet another course than builds from IA BoC, this course introduces the molecular components that regulate cell cycle progression and show how cell division is regulated. The experimental methods used to determine these molecular processes are broken down in greater depth to analyse the evidence supporting the current model of the cell cycle.
- **Immunology:** A rather short lecture series that gives a whistle-stop tour of the immune system, and introduces antibodies – how they work, are produced, and their relevance to research and vaccination. This course overlaps with BoD.
- **Oncogenes, Tumour Suppressor Genes and Cancer:** These lectures serve as an introduction to the multi-step process of cancer, exploring the roles of oncogenes

and tumour suppressor genes with many examples, and how they contribute to cancer. Also overlaps with BoD.

Easter:

- **Protists:** An interesting lecture series designed to broaden our understanding of eukaryotes, organisms outside the typical “model organisms” will be explored. Their biology includes some dramatic exceptions to the conventional way of doing things we’re used to from the model organisms.
- **Chemotaxis:** The last course of BMB explores bacterial motility and chemotaxis, starting with the structures of the flagellin, and exploring how their conformation can be changed, to give rise to the tumble/run behaviour of the bacteria. There will also be discussion on how attractants and repellents work to affect the movement of the bacteria, on a molecular scale.

Supervisions:

Supervisions are the best place to go through and clear your doubts about the lecture content. Many lectures are very information-dense, and going through it one more time with your supervisor will be very helpful. Supervision work is usually a mix of essay writing, short-answered questions, and practical questions to gear you to the final exam. There are also no written answers to any of the questions or tripos papers, so it is paramount that you go through your work thoroughly with your supervisor as this is the only avenue of obtaining feedback. It is also always a good idea to come prepared to supervision with a list of questions or discussion points – don’t be afraid to ask questions!

Practicals:

Being an experimental based subject, BMB practicals are very important and aim to give you experience to perform experiments on methods used in research. There is one BMB practical a week, scheduled from 12 – 5 pm and you will typically work in pairs. Attendance in the practicals is required as 5% of the overall grade, but this is only pass/fail as long as you fill in a wrap-up Inspera at the end of the session. The method and theory behind the practicals will be tested in a practical exam paper at the end of the year, similar to IA BoC. Most of the practicals will come with a set of pre-practical handouts and quizzes available on Moodle that aim to familiarise you with the theory and methods. Though not compulsory, completing these will aid immensely in the actual practical. Often, there are also small interactive simulations or videos on Moodle that are in no way necessary to do, but also supplement the understanding of the practical.

Most practicals are experimental and require you to sit in the lab for the better part of the afternoon. These mostly go through the experimental techniques first discussed in lectures and provide exposure to many techniques or equipment used in biochemical labs. Other than the experimental labs, a couple of BMB practicals are used as “Journal Clubs”, where you would have to read a chosen paper and try to answer the set of questions that come along with it before the actual practical slot. The demonstrator will then go through the paper and questions during the practical. This was interesting and is definitely a good way to start understanding how to read research papers and apply it to the content we study! There are also a couple of computational labs learning about protein structure, metabolic control analysis, and gene browsers.

Like IA BoC, the yellow sheet with the practical answers will be released at the end of the week, once everyone has attended the practical. However, even though the answers are provided, I would strongly recommend discussing the practical theory, results and questions with the supervisors at hand as this will help to deepen your understanding of the practical. Math is also very important in these practicals so make sure to understand the formulae you use!

Revision and Exams:

It is important to note that BMB is an extremely content heavy subject, requiring much memorisation and a thorough understanding of the lecture content throughout the year. Finding out how you study best for the essay, SAQ, and practical components will be useful throughout the year to retain the vast amount of information in the course.

There has been a change in examination format and syllabus, revised in 2021. What used to be a 3-paper exam format has been changed to 2 papers, and some of the sections have also been removed and switched around. However the questions themselves in the past papers beyond 2021 are largely the same format and are definitely an important tool in your revision. Certain parts of the syllabus have also been removed, so do not be too alarmed if you see a question with keywords you have not learnt! The BMB examinations are closed book and to be conducted online on the Inspera exam portal.

Paper 1 is 3 hours long and contains a total of 15 essay questions divided into 5 sections, of which you will need to choose 1 from each section (so total 5) to write. Each section contains the essay questions pertaining to the lecture content taught from half a term, i.e. you can only answer one essay question per half a term. Hence it is important to plan your revision out and see if you would prefer to focus on a few topics rather than the entire syllabus. Throughout the year, you will be writing many essays for your supervisions. With consistent practice and revision, the goal of writing an essay in just 36 minutes can be achieved! Integrate content across the lecture topics for your essays (e.g. you are writing an cell signalling essay but bring in some information about the control of metabolism) and put information outside lecture content for a better essay, which can be done starting from open-book supervision work and reading reviews and papers to supplement the course material.

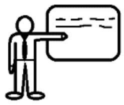
However, spotting is not an option with the short-answered questions (SAQs) in paper 2, which you also get 3 hours for. There are 10 of these questions, and can test absolutely anything from the lecture content, from an experiment you never thought was important in your notes, to an organism that was briefly mentioned in a couple of slides. Ideally, you should spend an hour in this section and hence 6 minutes to each SAQ.

This is followed by the practical sections, which are divided into 2 parts (should take an hour each). The first part consists of 3 smaller questions, mostly testing the Michaelmas practicals. The second part only contains one question, but it is much longer and extended, testing content from the lent practicals. There will be several calculation questions in these so do make sure to familiarise yourself with the formulae well. Constant practice as well as reviewing the past practical tripos questions are essential to do well.

Useful resources:

- Moodle! There are many hidden gems on the BMB Moodle page that aid in learning.
- *Lehninger's Principles of Biochemistry* (Nelson and Cox; Freeman) – your general biochemistry textbook with a wide coverage of topics!

Cell and Development Biology



Lectures:

The grown-up and more developed (sorry I had to) version of IA BOC, IB Cell and Developmental Biology similarly focuses on various cellular processes and structures, but with a much greater focus on developmental biology. Development enjoyers will be pleased to know that whereas IA BOC was limited to a few basic developmental concepts in Easter, IB CDB covers invertebrate development for 2 weeks of Lent and plant, vertebrate, and mammalian development for the entirety of Easter. Many topics covered in CDB are familiar, such as DNA replication and gene expression, but are covered in greater detail compared to IA BOC. Furthermore, CDB is a nice complement to IB Biochemistry, with several overlapping topics that are examined from the cellular point of view, allowing for content from one course to be incorporated into the other during the exams.

Lectures start 10am on Tuesdays, Thursdays, and rather annoyingly, Saturdays. The lecture blocks are nicely organised, with a focus on specific organelles during each term. A nice bonus is a little "breather week" in week 5 of Michaelmas where you have no lectures for… one Saturday. It ain't much, but it's better than nothing!

<u>Michaelmas:</u>

- **Molecular Biology of the Cell Nucleus:** The very first block of the subject covers everything about the nucleus of the cell. The first lecture covers the structure and function of DNA and histones, while the next lecture deals with organisation of the nuclear matrix. The final 3 lectures deal with chromosome replication, the dynamics of nucleosomes during chromosome replication, and nuclear import and export.

- **Genes, Gene Expression, and Cell Decisions:** Here, the ins and outs of transcription are covered for both prokaryotes and eukaryotes. The various transcription regulation methods employed by eukaryotes is a key focus here. 1 lecture is also dedicated to the concept of epigenetics, with a discussion of how epigenetics can regulate gene expression at the transcriptional level. The final two lectures focus on the lac and lambda phages and the gene expression mechanisms behind the decision to enter the lytic cycle or the lysogenic cycle.

- **Genetic Systems of Prokaryotes:** This lecture block focuses on prokaryotes, starting with an introduction to the structure, function, and organisation of the prokaryotic nucleoid. Comparisons between structural proteins of the eukaryotic chromosome and similar proteins in prokaryotes are discussed. Further in the block, the concept of supercoiling is introduced. Following the lectures on nucleoid structure, the regulation of both transcription and DNA replication in bacteria are discussed, with focus on the Trp operon and different types of plasmid replication. The block concludes with the flexibility of bacterial genomes, discussing insertion sequences, transposons, and bacterial conjugation, with these processes linked to the proliferation of antibiotic resistance.

- **Genome Function and Evolution:** This lecture block explores the complexities of eukaryotic genomes, with a particular focus on various strategies of genome sequencing and the pros and cons of each strategy. Single Nuclear Polymorphisms and GWAS are expanded upon further in later lectures, while DNA repeats such as microsatellites, minisatellites as well as eukaryotic transposons are discussed. The final lecture in the block discusses modern techniques of genetic engineering such as CRISPR/Cas9, the generation of transgenic organisms, and induced pluripotent stem cells. A key theme in this block is the various biochemical and genetic methods used in exploring genomes over the years.

- **Yeast as a Model Organism:** This lecture series delves into yeasts and how they are useful for genetic studies. Topics covered in IA such as various genetic crosses will make an appearance here, together with some new stuff such as the use of yeast in synthetic biology.

Lent:

- **Chloroplasts and Mitochondria:** The first lecture series of Lent goes through the genetics of chloroplasts and mitochondria. Transcription, translation, and protein processing in these organelles are covered, as are the mechanics of protein import. Finally, genetic methods used to study the genomes of these organelles are discussed and are a constant theme during this series.

- **Cytoskeleton & Mitotic Cell Division:** A series that expands on what you have learnt about the cytoskeleton in IA BOC. The structure of the cytoskeleton is discussed before the dynamics of the cytoskeleton such as actin and microtubule nucleation and polymerisation are explored. The lectures also cover the structure and function of molecular motors such as myosins, kinesins, and dyneins. Lastly, the role of these motor proteins are discussed in the context of cell division, with the dynamic events occurring at the chromosome during mitosis being a key focus towards the end of the block.

- **Membrane Trafficking:** A major lecture block which covers two important pathways: the secretory and endocytic pathways in cells used for exporting and importing various proteins. You will first encounter the secretory pathway, where techniques used to elucidate the pathway will be discussed, before the structure and function of key components of the pathway such as the ER, ERGIC, GA and other parts are explained. The various proteins involved in vesicle assembly are also discussed, before the lecture block eventually moves on to the endocytic pathway and discussed in a similar fashion to the secretory pathway. Throughout this lecture block, the methods the cell uses to achieve specificity and accuracy in targeting a large diversity of proteins to their destinations and correcting errors are discussed, and constant comparisons are made between these two pathways.

- **Coordination of organelle and cellular function:** A block of two lectures which focuses on how the cell coordinates function between various organelles, with the first lecture focusing on the machinery of cellular organelle degradation and turnover, and the second lecture dealing with mitochondria and the endoplasmic reticulum.

- **Intercellular Communication I and II:** This block is presented as 2 separate blocks in the lectures, but for brevity I have included them as 1 block in here. Both deal with cell signalling, with the first block focusing on photoperiodism and temperature in the control of flowering, while the second block discusses insulin signalling.

- **Invertebrate Development:** The first block of the development lectures. Tim Weil will take you through development of C. elegans and Drosophila while contrasting the two different modes of development. This lecture block also plays an introductory role to the rest of the development lectures that you will have in Easter.

<u>Easter</u>:

- **Plant Development:** This block covers plant development using Arabidopsis as a model organism, with the role of auxin taking centre stage. The 4 lectures start off with an introduction to plant development and the key differences compared to animal development, before going on to discuss the molecular mechanism of auxin traffic and response in plants, as well as phyllotaxis, root development and shoot development as case studies.

- **Xenopus and Zebrafish Development:** The first lecture block that introduces vertebrate development, using Xenopus and zebrafish as model organisms. You will learn the mechanisms underpinning the development of both organisms, from simple signalling pathways to major complex events such as organogenesis.

- **Mammalian Development:** The final lecture block in the subject, mammalian development uses the humble mouse as a model organism to study development in other mammals, including humans. You will learn both pre- and post-gastrulation events in mice, and the signalling pathways underpinning these events. This series also discusses stem cells, and the use of these stem cells in modelling human development.

Supervisions:

Depending on your supervisor, one change you might notice from your IA supervisions is that you might be asked to start reading more scientific papers and dissect the figures to both prepare for either Part II or your future career. Otherwise, much like IA, supervisions are an ideal time to discuss essay homework and clarify concepts, which is critical as CDB is after all a biological subject with various intersecting pathways that can be confusing.

Practicals:

Unlike IA BOC, you will have practicals pretty much every week. Like IA BOC, you have the option of sending your completed lab report to a demonstrator to get their comments, although your reports do not count towards your final grade and are mainly meant for your understanding. In addition, because the practical content closely tracks the lecture content and the complexity is a step up from IA, it is recommended that you minimally stay on par with the lectures before attending any of the practicals to ensure your maximal understanding of the content. That said, you do get to do some more fun stuff as well, such as expressing GFP in Drosophila larvae via transposons and watching them glow green under a microscope.

Revision and Exams:

Exams consist of a 3-hour essay paper and a 3-hour written practical. The essay paper contains 3 sections, each with 4-5 questions, and you write a total of 4 essays with at least 1 essay from each section. As for the practical, there are 2 sections, A and B, where the former is an essay section. You choose 2 essays from a selection of around 5 questions, and unlike the pure essay paper, these essays tend to be integrative and much more general in nature. Section B contains around 8 questions centered around the practical content, with varying lengths for each question. Both papers are likely to be closed book and online on the Inspera platform.

Past year papers are a great resource for revision, and the greatest utility comes from papers after 2020 (note that the 2020 practical paper is essay-only). Papers from the years prior to 2020 contain a short answer section, which is not applicable for you. However, if you do go so far as to complete all the newest practical papers, you can still use the older papers for practice, but bear in mind that the course content may have changed from then.

Writing the exam: 3 hours for 4 essays is on the somewhat more lenient side, giving you roughly 5-10 minutes for essay planning. Once again, like all your supervisors and lecturers have probably mentioned before, read and address the question in your essays! In addition, you could theoretically pick only the bits of the course you like and revise for those because you are only writing 4 out of a possible 13 essay questions. However, do have backups so you will not get caught out if your favourite essay topic is a curveball, a merger with another topic, or worst of all, a no-show!

For practicals, the best strategy for the integrative essay is just to prepare for a wide range of general topics. Multiple questions can come out for development, so be sure to spend some effort on this topic (which helps for section C in the essay paper as well). In addition, coming up with a list on breakthroughs and experimental techniques that have aided cell biology is very handy for questions on experimental techniques, which is another examiner favourite. Other questions potentially involve a general question of the role of biomolecules such as ATP, membrane proteins, phosphoinositides... The possibilities are endless here, but so long as you have a decent grasp of the lecture material, you should be fine with these. For the practical questions, read up on the practical yellow sheets and try to understand what every reagent does and the rationale for every step you carry out in the practical, and address any doubts with the demonstrators in the live sessions. One last thing: split your time wisely and avoid spending more than too much time on the essay (40 minutes per essay is reasonable but find your own sweet spot and stick to it) so you can complete the practical section comfortably!

Useful resources:

- Textbook:
  - Molecular Biology of the Cell by Alberts *et al*.
  - Covers a lot of the course content, and I have found it helpful in explaining the more esoteric concepts in development.
- Sources of papers that will help your essay stand out:
  - PubMed: https://pubmed.ncbi.nlm.nih.gov/
  - Google Scholar: https://scholar.google.com/

Chemistry A

Lectures:

Chemistry A is the more mathematical and physics-related Chemistry subject in Part IB, which spans both the theoretical and physical branches of chemistry. It builds up well on the foundations of Part IA Chemistry, with relation to the courses on Shapes and Structures of Molecules, Thermodynamics and Kinetics. While the Chemistry A course may appear to require an abundance of mathematics, the key mathematical concepts have been well covered in the Part IA Mathematics A/B course, with most calculations being well expounded in thorough explanations in the relevant lecture notes. The theme of the course revolves around using fundamental concepts like quantum mechanics and symmetry to predict structure and bonding, statistical thermodynamics, kinetics, and the bulk properties of materials, while using spectroscopy for experimental analyses.

As usual, most lecturers leave some blanks in the notes/examples to be annotated during the lectures (though the last course in Easter will be provided in full to allow for more flexible revision strategies). Lectures are usually held at 12pm on Tuesdays, Thursdays, and Saturdays unless informed otherwise.

The course is exceptionally well-structured and provides appreciable motivation for students to learn various theoretical and physical concepts. As the course progresses, future topics will draw on concepts learnt previously in past lecture topics, bringing everything full circle by the end of the course. The lecture series are outlined as below:

<u>Michaelmas:</u>

- **Introduction to Quantum Mechanics:** The year kicks off with the quantum mechanics lecture series which will span across more than half the term. This is arguably the most important series in the course, as future topics will be built on the concepts learnt here. You'll be exposed to wavefunction manipulation, hermicity, angular momentum, and the usefulness of orthogonality. The series will also include all-important models like the free particle system, (an)harmonic oscillators, and the rigid rotor, with their own relevant properties, which will be quintessential for future topics. Other more familiar ideas will be discussed further in depth, such as the hydrogen atom model, multi-electron system, Pauli Principle, and Hund's rules in relation to quantum mechanics concepts. Lastly, the course rounds up with the cryptic Variational Principle, and a sneak peek into the Hückel method to calculate minimized MO energies.

- **Molecular Spectroscopy:** Spectroscopy is the most experimentally relevant course. It seeks to use the principles learnt from quantum mechanics to rationalize experimental spectroscopic data in conjunction with relevant selection rules. Both Infra-Red (IR) and Raman spectroscopy will be discussed, in relation to rotational, vibrational, and electronic spectra. Half the experimental practicals will be based on concepts learnt in this series, and thus going through the content here will help motivate the experiments, measurements and analyses made there, and provide good revision for the viva session (see *Practical* section for more details).

<u>Lent:</u>

- **Symmetry and Bonding:** *(Note that the few starting lectures will likely take place during the end of Michaelmas).* Prepare your 3D spatial reasoning abilities, because in this lecture series, you'll be visualizing and mentally rotating LOTS of molecules. The course first lays down the foundations of symmetry, explaining relevant information about symmetry operators and point groups (N.B.: group theory but not so much mathematically - in a more relevant manner to chemistry). These ideas lead on to various techniques, like constructing irreducible representations (somewhat confusingly also acronymised as I.R.), forming symmetry orbitals (SOs) and applying direct products. Linear combinations of atomic orbitals (AOs) and SOs of similar symmetries then give an insight into how MOs eventually form, with their relative energies eventually calculated through Hückel calculations, which will be explained in detail (with extensive approximations). There will be a section on the symmetries of transition metal (TM) complexes which ties in nicely with the Chemistry B lecture block on TM chemistry as well. Other parts of the course include a further in-depth explanation of term symbols in the context of symmetry, how symmetry can be used in spectroscopy, and a newer section on the symmetries of polyatomic rings and chains.

- **Molecular Energy Levels and Thermodynamics:** Remember that little segment on statistical thermodynamics in Part IA Chemistry? Well, it's back, and it's back with a bang through 14 lectures of exhilaration. There will be minimal classical thermodynamics here, as we use concepts from quantum mechanics to pave the foundations of statistical thermodynamics, embodied in the fundamental idea of the molecular partition function. Expressed through the idea of a system existing in individual microstates, the partition function is broken down into translational, rotational, vibrational and electronic contributions, which are used to demonstrate trends in internal energy, heat capacity and entropy. There will also be a section on nuclear spin statistics, accounting for the variation in intensities in spectroscopic measurements. The partition function can then be used to explain familiar concepts in chemical equilibria, giving rise to expressions like the Saha equation and the Langmuir isotherm, and in chemical kinetics, estimating rate constants and discussing the volume of activation. The series then ends off with a short note on the Boltzmann distribution and density of states.

Easter:

- **Electronic Structure and Properties of Solids:** This series draws on everything that has been covered thus far in the Chemistry A course and serves to bring the course back in full circle. For those who have taken material science, the introductory concepts here will appear familiar, such as crystal structures and Bravais lattices. The first part of the course revolves around exploring the structure and bonding of solids, via the free electron gas (FEG) model and tight binding model which gives rise to electron bands, which will both be explored in 1D, 2D, and 3D. These models can then be used to explain the bulk properties of solids and will lead nicely into the second half of the course, which explores the chemistry behind semiconductors in greater detail, with a few examples of semiconductors devices like the p-n junction and bipolar junction transistor. The lecture series then finishes with a discussion on spectroscopic measurements in semiconductors and their relevance to band gaps, with a brief touch on phonons and excitons.

Supervisions:

Each lecture series has a list of supervision questions that assist you in understanding the various concepts covered. They are often quite well structured, such that after each lecture, it will be clear which questions can be done based on the content covered thus far. As such in terms of question planning for supervision work, it is generally advised to keep up with the relevant questions as the lecture series progresses (though this is admittedly not easy!). Some supervisors will choose to skip questions which may be repetitive in the skills practised, but students are highly encouraged to complete all supervision questions eventually in preparation for the exams, as they really provide the much-needed practice to tackle Tripos-style questions within a time limit.

(An important note is that you will not be expected to learn the detailed mathematical derivations behind some topics & equation solutions, often having to just accept the solution as it is, which is generally what's only required for the examinations. This can however be understandably frustrating for some who wish to understand the topic more thoroughly. It is advisable to discuss certain concepts and proofs you wish to find out more of with either your supervisors, lecturers, friends, or pretty much anybody you can get a hold of to avoid the usual "you'll learn this next year" or "you won't need to be knowing this so don't worry".)

Practicals:

Part IB Chemistry A, like Chemistry B, has a weekly practical session in the afternoons from 1.45pm to 6pm. There will be 12 practical sessions in total with 6 each a term (2 free weeks), alternating between computational and experimental practical sessions. There will be a practical lab booklet for each term, which compiles all the relevant information and taskings required for each practical, as well as more detailed information on the practical sessions and marking schedules themselves.

After each session, you will have slightly short of 2 weeks to compile your data and present it in a write-up that is to be submitted online on Moodle <u>**at least 24 hours**</u> before the start of your next computational/experimental practical. This is to give enough time for your senior demonstrator to review your work and prepare for the viva session which takes place during that practical session. Each practical is marked out of 20, 10 for your write-up, and 10 for your viva session. During the viva marking session, you'll be asked to give an overview of what you have done in the write-up and answer some questions about the theory behind the practical itself (mainly concepts from the lecture series). The senior demonstrator's goal is to ensure that you understand the purpose and objective behind each practical, and you'll be assessed based on your understanding of the practical and theory behind it, so be sure to do a little revision of the relevant theory before your viva session!

E.g. Your practical session is on Wednesday afternoons. You spend the whole afternoon hammering away at your excel sheet for computational practical A and possibly spending the rest of the week on it as well. You must submit your completed report by the Tuesday <u>two weeks later</u> before 1.45pm. On the next computational/experimental session the next day (Wednesday), you pull up to the respective location and work on your next computational practical B. During the session, you'll be called up for marking for computational practical A, and the cycle repeats until the end of term (hence the additional 2 weeks meant for marking).

Computational sessions are usually held in the G30 room, where there will be a junior demonstrator around during practical hours (until 5p.m.) to assist you should you need any help (similar to Part IA Math practical sessions). Python is primarily the main programming language used for coding, though you'll have the opportunity to use other open-source programs like Avogadro and ORCA for *ab initio* calculations. Content is mostly drawn from the quantum mechanics course, and a bit from the symmetry/bonding and statistical thermodynamics course. Experimental sessions are held in the Physical Lab. Most experiments are generally quite fast, and the majority of your time will be spent on analysing the data obtained. Half the experimental practicals will be on some form of spectroscopy, while the other half varies in content.

Revision and Exams:

It is absolutely essential that your revision is centred around timed practice of past year papers, as practising on Tripos-style questions is the best way to prepare for the Tripos itself. There are up to 25 years of past papers to complete in total, with suggested answers provided by faculty members to guide you towards the correct answer as you mark your work. The quality of these answers varies extensively, from some being highly detailed to others with almost illegible handwriting, so it would be best to check and discuss these answers with your supervisors as well. Keep in mind that for some lecture series, the lecture content has changed over the years (especially the last series on Electronic Structure and Properties of Solids), so keep a lookout for a section on suggested Tripos questions at the back of the respective lecture handout which will list the question (parts) that are still relevant to the current content.

Chemistry A is examined via two 3-hour-long papers: Paper 1 and Paper 2, each with 5 compulsory questions. In recent years, Paper 1 contains 2 questions on Quantum Mechanics (QM), 1 question on Spectroscopy, and 2 questions on Symmetry and Bonding. Paper 2 contains 3 questions on the Statistical Thermodynamics course, and 2 questions on the course on Electronic Structure and Properties of Solids. Especially for Paper 1, time control can be a real issue, due to the mathematical nature of QM questions, and the repetitive nature of Symmetry and Bonding questions. You should spend an average of 36 minutes on each question. It is recommended to get as much practice as possible to speed things up during the actual examination.

N.B. Do note that the format of papers has changed in 2012 from choosing 5 questions from 7 to answering all 5 compulsory questions for each paper – giving you more questions to practise.

Useful resources:

- Software to download for practicals:
    - Avogadro: https://avogadro.cc/
    - ORCA: https://orcaforum.kofo.mpg.de/app.php/portal

- Course guide for Part IB downloadable from the department website: https://www.ch.cam.ac.uk/teaching/course-guides
- Reading Lists Online for Part IB Chemistry A: https://cam.alma.exlibrisgroup.com/leganto/readinglist/lists/16277860380003606?institute=44CAM_INST&auth=SAML

Chemistry B

Lectures:

Chemistry B is one of the more popular subject choices in Part IB, with cohort sizes usually of around 150 students. It is usually taken by those also taking biological subjects who wish to gain a more ‘chemical/molecular’ perspective in these subjects. Chemistry B spans organic, inorganic, and biological chemistry, leading up smoothly from Part IA Chemistry and further laying the foundation for further, more specialized topics to come in Part II in (in)organic and biological chemistry. Courses are still focused on an introductory aspect, with many new foundational concepts introduced for the first time. As a standard, most lecturers prefer to leave blanks in the notes for annotation during lectures. As usual, going quickly through the notes ahead of the lectures will undoubtedly help in one’s understanding of the subject during the lecture. Lectures are usually at 9am on Tuesdays, Thursdays, Saturdays, unless informed otherwise. Students will be lectured by an excellent entourage of experienced chemists, all of which are more than happy to take questions in their respective areas of expertise.

The lecture course is overall well-structured, with each term corresponding to a specific area of chemistry. A brief description of each lecture series is explained as below:

<u>Michaelmas (Organic):</u>

- **Aromatic and Enolate Chemistry:** The first part of the course covers the reactions that aromatic rings undergo, with an emphasis on substitutive regioselectivity. The second part then moves on to explore enolate formation, stabilization, and reactions, which are extremely useful species for the synthetic chemist.
- **Nucleophilic Attack on π Systems:** Explains the ins and outs of conjugate addition (Michael addition), including selectivity (vs direct addition), as well as the ever-so important nucleophilic aromatic substitution reaction. There is also a brief explanation of chirality here, using the Cahn-Ingold-Prelog (CIP) rules.
- **Introduction to Stereochemistry:** Chirality is explained in further detail here, as well as different ways of visualizing molecules in 3D. The importance of the spatial configuration of molecules is highly emphasised, as illustrated by differences in reaction rates and spectroscopic data. There will be a great deal of ring visualization, as explained via a variety of cyclisation reactions.
- **Shape and Organic Reactivity:** This lecture course focuses mainly on covering various important organic reactions which are highly useful in synthetic chemistry. Some reactions may have been explained before in Part IA, while others are

completely new. The course covers alkene, alkyne and carbonyl chemistry, with new reactions such as ozonolysis, oxymercuration and Beckmann rearrangements. Stereoselectivity via the Felkin-Anh model and Houk's rule will also be explained in detail.

Lent (Inorganic):

- **Transition Metal (TM) Chemistry – Structure, Bonding and Reactivity:** Get ready, because this lecture course comprises 17 lectures, split into two parts. The first part covers the basics of TM chemistry, explaining ligand types via molecular orbital (MO) theory and ligand crystal field theory (CFT). These can be used to further explain physical properties of complexes and justify ligand/metal positions in their respective Spectrochemical Series.

  After laying the foundation, the reactivities of TM complexes are discussed in greater detail in the second part. Important concepts include hard-soft acid-base (HSAB) theory and the all-important electron counting techniques. Ligand properties are further explained, in conjunction with key reactions in catalysis involving TM complexes. This part of the course will cover a huge amount of content, and it is highly advised to minimally stay on par with the lectures here.

- **Structure, Bonding, and the p-Block elements:** A slight detour into main group chemistry, this course will cover the chemistry behind numerous p-Block elements. Starting off with a brief insight into the theory behind the formation of hypervalent compounds, the course proceeds into the chemistry behind O containing rings/chains (e.g. P=O, Si-O etc.). Next is a key highlight of this course, which involves learning the chemistry behind B/N, P/N and S/N rings and how we can compare them in terms of their structure and bonding. The course then rounds off with a touch on multinuclear NMR spectroscopy and a hint of EPR spectroscopy. Beware, ALL parts of this course are examinable – however esoteric they may appear to be.

Easter (Biological):

- **Introduction to Chemical Biology:** The final lecture course of 11 lectures provides a more "chemical" approach to common biological topics and concepts. Those who have taken biological subjects covering some aspect of molecular biology will have had some background knowledge in this course, which is split into 2 parts. The first part covers a recap of non-covalent interactions, and a more molecular view of nucleic acid and protein structure. A key examinable component of this part is the ability to design a small molecule able to bind well to the pocket of a receptor via maximizing intermolecular interactions. The second part of this course will cover different methods of biological catalysis with a variety of enzymes as examples. It ends off with a brief explanation of how enzyme inhibitors are designed. Examinable components involve identifying possible catalytic mechanisms based on various experimental data provided (e.g. Kinetic Isotope Effect [KIE], site directed mutagenesis etc.).

Supervisions:

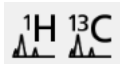
As usual, each lecture course comes with a variety of fun and engaging supervision questions to assist you in navigating the ins and outs of each course. In particular, the 1st lecture course will have many more questions than what is required for the usual supervision, which are great for additional practice. Do note that some questions are a little funkier than others and may not be fully representative of the types of questions that may be examined, but instead assist in the student's appreciation of the topics involved – so don't take these too seriously. (However generally of course, it is important to take your work seriously!) Often, supervisors are willing to discuss the written answers to the supervision questions (which importantly, may not even be entirely correct!). As always, come prepared having revised on the topic to be discussed for a fruitful session!

Practicals:

As opposed to Part IA, Part IB Chemistry B features a chemistry practical <u>every week</u> in the afternoons. The main difference is that practical hours are mainly allocated for only lab work. The lab write-ups (reports) will be written entirely (and formatted) on your own **<u>outside of practical hours</u>**. You'll have a week after each practical to complete the write-up, during which you'll have the opportunity to come to the lab in the morning for analytical work, which mainly encompasses taking the IR spectra, melting point, and TLC, and any other relevant characteristics measurements of your compound (where applicable). The analytical results will have to be attached to your final lab report to be submitted.

The lab report is marked out of 10, with marks allocated for appropriately completed sections such as reaction mechanisms, experimental protocol, accurate spectra assignment and analysis, your calculations, and lastly any relevant theory questions in the lab booklet for that practical. Marking varies vastly across different lab demonstrators, though marks will be moderated accordingly for each demonstrator. It is crucial to ask your demonstrators if you are unsure of what is required in the lab report, or if you're having trouble with the experiment. One top tip is to always clarify the purpose of each step of the protocol (e.g. purpose of adding 10 ml of reagent X), which will both help you in writing the lab report, and having a greater appreciation for experimental chemistry.

E.g. Your practical session is on Thursday afternoons. You spend the whole Thursday afternoon happily mixing chemicals and when you're done, you place your product in the desiccator before leaving. You then come back on Friday/Monday/Tuesday/Wednesday morning (of your own choice) to complete your analysis of your product before compiling and submitting your report on the following Thursday afternoon before you start your next practical.

P.S. These two buttons in ChemDraw will be your best friends: 

when it comes to spectra analyses. Do note that they may not be entirely accurate, so use them wisely.

Revision and Exams:

Past papers are once again (no surprise) your best friend for revision. Though the format may vary slightly over the years, the overall segregation of questions corresponds to each lecture course rather consistently. These provide the best practice for what may come up in an exam, because as you have guessed, they have come up in the exams before! With close to 25 years of past papers, you'll have more than enough resources to hone your skills in Tripos-style questions. As luck would have it, chemists have been blessed with suggested answers that have been provided by faculty members, with a large emphasis on "suggested". These are ever so useful to cross-check your answers with and gauge the standard of answers that examiners will be expecting. As always, there is more than one answer to a question and should you have an alternative way to approach the question, it would be a good idea to bring it up for discussion with your supervisor.

Chemistry B culminates in two 3-hour-long papers, which are very non-confusingly named Paper 1 and Paper 2, each with 5 compulsory questions. In recent years, Paper 1 tests both organic and biological chemistry, drawing on content from the whole of Michaelmas term and half of Easter term. There will be 1 question centred on each of the four organic courses, and 1 question on either half of the chemical biology course. Paper 2 tests inorganic and biological chemistry, drawing on content from the whole of Lent term and the other half of Easter term. Generally, there will be 1 question from each half of the TM course, and 1 question that is a mix of both halves. There will also be 1 question from the P-block element course, and the last question from the remaining half of the chemical biology course.

Time is of the essence in these papers, with an average of 36 minutes for each question. As such, timed practice is crucial leading up to the exams. As the old saying goes, if you must stop to ponder, your marks are miles yonder. Though also importantly, focus on completion, not perfection. A paper with fully and decently attempted questions will usually gain more marks than completing 60% of the paper "perfectly" and then not-so-gracefully running out of time.

N.B.: Do note that the format of papers has changed in 2012 from choosing 5 questions from 7 to answering all 5 compulsory questions for each paper – meaning more questions to practice! Also, there is an erratum in 2005 Paper 1 Q3bi and 2017 Paper 1 Q4b (yes, they are the same question, questions do get reused!) – the sulfone in compound C will remain a sulfone when converted to compound D.

Useful resources:

- Software that gives predictions of NMR spectra for any molecule:
    - ChemDraw: http://www.ch.cam.ac.uk/computing/software/chemdraw-and-chemoffice
    - NMRdb: https://www.nmrdb.org/
- Search by structure - https://www.chemspider.com/StructureSearch.aspx
- 3D complex visualization - https://3dchem.com/
- Course guide for Part IB downloadable from the department website: https://www.ch.cam.ac.uk/teaching/course-guides
- Reading Lists Online for Part IB Chemistry B: https://cam.alma.exlibrisgroup.com/leganto/readinglist/lists/16638761570003606?institute=44CAM_INST&auth=SAML

Earth Sciences A/B

Introduction:

Earth Sciences IB draws upon the knowledge acquired in Earth Sciences IA and develops a deeper understanding of Earth's processes on the surface and the interior. Earth Sciences A/B complements QES, Material Sciences and Chemistry very well and can also be paired with Ecology, Evolution and Conservation and Plants and Microbial Sciences. The prerequisite for IBs is Earth Sciences IA.

Earth Sciences IB is split into two subjects — Earth Sciences A (ESA) and Earth Sciences B (ESB).

ESA covers processes that occur on the Earth surface and how it influenced the geologic record. It concentrates on the atmosphere, hydrosphere and biosphere, examining the processes that occur within it and their relation to the geological record. The course thus covers topics such as structural geology/lithosphere deformation, the formation of basins, climate, ocean chemistry and circulation, sedimentology, and paleobiology.

ESB covers processes relating to the geophysical and geochemical processes in the Earth's interior. It also looks at the solar system and its evolution. ESB thus covers topics such as plate tectonics, seismic imaging, mineral behaviour, melting, crystallisation and the deformation of rocks from igneous and metamorphic terrains. It involves concepts from chemistry, physics and material sciences such as thermodynamics.

Earth Sciences IB is a highly dynamic and interdisciplinary course, requiring students to draw knowledge and concepts from different disciplines in Science and applying them in tandem. For instance, there are concepts from physics and chemistry in structural geology, mineralogy and evolutionary thinking in paleobiology. This high level of integration between different disciplines of sciences is unique to ESA and ESB.

Practicals and Fieldwork:

Practical and hands-on work also form an essential part of Earth Sciences. Aside from lectures and supervisions, there are 6 hours of practicals (3 2-hour lab sessions) per week for ESA/ESB. Practicals, depending on the lecture block, can involve coding (Python and R), use of petrographic microscopes to look at thin sections of rocks, examining hand specimens and geological maps (not inexhaustible). Hard skills that will be honed include coding and programming skills (Python and R) as well as GIS.

Field trips remain a core part of the practical side of Earth Sciences. In IB, the three field trips that all ESA or ESB students go on are:

- Sedbergh, Cumbria
- Cornwall and Dorset
- Isle of Skye, Scotland

Exams:

- Practical Paper 1 and 2 (40%)
- Theory Paper 1 and 2 (60%)

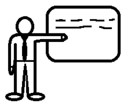
Useful resources:

- Course website

Ecology, Evolution and Conservation

Disclaimer:

The 1B EEC Course is likely to undergo changes again for the 2024/2025 iteration - the order in which some lecture blocks are delivered is likely to change, while others may be entirely replaced. Keep an eye out on the course website for updates!



Lectures:

The part 1B Ecology, Evolution and Conservation course is split into 9 2-week blocks, (4 each in Michaelmas and Lent, 1 in Easter) each with 6 lectures. Some of them build upon lecture blocks in 1A, especially those in E&B. 1A PoO, Earth Sciences, A-level Biology and Geography may prove useful in supplementing the content in other lecture blocks. The lecture content may complement those in other 1B courses, especially Evolution and Animal Diversity, Earth Sciences A, Plant and Microbial Sciences, Quantitative Environmental Science, and Mathematical and Computational Biology. They also lead well into Part 2 Zoology, Earth Sciences, and Plant Sciences. There are no prerequisite courses to take 1B EEC, and EEC itself is not a prerequisite for any Part 2 options.

For almost all lecture series, you will be given notes (though the style and level of detail will vary with the lecturer), as well as the slides used during the lectures. Some lecturers may also provide sample supervision or Tripos questions. These resources are usually made available before lectures, which take place at 12pm on Monday, Wednesday, and Friday. You may want to read outside of the lecture handouts for more examples than what is provided.

Below is a short summary of the lecture series in the 2023/2024 iteration, in order:

<u>**Michaelmas**</u>

- Prof Andrew Balmford leads Michaelmas Term with **Humans & Ecology**: an expanded refresher of his 3 lectures that closed out Easter term in 1A E&B. These lectures focus on the human aspect of many topics that you will encounter again in later lecture blocks, such as agriculture, megafaunal extinctions, habitat loss and invasion.
- Prof David Coomes covers **Factors Shaping Global Vegetation**, focusing on climactic, physiological and ecological factors that explain the global distribution of plant life. Key topics include plant responses to changing temperature, water, fire and herbivory regimes, as well as the ecology of invasive plants.

- Dr Emily Mitchell explores an entirely different realm with **Marine Ecology**, with her starting and ending lectures covering overarching themes of marine population dynamics and biodiversity trends. The other lectures are specific to one type of marine ecosystem each, covering reefs, open oceans, deep seas and polar oceans.
- Dr Lucas Braga closes Michaelmas Term with **Evolutionary Ecology**, exploring how evolutionary dynamics and ecological interactions shape each other. The different interaction types and concept of ecosystem function is first introduced here, with later lectures focusing on modes and requirements of speciation, adaptive radiations and ecological genetics.

Lent

- Lent Term begins with Prof Ed Turner's course on **Biodiversity and Ecosystems**, with returning themes of ecosystem function, global patterns in biodiversity and how to best measure and protect it. The last few lectures explore the value of the natural world, the creation and management of novel (especially urban) ecosystems.
- Prof Lynn Dicks continues with **Ecological Interactions and Community Structure**, dedicating one lecture each to competition, predation, parasitism and mutualism. This feeds into two larger scale lectures on ecological networks, ecosystem structure and its effects on ecosystem stability and resilience.
- Dr Adam Pellegrini covers **Ecosystem Productivity and Climate Change**, with a heavy emphasis on overarching Carbon (then Nitrogen and Phosphorus) cycles in terrestrial, plant-based ecosystems. Two lectures are dedicated to the roles of plants and soils, with two more covering disturbance regimes, succession, their predictability and the factors controlling them.
- Lent term is closed out with the **Collections** lecture series, jointly provided by multiple past lecturers and staff of the Zoology museum. Lectures are either collection-specific (avian, herbaria, paleontological) or cover overarching themes of the scientific and cultural aims of collections (especially the aspect of colonial legacies), or how they may continue to change and adapt in the future.

Easter

- Dr Eske Willerslev claims the entirety of Easter Term with his course on **Paleoecology and Human Migrations**, with a heavy focus on the role of humans in the Pleistocene Megafaunal extinction and subsequent colonisations. His lectures mostly expand upon those in 1A E&B, starting with the role of ancient and eDNA, then devoting a lecture each to the peoplings of Eurasia, Oceania and the Americas.

Supervisions:

Supervisions are similar to those in 1A E&B, though what is covered during the hour and the homework set will vary depending on your supervisor. The former may include summaries of course content with additional prompts or links to other parts of the course. If your supervisor specialises in a relevant area of research, you may get some crucial bits of extra reading that supplement your understanding of course material (though it certainly helps to read up on your own relevant research areas of interest). You may also prepare and give presentations on either papers or certain key topics within course content, or discuss essay plans on supervisor-made, lecturer-provided or past tripos questions. Most supervisors set one essay a week as homework - some may also organise Mock exams over the winter or Easter holidays, often in the style of a tripos paper.

Projects:

Perhaps the most unique aspect about the EEC course is project work, entirely replacing the weekly practicals that most 1B courses offer and accounting for a third of your course grade. Projects fall under two categories - Summer projects are initiated as fieldwork in the Juniper Hall Field Course, and have an earlier submission deadline towards the end of Michaelmas Term. Term-time projects are instead initiated at the start of Michaelmas Term, with a deadline at the end of Lent. These may be selected from a list of available projects, or if you find a suitable supervisor in Zoology or Plant Sciences, you may design a bespoke project. Projects may span a range of topics and methods (statistical analyses of fossil paleoclimate data, field studies on vegetation communities, wet lab work on marine invertebrates etc). In all cases, you may collect data in a group, but everyone's analysis and writeup will be unique. There will also be ungraded project presentations (either at the end of the Juniper Hall Field Course, or in mid-Lent for term projects) for you to practise presenting, and also receive valuable feedback from peers and professors. In total, the project is expected to take around 60 hours of total work, so pace yourself accordingly!

Fieldwork:

Often slated for the start of Summer preceding second year, the optional Juniper Hall field course is often considered an extended spiritual successor to the field courses in 1A E&B (regrettably, without the marine biology component). You can design and carry out your own research project in the quaint English countryside, get closer to department members (most of which would also have carried out the 1A E&B field trips) and spend some quality time with your future coursemates. If funding is a concern (keeping in mind that the trip is already heavily subsidised by the department), many colleges are happy to provide subsidisation and make sure to ask your DoS if you're not sure.

In Michaelmas and Lent Terms, there will also be visits to a variety of nature reserves and museum collections to supplement the lecture material, about once every other Monday. Everyone is expected to attend as the concepts covered may be examined - on weeks where there are no excursions, you are expected to spend the time working on your project. There are also optional data analysis workshops catered towards students undertaking term-time projects, though all course members are free to attend.

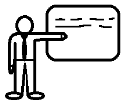
Exams:

EEC has 2 3-hour, closed-book essay examinations, in-person via Inspera, both carrying equal weight (a third of the course grade each). Paper 1 and 2 each both consist of ten essay questions, split into five sections containing two questions in each. You must answer four questions, and no more than one question from each section. The essays in Paper 1 pertain to lecture blocks 1-4 and the excursions, while those in paper 2 pertain to lecture blocks 5-9 (this means 8 essays total).

Useful resources:

- https://www.biology.cam.ac.uk/undergrads/nst/courses/ecology-evolution-conservation
- https://www.natsci.tripos.cam.ac.uk/subject-information/part1b/ecol
- Begon, M., & Townsend, C.R. (2021) Ecology: From Individuals to Ecosystems, 5th edition, Blackwell Science
- Eichhorn M.P. (2016) Natural Systems: The Organisation of Life, John Wiley and Sons
- Balmford, A. (2012) Wild Hope: On the Front Lines of Conservation Success, Chicago. Diamond, J. (1998) Guns, Germs & Steel, Vintage.
- Flannery, T. (2005) The Weather Makers, Text Publishing Company.

Evolution and Animal Diversity



Lectures:

The part 1A Evolution and Animal Diversity course follows a similar structure to 1A Evolution & Behaviour, with more detailed insights into animal behaviour, especially in Michaelmas term. If you took 1A E&B, you will be familiar with the reappearing themes of trade-offs and conflict in evolution, which continue to be core concepts in 1B EAD as it focuses primarily on animals. There is no prerequisite for this course, although it may be an advantage to have taken 1A E&B.

The bulk of the Lent term lectures are dedicated to genetics and macroevolution, where you will expand on previously discussed topics such as selection and drift, introgression, GWAS and QTL analysis, etc. Some lectures also explore infectious disease and their evolution, using recent examples such as SARS-CoV-2.

One novel element of 1B EAD is insects! There are two lecture blocks on insects – one on their amazing physiology, and another on insect learning. These lectures cover everything from insect respiration, cuticle, and flight to the circuit motifs in the Drosophila brain. Similarly, there is also a lecture block which explores vertebrate evolution where you will learn about vertebrate hearing, circulation, thermoregulation, etc. You will also hear about dinosaurs in your lectures!

For almost all the lecture series, you will be given access to complete and detailed notes, as well as the slides used during the lectures. They are usually made available before lectures, which take place at 11am on Monday, Wednesday, and Friday. You may want to read outside of the lecture handouts for more examples than what is provided.

The lecture series titles are listed below:

Michaelmas

- Behavioural Ecology of Predators and Prey
- Development and Organisation of Adaptive Behaviour
- Phenotypic Models
- Vertebrate Evolutionary Biology

Lent

- Population & Quantitative Genetics

- Evolutionary Genomics & Infectious Disease
- Phylogeny & Macroevolution
- Insect Physiology

Easter
- Brains & Behaviour

Supervisions:

Supervisions are likely to be similar to what you had in 1A. You discuss content from the past week's lectures with your supervisor and perhaps discuss some essay plans. Depending on your supervisor, you may also be asked to prepare short presentations on scientific papers, just to get into the practice of reading more widely around the subject.

Practicals:

1B EAD practicals are timetabled to happen every other week, so you are expected to attend a total of 4 sessions per term (excluding Easter term). For every practical, you are expected to produce a write-up, which is due one week after your practical session.

All practical write-ups are **assessed** and contribute to 20% of your final 1B EAD mark. You can expect to submit a total of 7 write-ups throughout the year (4 in Michaelmas, 2 in Lent*, 1 in Easter Term). The way these write-ups are graded are similar to 1A E&B, where you will be marked on a scale of A, B, C and D. The content and format of each write-up will differ depending on the expectations of the practical organisers.

Practical topics follow quite closely what you learn in your lectures and are often organised by your lecturers. The practical titles for 2022/23 are as follows:

Michaelmas
- Measuring the behavioural preferences of animals
- Barnacle geese
- Game theoretical models of animal behaviour
- Vertebrate cranial and histological anatomy

Lent
- Moths and symbionts* – carried out over 3 practical sessions (i.e. 6 weeks of term)
- Respiration in aquatic insects

Easter

- Learning in insects

Revision and Exams:

There are 2 written papers for 1B EAD, each 3 hours long, closed-book, in-person via Inspera (as of 2022/23). Both Paper 1 & 2 carry equal weight of 40% of your total 1B EAD mark.

The 2022/23 format is as follows:

Paper 1 (3 hours)

- Choose 4 out of 9 essay questions, from at least 3 out of 4 sections:
    a. Behavioural Evolution (Michaelmas lectures)
    b. Genes and Genomes
    c. Macroevolution and Diversity (incl. Vertebrate Evolutionary Biology)
    d. Adaptations
        - Insect Physiology
        - Brains & Behaviour
- Each essay is 10% of total 1B EAD mark

Paper 2 (3 hours)

- Answer 5 out of 6 questions (any lecture series could be tested!)
- 'Short-answer' questions, with sub-questions carrying equal marks. The answers are still expected to be relatively long, but not in an essay style.
    - You may be asked to draw diagrams, read graphs, do some calculations, etc.
- A relatively new format, which evaluates more on experimental thinking and design. You may want to practise this with your supervisor!

Useful resources:

- https://www.biology.cam.ac.uk/undergrads/nst/courses/Evolution-Animal-Diversity

Experimental Psychology

Course Overview:

The NST IB Experimental Psychology course is designed to introduce students to the scientific study of psychology, focusing on cognitive neuroscience and experimental methods. This course serves as a comprehensive entry point for students, whether they have previous exposure to psychology or are encountering it for the first time. It encompasses a broad range of topics, aiming to provide a solid foundation in understanding mental processes and behaviour through empirical research and experimental techniques.

The primary objectives of the NST IB Experimental Psychology course are:

- **To Introduce Key Topics:** You will explore a wide array of subjects within experimental psychology and cognitive neuroscience, including perception, learning, memory, language, attention, and social behaviour.
- **To Develop Experimental Skills:** The course emphasises the importance of experimental design, data acquisition, and analysis.
- **To Prepare for Advanced Studies:** This course lays the groundwork for further study in Part II Psychology and beyond, preparing you for research and professional careers in psychology.

Experimental psychology has a rich history, beginning with early introspective methods and evolving into a rigorous empirical science. The course traces this development, starting from foundational figures like Wilhelm Wundt and William James, and progressing to modern cognitive psychology and neuroscience. It highlights the philosophical underpinnings of the field and the transition from behaviourist approaches to contemporary cognitive models.

Lectures:

The course is structured into three terms, each focusing on different aspects of psychology:

Michaelmas Term

- **Historical Background:** An overview of the origins and evolution of experimental psychology.

- **Visual Perception:** Understanding how the visual system processes information, including colour vision, depth perception, and motion.
- **Auditory Perception:** Exploration of how the auditory system interprets sound, from basic hearing mechanisms to complex auditory processing.
- **Attention:** Examining the mechanisms of attention, how we allocate cognitive resources, and the effects of attentional processes on perception.
- **Learning:** An introduction to associative learning, including Pavlovian and instrumental conditioning, prediction error, and generalisation.
- **Higher Cognition:** Exploring executive functions, attention, awareness, and the integration of cognitive processes.

Lent Term

- **Language and the Brain:** Investigating the neuro-cognitive mechanisms underlying language processing, including reading, spoken word recognition, and bilingualism.
- **Reasoning and Decision Making:** How individuals make decisions, estimate probabilities, and the influence of emotions on decision-making processes.
- **Developmental Psychology:** Cognitive and social development from infancy through childhood, integrating recent neuroscientific findings.
- **Personality:** Exploring the genetic and behavioural foundation of personality development and categorisation, as well as atypical psychological phenomena.

Easter Term

- **Social Psychology:** Examining how social contexts influence human behaviour, including topics like stereotyping, group processes, prosocial behaviour, and aggression.

Supervisions:

Supervisions in the NST IB Experimental Psychology course are typically conducted on a weekly basis. Usually, 2-3 students will be in a supervision group, arranged by their College Director of Studies. It is very likely that your supervision partners are taking different courses and are from different colleges.

Key aspects of supervisions include:

- **Discussion and Clarification:** Supervisors discuss lecture content, address any questions or difficulties you may have and provide deeper insights into the subject matter.

- **Preparation for Exams:** Supervisors advise on effective study techniques, provide feedback on past exam questions, and help you practice essay writing skills.
- **Feedback on Practical Reports:** Supervisors can give feedback on practical reports, helping you improve experimental write-ups and data analysis skills.

Practicals:

Practicals in the NST IB Experimental Psychology course are designed to complement the lecture material by providing hands-on experience with experimental techniques and data analysis. Each term includes a series of practical classes, usually 2 2-hour sections per week, where students engage in various research activities.

Key aspects of the practicals include:

- **Research Techniques:** Students learn essential skills for measuring the brain and behaviour, including experimental design, control conditions, and statistical analysis.
- **Practical Reports:** Students are required to write reports on specific practical sessions. For NST IB students, seven reports are required, with two being formative and the rest summative. PBST Part IB PBS4 students submit five reports. This constitutes 10% of your final EP grade.
- **Hands-On Experiments:** Practicals involve performing experiments, collecting data, and analysing results. Topics include neural measurements, behavioural assessments, data analysis, and psychometric evaluations.

Revision:

Effective revision is crucial for success in the exams. The course offers several resources and strategies to aid students in their preparation.

- **Previous Exam Papers:** Students are encouraged to review past exam papers to familiarise themselves with the format and types of questions. There should be at least 3 years of past papers available, along with examiners' reports for each year's paper.
- **Supervisions:** Your supervisors play an important role in helping you prepare for exams by discussing relevant topics, providing feedback on practice essays, and guiding revision strategies. As the EP exam consists of short answer questions and essays, make sure you have ample practice doing both these question types, and have a clear understanding of what is required in a good response.

- **Inspera Exam Portal:** Exams are conducted via the Inspera exam portal, and you are advised to participate in bootcamps and familiarise yourself with the portal's functionalities ahead of time.

Exams:

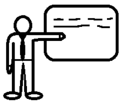
The assessment for the NST IB Experimental Psychology course includes two unseen three-hour written papers, each contributing 45% to the total mark. The exams are designed to test students' understanding of the material covered in lectures and practical classes.

- **Paper 1 and Paper 2:** Each paper is divided into three sections, each corresponding to different topic areas.
    - **Section A:** Perception and Cognition (Paper 1), Personality & Atypical Psychology (Paper 2)
    - **Section B:** Cognitive Psychology (Paper 1), Developmental Psychology (Paper 2)
    - **Section C:** Biological Psychology (Paper 1), Social Psychology (Paper 2)
- **Format:** In each section, students are required to write a short account of two topics from a choice of four and one essay from a choice of two. The essay carries two-thirds of the marks in each section.

Useful resources:

- Moodle! A lot of information as well as further reading materials will be uploaded there for you to access during the course.

History and Philosophy of Science



Lectures:

History and Philosophy of Science (or HPS) is a subject that aims to understand the nature of science and its role in society by exploring the social forces that shaped the sciences across time and the different ideologies that underpin scientific inquiry. If you've ever wondered where the "scientific method" comes from, or how scientists deal with discoveries that could be used for great harm, or why physics students (used to) have higher paying jobs than biology students, then you could find your answers here (or better yet, find more questions to ask!) This subject may seem rather abstract and disconnected from the other natural sciences, but it provides a fundamental understanding of how scientific inquiry functions and the historical factors that contributed to science as we know it today, greatly enriching your appreciation and understanding of the scientific work of other disciplines. If you just want to know how and why science is the way it is, as we study and expand it, or would just like a break from problem sheets and fact regurgitation, then this subject may be of interest to you.

Some STEM students might be concerned that they will be overwhelmed, as they haven't taken history nor philosophy before, or haven't done anything related to humanities for a long time. However, you don't need a background in either to take this subject, and the lecturers and supervisors will help ease you into studying and revising. The lecture handouts can be a little sparse, so do remember to take good notes. The lectures are also at 5pm on Mondays, Wednesdays, and Fridays, which is great for those who can't wake up early.

The lecture series titles are listed below:

Michaelmas

- *History of Science*
    - **Early Modern Science, 1400-1700**
- *Philosophy of Science*
    - **What is Science?**
    - **Philosophy of Medicine**

Lent

- *History of Science*
    - **Empires of Knowledge, 1789-1914**
    - **Science in Power, 1914-1989**
- *Philosophy of Science*
    - **Philosophy of Science in Practice**
    - **Space, Time and Reality: The Philosophy of Physics**
    - **Is Social Science an Oxymoron?**

Easter

- *History of Science*
    - **Science and Crisis, 1989-present**
- *Philosophy of Science*
    - **Can Machines Think?**
    - **Philosophy of Biology**

Supervisions:

Your supervisions will likely alternate weekly between History of Science and Philosophy of Science, with a different supervisor for the two fields. Supervisions are an opportunity to practise writing out discursive essays for history and philosophy, which can be slightly difficult for those who are new at it. Your supervisors will guide you in structuring arguments and finding examples for your essay questions, which in turn help you to better understand how to critically think about questions regarding the history and philosophy of science. As a general tip, your lectures will provide the basic facts and ideas needed to answer the questions, but for a good essay, you will need additional historical narratives or philosophical arguments that you get from the recommended readings. Besides this, supervisions are a sounding board for any questions that you come across in the lectures or in your readings, which happens often in this course.

HPS supervisions can really be a breath of fresh air, especially for those doing physical sciences, as you spend more time chatting with your supervisors about interesting things relating to that particular topic, way more than you discuss your supervision work for the week. It can be a lot of fun to explore lots of interesting questions that have not crossed your mind before (such as “Can being ugly be considered a disease?” among other fascinating questions).

Practicals...?

Good news! There are no practicals in the History and Philosophy of Science. However, the extra time you get from this is meant to go into your recommended and additional readings, so don't think you're completely off the hook. Doing well in HPS will require a lot of reading, far more than most STEM students, so you will need to cultivate the ability to read quickly and effectively, skimming through texts while still picking up the key concepts and ideas.

Revision:

Revising for HPS really just amounts to a lot of reading and writing. There are a lot of recommended readings, almost certainly too much for someone to finish on top of two other subjects. It is probably wise to pick 4-5 topics to focus on, then reading up and practising essays for those topics. Do remember that the exam has a required question that broadly covers the entire course, so you need to have a wide enough variety of topics to tackle that question properly. At this point it is useful to note down the names of specific historians that have raised different and interesting historical narratives, and specific philosophers that have raised arguments and counterarguments to the questions you are discussing. Namedropping these thinkers will show evidence that you have done your reading. (Extra tip: you can also go through your lecturers' papers and cite their arguments in your essays!)

You can find past HPS papers very easily on Google, and they provide a good idea of what the exam will be like. Your supervisors can help comment on essay plans and practice essays, but do remember to send them in early to avoid swamping them with work. Given the large amount of reading to do, it can also be helpful to team up with a few other HPS students and share essays, to increase the amount of content that you all can cover.

Exams:

The HPS exam is entirely essay-based, and is split into two papers, one for history and one for philosophy. Each paper has two sections, with Section A consisting of usually 2 questions that broadly cover the entire course, and Section B consisting of questions that are from specific topics covered in the course. You will need to answer 1 question from Section A and 3 questions from Section B, usually with a word limit of 1500 words. The format of the paper has fluctuated in the past few years due to the pandemic, but the most recent papers have been conducted online, in an open-book format.

Your biggest enemy in the exam will be time, and there will be hardly any time for you to think up arguments while writing your essays. It will serve you well to have your arguments and examples prepped and ready when entering the exam. Also, try not to let perfect be the enemy of good, and spend too much time on any single question. Remember that 4 mediocre essays are better than 3 perfect essays and 1 unanswered question.

Useful resources:

- Dear, P. (2009) Revolutionizing the sciences: European knowledge and its ambitions, 1500-1700, 2nd ed. Princeton, NJ: Princeton University Press
- Shapin, S. (1996) The scientific revolution. Chicago, IL: University of Chicago Press
- Cambridge History of Science, volumes 3-5
- Morus, I. R. (2005) When physics became king. Chicago, IL: University of Chicago Press
- Oreskes, N. (2019) Why Trust Science? Princeton, NJ: Princeton University Press
- Lewens, T. (2015) The Meaning of Science. London: Pelican Books
- Longino, H. (1990) Science as Social Knowledge: Values and Objectivity in Scientific Inquiry. Princeton, NJ: Princeton University Press

Materials Science

Lectures:

The lectures in the Michaelmas term mainly build from the content in IA, so it's good to look through the content from 'Microstructure', 'Mechanical Behaviour of Materials', and 'Materials under Extreme Conditions' from IA.

The topics in the Lent term are new and more manageable. If you're also taking Chemistry A, Course F in the Easter term overlaps to a large extent with what's taught in Chemistry A.

Michaelmas:

- Course A: Metals and Alloys
- Course B: Mechanical Properties of Materials

Lent:

- Course C: Materials Chemistry
- Course D: Structure and Characterisation
- Course E: Non-Metallic Materials

Easter:

- Course F: Electrical Properties of Materials

Supervisions:

The supervision sheets have the same format as those in IA (i.e. one sheet per week).

Practicals:

In Michaelmas, there is one practical per week. The format is the same as the labs in IA, i.e. lab notes submitted on Moodle after the lab. There is also a microscopy booklet to be completed during the term.

In Lent, there are practical sessions in alternate weeks. In the week where there is no practical, there is something called 'Project Tasks'. There are 5 tasks in total, covering topics such as 3D printing, and each one is a OTOT task to be submitted before the deadline. This was something new this year and might be modified for the next few batches.

No practical in Easter term!

Revision and Exams:

IB Materials Science has 2 papers with 3 hours each. The format is the same as IA – choose 5 questions out of 7 to do. Paper 1 is made up of questions from Course A and B while Paper 2 is made up of questions from Course C to F (usually 2 from Course C, 1 from Course D, 2 from Course E, and 2 from Course F). Questions in Paper 2 are generally easier than those in Paper 1 (the average marks from past Tripos Examiners' Reports are also higher for Paper 2).

Useful resources:

- DoITPoMS (https://www.doitpoms.ac.uk/index.php)!!

Mathematics

Lectures:

The mathematics course is a service course taught by the DAMTP and mainly covers the mathematical methods used in the Physics and Chemistry courses in future years. It closely complements the Physics A and B courses with some topics even being repeated, albeit from a more mathematical perspective. Based on a straw poll done at a lecture this writer was attending, students taking IB Maths also took a variety of subjects, with a very small number also taking a biological subject with Maths. However, the usefulness of the IB Maths course to the Physics A and B course makes it a rather popular combination to take for those wishing to specialise in either Physics or Astrophysics in the third year. Lectures are usually at 11 am on Mondays, Wednesdays and Fridays.

The course begins with a refresher on vector calculus, before ploughing through the rest of the syllabus. In Michaelmas, you will be lectured on Vector Calculus, Green's Functions, Fourier Transforms, PDEs, Matrices, Elementary Analysis and Series Solutions. In Lent, lectures begin with Sturm-Liouville theory, before continuing with Variational Calculus, Laplace's and Poisson's Equations, Cartesian Tensors, Contour Integration and its application to Fourier Transforms. Easter term will see Normal Modes, Group Theory, and Representation Theory being covered.

In general, the format of the lecture notes either tends to be partially filled or filled. In the case of partially filled notes, the filled notes are uploaded to the portal after the lecture.

Supervisions:

You can expect supervision problems to take longer to solve than they have in IA and difficult problems are starred to indicate as such.

Practicals:

One of the benefits of Maths is that there are no practicals. There are about 3 Scientific Computing exercises to complete before the end of Michaelmas and Lent each, but these are relatively doable, if not a little time-consuming. These form about 10% of the total mark.

Revision and Exams:

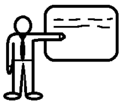
The bulk of the total marks come from two 3 hour written exams at the end of the year. Each paper consists of 10 questions, of which you may attempt a maximum of 6 questions (leaving about 30 minutes for each question). Unlike in IA, the division of the topics across paper 1 and paper 2 is much more consistent across the years, and roughly follows the order in which the topics were lectured throughout the year. In paper 1, you can usually expect to see questions related to Vector Calculus, Green's Functions, Delta Functions, Matrixes, Fourier Transforms, Elementary & Complex Analysis, Series Solutions, SL Operators and Variational Calculus. In paper 2, it is common to see questions from SL Operators and Variational Calculus as well as Poisson's and Laplace's equations, Tensors, Contour Integration, Normal Modes, Group Theory and Representation Theory. These are just rough guidelines and are by no means a guarantee, but in this writer's experience they have been generally true.

As expected, the time limit can be a challenge during the exam, and the questions can be inherently challenging. The best way to prepare is to work through past papers and refer to worked solutions (some supervisors provide unofficial solutions). There have been years where questions have been repeated without any changes so there is much to be gained through this process. Make sure to schedule timed practice, without referring to any notes, since you won't have a formula sheet (or less crucially, a calculator) in the exam.

Useful resources:

- Course Website: https://www.natsci.tripos.cam.ac.uk/subject-information/part1b/maths

Mathematical and Computational Biology



Lectures:

This course gives you a taste of the mathematical and computational techniques that underpin modern day biology and bioinformatics. The course is highly recommended for those who want to develop the vocabulary to collaborate with computational biologists, or perhaps become one themselves. Note that this is a young course, with AY2023/24 being its second iteration. There have been significant changes between the first and second years of this course's existence and there will no doubt be many more changes to come. Despite the teething pains however, the course is an invaluable introduction to a ubiquitous set of techniques that often fly under the radars (and over the heads) of the majority of biologists—but not yours!

Lectures commence at 9am on Mondays, Wednesdays, and Fridays. The Monday and Friday lectures focus on the mathematical principles behind the content while the Wednesday lecture focuses on the code. The curriculum is structured to sequentially introduce the mathematical and computational aspects which become more complex as the year progresses.

<u>Michaelmas</u>

Block A: Introduction (4 weeks)

The first two weeks of this block eases you into the course, with the latter two building up the statistical foundation for the rest of the year.

- Alexia Cardona: Python
  - Three introductory python programming lectures delivered over the first three wednesdays of the term. Great for absolute beginners to the language.

- Henrik Salje: Assorted Topics
  - A whistle stop tour in four lectures of some of the techniques coming up later in the course (dimensionality reduction, statistical sampling, regression models).

- Nik Cunniffe: Statistics and probability
    - 5 lectures on random variables, maximum likelihood methods and hypothesis testing. The methods covered form the statistical foundation of the rest of the course, and are thankfully taught brilliantly here.

Block B: Foundations (4 weeks)

4 weeks, 4 lecturers. Things start to heat up.

- Nik Cunniffe: Discrete time systems
    - These are analogous to the systems of ODEs covered in IA Mathematical Biology, but in discrete time. Should be familiar to most.

- Richard Durbin: Bayesian statistics
    - Covers bayesian inference and markov chain monte carlo (MCMC) in a biological context — which are two absolutely core approaches used in nearly all of modern day mathematical modelling and bioinformatics in biology. Bafflingly, however, the first pair of conjugate distributions that students are introduced to are the multinomial/Dirichlet distributions (rather than the much more sensible binomial/beta distribution). Furthermore, the MCMC content made no intuitive sense when first covered.
    - Thankfully, however, a 1h recap lecture was delivered at the start of Lent term that clarified all the confusion from the 3 lectures delivered during Michaelmas. One hopes that the department has learnt from this and updates the Michaelmas lectures accordingly. Complaints aside, these are some of the most satisfying concepts to grasp and once you do, you will not regret having taken the course.

- Paul Fannon: Mixed Models
    - A continuation of linear models from IA Mathematical Biology, bringing in random factors in addition to fixed factors. This brings students close if not up to the state of the art with the models used in much of ecology.

- Aylwyn Scally: Linear Algebra
    - 3 lectures is quite a short time to cover linear algebra in a satisfactory manner but they do a fairly decent job here. The three lectures cover the basics, and this topic is thankfully one in which there is no shortage of high quality learning material online.

<u>Lent</u>

Block C: Bioinformatics (4 weeks)

- Anton Enright:
  - 9 lectures that bring you through the majority of the pipeline of modern bioinformatic analyses. Anton covers dynamic programming algorithms in sequence alignment, multiple sequence alignment, hidden markov models, as well as sequencing read mapping. You will come out of this with a solid appreciation of the bioinformatic techniques that any modern biologist will have to use at some point or another.

- Richard Durbin:
  - 3 lectures that cover modern phylogenetic techniques, from naive approaches such as UPGMA, to neighbour joining, probabilistic transition models, and finally state-of-the-art bayesian methods. At each step, the problems with tree construction and inference are clearly stated and the techniques to overcome each of these problems are motivated and introduced. A good introduction to a vast field.

Block D: Systems (4 weeks)

Much like Block B we have 4 weeks, 4 lecturers. Exciting stuff.

- Henrik Salje: Infection Models
  - Covers familiar ground of compartment models such as SIR as well as new ground including catalytic models, which can be solved to generate insights into historic infection rates from seropositivity data.

- Olivier Restif: Continuous Time Markov Chains
  - A real doozy. 3 lectures is very little time to satisfyingly cover a set of methods that can easily take whole semesters of mathematics courses to properly build up to. Mathematical rigour gives way to practicality in this block, with a reasonably limited set of examples of biological relevance that are properly motivated and covered. This block takes a bit more work than some of the others to fully grasp, but is an interesting challenge that gives you some appreciation of some powerful mathematics. Nonetheless — a rigorous mathematical understanding is far beyond what this course can reasonably offer.

- Rafael Romero-Garcia: Networks
    - An overview of network science and its applications to various areas of biology (e.g. neuroscience, molecular biology, metabolism). Not exactly the hardest thing in the world conceptually, but quite a few definitions and algorithms to remember.

- Wolfram Ponisch: Diffusion
    - For the physicists in the audience, this one's for you. Brings you briefly through both stochastic (random walks) and deterministic (Fick's laws) models of diffusion. Great if you enjoy solving systems of ODEs, not so much if you don't.

<u>Easter</u>

Block E: Data Science (2 weeks)

- Paul Fannon
    - 6 lectures bring you through a whistlestop tour of dimensionality reduction, clustering, as well as the basics of gradient descent and neural networks. A nice taster but one that will definitely leave aficionados hungry for more.

Supervisions:

Simple enough, you work through the problem sheets and bring them along for discussion each week. However, do note that although supervisions are department-organised, the quality of supervisors varies dramatically. The simple truth is that the list of academics or postgraduates in cambridge that have a reasonable understanding of all of the methods covered in this course is undeniably thin. Despite this, the department tries their best, and sometimes allocates a different supervisor for the first and second half of the courses for the best coverage.

Practicals:

Computational practicals are held for ~3h once a week and are in Python. These offer exposure to a set of computational techniques that complements and sometimes adds on to the taught content in the lectures.

Coursework and Exams:

The weightage for this subject is 50% mathematical and 50% computational — with the latter consisting of coursework (35% of the overall grade) and a timed closed-book computational exam (15% of the overall grade).

The 3 hour mathematical paper offers a choice of 6 questions out of 8, with no restrictions on sections, which is fairly generous and lets you avoid one or two of your least favourite topics with next to no risk. A key challenge with the first two years this course was taught was the dearth of past papers with which to practise, however with more practice papers and actual tripos papers being added each year this becomes less and less of a problem.

The 35% coursework component consists of a 5% mini-project to be completed over the Christmas vacation which, despite taking a shocking amount of time, is meant to be a practice and is therefore not competitively marked—most students achieve a full mark. The remaining two mini-projects are worth 15% each and are completed over easter vacation. The projects in AY2023/24 included i) a bioinformatic whodunnit as to the identity of an unknown DNA sequence, as well as ii) some serious epidemiological modelling of salmonella infection using maximum likelihood methods. Overall, the projects were a decent challenge and offered room for creativity. These likely represent the best assessment format for computational biology.

The 15% that comes from the closed book computational exam, however, may be the absolute worst part of the course. The test is administered on department computers in a development environment of their choice (JupyterLab) and is ultimately a test of syntax recall and speed typing rather than any genuine understanding or creativity. Thankfully, however, the Easter 2024 computational exam was miraculously thwarted by a last minute power cut to the department building which left enough machines out of commission for the examination to be delayed. In light of this, the examiners allowed the concession that the mark for this paper only counted to a student's overall grade if it caused the grade to increase—effectively nullifying its evil energies. One hopes that the protests of the students are heard in future years and the paper is either significantly revamped or scrapped.

Useful resources:

- Course website

Neurobiology

Lectures:

The 1B Neurobiology lectures are shared between NST and PBS students. Michaelmas term starts out by discussing neurobiology at the level of the neuron, where you will hear a lot about ion channels and neurotransmitters. Then you progress into the major senses, namely somatosensation and pain, hearing, olfaction and taste, as well as vision. You will move on into Lent by learning about the motor system, proprioception and sensorimotor integration. In Lent, you will also learn about neurobiology from a development perspective, ending off the term by exploring the psychology side of neurobiology, motivation and emotion. You will end the year by looking at learning and memory, and finally consolidating all that you have been learning about in the final lecture series discussing the higher functions of the nervous system.

The 1B Neurobiology course is well suited for those who have had some prior knowledge and/or deeper interest in neurobiology, as the learning curve for this course gets steep very quickly. It can be quite a challenging course to follow for those who haven't been exposed much to the neuron or the nervous system in school (plus, the 1A NST biological courses do not prepare you very well to transition into 1B Neurobiology). However, it can be done, if you are genuinely interested in this fascinating and complex field of biology.

Towards the end of the course, the focus shifts to more experimental and clinical evidence, as there are still many questions that still need to be answered in the field. It's an up and coming field of interest, so you might want to check this course out if you're curious to learn more! Lectures are at 12pm on Tuesday, Thursday and Saturdays, and lecture notes and slides are available ahead of time on Moodle.

The lecture series titles are listed below:

Michaelmas

- Introduction to Neurobiology
- Electrical Properties of Neurons
- Neurotransmission and Neuromodulation
- Somatic Sensation
- Hearing
- Olfaction and Taste
- Vision

Lent

- Motor System
- Sensorimotor Integration
- Neural Determination
- Development of Neural Connections
- Synaptic Efficacy
- Motivation and Emotion

Easter

- Learning and Memory
- Higher Functions of the Nervous System

Supervisions:

Supervisions are pretty standard and are similar to what you may have experienced in part 1A. However, this may also be your first time having supervision partners who are doing a different course than you. You will have different insights from your different disciplines and different prior knowledge from the other modules you have done as part of your respective courses. The different perspectives are helpful for you to think more holistically on neurobiology and may help you write better essays with different inputs.

Practicals:

Practicals for the 1B Neurobiology course are only taken by the NatScis. If you took 1A PoO, you will find that the general structure of 1B Neurobiology practicals is similar, as they are organised by the PDN department.

These practicals are not assessed but are mostly tools to consolidate your knowledge from the lectures. There are a wide range of different formats of practicals, including a visit to the MRC Cognition and Brain Sciences Unit, computer simulations, histology practicals, as well as an opportunity to learn human neuroanatomy hands-on using cadaver brains.

The practical session titles are as follows (subject to change):

Michaelmas

- Computer simulation of action potentials and synaptic transmission
- Cutaneous sensation
- Hearing

- Vision: function of the eye

Lent

- Zebrafish embryo and the nematode, *C. elegans*
- Eye movements and vestibulo-ocular reflex
- Human electrophysiology and motor reflexes
- Functional brain imaging
- Human neuroanatomy

Easter

- Brain histology

Revision:

While lecture series are given within specific topics, the exam will test you on how the different topics are interconnected. For example, you may be asked to compare and contrast certain features of a subset of the sensory systems you have studied in Michaelmas term. Or, how the higher functions of the brain are tied back to specific senses such as vision. Therefore, you might want to think critically about the course as a whole, when preparing for the examinations.

Past essay questions can be found on Moodle dating back over 10 years ago, for your reference.

Exams:

There are two written papers for the 1B Neurobiology course:

Paper 1 (3 hours)

- Write 4 out of 10 essay questions
- To be taken by all 1B Neurobiology candidates

Paper 2 (1.5 hours)

There are two sections in this paper:

- Section A (1 hour)
    - To be taken by all 1B Neurobiology candidates
    - 20 short answer questions
- Section B (30 mins)

- Practical paper to be answered by NST candidates only
- 4 short answer questions

Useful resources:

Some recommended textbooks from the course handout:

- Bear, M.F., Connors, B. & Paradiso, M. (2015). 'Neuroscience: Exploring the Brain', 4th edition, Lippincott. Also available in Kindle edition.
- Purves, D., Augustine, G.J., Fitzpatrick, D., Hall, W.C., Lamantia, A.-S., McNamara, J.O. & White, L.E. (2012). 'Neuroscience', 5th edition, Sinauer. Available in electronic form; see http://www.sinauer.com/neuroscience-609.html
- Nicholls, J.G., Martin, A.R., Fuchs, P.A., Brown, D.A., Diamond, M.E. & Weisblat, D.A. (2012). 'From Neuron to Brain', 5th edition, Sinauer. Available in electronic form; see http://www.sinauer.com/from-neuron-to-brain.html

Pharmacology.

Lectures:

The Part IB Pharmacology course is an excellent introductory course, with content shared with the Medics and VetMeds. It covers how various types of therapeutics can interact with and influence biological systems, from the chemical mechanisms to whole body responses. The course will also teach fundamental practical techniques commonly used in pharmacological research in the practical lessons.

Part IB Pharmacology can be neatly split into content-based and practical-based lecture series, which will be examined accordingly in separate papers. It builds up neatly from both the Part IA Physiology of Organisms and Biology of Cells courses, leading on from the courses on the different human physiological systems, and in biochemistry and cellular signalling. There is a lot of physiology in Pharmacology, especially in Lent Term. A typical content-based lecture series can be divided into two parts, one covering the physiology of the systems involved and the pathophysiology of related diseases, and the other discussing the possible pharmacological interventions to influence the systems or target the diseases as mentioned. There is less emphasis on the chemistry of the drugs in the lectures. Practical-based lecture series aim to teach the more technical concepts of pharmacology, such as on ligand binding and pharmacokinetics, which will be considered and applied in practice to a large extent.

All lectures will come with the relevant handouts, and most lecturers' slides will largely follow the content in the handouts (except for a few). Keep in mind that some handouts can be quite wordy and content-heavy, with their associated lectures being considerably fast-paced. It is advisable to read up more on these handouts outside of lectures, as the content covered will be highly useful in the examinations. Lectures will usually be held at 11am on Mondays, Wednesdays, and Fridays.

The lecture synopses are given below (P for practical-based, C for content based):

<u>Michaelmas:</u>

- **Drug-Receptor Interactions (P):** The course starts with the most fundamental concept in pharmacology, where a drug interacts with a receptor and thus discussing what the drug does to the body. Foundational pharmacological concepts will be discussed in greater detail, such as affinity, efficacy, selectivity, specificity, agonism and antagonism etc.. Different types of receptors will be explained, each functioning via different mechanisms of action – leading on from the Cellular Signalling course in IA Biology of Cells. It is useful to remember the different ways receptors can be activated, as they will be seen again repeatedly throughout the whole course.

- **Synaptic Pharmacology (C)**: Here is where the content begins – and it rolls fast and hard, especially in these lectures. This lecture block focusses on pharmacology of the nervous system, and introduces the basic mechanism of neurotransmission. It then goes into detail to how each step of neurotransmission can be targeted pharmacologically by various classes of drugs. Cholinergic and adrenergic neurotransmission will be discussed, covering the different types of receptors and their respective locations and functions. Non-cholinergic and non-adrenergic (NANC) neurotransmission will also be covered, such as purinergic and nitric oxide neurotransmission.
- **Small Molecule Drug Discovery (C)**: A slight aside from the usual biology-related pharmacology content, this small lecture block gives a brief overview of the drug discovery process for contextualization, though it will mainly focus on the early stages of small molecule drug discovery. You'll be introduced to various types of techniques used in hit finding, hit to lead, and lead optimization, such as virtual screening, fragment-based drug discovery, and drug repurposing.
- **Antimicrobial & Antiviral Drugs (C)**: These classes of drugs are extremely important in a medical setting, and in this lecture series, antibiotics and antivirals will be discussed in further detail. The course begins with the development of antibiotics, and the different mechanisms in which they work alongside the drugs that treat them. It then touches on anti-parasitic drugs – split into anti-protozoal and anti-helminthic drugs, before moving onto detailing the mechanisms behind antivirals. The course ends with an important (examinable) section on various mechanisms of drug resistance, and several strategies to counter them.
- **Growth Factor Signalling (C)**: This short lecture series mainly covers the physiology of growth factors, with emphasis on signalling pathways. Receptor tyrosine kinases (RTKs), G-protein cascades, and various types of growth factors will be further discussed as well. It ends with what can go wrong in these signalling pathways, which nicely lead up to the final course of the Michaelmas term…
- **Anti-cancer Drugs (C)**: This series touches briefly on the pathophysiology of cancer and the various types of treatments that we have come up for it, comparing traditional chemotherapy and modern targeted anti-cancer therapy. The whole series will be contextualized in how these treatments target the ever-evolving hallmarks of cancer.

Lent:

- **Pharmacokinetics (P):** The second practical-based course, pharmacokinetics is one of the cornerstones of pharmacology, discussing what the body does to the drug. The course is logically structured around the ADME scheme. It first covers different types of drug administration with their respective benefits and disadvantages, before moving into how the drug is distributed across different compartments of the body. First and second-pass metabolism via a range of enzymes is then explained, before ending with how the drug or its metabolites are excreted from the body. Various pharmacokinetic concepts and metrics such as clearance, volume of distribution and bioavailability (along with many others) will be introduced here, which constitutes another **important** component for the practical examination.
- **Inflammation, Immunosuppression, and Pain (C)**: This lecture series begins with a brief explanation of the physiology of inflammation and the role, synthesis, and metabolism of histamine. Other peptide inflammatory mediators like bradykinin and lipid inflammatory mediators like leukotrienes and prostanoids will be discussed with respect to how they influence inflammation. As expected, the pharmacology of NSAIDs will be discussed extensively here. The course then proceeds to explain more about immunology and the pharmacological action of corticosteroids, before moving into various inflammatory-related diseases such as Asthma and COPD and autoimmune disorders like rheumatoid arthritis, explaining the pathophysiology and pharmacological interventions. This is followed by a section which details more immunosuppressive drugs before a brief explanation on the production of monoclonal antibodies. Lastly, the series rounds up with explaining the pharmacology of pain management, with a discussion on opioids and other types of painkillers.
- **Cardiovascular and Renal Pharmacology (C)**: This is the longest IB Pharmacology lecture series (and yet somehow the most enjoyable one). It first introduces the structure, role, and distribution of K^+, Na^+ and Ca^{2+} ion channels across the cardiovascular system, before explaining the physiology and pharmacology of the heart, delving into the production of both pacemaker and ventricular action potentials. The series then discusses how to target dysrhythmia (cardiac conduction) and cardiac contraction, before moving onto the pharmacology of the vascular system, where renal physiology plays a large role in controlling as well. Diseases like hypertension, chronic heart failure, angina, and myocardial infarction, alongside thrombosis, will be discussed in both pathophysiology and pharmacology. The course then ends with a short discourse on beta-blockers, which are extremely instrumental in the treatment of cardiovascular disorders.
- **Endocrinology and Reproductive Pharmacology (C)**: This short chapter on the endocrine system is explored in two distinct settings: reproductive pharmacology and diabetes. It first covers the hormonal physiology of various sex hormones and

various treatments for issues like contraception and infertility. The lecture series then explains the different types of pharmacological interventions available for treating diabetes (in particular, type II diabetes mellitus – T2DM).

Easter:

- **Central Nervous System (CNS) Pharmacology (Neuropharmacology) (C):** The IB pharmacology course ends with arguably one of the least understood areas in medical sciences. It begins with a brief physiological overview of the CNS, before expanding on the excitatory glutaminergic and inhibitory GABA neurotransmission, both vital forms of regulatory neurotransmission which are crucially balanced. The pharmacology of various disorders is then discussed, such as anxiety, insomnia, and epilepsy. Antidepressants are covered extensively, before moving into dopaminergic neurotransmission, which brings disorders like Parkinson's and schizophrenia into the picture and ways to treat them via anti-Parkinsonian drugs and antipsychotics. The lecture series then ends with a brief mention of Alzheimer's disease and related emerging therapies.

Supervisions:

Supervisions aim to consolidate your understanding of the important ideas from each lecture series. Supervision work usually comprises practice from past year tripos essays for the relevant topics, as well as past year practical questions, which should be at least reviewed by your supervisors and advised on. Otherwise, supervisors often spend supervision time going through the content from each lecture series. In addition, as the examination format has only been revised very recently in 2021, it is advisable to ensure that both you and your supervisor are aware of the new format such that you're able to get adequate experience practising the relevant examination questions in the appropriate time frame given.

Practicals:

Part IB Pharmacology practical sessions mainly aim to give you first-hand experience on techniques used in pharmacological research. These sessions will cover basic pharmacological assays used (e.g. saturation binding assays, competitive binding assays etc.) and methods to analyse experimental data, such as deriving dose ratios. You'll have plenty of experience hooking up a guinea pig ileum to a force transducer too, which will be a staple experimental set-up in determining the effects of drugs on ileum contraction.

Usually, these practical sessions will be on either Tuesday or Wednesday afternoons from about 2pm to 5pm and will primarily take place in Michaelmas.

In Lent, in addition to a few in-person practical sessions, you'll spend most practical slots working on a drug review project in your own time, which requires you to compile information about a drug and present it with relevant slides within 3 minutes. You'll be selecting the drug from a chosen list and will be given an allocation based on your preference which you'll indicate. Each drug will be paired with a supervisor as well, which you can direct any specific questions about the chosen drug towards. You'll also have the chance to send a first draft of your slides and recording for them to provide feedback on before the final submission. This is the only examinable 'practical' component, taking up 10% of your total grade. Just for fun, there will be a chance to have your recording uploaded for the rest of the cohort to view and vote upon, with prizes (typically vouchers) for the top 3 videos with the most votes.

Revision and Exams:

Once again, it is absolutely essential that you familiarize yourself with the examination format which was revised in 2021. This new format confers 60% of your total grade to Paper 1 (Extended Answers), 30% to Paper 2 (or WP: written practical), and 10% to the drug review project. Moving forward, the written examinations are likely to be closed book and are quite likely to be conducted online on the Inspera exam portal.

Paper 1 is 3 hours long and contains a total of 6 short-essay (or 'extended answer') questions, each of which you'll have 2 parts: (a) or (b) that you can choose either from, giving a total of 6 responses which you should ideally spend ONLY 30 minutes each. The two parts can either be from the same lecture series (typically a longer one), or from two separate lecture series (typically the shorter ones). You can refer to past year or specimen papers for a better grasp of the types and range of questions that can be asked. This can be used to your advantage in strategizing which sub-topics you wish to focus on within each lecture series when prioritising what to revise under limited revision time.

Paper 2 (or WP) is also 3 hours long and contains 4 questions of 20 marks each. Question 1 is a practical-based question on ligand binding, typically involving the analysis and interpretation of experimental binding data obtained from a series of experiments. This is followed by question 2 which is an essay-based question on the theory behind ligand binding. Question 3 is a practical-based question on pharmacokinetics, which often involves detailed pharmacokinetic calculations based on the type of drug administration and dosage, as well as your interpretation regarding the results. Lastly, question 4 is an essay-based question on the theory of pharmacokinetics. 2 practical (short answer/calculation) questions, 2 essay questions: plan your time wisely according to what is the best strategy for yourself.

A common strategy for revision is to split your notes into two sections for each topic. The first section covers the physiology of relevant systems and the pathophysiology of diseases involved. The second section, and the core of pharmacology, is to compile a list of drugs which can be used to target the relevant diseases or conditions. Within each list, drugs can be categorised separately (e.g. by mechanism of action or side effects etc.). Additional information about each drug (e.g. side effect profile, pharmacokinetics, contraindications etc.) can be added such that pharmacological treatments can be more easily compared and contrasted as well (which is an important skill often required in Tripos essay questions).

It is encouraged to try to simulate closed-book conditions, and attempt essay questions within the given time limit, then review your answers either with your supervisors to evaluate the structuring and coverage of your essay or by cross-checking with your own notes to see if there is anything you wished to write but you missed out on. The same kind of timed practice is also relevant for practical-based questions as well. You'll be given a formula sheet that you can refer to, but practising how to use the formulae is also important and can save you a fair amount of time during the WP paper to spend on essay-based questions.

Useful resources:

- ➔ The bible for Part IB Pharmacology: *Rang & Dale's Pharmacology* (Rang et al., latest edition not required) – the go-to for all additional knowledge required about literally any topic, complete with stylish and detailed diagrams (most lecture notes/diagrams are based on this book too).
- ➔ For any other information about the course, a good reference would be the latest edition of the *NST Part IB Pharmacology Course Handbook* typically available on Moodle.

Physics A

Lectures:

Physics A is the more popular choice between the two physics options available at IB (for those not taking both), particularly because of the greater relevance of its content to other subjects. It is commonly taken together with Physics B and Mathematics, for those who are certain that will be specialising in Physics or Astrophysics in Part II. It is also common to take either double physics (A & B) with another unrelated subject or indeed combine single physics (A or B) with other subjects. This would allow one to keep their options open for Part II, but those who are not taking IB Maths would have to attend the Mathematical Methods course in Michaelmas term to build the mathematical foundations for the concepts that will be covered in Physics A. Both Physics A & B must be taken at the IB level to take it as a Part II course or as a half subject as part of the Physical Sciences option. Lectures are usually at 11 am on Mondays, Wednesdays and Fridays.

Physics A transitions rather smoothly from IA Physics, starting with Oscillations, Waves and Optics (OWO – still not as questionable as PoO) which begins by covering most of the content from the IA Oscillations course before progressing to new content. This course is lectured concurrently with the Experimental Methods course. The course then continues with Quantum Physics, arguably the highlight of the course, which is then lectured throughout Lent. Finally, the course concludes with Condensed Matter Physics which draws upon ideas from earlier courses. Although the course is designed to be self-contained, those also taking Physics B and Maths will definitely be able to appreciate some of the concepts covered on a deeper level.

In general, most lecture notes tend to be filled (without blanks for you to fill in), either in the form of slides or handouts, but each course is lectured differently with each lecturer referring to the lecture notes to differing extents. A short summary of each lecture course is as follows:

<u>Michaelmas (OWO & Experimental Physics):</u>

- **Oscillations, Waves and Optics:** The course begins with oscillations and essentially revises the entirety of the IA Oscillations and Waves courses before introducing extensions to existing concepts such as response factors and polarisation. Then, it continues with waves where students are introduced to sound waves and dispersion for the first time. The course concludes with optics, which introduces Fresnel and Fraunhofer diffraction, delves deep into how Fourier Transforms can be applied to

Fraunhofer diffraction, and briefly covers interferometry. Most of what is covered is derived rigorously, and the accompanying example questions provide many opportunities for one to convince themselves of the validity of the concepts presented.

- **Experimental Methods:** This is lectured simultaneously with the Monday and Friday lectures covering OWO, and the Wednesday lecture covering Experimental Methods. The aim of the course is to provide the theoretical background for the practical sessions and cover important concepts necessary in experimental work at higher levels. The course heavily uses electrical circuits, in particular Op-Amps, as a subject. As such, it can feel like an electronics course rather than an experimental methods course at times. The lecture slides alone are not very helpful in building understanding, hence clarifying concepts in supervisions is key to understanding what is being covered.

<u>Lent (Inorganic):</u>

- **Quantum Physics (QP):** This course, spanning a mammoth 24 lectures, will be the first time you encounter QP properly (having been briefly introduced to some related concepts in the IA Waves course). The course builds foundations well, by first motivating the need for QP with a brief discussion of historical developments, before moving onto Wavefunctions and the Schrodinger Equation. It then covers potential wells (and bound and unbound particles) from IA Waves much more rigorously. Following this, you will be introduced to operators in physics for the first time, which sets the stage to derive many important results such as the uncertainty principle, the orbitals of electrons in a hydrogen-like atom and two-particle systems. Finally, you are introduced to Spin and its implications on particle exchange (which gives rise to the Pauli Exclusion Principle amongst other things).

<u>Easter (Biological):</u>

- **Condensed Matter Physics (CMP):** The final lecture course consists of just 10 lectures, before examinations begin and builds very quickly on the concepts in the QP, so you must be solid on everything covered in Lent before Easter term begins. The course begins by introducing the concept of phonons (not a spelling mistake!), and covers theoretical models used to explain trends in properties such as heat capacity and thermal conductivity of insulators and conductors. The course concludes by deriving the band structure. This is then used to differentiate between conductors, insulators, and semiconductors, and explain some of the properties of semiconductors.

Supervisions:

The content covered in supervisions will obviously vary from supervisor to supervisor, but in general you can expect for supervision problems to take longer to solve than they have in IA. Problems are usually graded from A to C, with A indicating a simple problem meant to test basic understanding, and C implying the problem is significantly challenging. Most tripos questions would probably fall somewhere between B and C. There are usually also a few computational problems on the example sheet, which can be solved using content covered in IA Scientific Computing. These problems are mainly on the supervision sheet to extend your understanding (as opposed to providing exam practice) so don't be put off by their difficulty. It is worth highlighting that some courses' supervision problems require content not strictly covered in the lecture notes. Do take note of these questions, because this content may very well appear in the examinations.

Practicals:

As in the case for many Part IB subjects, there is a practical session every week. This can either be a continuous 7h 45min slot (with a break for lunch) on one day, or two shorter sessions distributed over two days depending on your slot allocation. You have some ability to choose your practical slot: It is likely that during the induction briefing at the start of the year you will be handed a piece of paper on the way in. This is randomised and will decide your practical slot, but you can make mutual swaps with others before handing this piece of paper back with your name on it. After this point, it is extremely difficult to change your practical slot.

Practicals are like IA in that marking is formative with standard credit, but there is a graded scientific report due shortly after Michaelmas term ends (or you can instead choose to submit one after Lent term ends if you are taking single physics – refer to the lab manual for more detail). Practicals in Michaelmas don't necessarily follow the Experimental Methods course closely, but will draw upon much of the course's content, particularly when it comes to Op Amps.

Lent term gets much busier. If you are taking double physics students, you will be assigned to a group at the start of Lent and you will be expected to work together on:

1. a scientific poster on a topic in the course syllabus that you will present at a poster session at the end of the term
2. an extended investigation at the end of the term that will involve using the techniques learnt throughout the Lent practicals to investigate an open problem

(e.g., what is the wavelength of a given laser). You then prepare a group presentation detailing your findings. This is also due at the end of the term.

If you are taking Physics A as a single physics option, you don't have to do the extended investigation, but will still have to participate in a poster session. Practicals in Lent follow the same format as in Michaelmas vis-à-vis standard credit, but you can choose 3 out of about 5 available practicals to perform in weeks 3, 4 and 5 if you are doing double physics. If you are doing single physics, the choice of practicals has some restrictions which are detailed in the lab manual. Choosing your practical is done at the start of the practical session on a first-come-first-served basis where the limiting factor is the number of setups available for that experiment. It has been the case at least this year that the extended investigation was related to optics, if this remains the case next year, doing the optics experiments would probably provide the most benefit for those doing the extended investigation.

Revision and Exams:

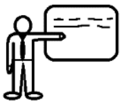
In addition to the assessed practical coursework (which forms 25% of the overall grade), there are two 3-hour papers at the end of the year. There is no choice of question, but the content is usually split such that Paper 1 covers Experimental Methods and QP, while Paper 2 covers OWO and CMP. There are 5 short questions in Section A, 3 to 4 long questions and either essay or brief notes questions forming the remainder of the marks.

Past papers are the main resource for revision. The TIS has papers ranging all the way back until 1995 so there is no shortage of these. As for suggested answers, the TIS has these for certain years, though some supervisors provide unofficial solutions for other years as well. The brief notes and essay questions can be prepared for by preparing essay plans in advance. There is a somewhat limited set of essay/brief notes questions that can be asked, hence it is possible to work through a few years' worth of questions and find that you have covered a decent chunk of examinable content that can be tested in the form of essay questions.

Useful resources:

- Course Website: https://www.natsci.tripos.cam.ac.uk/subject-information/part1b/phy
- TIS: https://www-teach.phy.cam.ac.uk/students/

Physics B



Lectures:

The Physics B course complements the content in Physics A and is usually the less popular choice between the two physics options available at IB (for those not taking both), particularly because of the greater relevance of the Physics A course's content to other subjects. It is commonly taken together with Physics A and Mathematics, for those who are certain they will be specialising in Physics or Astrophysics in Part II.

It is also common to take either double physics (A & B) with another unrelated subject or indeed combine single physics (A or B) with other subjects. This would allow one to keep their options open for Part II, but those who are not taking IB Maths would have to attend the Mathematical Methods course in Michaelmas term to build the mathematical background necessary for the concepts that will be covered in Physics B. Both Physics A & B must be taken at the IB level to take it as a Part II course or as a half subject as part of the Physical Sciences option. Lectures are usually at 9 am on Mondays, Wednesdays, and Fridays.

Physics B begins with Electromagnetism, which builds upon the content briefly covered in the IA Fields course. This course spans 20 lectures, after which comes Classical Dynamics which introduces much more complicated dynamical systems than you might have seen so far (and the tools used to analyse them). This course spans 16 lectures, with the first 4 in Michaelmas. Lastly, the course concludes with Thermodynamics, which introduces you to the analytical and statistical treatment of thermodynamics over 8 lectures before exams begin.

In general, most lecture notes tend to be filled (without blanks for you to fill in), either in the form of slides or handouts, but each course is lectured differently with each lecturer referring to the lecture notes to differing extents. A summary of each lecture course is as follows:

<u>Michaelmas:</u>

1. **Electromagnetism:** The 20-lecture course begins where IA ended by looking at Maxwell's Equations, before delving deeper into electrostatics and magnetism. For each case, the course uses vector calculus to derive the relevant Maxwell's equations and looks at interesting problem-solving techniques such as the method of images. Much of the mathematics covered here provides a neat background when

it is covered more rigorously in IB Mathematics. The lecture course itself is rather enjoyable with lots of demonstrations spaced throughout the course, which certainly makes taking the trip down to lecture theatre for a 9 am worth it.

2. **Classical Mechanics:** This course begins with a brief recap of IA dynamics before rushing into rotating frames. The lecture notes tend to be extremely brief, and this topic takes a few readings to understand. The course then moves onto planetary orbits, before covering lagrangian mechanics, normal modes, elasticity and finally some fluid dynamics. The notes are formatted as slides, and thus read more like revision notes than lecture notes. This means that there is a lot of information that is important, packed into a very short document. There are 4 lectures in Michaelmas and 16 in Lent.

<u>Lent:</u>

3. **Classical Mechanics:** (As explained above)

4. **Thermodynamics:** The final lecture course in Physics B consists of 8 lectures in Lent and 8 lectures in Easter. It is quite possibly the first time you might encounter thermodynamics if you hadn't taken IA Chemistry and the course is structured with the assumption that you didn't. Beginning with analytical thermodynamics, you are first introduced to state variables and the laws of thermodynamics, before moving on to phase transitions, and then finally statistical thermodynamics. It is worth highlighting that this course is lectured right before the start of exams, and it is probably a good idea to spend some time in summer looking through the thermodynamics course material to do your future self a favour. As with Classical Mechanics, the lecture notes are slides which makes understanding the material at first glance challenging. A good reference textbook is Concepts in Thermal Physics by Blundell & Blundell. The textbook is easy to understand and entertaining to read (as entertaining as Physics textbooks can get), and can be a lifesaver during the frenzy of Easter term.

<u>Easter (Thermodynamics):</u>

5. **Thermodynamics:** (As explained above)

Supervisions:

The content covered in supervisions will vary from supervisor to supervisor, but in general, you can expect supervision problems to take longer to solve than they have in IA. Problems are usually graded from A to C, with A indicating a simple problem meant to test basic understanding, and C implying the problem is significantly challenging (similar to Phys A).

Most tripos questions would probably fall somewhere between B and C. There are usually one or two computational problems on the example sheet to extend your understanding, which can be solved using content covered in IA Scientific Computing.

Practicals:

As in the case for many Part IB subjects, there is a practical session every week. This can either be a continuous 7h 45min slot (with a break for lunch) on one day, or two shorter sessions distributed over two days depending on your slot allocation. You have some ability to choose your practical slot: It is likely that during the induction briefing at the start of the year you will be handed a piece of paper on the way in. This is randomised and will decide your practical slot, but you can make mutual swaps with others before handing this piece of paper back with your name on it. After this point, it is extremely difficult to change your practical slot.

Practicals are like IA in that marking is formative with standard credit, but there is a graded scientific report due shortly after Michaelmas term ends (or you can instead choose to submit one after Lent term ends if you are taking single physics – refer to the lab manual for more detail). Practicals in Michaelmas don't necessarily follow the Physics B content very closely, but you are likely to see more Physics B relevant experiments in Lent (for instance there was a practical about Waveguides).

Lent term gets much busier. If you are taking double physics, you will be assigned to a group at the start of Lent and you will be expected to work together on:

1. a scientific poster on a topic in the course syllabus that you will present at a poster session at the end of the term.
2. an extended investigation at the end of the term that will involve using the techniques learnt throughout the Lent practicals to investigate an open problem (e.g., what is the wavelength of a given laser). You then prepare a group presentation detailing your findings. This is also due at the end of the term.

If you are taking Physics B as a single physics option, you don't have to do the extended investigation, or the poster session. Practicals in Lent follow the same format as in Michaelmas vis-à-vis standard credit, but you can choose 3 out of about 5 available practicals to perform in weeks 3, 4 and 5 if you are doing double physics. If you are doing single physics, the choice of practicals has some restrictions which are detailed in the lab handout. Choosing your practical is done at the start of the practical session on a first-come-first-served basis where the limiting factor is the number of setups available for that experiment. It has been the case at least this year that the extended investigation was related to optics, if this remains the case next year, doing the optics experiments would probably provide the most benefit for those doing the extended investigation.

Revision and Exams:

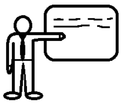
In addition to the assessed practical coursework (which forms 25% of the overall grade), there are two 3-hour papers at the end of the year. There is no choice of question, but the content is usually split such that Paper 1 usually covers calculation questions from Electromagnetism and Classical Dynamics, with maybe Section A questions from Thermodynamics, while Paper 2 covers mainly Thermodynamics calculation questions with essay questions related to Electromagnetism and Classical Dynamics. There are 5 short questions in Section A, 2 to 3 long questions and either essay or brief notes questions forming the remainder of the marks.

Past papers are the main resource for revision. The TIS has papers ranging back until 1995 so there is no shortage of these. As for suggested answers, the TIS has these for certain years, though some supervisors provide unofficial solutions for other years as well. The brief notes and essay questions can be prepared for by preparing essay plans. There is a somewhat limited set of essay/brief notes questions that can be asked; hence it is possible to work through a few years' worth of questions and find that you have covered a decent chunk of examinable content that can be tested in the form of essay questions.

Useful resources:

- Course Website: https://www.natsci.tripos.cam.ac.uk/subject-information/part1b/advphy
- TIS: https://www-teach.phy.cam.ac.uk/students/

Physiology



Lectures:

The part 1B Physiology course, in contrast to 1A Physiology of Organisms (PoO), is heavily focused on humans and no longer discusses plants. While lecture series are split by the different physiological systems, this 1B course is a fun and rewarding one, as you will find that by the end of the year, you are able to synthesise the different information to explain the physiological responses to different stresses, such as exercise, pregnancy, altitude, and extreme climates. As physiologists love their hormones, you will be introduced to quite a few hormones across the different physiological systems and how they are involved in different feedback and feedforward systems.

For the majority of Lent term, you will learn about reproductive physiology alongside the VetMeds. This part of the course covers a broad range of material not previously discussed in NST 1A. The 6 weeks of lectures starts by discussing sexual differentiation, which includes comparing and contrasting gametogenesis between the two sexes, as well as the menstrual and oestrous cycles in mammals. You will also learn about the earliest point of pregnancy following fertilisation, where embryogenesis and maternal recognition of pregnancy occurs, which is pivotal for a successful and sustained state of pregnancy. There maintains a strong emphasis on integrated physiology, where you learn about the physiological responses of the mother, foetus, and neonate to the different challenges they face, such as nutrition and hypoxia.

For almost all of the lecture series, you will be given access to complete and detailed notes, as well as the slides used during the lectures. They are usually made available before lectures, which take place at 9am on Tuesday, Thursday, and Saturday. I highly recommend taking this 1B course, not just for the fascinating content, but also for the very engaging lectures. You will have met most of the lecturers at some point in PoO and I assure you that they are as wonderful in 1B Physiology, if not better!

The lecture series titles are listed below:

Michaelmas

- The Mammalian Cardiovascular System
- Human Endocrinology
- Respiratory Physiology
- Human Renal Physiology

- Physiology of pH Regulation
- Blood, Lymph & Inflammation

Lent

- Reproduction
    - Sexual Differentiation
    - Early Pregnancy
    - Pregnancy & The Foetus
    - Birth & Lactation
    - Neonatal Physiology
- Digestive Physiology
- Weight Regulation & Nutrition

Easter

- Endurance Performance & Training
- High Altitude Physiology
- Physiology of Microgravity
- Arctic & Desert Physiology

Supervisions:

Supervisions are pretty standard. You go through content from the past week with your supervisor and perhaps discuss some essay plans. While contents from the lectures are mostly based on human physiology, you may be able to discuss animal physiology with your supervisor as well, which could be good additional information for your essays. For instance, my supervisor is a VetMed by training and actively works with horses, so we got lots of fun facts about horses and their unique reproductive physiology!

Practicals:

There are two types of practicals in 1B Physiology – histology practicals and experimental physiology practicals.

Experimental Physiology

For the most part, the experimental physiology practicals (and PDN practicals by extension) are similar to those in 1A PoO. The practicals themselves are not graded, but are helpful tools to consolidate the content from the lectures. For example, we did some dissection work and studied the cardiovascular system in the frog, although we had some pretty anomalous data due to issues with the batch of frogs we got. Otherwise, we did not have many other opportunities to do dissection work and had to watch videos of the dissections instead, such as when studying the rabbit gut in Lent term.

There is also a 5-week long experiment on exercise physiology, where a test subject undergoes training for a few weeks, and you can witness the changes in stroke volume, cardiac output, respiratory quotient, etc. in response to the stresses from exercise! I would encourage you to volunteer for this experiment, as it is truly a fascinating experience to be able to quantify these physiological changes in your body.

Histology

There are histology practical sessions for you to learn about the different physiological systems at the microscopic level. Most practical sessions are an opportunity for you to look under the microscope at different cell types and learn to identify the slides that you are looking at. You will be asked to identify different structures and cells in the practical exam. This includes microscopic images of the male and female reproductive systems, the respiratory system, cardiovascular system, renal system etc.

Revision:

Past papers (up until around 2004) are available on Moodle, although the format has changed a bit over the years. There are limited MCQ papers available, with no answers provided, so try and leave those until Easter term to fully utilise the resources. You may ask to discuss the questions during your supervision, or ask your supervisors to check the answers for you, if they are willing to do so!

Focus on first understanding each of the systems learned (in Michaelmas) and what they do. You will then be able to reason how each of the systems might respond in response to specific challenges, which is important for essays on integrated physiology.

Exams:

There are 2 written papers for 1B Physiology. On the whole, you are expected to write 3 essays and 107 multiple-choice questions for exams. For a NST exam, this might sound straightforward enough to prepare for, but you need a thorough understanding of all the elements in the course to answer the questions confidently.

The 2022/23 format is as follows:

Paper 1 (3 hours)

- Section A
  - 20% of total marks for 1B Physiology
  - 55 compulsory MCQs (1 mark each)
- Section B
  - Candidates should write 3 out of 6 essay questions
  - The recommended time for this section is 2 hours

Paper 2 (1 hour 40 minutes)

This is the practical paper which accounts for 30% of the total marks for 1B Physiology, consisting of 52 compulsory MCQs.

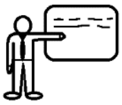
- Section A
  - 42 MCQs on the histology and experimental practical components of the course (1 mark each)

- Section B
  - 10 data-handling (3 marks each)

Useful resources:

- Koeppen, Bruce M., et al. *Berne & Levy Physiology*. Elsevier, 2024.
- Johnson, Martin H. *Essential Reproduction*. Wiley Blackwell, 2018.
- https://www.pdn.cam.ac.uk/undergraduate/part-ib-courses-0#phys

Plant & Microbial Sciences



Lectures:

The Part IB Plant & Microbial Sciences course is a really fun course that covers a wide array of all things plants! Unlike other IB courses, the IBPMS course has a lot of breadth, covering topics from molecular biology to physiology, epidemiology, ecology and more. This helps to place the topics you study into context and showcases the full range of biological scales you can study. In my opinion, the Plant Sciences department is also a really friendly department that cares a lot about its students, with fun activities like walks around the Botanical garden and occasional pizza lunches. Also, who can forget about the Portugal trip during the Easter break, which is one of the highlights of the course!

All lectures will come with the relevant handouts, and most lecturers' slides will largely follow the content in the handouts. Lectures will usually be held at 11am on Tuesdays, Thursdays, and Saturdays.

More information can be found in the very helpful course booklet available on their website: https://www.plantsci.cam.ac.uk/files/ib_pms_booklet_2021-22.pdf so I will not bore you with too many details. Briefly, the main themes of topics covered are:

Michaelmas: Plant genetics, physiology (including sunlight, nutrients, water uptake), biochemistry (photosynthesis, sugar processing).
Lent: Microbe physiology & pathology, epidemiology in plant diseases, plant immunity, plant-microbe symbiosis, plant development, crops and food supplies.
Easter: Plants in ecology and conservation, plant genetics.

The course is well-organised in drawing constant links between the blocks throughout the year, especially in the genetics courses that highlight the use of tools to improve aspects of plant physiology that have been improved in the different areas previously covered. There are larger themes of crop development and pathogen resistance throughout the course that are relevant for the development of better crops and agriculture. The wide breadth of the course also lends itself to drawing links with several other subjects, such as BMB, CDB, EEC, and EAD.

Supervisions:

One unique thing about the IB Plant Sciences course is that supervisions are centralised, and organised by the department instead of your college! This means that the department can find well equipped supervisors to teach the different subjects, and you might often find that you change supervisors during the year depending on the lecture content. This is a good thing though, since you will often get supervisors who are working on the subject area you are studying, and they will have a lot of insight.

Practicals:

6 of the IBPMS practicals are graded – you will have to submit a short writeup or answer some questions. However, this is not as daunting as you might expect, as only the top 5 practical scores are taken into account. This gives you some leeway to make mistakes and learn from them, since some short feedback is also given after your work is graded.

As with the lectures, a wide range of different topics are also covered, which allows you to learn many different techniques. You'll be exposed to molecular techniques for plant genetic manipulation, instruments to measure photosynthesis and more! There is also a short 4hr field trip in Easter to the nearby woods, where you can learn more about conservation, and a few practicals at the Botanical Garden to learn about floral development and Mediterranean plant diversity. Additionally, there is a practical where you will have to present a topic that was covered during an earlier practical, which I thought was really unique in developing research skills. The department does a good job of providing tips and advice on how to give a good presentation.

Portugal Field Course:

THE highlight of the part IBPMS course, though it is optional. It is rare to have the amazing opportunity to go overseas on a field trip, and even rarer to have it at such an affordable price! (It was £120 for 6 days in the past, but details may change from year to year – you may also be able to get your college to cover some or all of this)

The field trip is a great place to put what you have learnt through the year in context, as they go through a lot of the concepts that you have learnt, but you get to see the plants in their native habitats. Portugal has many different types of environments, so you'll get to learn about how different plants adapt and do some comparative physiology as well. On top of that, the staff and PhD student supervisors that go with you on the trip are super friendly, and I had an excellent time overall. There's also some time for exploring Lisbon and other activities with friends on the course.

Revision and Exams:

Paper 1: Short answer theory & practical paper (40%)

Paper 1 is 3 hours long and is split into 2 sections. Section A has 8 short answer questions, much like what you would have encountered in IA BoC or PoO. Pretty straightforward stuff, but requires you to have a good understanding of all lecture material covered. Section B has 10 practical questions, again like what you might have encountered in IA BoC.

Paper 2: Essay paper (50%)

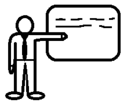
Paper 2 is an essay paper, and for plants you'll have to write 4 essays in 3 hours. Pretty tight time limit, though not the worst you'll encounter in the natsci course. The essay paper is split into 3 sections – Michaelmas, Lent + Easter and synoptic essays. You'll have to answer 1 question from each section, plus an additional essay from one of the Michaelmas or Lent + Easter sections. The synoptic essays are something unique to Plants Sciences – they require you to integrate information across the different lectures that are linked by a common theme. There isn't much essay choice (in 2024, 2 in Michaelmas, 3 in Lent/Easter, and 2 synoptic essays), so you will need to know most of the course content.

Don't fear too much about the exams though – the department is one of the most invested departments (in my opinion) in preparing you for exams. There will be multiple exams skills sessions, as well as revision sessions with the lecturers themselves in Easter term, where they go through the key concepts again and take questions. There are also sessions that will specifically prepare you for the synoptic essays, so don't worry too much about them!

Useful resources:

- The plant department webpage: https://www.plantsci.cam.ac.uk/undergraduate-0/part-ib-plant-and-microbial-sciences

Quantitative Environmental Sciences



Lectures:

QES is a combination of Earth Science, Mathematics and Programming, which explores Earth Systems and methods of representing and modelling them. The course also covers environmental policy and the application and role of science in policy and decision making. The course does not have any prerequisites in Part IA but an understanding of chemistry (reaction kinetics), earth science (weathering, climate systems) and mathematics (ordinary differential equations) is beneficial, though these topics are taught and not a requirement. The programming language used in teaching is Python, though there is no restriction on using other languages for assessments if you feel more comfortable.

The full course notes are available online and is complete and clear, covering all the content in the lectures and will explain the content better than I can:
https://quantitative-environmental-science.github.io/Notes/intro.html

Note: As this is a very new course (introduced in 2022-2023), the course structure, content and assessment are likely subject to changes. See resources below for more information.

Lectures are conducted in the Earth Science Department, at 11am on Mondays, Wednesdays and Fridays. Lectures are taught by lecturers from the Maths (DAMTP), Chemistry, Earth Sciences Departments, and the British Antarctic Survey. The course topics often seem rather discrete, but the concepts build on top of each other throughout the course. Each lecture has slides that are accompanied by complete online notes and lecturers often supplement the slides with written equations, particularly for the more mathematically intensive portions, which will be uploaded to Moodle after the lectures.

Michaelmas:

- **Groundwater Flow**: *Introduces concepts that come back often in the course.*
    - Introduction to basic concepts of modelling such as box models, fluxes, and residence time.
    - Understanding groundwater systems (aquifers) and groundwater flow (Darcy's Law, hydraulic gradient, and hydraulic conductivity).
    - Simple mass balance box model for groundwater systems, pumping and sustainably groundwater.

- **Cryosphere**:

- Polar ice types; global warming and its impacts; ice growth and melting model (Stefan problem, seasonality of surface heat flux); ice sheets and steady state glacial flow; floating sea ice and flow in fjords.
- Most of the lectures will be spent deriving the equations describing ice growth and glacial flow systems. Differential equations would not be more advanced than ODEs, would be useful to brush up on IA Mathematics on differential equations.

- **Surface Water - River Flow Models**:
  - Catchment box model (1D drainage into rivers); river steady state flow model; reservoir filling and flood prevention; flood waves; flood defences and urban flooding.
  - Lectures will focus on the equations that describe river and catchment flow, with a few different equations describing different scales of flow. One of the more challenging portions of the course.
- **Air Pollution and Atmospheric Chemistry**:
  - Atmospheric structure (Troposphere and adiabatic lapse rate); air pollutant sources; sinks and chemical reactions; mass balance equation for air pollutants; aerosols and particulate matter; aerosol formation rates; aerosol-cloud interactions.
  - These lectures are focused on chemistry, particularly reaction kinetics and spectrometry. Aerosols focus on the formation and deposition/removal of the aerosols, considering the nucleation rate and growth of particles.

<u>Lent</u>:

- **Global Environment**:
  - Physics in a rotating reference frame; Coriolis forcing; Hadley and atmospheric circulation; atmospheric heat transport; 2 box model for heat transport; Stommel box model of ocean circulation; shallow ocean forcing; density stratification of oceans; thermohaline circulation.
  - The first few lectures are focused on the physics of rotation, requiring basic vector calculus which will be reviewed during the lectures. These derivations will show why atmospheric and ocean currents flow on Earth. The establishment of thermohaline circulation is important for the next section of the course and the lab report.
- **Ocean Carbon**:
  - Solubility, biological and carbonate pumps, and ocean carbon storage; future oceans.
  - Establishing the processes of transfer of carbon in oceans and the 3-box model of the ocean, which is the focus of the lab report. The lectures will

cover processes of transfer and be subsequently added to the model in the weekly practicals. At the end of this section, the completed model should be ready for the lab report.

- **Polar case study**:
    - Field work on polar regions and polar systems.
    - Methods used for research into ocean circulations and characterising ocean dynamics in polar regions.
- **Terrestrial Carbon**:
    - Soil formation; atmospheric models; methane cycle and flux estimation; soil gas formations.
    - This section is more content-heavy and focuses on how fluxes are estimated, including methods of emissions inventory.
    - Common Exam Questions: Methane flux calculation out of the soil

<u>Easter</u>:

- **Energy Transition**:
    - Renewable power; energy storage; carbon capture and storage; heating; heat pumps; cars and minerals.
    - This section focuses on decarbonising technologies and the mathematics of quantifying power demand and generation. The underground storage of carbon (if it works) is similar to groundwater flow and heating covers some thermodynamics.

Supervisions:

Every week there will be a set of supervision questions which covers the content taught over the week. There will also be some supervision sessions dedicated to going through the policy paper (one of the required submissions) to check in on your progress and discuss. Supervision questions typically follow the content covered closely and are a good way to help understand the concepts and work through the derivation of the models. Due to the interdisciplinary nature of the course, there is often more to discuss outside of the coursework for anyone who is interested.

Supervisors for the course could be from many different departments (Math, Earth Science, Chemistry) and hence will have very different styles. It would be advisable to speak to your DoS or the course coordinator early if you feel that their teaching style is not compatible with you to request a change.

Practicals:

Practicals are all computing practicals, once a week, meant to teach basic Python, data processing and visualisation. Packages include: numpy, scipy, pandas, cartopy, seaborn.

The practicals are Google Colab sheets and are guided step by step. Weekly drop-in sessions are also held on Tuesday, Wednesday, and Friday afternoons at the DAPTM where the demonstrators can help answer any questions you may have. The practicals are not graded, however, there are check ins that require submissions every few practicals. It is strongly advised to attend and keep up with the practicals as they are linked to your policy paper, lab report and the final coding examination. The lab report and policy paper required would both assess the practical skills.

Policy Paper and Lab Report

There are 2 reports required (25% of the course grade each) to be submitted. Firstly, the Policy paper is due at the start of Lent term. The policy paper requires the analysis of a dataset to answer a policy questions (eg. analyse River Cam data to determine if the river is safe for use) and explaining the data to policy makers. It is meant to be a postnote-style note intended to provide clear and accessible information to policy makers, with clear graphs and diagrams to be the focus of the report. The aim of the policy paper is to convince policy makers, as scientists, to implement policies to tackle environmental challenges (ie climate change). There will be time given for discussion with your supervisors for advice on how to portray the data and writing the policy paper.

Secondly, the Lab Report is a report of 5 practicals in the Lent term and an additional extension question. The report is due during the Easter break. The practical is based on the 3-box model of ocean carbon circulation and the practicals guide you through the development of the model. The extension question required the implementation of some changes, such as ocean acidification, to the model and assessing the impact on the system. There are questions at the end of the practicals which have to be answered, along with graphs required to show the results of the model.

Revision and Exams:

There is a computational exam (20%) and written exam (30%). The computational exam required familiarity with the python modules taught in the practicals. As the exam is short (2h), there is a good amount of time pressure. As you are likely allowed to refer to the practical materials, there is no need to memorise all the information (especially all the formatting) but having to refer to the documents frequently would result in not enough time to complete. Practising example papers would be the most effective and familiarising yourself with data manipulation in pandas would be beneficial. ChatGPT is a useful resource to use for your practicals, as it can answer simple questions or errors in your code. It is advised to not be too reliant on it, as you do not have access to ChatGPT during the examination. I would personally advise buying ChatGPT Premium to use as it generates better responses.

The written exam would contain mostly mathematical questions, requiring the derivation of certain portions of the models and some content questions which require information on the topics. The mathematical questions are typically partial derivations of certain models covered in the lectures, with some changes to the conditions. The initial equation describing the system is typically provided and manipulation and derivation is the focus of the exam. Being familiar and clear on the derivation of the equations describing the different systems would be important and the online course notes typically have the derivations shown and would be useful to study.

Throughout the course, I would recommend practising your intuition when dealing with questions. The questions are never meant to be hard, and the main challenge lies in understanding what the question is asking you to do. You will excel if you understand the concepts, and know what the questions want you to do. As the course is still new, you may encounter errors in questions.

Useful resources:

- Course description: https://www.natsci.tripos.cam.ac.uk/qes
- Course Notes: https://quantitative-environmental-science.github.io/Notes/intro.html

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- Ecology, Evolution and Conservation: Chan Kei Fung
- Evolution and Animal Diversity: Yvswenne Liew, Landy Zhou
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- Physiology: Yvswenne Liew
- Plant & Microbial Sciences: Aaron Koh, Cameron Goh
- Quantitative Environmental Sciences: Lin Xianzhen, Xu Kuang

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