

# The Natural Sciences Tripos

## Subject summary

This document is intended to provide a concise summary of the content of each of the subjects available in each Part of the Tripos. Every effort has been made to ensure the accuracy of the information in this document at the time of revision, however, we reserve the right to withdraw, update or amend the content at any time without notice.

Further information can be obtained from the following sources:

Natural Sciences Tripos website:

<http://www.natsci.tripos.cam.ac.uk/contacts/course-websites>

(links to information on each subject)

<http://www.natsci.tripos.cam.ac.uk/students>

(information for new and current students – structure of each Part)

Undergraduate Admissions (Applying, Entrance requirements, Colleges, Finance, Open Days):

<http://www.study.cam.ac.uk/undergraduate/>

Programme specifications (including recommended courses of preparation for each subject):

<http://www.natsci.tripos.cam.ac.uk/subject-information/overallps>

Statutes and Ordinances of the University of Cambridge - (Chapter IV. Tripos regulations) :

<http://www.admin.cam.ac.uk/univ/so/pdfs>

<p><b><u>Part IA</u></b>            Biology of Cells            Chemistry            Computer Science            Earth Sciences            Elementary Mathematics for Biologists            Evolution and Behaviour            Materials Science            Mathematical Biology            Mathematics            Physics            Physiology of Organisms</p> <p><b><u>Part IB</u></b>            Animal Biology            Biochemistry and Molecular Biology            Cell and Developmental Biology            Chemistry A            Chemistry B            Ecology            Experimental Psychology            Earth Sciences A            Earth Sciences B            History and Philosophy of Science            Materials Science            Mathematics            Neurobiology            Pathology            Pharmacology            Physics A            Physics B            Physiology            Plant &amp; Microbial Sciences</p>	<p><b><u>Part II</u></b>            Astrophysics            Biochemistry            Chemistry            Genetics            Earth Sciences            History and Philosophy of Science            Materials Science            Psychology, Neuroscience &amp; Behaviour            Pathology            Pharmacology            Physics            Physiology, Development, &amp; Neuroscience            Plant Sciences            Psychology            Zoology</p> <p>Biological and Biomedical Science            Physical Sciences</p> <p><b><u>Part III</u></b>            Astrophysics            Biochemistry            Chemistry            Earth Sciences            History and Philosophy of Science            Materials Science            Physics            Systems Biology</p>
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## Part IA

Structure: <http://www.natsci.tripos.cam.ac.uk/subject-information/part-ia>

Further details: <http://www.natsci.tripos.cam.ac.uk/students/first>

### Biology of Cells

The course aims to provide an introduction to biology at the molecular and cellular level, and considers what cells are, what they look like, and how they work. The Biology of Cells course is complete in its own right, but it also provides a useful introduction to further studies in biology, biochemistry and genetics, for both biologists and non-biologists. The course is organised jointly by the Departments of Biochemistry, Plant Sciences, Genetics, and Zoology. All Lecturers for the course issue printed lecture notes.

In the first term, the lectures deal with the basic structure of cells and macromolecules, with the structure and function of cell membranes, and with the essential biochemistry of cell metabolism. The second term's lectures are concerned with genetics (including the organisation and inheritance of genetic information), genetic engineering, nucleic acid and protein synthesis, and with cell growth and multiplication. Lectures in the third term consider animal and plant development, and cell communication.

The practical side of the course is organised so that, so far as possible, the experiments are related to the subject matter of the concurrent lecture course.

A Level Chemistry is highly desirable but not essential: some knowledge of Chemistry beyond GCSE is assumed. Past experience shows that the course appeals to students who have no AS or A2-level Biology as well as to those who have. Those without A-2 level Biology are often attracted by the increasing ability to understand biological events in molecular terms. At the beginning of the course non-biologists may sometimes find it difficult to keep up with new jargon and concepts, but students can readily overcome this by doing preliminary reading before coming up, using the titles suggested by their College and on the following NST website:

<http://www.natsci.tripos.cam.ac.uk/prospective-students/reading>. Generally, well before the end of the year, non-biologists have caught up with biologists. Although students who have A2-level Biology will find that some of the material presented is apparently familiar to them, the depth of treatment and the differences in viewpoint distinguish this course significantly from A2-level Biology.

### Chemistry

In this course we begin to explore the complex and subtle relationship between the structure of a molecule and its chemical properties; an understanding of this relationship is central to making sense of the physical and biological worlds. The ideas and concepts introduced in the course are relevant to all areas of molecular science, from biochemistry to materials science, and also form a foundation for more advanced study in chemistry in subsequent years. The course emphasises the underlying concepts in chemistry and how these can be used to rationalise and understand the behaviour of chemical systems and molecular interactions.

The course begins by looking at how chemists use spectroscopy to determine the shape and structures of molecules, and then goes on to consider how modern theories of chemical bonding give us an understanding of why molecules adopt the shapes and structures they do. We will also look at how these theories point to the type of chemical reactivity that a particular molecule will have. The consequences of these shapes and electronic structures are then explored in a number of ways. We will consider how the molecules react and how mechanistic ideas can be used to rationalise and predict the outcome of a chemical reaction. The way in which a qualitative study of the rates of chemical reactions sheds light on mechanisms will be discussed, and the way in which chemical equilibrium can be understood in a quantitative way will be introduced and illustrated. The

course closes by drawing together all of these concepts and using them to make sense of the widely different chemistry shown by some key non-metallic and metallic elements.

Practical classes, which are synchronised closely with the lectures, form an essential part of the course. In them students will have the opportunity to try out and experience at first hand the consequences of the ideas introduced in the lectures. Some of the practicals involve "wet chemistry", and some involve making and interpreting quantitative measurements. Students are expected to attend one practical session every two weeks.

Knowledge of A Level Chemistry or an equivalent course is assumed. However, with extra support from their supervisors it is possible for students to follow the course without A Level Chemistry. A knowledge of elementary calculus is also required; students who have not taken A Level Mathematics (or equivalent), will attend the Elementary Mathematics course in order to acquire the required skills.

### **Computer Science**

Computer science is becoming as essential to science as mathematics. Whole disciplines, ranging from particle physics to genomics, are now dependent on efficient and effective use of computers for the analysis of data. This option gives a foundation in computer science that concentrates on programming practice, algorithm design, and the underlying theory of computation. ML, a modern functional language, is used to survey the whole field before Object-Orientated Programming is studied in more detail. This is complemented by practical-based learning of Java. Both language modules have assessed exercises. The course also covers the use and abuse of digital computers in numerical calculations and simulations, and the design of efficient, effective algorithms. The course is useful for those who will need to apply computational methods in their future scientific career. Students who wish to continue with computer science may switch into the Computer Science Tripos at the end of their first year. Further details of the Computer Science NST option can be found at <http://www.cl.cam.ac.uk/admissions/undergraduate/nst/> and Computer Science more generally at: <http://www.cl.cam.ac.uk/admissions/undergraduate/>

### **Earth Sciences**

The course is an introduction to the whole field of earth and planetary geology. It covers the nature and properties of the Earth, particularly of the mantle and the crust; observed and deduced processes of change both of the Earth's interior and also in its oceans and atmosphere; biological, physical, and chemical methods of dating to establish rates of geological and global environmental change; and major economic considerations. Emphasis is placed on practical and field work including general identifications and interpretation of rocks, interpretation of geological maps of large areas, and the use of fossils, sediments and rocks in determining internal and external changes.

Much of the course is concerned with application of principles of physics, chemistry, and biology to gain an understanding of the behaviour of Earth and the planets, so that a school background in some of these subjects is necessary. Previous knowledge of geology is not necessary. Fieldwork is carried out in the Easter Vacation, and is an essential part of the course.

For more details, please see:

<http://www.esc.cam.ac.uk/esc/files/Department/admissions/Undergraduate%20Prospectus%202011.pdf>

### **Elementary Mathematics for Biologists**

This course is designed for students who do not have GCE A level Mathematics. It covers applications of mathematics and statistics in the context of biology and is problem-based. In addition to standard techniques, students will be introduced to the principles of modelling biological systems and experimental design. This course fulfils the requirements for a mathematical

qualification in Part IA of the Natural Sciences Tripos, but does not provide a qualification to read Mathematics in Part IB.

## **Evolution and Behaviour**

Evolution and Behaviour aims to introduce students to two main fields of whole organism biology. The course is taught jointly by the Departments of Zoology, Genetics, Biochemistry, Plant Sciences, Psychology and the Division of Biological Anthropology.

The course consists of five half term sections:

- Evolutionary theory
- The origins of cells and the evolution of plants
- The evolution and diversity of animals
- The evolution of behaviour
- Primate and human evolution and behaviour

The course introduces students to the major principles of evolutionary theory, and ranges from the origins of life, through the evolution of plants and animals to the evolution of behaviour. Lectures and practicals are designed to show how natural selection ultimately underpins all biological processes and how evolution has generated biological diversity. The major transitions in evolution, from the origin of life and of sex, to hominid evolution are detailed, and the evolutionary basis of behaviour in animals, including primates and humans is considered. The practical side of the course comprises practicals that complement lecture material and aim to develop students' practical skills. Some of the practicals are assessed: there is no practical examination.

Evolution and Behaviour provides a broad base for further studies across the whole spectrum of biology, and should be considered by all biologists. The course is also appropriate for physical scientists with an interest in evolutionary biology or psychology.

Knowledge of A Level Biology is highly desirable for this course. In particular, knowledge of basic principles of genetics and biochemistry is assumed. Evolution and Behaviour is an excellent precursor for all second-year biological and psychological courses.

## **Materials Science**

This course covers a modern, fast-growing and interdisciplinary area with very flexible boundaries. Great diversity arises in materials because they comprise atomic and molecular structures organised in complex patterns over many different length scales. The resulting intricate microstructures produce striking physical properties, leading to electrical, optical and mechanical behaviour of both scientific and technological importance.

This course explores the fascinating science of structure-property relationships through an integrated system of lectures and practicals that are supplemented by web-based learning. You will engage in a wide range of hands-on activities, including nanoscale characterisation and fuel-cell construction. In addition, you will learn, for example, how liquid-crystal displays work, how biomaterials inspire materials design, and why aeroplanes do not fall apart. The course forms an important part of physical sciences teaching at Cambridge, and contains invaluable background knowledge to underpin in subsequent years, the study of Materials Science or other physical sciences such as Physics and Chemistry. European vacation-placement schemes are available for those wishing to continue into IB.

The lectures are supplemented by weekly practical sessions. These practicals are closely related to the lectures and are expressly designed to help develop and clarify concepts introduced during the lectures. These form an essential part of the course and are an effective means of consolidating understanding. The practicals are continuously assessed.

The A2-level (or equivalent) background of those taking the course normally includes Mathematics and either Chemistry or Physics. Materials Science in Part IA is often combined with both

Chemistry and Physics, but significant numbers of students each year take it with only one of these, together with either Earth Sciences or Biology of Cells.

### **Mathematical Biology**

This course provides an introduction to mathematical biology. It involves mathematical, statistical, and computing methods, and is designed to approach these three elements from an integrated biological point of view. The underlying theme is the modelling and analysis of populations of molecules, cells, and organisms. The principal biological topics are: growth and decline of populations; physiological modelling, statistical methods, matrix algebra and ecological and epidemiological modelling. A range of mathematical and statistical techniques, including ordinary differential equations, local stability analysis, coupled differential equations, hypothesis testing, linear regression, and probability distributions are introduced in the context of biological systems. The lectures are supplemented by practical classes using modern computing methods.

Mathematical Biology is designed for students who have continued with mathematics during their sixth form (or equivalent) studies, and a certain level of prior knowledge is assumed. For students from England, Wales or Northern Ireland this would most likely have been gained by the study of GCE Mathematics at A Level. Students who have only taken mathematics as far as AS Level would be well advised to carefully consider taking Elementary Mathematics for Biologists.

Experience proves that students with other qualifications can perform very well on this course. In particular students who have studied the International Baccalaureate, Scottish Highers, the German Abitur and other similar qualifications have all performed outstandingly in the past. However students who do not have a thorough grounding in calculus (including differentiation of polynomials and other simple forms such as trigonometric functions; the product and quotient rules; the chain rule; and integration at least as far as integration by substitution and parts) and algebra (including exponentials and logarithms) are unlikely to succeed.

Any student who is concerned about their background should discuss this with their Director of Studies soon after arriving in Cambridge. In borderline cases it is possible that their College will be able to make extra support available (e.g. extra supervisions). Students can also discuss their background with the lecturer and/or practical demonstrators during the first week or two of term. Please note that prior study of statistics is definitely NOT necessary for this course; statistics is less than a quarter of the material you will be learning, and we teach all necessary concepts from scratch.

### **Mathematics**

The subject matter of this course is drawn from mathematical techniques used in the physical sciences and includes lectures on vector calculus, vector algebra, matrices, complex numbers, ordinary and partial differential equations, elementary probability theory, and computing techniques.

There are two versions of the course, A and B. Course A provides a thorough grounding in methods of mathematical science and contains everything prerequisite for the mathematical content of all physical science courses in Part IB of the Natural Sciences Tripos, including specifically Mathematics, Physics A and Physics B.

Course B contains additional material for those students who find mathematics rewarding in its own right, and it proceeds at a significantly faster pace. Students are strongly encouraged to take Course A unless they have a thorough understanding of material in Further Mathematics A2 level. Both courses lead to the same examination and qualification.

### **Physics**

The first year course (which is also available within the Computer Science Tripos Part IA and the Mathematics Tripos Part IA option (c)) provides a foundation in physics both for those going on to further study of the subject and for those whose main interests lie elsewhere, especially for future chemists, materials scientists, and earth scientists.

Physics is concerned with the fundamental laws which govern the behaviour of all forms of matter and therefore underlie all science. In exploring these laws, the first year course has several aims. It is designed to bridge the gap between school and university physics. It aims to consolidate school physics by providing a more logical and analytical framework for classical physics. It introduces non-classical topics such as special relativity and quantum physics which foreshadow major themes of the physics course in later years. Finally the course aims to broaden your perspective, so that you can begin to appreciate the flexibility and generality of the laws of physics, which allow us to apply them to topics ranging from the extremely remote and theoretical, such as the behaviour of matter near black holes, to matters of everyday and technical application.

The lectures cover mechanics, relativity, oscillating systems, waves (including quantum waves) and fields. The course assumes that students will be taking Mathematics concurrently - the two physics courses in Part IB assume a knowledge only of the material covered in Mathematics A.

Practical work forms an important part of the course, both in its own right and where practicable as an illustration of lecture material. Students attend practical classes once a fortnight, and the practical work is continuously assessed.

Knowledge of both physics and mathematics equivalent to GCE A Level is assumed and students are recommended to have either A-2 levels in Mathematics and Physics or, provided they contain at least three units of mechanics, A-2 levels in Mathematics and Further Mathematics.

### **Physiology of Organisms**

Physiology deals with how living organisms work. While often concentrating on the organ-level ("how does the heart work?"), it covers life from the molecular level right up to the behaviour of the whole organism. In its applied aspects, physiology deals with the function and malfunction of parts of the human body with reference to health and disease (areas relating to medicine), how to improve crop yield (areas relating to plant sciences) as well as how organisms respond to challenging conditions (areas relating to ecology).

We begin with an overview of physiological ideas and problems, as applied to animal physiology. We look at how the basic organ systems such as the nervous, cardiovascular and respiratory systems work, how homeostasis is maintained and how animals respond to environmental challenges. Although mammalian physiology is taught in most detail, this is a comparative physiology course and so we also consider some of the different strategies found in other animals, such as fish and insects.

In the second term we move to plants. How do plants interact with the environment to obtain raw materials, and how these are processed and distributed? Control of growth and development is a major contributor to the survival and propagation of plants at all stages of the life cycle, and we explore the functional links between changes in the world outside and the physiological responses that enable plants to counter or exploit them. The second term concludes with an overview of microbial physiology, and considers how microbes and plants interact.

The third term takes a more integrative approach, drawing on what you now know about plant and animal physiology. We consider the profound importance of body size and scaling in both groups of organisms, exploring aspects such as structure and locomotion.

Experimental practical classes allow you to explore for yourself what you hear about in lectures, and see how science is actually done. In the animal physiology classes you will, among other things, look at the properties of nerves and muscles, examine the activity of your own heart, discover how different inhaled gas mixtures affect your breathing and even see how much sweat you produce while exercising! In the Plant Sciences practicals you will explore how leaves control gas exchange, how enzymes are regulated and how plants respond to viral infection.

The Physiology of Organisms course gives a contemporary and integrated understanding of how organisms function. It provides a wider context for the material in the other 1A biology courses and represents a strong background for many of our IB courses...as well as being of general interest to anyone curious to know how complex biological machines work.

Knowledge of A2-level Biology (or equivalent) is not assumed in this course but is certainly helpful. Some AS-level knowledge of physics in particular would also be very helpful, but many of our students do not have a physics background.

## **Part IB**

Structure: <http://www.natsci.tripos.cam.ac.uk/subject-information/part-ib>

Further details: <http://www.natsci.tripos.cam.ac.uk/students/second>

### **Animal Biology**

The overall aim of the course is to demonstrate the extraordinary diversity of ways in which the behaviour, physiology, and development of animals are adjusted by evolutionary processes to result in adaptation to environment.

The first term begins with Behaviour and Ecology, which considers how different behaviour patterns will be favoured by natural selection under different ecological conditions. Life history strategies, foraging behaviour, habitat selection, and mate choice are some of the topics covered. This is followed by Brains and Behaviour, which explores the ways in which brains are organized for the control of behaviour and for learning.

In the second term, lectures on Insect Biology and Vertebrate Evolutionary Biology will focus on adaptation and evolution. Lectures in the first half of term will discuss the success of the most abundant land animals, the insects. Topics covered include flight, water balance, insect-plant relationships, mating strategies, and the evolution of insect societies. Work in the second half of term draws on vertebrate examples to show that integration of developmental and evolutionary studies can enhance the understanding of adaptation.

In the third term, lectures on Evolutionary Principles review the theoretical fundamentals of evolutionary biology, and the methods available to interpret, understand, and predict the pattern and process of evolution.

All parts of the course are accompanied by practical work, which is continuously assessed. There is no practical examination.

### **Biochemistry and Molecular Biology**

This course can be read by any Part IB scientist, physical or biological, who wishes to pursue the study of biological processes at the molecular and cellular level. It builds on basic concepts discussed in the Part IA course 'Biology of Cells'. The aims of the course are to describe how information is stored as DNA and expressed as specific proteins, how enzymes and other proteins exert their functions, how cells function as integrated and co-ordinated metabolic systems, and how the growth and differentiation of cells is controlled.

The first term is concerned with Molecular Biochemistry: genes and proteins in action. The three main themes are firstly gene cloning and manipulation, secondly the control of gene expression in prokaryotes and eukaryotes, and finally the structure of proteins, the molecular mechanisms of enzyme action and the manipulation of protein structure to modify function.

The second term builds on these basic molecular concepts to deal with Cell Biochemistry: properties and functions of membranes and organelles and the integration of metabolism. The first topic is bioenergetics (how cells obtain their energy supply on which all metabolism is based),

which is followed by a discussion of the mechanisms by which metabolism is controlled and integrated. The hormonal control of metabolism and mechanisms of signal transduction across the cell membrane lead on naturally at the end of the term to a discussion of the control of eukaryotic cell proliferation and how signalling pathways in mammalian cells are activated by growth factors. This topic is continued with a discussion of 'cancer genes' (oncogenes and tumour suppressor genes) and how the control of the cell cycle may be subverted in the development of tumours. The third term covers aspects of the biochemistry of microorganisms, including chemotaxis, protein secretion and targeting in prokaryotes.

Practical work is designed to complement the lectures. It involves experiments and integrated discussion sessions, the use of computers in the analysis of DNA and protein sequences and in the simulation of metabolic control, and journal clubs where small groups are guided by a senior scientist in the interpretation of a recent scientific paper.

### **Cell and Developmental Biology**

Cell biology and developmental biology are fields that are advancing rapidly. Part IB Cell and Developmental Biology aims to illustrate the excitement of those advances, building on the foundation provided in the first year by Part IA Biology of Cells to extend and consolidate coverage of cell biology. The course is taught by members of the Departments of Biochemistry, Plant Sciences, Genetics, and Zoology and it is designed to be taken in conjunction with any other subject in Part IB of the Natural Sciences Tripos except Materials Science, with which it shares slots in the lecture timetable. Since many students may wish to take Part IB Biochemistry and Molecular Biology in addition to Part IB Cell and Developmental Biology, the two courses are designed to be complementary, with minimal overlap.

The first term considers how genetic information is organised and expressed within the nuclei of eukaryotic cells and in prokaryotic systems, together with systems biology approaches using yeast as a model organism. The second term starts with the biogenesis of chloroplasts and mitochondria, followed by consideration of the cytoskeleton and cell motility, membrane vesicle trafficking, and cell signalling. The remainder of the course then focuses on development in animals and plants, addressing questions such as: How do cells which contain similar genetic material diverge to make specialised products and to perform different functions within a multicellular organism; and how do populations of cells become organised into complex body patterns?

Practical work involves experimental techniques that illustrate fundamental concepts and which are in current use in cell biology research.

### **Chemistry (two courses: Chemistry A and Chemistry B)**

Our second-year courses present the fundamental ideas of chemistry both for those who are intending to carry on with chemistry in the third year, and also for those who regard chemistry as a complement to their other Part IB subjects. The course builds on the material covered in the first year and continues to emphasise the interconnections between different areas of chemistry and the way in which fundamental concepts illuminate broad areas of the subject.

Chemistry A focuses mainly on the theories which are used to understand and probe chemical bonding, structures, and reactions. It starts out with a discussion of quantum mechanics which is the fundamental theory used by chemists to understand the microscopic nature of matter and molecules. The course goes on to use these ideas to discuss chemical bonding, the way in which microscopic properties influence those of bulk matter, and how all of these ideas can be used together to understand the structure and properties of solid materials and their surfaces.

Chemistry B focuses mainly on how chemists find out about and rationalise the enormous range of chemical structures and reactions that are known. Despite the apparently overwhelming number of these we can make sense of them by using a relatively small number of key concepts in chemical bonding and reactivity. As the discussion develops, the central role taken by electronic structure and the three-dimensional shape of molecules becomes apparent. The course closes with an introduction to Chemical Biology - that is the chemistry of life.



Taken together, Chemistry A and B provide a good grounding in the chemical principles which are of relevance to many other Part IB subjects. On its own, Chemistry A fits in well with the more Physical Part IB subjects, such as Geology, Materials Science or Physics. Chemistry B is particularly relevant to students with interests in the molecular aspects of biology.

Chemistry is above all an experimentally based science, so practical work is very much an integral part of the course and one of the key aims of the practical course is to develop the skills that an accomplished practical chemist needs. Practical work is continuously assessed; there are no practical examinations.

Students who propose to carry on with Chemistry in the third and possibly fourth years, should certainly consider taking both Chemistry A and B so that they will experience the fullest grounding in chemical principles. However, the Part II Chemistry course will be accessible to students if they have only taken one out of Chemistry A and Chemistry B. By only taking one of Chemistry A and B students will have a more restricted choice, but there are more than sufficient courses on offer for students to be able to put together an interesting and challenging year tailored to their interests.

### **Ecology**

The course, run jointly by the Departments of Genetics, Plant Sciences, and Zoology, introduces a variety of approaches to the study of the relationships between plants, animals, and the environment. It begins with a critical exposition of the characteristics of selected freshwater, marine, and terrestrial systems. The dynamics of these systems on different scales of time and space are emphasised. The impacts of humans are considered particularly in the context of global climate change, fire and aerial pollution. Aspects of evolutionary ecology include how interactions between predators and prey influence co-evolution of adaptations and counter-adaptations, and community structure. The lectures on 'ecological genetics' considers arms races from a genetic perspective before discussing the behaviour of genes in populations and considering the evolution and maintenance of genetic variation using examples of conspicuous polymorphisms. 'Ecological dynamics' introduces general features of the dynamics of ecological systems at population and community levels. The third term starts with an overview of the world's biodiversity, its origin, and maintenance. The course ends with an investigation of the importance of humans in ecology, specifically studies of changes caused by humans and the role of conservation.

Students taking the course are expected to attend one of two ten day residential field courses during the Long Vacation between the first and second years. Projects, normally done during the field courses, will be examined. For students unable to attend a field course, alternative project work will be available during the year.

### **Experimental Psychology**

The course provides an introduction to the study of mind, brain, and behaviour, with an emphasis on experimental and observational methods of investigation. Topics covered in the first term include: sensory processes and perception with special emphasis on vision and hearing; attention and the control of action; language and cognitive processes. The remainder of the course covers learning and memory; cognitive and social development; intelligence (and its measurement); reasoning and problem-solving; cognitive neuropsychology; and psychopathology.

The course aims to instil a broad understanding of the various approaches to the study of the mind and behaviour, of the interplay among experimental, behavioural and neurological evidence, and of the different levels of explanation used in modern experimental psychology.

Lectures are supplemented by practical classes whose topics are related as closely as possible to those of the concurrent lectures. Sometimes students will run experiments and sometimes they will witness demonstrations or videos of phenomena. Students are required to write reports on a certain number of these classes. Other practical classes provide an introduction to basic neurobiology and elementary statistics for psychology.

There are no prerequisites for the course, which is equally accessible to those who have specialised in biological or in physical sciences in Part IA.

Students taking Part IIA in the Psychological and Behavioural Tripos may take the NST Part IB Experimental Psychology course as Paper PBS 5. It can also be taken by students taking Part IB in the Philosophy Tripos. A subset of the course is also offered to Psychological and Behavioural Sciences as paper PBS 4.

## **Geological Sciences (two courses: Geological Sciences A and Geological Sciences B)**

The Department of Earth Sciences teaches two complementary courses which lead to Part II Geological Sciences. The courses are, however, independent and self-contained and each may be combined with other appropriate subjects in Part IB, such as Physics A, or biological subjects and also lead to Part II Geological Sciences. Part IA Earth Sciences is a pre-requisite for either of the IB Geological Sciences courses.

*Geological Sciences A* concentrates on the surface environments of the Earth - the atmosphere, hydrosphere, and biosphere - together with their geological products. It encompasses the fields of sedimentology, palaeontology, and oceanography. This course also covers tectonics on scales from lithospheric plates down to hand specimens, emphasising the processes that form and deform sedimentary basins.

*Geological Sciences B* deals with the Solid Earth and examines the subsurface processes associated with the lithosphere and asthenosphere. It focuses on igneous and metamorphic rocks, but includes the study of mineralogy, geophysics and geochemistry relevant to the deep Earth and solar system. This course also includes the tectonics of mountain belts in relation to their thermal and chemical evolution, and volcanic activity in a variety of tectonic settings.

Practical work and map analysis are emphasised in both courses and there is a combined field course in the Easter Vacation, which is an essential part of both courses.

## **History and Philosophy of Science**

This course offers an historical and philosophical perspective on the nature of scientific knowledge and the place of the sciences in society. Examples are drawn from a range of disciplines, over a period extending from classical natural philosophies to the present day. Historical examples discussed include early astronomy, alchemy, medicine, and natural philosophy, as well as more recent physical and life sciences up to the nuclear age and the emergence of molecular medicine. The course also examines how theories are tested and changed; the nature of causation, laws, and explanations; whether science provides an increasingly accurate account of reality, and problems in scientific and biomedical ethics. The examination consists of two papers, one historical in character, and the other on philosophical topics.

## **Materials Science**

This course applies a broad range of scientific principles in the quest to design new, more advanced materials as well as to understand the functions of materials in modern society. Hence the course is of great benefit to anyone intending to pursue Materials Science, Physics or Chemistry at a higher level. Some ideas introduced in the IA course are studied in much greater depth in order to produce a thorough understanding of how the key scientific aspects of processing, structure and properties interact with factors such as cost, safety and sustainability when considering which materials are suitable for particular applications.

The course looks at advances that continue to be made with metallic materials, where new developments continue to drive forward the improvements in properties of metallic alloys, and also in the area of polymers. Alongside this, you will look at how materials function in service, whether a material is likely to degrade through chemical processes and when a structure may be susceptible to failure under the imposed mechanical forces. In addition, you will learn the scientific principles of functional materials, such as semiconductors, that have revolutionized society in the last few

decades, allowing us to build smaller and more powerful devices by combining new materials with advanced fabrication processes. In addition to the lecture courses and associated practicals, there is also a project which involves dismantling and examining a manufactured article.

The course follows on from Materials Sciences in Part IA and combines well with other subjects in Part IB such as Physics A and/or B, Chemistry A and/or B, Mathematics and Geological Sciences A and/or B.

### **Mathematics**

This course is especially useful for students intending to study Physics or Theoretical Chemistry in Part II. It is also occasionally attended by students taking other courses. The following topics are included: introduction to group theory; more advanced matrix theory; Cartesian tensors; more advanced theory of differential equations (including solution in power series and expansions in characteristic functions); Fourier transforms; calculus of variations; functions of a complex variable; calculus of residues. Some continually-assessed practical work is associated with particular topics in the course. This involves the use of computers to illustrate and exploit numerical techniques. No candidate may take Mathematics unless he or she has read Mathematics in Part IA, unless he or she has been placed in a class not lower than the second class in Part IA of the Engineering Tripos, or unless he or she has been classed in Part IA of the Mathematical Tripos, or is an Affiliated Student.

### **Neurobiology**

This course is an interdepartmental collaboration between four biological departments (Pharmacology; Physiology; Development and Neuroscience; Psychology; and Zoology). It aims to provide a unified approach to the teaching of neurobiology at Part IB level.

The lecture course begins at the cellular and molecular level with the electrical and chemical properties of individual neurons. It next examines the major sensory systems: vision, hearing, olfaction and taste, and somatosensation and pain. The motor system and sensorimotor integration is then explored in detail followed by consideration of the mechanisms underlying development of the nervous system, the origin of neuronal types and neuronal architecture, and the way that connections between neurons develop and are regulated. The modulation of synaptic activity is then discussed, followed by motivation and emotion at the end of the Lent term. Easter term lectures are devoted to learning, memory and higher functions of the nervous system, including language.

A wide range of experimental techniques and approaches is explored in the practical classes including: neural activity in frog nerve and synapse and in cockroach sensory nerves; computer simulation of neural activity; neural development in zebrafish; the genetic basis of neural function in the nematode *C. elegans*; human sensory and motor function; brain anatomy and histology; brain imaging; and neuropsychological assessment. One aim of the practical classes is to provide hands-on experience of a variety of the experimental techniques that are used in modern neurobiology: from microscopy, through single-neuron recordings, to stimulation and extracellular recordings from your own nerves and muscles, and finally to psychophysical measurements of human sensory and cognitive performance.

<http://www.bio.cam.ac.uk/undergraduate/courses/neurobiology>

### **Pathology**

Pathology is concerned with the scientific study of disease, and is one of the foundations of medical science and practice. It encompasses all aspects of disease, including knowledge of the causes and effects of disease, and the organism's response to disease. The cause of a disease is often an injurious agent, but defects and deficiencies may also cause disease. Knowledge of how an organism responds to disease is important, as sometimes disease may arise as a result of an innate response of the organism to injury or infection.

The overall aim of the Part IB Pathology course is to explore the underlying general principles of Pathology and illustrate them using specific examples. This endeavour encompasses a broad range of biological disciplines, including cellular and genetic pathology, immunology, microbiology, parasitology, and virology. The lectures in these topics are closely integrated with practical sessions that take place twice each week. The course is equally suitable for all biological, medical, and veterinary students.

### **Pharmacology**

The course deals with the action of chemical substances on biological materials and thus has roots in both the physical and biological sciences. The first part of the course will be concerned with understanding, at the molecular level, how receptors work. These lectures will examine the fundamental processes of molecular recognition and then consider in detail how, having recognised a drug, receptors are able to generate a signal that changes cellular activity. Following a detailed consideration on synaptic pharmacology, lectures will focus on drugs that influence the function of the central nervous system. The second and third terms will emphasize the importance of combining molecular and cellular biology with more traditional pharmacological approaches, drawing on examples from the control of inflammation and immune responses. Lectures will focus on processes that control the distribution and fate of drugs in our body, with a lecture on general anaesthetics as an example. In addition, lectures will introduce the use of drugs to produce selective inhibition of bacteria, protozoa and viruses. This is followed by two lectures on drug discovery, by lectures on cell growth, cancer and anticancer drugs, and by lectures on steroid receptors and reproductive pharmacology. In the third term the molecular characteristics of ion channels will be combined with essential physiology to explain drug actions on the heart. Guidance for revision will be provided for students who have not taken Part IA Physiology of Organisms.

In the first term, a series of eight practicals complement the lectures by providing practical experience of basic techniques and illustrating important points. In the second term, most of the conventional practicals are replaced by mini-projects lasting for several sessions. In these you will have the opportunity to participate in ongoing research in the Department and to gain experience in performing research.

### **Physics (two courses: Physics A and Physics B)**

The course assumes a knowledge of Part IA Physics. Physical Scientists who will not be specialising in physics in the third year may offer one or other or both of the IB Physics courses, while those who intend to study either Part II Physics or Half-Subject Physics are expected to offer both the Physics A and the Physics B courses.

The Physics A course provides a rigorous grounding in the principal themes of modern physics. The course deals with waves and optical systems; it provides a substantial course in quantum physics; and it provides an introduction to condensed matter. In addition there is a course on experimental methods, which gives the necessary formal background to support work in the practical class. Practical experiments are more advanced and longer than those encountered in Part IA.

The Physics B course lays the foundation for a professional understanding of physics and is built on three key courses in classical mechanics, electromagnetism, and thermodynamics.

Practical experiments are more advanced and longer than those encountered in Part IA. All students also take an introductory course in C++ programming, with associated practical exercises.

Those students not taking Part IB Mathematics as a separate subject take an additional course in Mathematical Methods, intended to cover the mathematics required in Physics A, Physics B and for the Part II core courses: the course is supervised. (Extra preparation would be required over the long vacation if students then wished to take the Theoretical Physics options in Part II.)

## **Physiology**

This course allows students to study systems physiology in detail and concentrates on mammals, in particular man. The course builds from knowledge of function at the cellular level to the complex operation of major body systems at the level of the whole organism. About 60% of the course is devoted to the study of all the major body systems. The remaining 40% takes an integrated approach to examine how these systems respond to various challenges from the everyday to the extreme.

The course begins with a summary of the autonomic nervous system, and then continues in the first term to explore the cardiovascular system, breathing, the endocrine system, the kidney and body fluid homeostasis. The first part of the second term involves the study of reproductive physiology, starting with the male and female reproductive systems and following events from conception through implantation and embryonic development to parturition, and examining fetal, maternal, and neonatal physiology on the way. The second half of the second term looks at digestion, absorption, nutrition and body weight regulation. In the Easter term we examine the response of the body to exercise, including the effects of training, detraining and the limitations on performance. In the third term we also look at the responses of the body to extreme conditions presented by life in the arctic and in the desert, during space flight, when diving, when dieting, and during starvation.

Practical work is largely designed to allow students to study their own physiology. Examples include examining the effects of exercise on cardiac output and oxygen consumption, the effects of eating chocolate on blood glucose and respiratory quotient, and the pharmacological effects of drugs on isolated intestinal muscle. You will also be introduced to the principles of histology, including working with some of the latest, computer-based packages. Two practical classes in the second term are given over to the assessment of fitness and the effects of training in selected individuals.

Part IB Physiology builds on topics introduced in Part IA Physiology of Organisms, but it is not essential to have taken this course to read Part IB Physiology. As well as being interesting in its own right (even to predominantly physical scientists), Physiology is well suited to accompany many other Part IB courses in the life sciences, including Biochemistry and Molecular Biology, Cell and Developmental Biology, Experimental Psychology, Neurobiology, Pathology, and Pharmacology.

## **Plant and Microbial Sciences**

Plant productivity is the basis for life on Earth. Research into fundamental plant processes informs teaching and learning, as we discover how plants continue their vital role: from providing food and sustainable fuel sources, to sequestering carbon, maintaining diversity and ecosystems. Learn how plant selection and crop improvement – or even designer plants and micro-organisms – will be used to tackle environmental stress, pests and pathogens, so as to feed humankind and provide a sustainable future. The course reflects the growing need to understand how plants work, from cellular to population and community levels. It also features microbial science, currently one of the most dynamic areas of biology. This scope enables you to experience experimental approaches ranging from molecular biology to ecological modelling. Specific supervision support offers additional examples of how your learning translates into wider global issues such as food and fuel security, bioremediation, biodiversity and climate change. The study of plants is essential if we are to achieve the conservation and sustainable exploitation of the biosphere, and deal with issues such as renewable energy, nutrition, pollution and biotechnology. The Part IB Plant and Microbial Sciences course develops a number of aspects introduced in the first year (Part IA) Biology of Cells, Physiology of Organisms and Evolution and Behaviour courses. The aim of the course is to provide a treatment of plant and microbial sciences that truly integrates molecular, cellular and ecological approaches to the subject. Under each topic the lectures deal with the major issues and ideas to arise from studying plants in the field, and describe our current understanding of the relevant processes at the cellular and molecular levels. The course offers students the opportunity to consider all aspects of modern plant biology, including fundamental physiological processes such as photosynthesis, water relations and water uptake, the interaction of plants with micro-

organisms and animals, plant development, and conservation, along with the exploitation of plant products.

Accompanying the lecture course is a set of integrated practical sessions, which comprises both lab-based experiments and field work, and which provide a fundamental training in good laboratory practice through the maintenance of laboratory notebooks. Students work collaboratively on a joint, themed research project in which they contribute to the design and development of the research strategies. A field course to Portugal is also offered to all students during the Easter Vacation.

The Part IB Plant and Microbial Sciences course is an ideal complement to several other Part IB subjects including Biochemistry and Molecular Biology, Cell and Developmental Biology, Animal Biology, and Ecology. It provides important background to the more specialised subjects covered in Part II Plant Sciences, and also provides an excellent basis for Part II in Biochemistry, Genetics, Zoology, or Ecology.

It would be difficult to take Part IB Plant Sciences without some previous training in Biology, as provided for example by Part IA Physiology of Organisms or Biology of Cells. However, mathematicians, physicists, and chemists may wish to take the course to maintain an interest in Biology, and are in an excellent position to learn from and make a valuable contribution to a number of aspects of the subject.

## **Part II**

Structure: <http://www.natsci.tripos.cam.ac.uk/subject-information/part-ii>

Further details: <http://www.natsci.tripos.cam.ac.uk/students/third>

### **Astrophysics**

Students usually enter Part II Astrophysics on completion of Part IB in either Mathematics or Physics. The course provides the scientific reasoning that underlies modern astronomy and astrophysics.

The Michaelmas Term consists of four 24 lecture courses which teach the fundamental physics underlying the rest of the course - viz Relativity, Astrophysical Fluid Dynamics, Principles of Quantum Mechanics and Topics in Astrophysics.

Three of the courses in the Lent Term cover, in descending size scale, the main areas of contemporary astronomy (i.e. cosmology, galaxies and stars). The fourth course is Statistical Physics.

The style requires minimal memorizing of descriptive terminology; lecturers rather concentrate on the derivations of fundamentals from first principles and the teaching of basic understanding. In addition to written examinations, there is an examinable coursework component of either an extended essay or two or more of the CATAM computer projects organized by the Mathematics Faculty. Students proceeding to Part III Astrophysics will be required to demonstrate the necessary computing skills, normally by completing at least one CATAM computing project, before commencing Part III. Any prospective part III students who chooses the essay will need to complete a CATAM project over the summer.

Those going on to Part III Astrophysics have normally taken Part II Astrophysics. The number of Part III places is limited by the number of potential projects (and project supervisors) available and preference is given to students who have taken Part II Astrophysics. Students need not decide about Part III at the time they begin the Part II course but those who have obtained an appropriate level in Part IB (at the discretion of the Institute of Astronomy, but typically a good 2.1 or above in either Mathematics or the Mathematics component of Part IB Natural Sciences) may reserve a conditional place on the Part III Astrophysics course for the following year. There are detailed standards of entry for Part III which are given at: <http://www.natsci.tripos.cam.ac.uk/students/fourth> Further details are available at <http://www.ast.cam.ac.uk/teaching/undergrad/>.

### **Biochemistry**

Biochemistry is the study of living organisms at the molecular and cellular level. As a core course for the whole of biological sciences, a training in Biochemistry leaves you with the widest choice when you come to select an area of cell/molecular biology in any subsequent research programme or career. Recruiters in industry, government, investment management, regulatory authorities, and industrial law appreciate the breadth and diversity of biological knowledge that Biochemistry provides.

Students have a choice between a one year Part II (B.A. degree) and two years of study, in which Part II is followed by Part III (B.A. and M.Sci. degrees). Part II Biochemistry also provides an appropriate training for Part III Systems Biology. The subject Part IB Biochemistry and Molecular Biology is the normal precursor to the Part II course but is not compulsory e.g. Part IB Cell and Developmental Biology is an adequate background to Part II Biochemistry. MVST students who are considering a career in medical research after qualifying will find the Part II course an excellent foundation.

The Part II course provides an advanced Biochemistry education, with modules entitled “Structural and Chemical Biology”, “From Genome to Proteome”, “Signalling and Cancer”, “The Dynamic Cell” and either “Molecular Microbiology of Infectious Disease” or “Bioenergy – The Exploitation of

Plants and Microorganisms". Teaching of transferable laboratory and communication skills (such as graphic illustration, record keeping, data analysis, database searching, seminar presentation, and report writing) is included in the course. Notice also that we place an emphasis through our extended critical essay on communication between scientists and society. See <http://www.bioc.cam.ac.uk/teaching/third-year/biochemistry/part-ii-biochemistry>

The Part II course offers research experience through an eight-week research project. Students choose from possible research areas ranging from literature based projects to bioinformatics or bench work and write a report. In the project each student will work closely with one of the research teams in the Department. There are also departmental-based group supervisions involving students and staff throughout the year.

Students should consider carefully whether the three- or four-year course is right for them. The three-year course is likely to be appropriate for students who see their degree as education for a science-based or more general career rather than as a preparation for a life in scientific research. The four-year course is for committed enthusiasts preparing for a career in research in Biochemistry or a related area. You are not bound to remain for the fourth year even if you choose the four-year course. Acceptance for Part III is conditional upon performance at II-1 or better in Part II Biochemistry.

## **Chemistry**

The Part II course builds on the ideas which were presented in the first and second year, and offers students the opportunity to both broaden and deepen their knowledge of chemistry. As the year progresses there is the opportunity for students to narrow their focus somewhat, for example towards chemical biology or chemical physics; however, they can equally well choose to pursue a broad range of topics across all areas of chemistry.

Practical work is given a prominent place, and the programme of work is designed to continue to develop skills in this area by tackling more sophisticated and open-ended experiments. In addition to conventional practical, there will be the opportunity to do other kinds of continuously assessed work, such as learning a language.

For convenience the lectures are organised into three "Levels". To complete the course students will need to obtain four credits at Level 1, three at Level 2, and three at Level 3. One credit is equivalent to a course of 12 lectures.

The courses offered in Level 1 can be considered as laying the foundations for the whole year. Students who have taken both Chemistry A and Chemistry B in the second year will take four lecture courses (transition metal chemistry, organic synthesis, spectroscopy, and theoretical techniques). Students who have only taken Chemistry B in the second year will take transition metal chemistry, organic synthesis, and "Concepts in Physical Chemistry". This course (worth 2 credits) will introduce topics from physical chemistry that will be relevant to further study in inorganic, organic, and biological chemistry.

At Levels 2 and 3 a wide range of lecture courses are offered (from chemical physics through to chemical biology). Students may take any courses that they feel prepared for. The emphasis in the final part of the course is the development of specialised knowledge in particular areas of chemistry, very much with a view to the kind of advanced research-based topics that will be studied in the fourth year (Part III).

The practical course continues throughout the first and second terms. Various options are on offer, including advanced experiments in all areas of chemistry and study of a foreign language.



## **Genetics**

Genetics has become an even more high profile subject in recent years as a result of rapid developments in genomics and the application of this knowledge to the problems of disease and the genetic manipulation of plants and animals. Whatever your opinion of these applications, genetics offers a viewpoint and a range of experimental approaches that is deeply embedded in most areas of biological enquiry.

The subject has always been concerned with the problem of how the hereditary information in DNA specifies the form and function of the organism. Classically this involved the use of genetic variants (mutants) to upset the biological function of the cell and, from the effect of these mutations, to make deductions about the way cells and organisms worked. The rise of high throughput sequencing, genomics and sophisticated techniques for gene replacement and analysis of gene expression and its consequences (transcriptomics, proteomics and metabolomics), give us much more powerful tools for looking at the way genes make us what we are. At the same time, a knowledge of genetics is fundamental to an understanding of the evolution of populations and species. Some of the most exciting developments in the subject in the last few years have emerged from the application of genetics and molecular biology to the problems of development, evolution, and speciation.

The aim of the Part II Genetics course is to produce biologists with a wide knowledge of the principles of genetics and an understanding of how they can be applied. As a result the course is broad in scope, ranging from molecular genetics of bacteria to the genetics of evolution and populations. The first term course covers (i) plant and microbial genetics; (ii) chromosomes and the cell cycle; (iii) developmental genetics (part 1); and (iv) human genetics, genomics, and systems biology (part 1). In the second term the course covers (i) developmental genetics (part 2); (ii) human genetics, genomics, and systems biology (part 2); and (iii) evolutionary genetics. The course includes training in evaluation of scientific papers and features discussion sessions on the social and ethical aspects of genetics.

As a result of a training with this breadth of approach, Part II Genetics graduates remain in demand and find it easy to move between scientific disciplines. Prospects can only improve as a result of genome projects, programmes in agricultural and medical genetics, the application of genetics to environmental problems and molecular genetic approaches to brain structure and function.

<http://www.gen.cam.ac.uk/undergraduate/nst2-genetics-overview>

## **Earth Sciences**

Part II Geological Sciences provides a rounded geological education either for students intending to complete their undergraduate training in three years, or for those planning to continue to Part III Geological Sciences.

Students completing their studies after three years qualify for the B.A. Degree. Graduating after three years is most suited to students wanting to pursue a career or further training outside geology, whilst providing a fully accredited honours geology degree for entry to professional careers or further geological training.

Most students use Part II Geological Sciences as a precursor to Part III Geological Sciences (fourth year) which offers a full geological education up to the active research level. The B.A. Degree is earned after passing Part II, and the M.Sci. (Master of Natural Sciences) degree after Part III. The four year route is intended for students planning a career, further training or research within Earth Sciences, or for students wanting the intellectual challenge of an advanced course in this field.

Part II Geological Sciences will have taught cores on the scientific and technical fundamentals of the subject in the first term, followed by a choice of options in the second and third terms covering a wide spectrum of the subject. Fieldwork is an essential part of the course.

Project work (essentially a field mapping project) is carried out in the Long Vacation preceding the Part II year and during the first term.

Whilst there is no minimum exam class required for entry to Part II Geological Sciences, entry to Part III Geological Sciences will depend on getting at least a 2.2 in both Part IB NST and in Part II Geological Sciences. More details can be found at [www.esc.cam.ac.uk/teaching](http://www.esc.cam.ac.uk/teaching).

### **History and Philosophy of Science**

This course aims to give insight into the development of science and medicine within Western society, and into their philosophical structure and presuppositions. Students from a variety of backgrounds are encouraged to consider the course; those from the humanities and social sciences find that the insights they bring from their previous training compensate for any lack of knowledge of science. Students who have not read the subject at Part IB are welcome to attend the Part IB lectures in addition to those given specifically for Part II.

The Part II course is arranged in three sections as follows:

*Papers:* There are eleven groups of courses corresponding to eleven unseen examination papers from which Option A students choose any three from the following list and Option B students choose any four from the following list:

- Paper 1. Ancients and Moderns
- Paper 2: Early Medicine
- Paper 3: Sciences in transition: Renaissance to Enlightenment
- Paper 4. Science, Industry and Empire
- Paper 5. Modern Medicine and Biomedical Sciences
- Paper 6. Metaphysics, Epistemology, and the sciences
- Paper 7. Ethics and Politics of Science, Technology and Medicine
- Paper 8. History and Philosophy of the Physical Sciences
- Paper 9: History of Philosophy of Science
- Paper 10: Human and Behavioural Sciences
- Paper 11: Science and Technology since 1900

*Primary sources:* students are required to submit two essays, of not more than 3,000 words in length, prepared on the basis of attending the compulsory HPS Primary Sources Seminars and receiving two supervisions on their chosen topics. Each Primary Source corresponds to one of the eleven papers. A list of texts to be covered in the seminars will be published in the academical year preceding that of the course and the examination. The essays are to be submitted in the early part of the Lent Term.

*Dissertation:* students are required to submit a dissertation of up to 12,000 words. This is expected to embody a substantial piece of study on a topic of the student's own choosing, subject to approval by the HPS Board, that falls anywhere within the History and Philosophy of Science; it must be submitted early in the third term. Potential topics are discussed with any of the teaching officers, preferably before the preceding Long Vacation but otherwise as early as possible in the academical year.

### **Materials Science**

Materials Science is increasingly recognised as a key discipline in the modern world, spanning both physical and biological sciences and also involving various branches of engineering. Recent technological developments in areas as diverse as medicine, sports goods, forensics, energy generation, electronics, communications and transport have all been largely dependent on improvements in the performance limits of constituent materials, rather than on advances related to physical principles or engineering design. People with an understanding of how the properties and

performance of a material are determined, and might be improved, are therefore in great demand throughout the world, across a wide range of organisations. This understanding cannot be obtained solely by studying courses such as Physics, Chemistry or Engineering, since it relies on familiarity with various subtleties and interplays in the processing-microstructure-property relationships. The Materials Science course covers these relationships for all of the main types of material. It builds on the basics provided in the IA and IB Materials Science courses, although students who have missed one or both of them might nevertheless be able to take it.

The aim of the course is to complete basic instruction in Materials Science by providing a core set of lectures supplemented by examples classes and practical work. Students choose either a management course or language classes in addition to the central curriculum in Materials Science. The Part II course also involves project work and a literature review. The projects provide an introduction to sophisticated analytical tools (e.g. transmission electron microscopy, X-ray diffraction and thermal analysis) and computational techniques (finite element analysis and molecular simulation). Invited lectures from industrialists trained originally in Materials science will also enable students to set the subject in a wider context. Students are strongly encouraged to gain industrial experience in materials science and technology. Help in finding jobs or projects during the summer is available through the Department for all students. The Part II Materials Science course is an accredited qualification towards Chartered Engineer (CEng) status.

### **Psychology, Neuroscience & Behaviour**

The neurosciences are one of the most exciting and fast moving areas in biology and these features are well represented in this interdepartmental course. Neurosciences are noted for the breadth of their theoretical base in diverse areas of modern biology and in the range of their medical and social applications. In particular, neuroscience draws its creativity from the integration of different levels of analysis that transcend the boundaries of traditional disciplines and individual departments: from the molecular events taking place within cells, through the electrical and chemical interactions between cells in the nervous system, to the integrated behaviour of the whole organism. This course provides an integrated treatment of the neurosciences, and is built around lectures, workshops and a research project.

The lectures are organised in eight modules of 24 lectures. Four modules - Developmental Neurobiology, Cellular Neuroscience, Control of Action, and Sensory Transduction - are given in the first term. The remaining four - Neural Degeneration and Regeneration, Central Mechanisms of Sensation and Behaviour, Local Circuits and Neural Networks, Memory and Higher Functions - are delivered in the second term. These modules are also taken by students taking Part II Physiology Development and Neuroscience. The technical workshops in the first term will provide practical experience of a wide choice of techniques used in modern neuroscience. In the second term each student will do an experimental project in the laboratory of an individual supervisor. To achieve its inter-disciplinary aim the course is interdepartmental, being organised jointly by the Departments of Physiology Development and Neuroscience, Psychology, Pharmacology and Zoology, with each contributing equally to the integrated lecture modules, workshops and projects. Additional input from other Departments is included as appropriate. The examination will be based on four written papers, requiring answers from at least two first term lecture modules and two second term modules, a written analysis of a research paper, the research project report and a viva at the discretion of the examiners.

The course is designed to be suitable for both Natural Sciences and Medical and Veterinary students and will provide a basis for future careers in research, and neuroscience-based disciplines such as the pharmaceutical industry and the emerging biotechnologies.

### **Pathology**

This course offers study in the main constituent disciplines of Pathology. In order to facilitate study in depth each discipline is presented as an optional subject. Students take any two options (except the combination of options 1 and 5, which is precluded).

1. *Cancer and Genetic Diseases*: This option deals with the cellular and genetic basis of disease using a number of different examples. Topics include cancer biology, reproductive immunology, and identification of genes encoding inherited disorders.
2. *Immunology*: This aims to give a comprehensive course in Immunology, dealing with such topics as the molecular biology of antibodies, the cellular basis of the immune response and its genetic control, effector mechanisms, immunity and hypersensitivity, and immunopathology.
3. *Microbial and Parasitic Disease*: This option is concerned with the fundamental processes involved in bacterial and parasitic disease. The course includes molecular details of bacterial pathogenicity and explores host-parasite interactions for a range of parasite protozoa and helminths.
4. *Virology*: This deals with molecular and general virology including structure and function of the virion, the processes of replication and its control, virus genetics, pathogenesis, epidemiology, and oncogenesis.
5. *Dynamics of Infectious Diseases*: This option covers infectious disease of animal pathogens as it applies to acute and chronic infectious disease across a range of scales, from individual molecular interactions to the dynamics of global epidemic transmission.

In addition to lectures, students attend discussion classes in each of their chosen options and undertake a research project in one of these. The course is a suitable prelude for those wishing to make research careers in the biological sciences as well as for those going on to do clinical and veterinary medicine. There are no particular requirements for entry though Part I courses in one or more biological disciplines are essential. Similar experience is required for entry by Affiliated Students.

## Pharmacology

The course emphasises the mechanisms of drug action at the molecular and cellular level and the consequent effects on organ systems and the whole animal including man. A recurrent theme is the recognition of chemical substances by biological structures and how this recognition produces a biological response. Topics considered in relation to this general theme are drug design, membrane ion channels, intracellular messengers, neurobiology, cancer chemotherapy, and the pharmacology of epithelial and endothelial systems. Some aspects of current and future clinical applications of drugs are discussed. There is no formal system of options and the timetable has been devised so that it is possible to attend every lecture. This structure provides for a wide diversity of interest and allows considerable personal choice in the selection of topics for more intensive study. The examinations are structured to take this provision for choice into account. The course work consists of lectures, discussion groups, technique talks and a research project. Discussion groups consist of 10 students and two members of academic staff; they meet four times a term during both Michaelmas and Lent Terms. During these informal meetings students present literature-based and project-based seminars and practice presenting facts and arguments. In the second term, students work on a research project. The results of the project are presented by the student at a seminar in the third term, and the work is written up as a short dissertation.

Most students entering this course have taken either Part IB of the Medical and Veterinary Sciences Tripos or Part IB Pharmacology in the Natural Sciences Tripos. However, Natural Scientists who have taken any biological subject or Chemistry A and/or B are encouraged to enquire.

The final examination consists of four written papers, submission of the project report, an oral presentation of the project, and, in some cases, a *viva voce* examination. There are substantial vocational opportunities for natural scientists reading pharmacology as well as for medical students who do so before proceeding to clinical studies.

## Physics

The course contains work of three types: 'Core Lectures Courses' and 'Optional Lecture Courses', which are examined at the end of the year in the usual manner, and units of 'Further Work', which are assessed during the year. The four core Lecture Courses and the computing exercises are

compulsory for all students. Students also choose three or four Optional Lecture Courses and take three or more units of Further Work.

The aim of the Core Lecture Courses is to complete basic instruction in physics. In the first term there are four Core Lecture Courses in Advanced Quantum Physics, Thermal and Statistical Physics, Relativity, and Electrodynamics and Optics. In the second term there are four Optional Lecture Courses in Particle and Nuclear Physics, Soft Condensed Matter Physics, Quantum Condensed Matter Physics, and Astrophysical Fluid Dynamics. All students take the Computational Physics course, which is assessed by performance on the class exercises.

For Further Work, students choose three or more options from several on offer. They may select a more experimental course by carrying out up to two experimental investigations, each lasting two weeks. Alternatively they may choose up to two theoretical courses. Students may also take a mix of experimental and theoretical options. Students may also choose to carry out a Computational Physics project, write a Research Review or take a course in Physics Education. The Physics Education course offers experience of developing and presenting teaching material at the secondary-school level. Students may also choose to perform supervised Long Vacation Work, for instance in industry or a Government Laboratory.

There are also unexamined courses on Concepts in Physics and all students have an opportunity to explore Current Research Work in the Cavendish Laboratory.

### **Physiology, Development, and Neuroscience**

The Part II Physiology, Development, and Neuroscience course offers a choice of seventeen modules which fall into three main areas: (i) Development and Reproductive Biology, (ii) Integrative Physiology, and (iii) Neuroscience. Many students will want to study one theme but it is also possible to follow a more general course, combining modules across themes. Those teaching in the course include most members of staff of the Department of Physiology, Development, and Neuroscience as well as invited specialists from the across the University, and from University College London, The Babraham Institute, Takeda Cambridge Limited, Cancer Research UK Cambridge Research Institute, and Addenbrooke's Hospital.

The Department of Physiology, Development, and Neuroscience is concerned with material central to the life sciences. It asks and answers questions about the way that cells, tissues, and organs develop and function in people and animals. Many parts of the course concentrate particularly on the important areas where recent discoveries have changed our perception of disease and have posed new questions to be answered.

The course has been designed to be suitable for both natural scientists and medical or veterinary students.

### **Plant Sciences**

There will be six modules (each comprising a total of 24 hours of teaching, mostly in one-hour slots) which together cover cellular and ecological options. Within a given module there are (in addition to the traditional one-hour lecture slots) workshops, seminars, and discussion groups. It is expected that each student will attend two modules in each term.

#### *First term modules.*

M1: Plant Signalling Networks  
M2: Microbes and organelle evolution;  
M3: Dynamics, History and Phylogeny of Vegetation;

#### *Second term modules.*

L1: Genomes and Development;  
L2: Plants in a Changing Environment;

### L3: Frontiers in Plant Metabolism.

The inter-departmental course in Ecology allows Conservation to be taken with other modules in Zoology or Genetics.

In addition to lectures, students are required to undertake a practical-based research project amounting to the equivalent of two days per week over twelve weeks. Opportunities exist for students to design their own projects, and projects that combine different disciplines within the Plant Sciences are encouraged. The project should be completed in the first and second terms, and the project report submitted at the start of the second term. Students prepare a short oral presentation on their project material at the start of the third term. Tuition in communication skills and effective speaking, with video-tutoring, is offered and the final presentation is assessed. In addition, students are required to complete a Trends-style essay of 2,500 words in the term in which they are not doing their research project.

The Plant Sciences Part II course reflects the growing need to understand more fully how plants work from the cellular to population and community levels. This scope enables you to experience experimental approaches ranging from molecular biology to ecology modelling. The modular nature of the course means that students can study for a Plant Sciences degree with almost any combination of physiological, ecological, or molecular components.

There is a resurgence of interest in plants, whether in terms of their role in carbon sequestration, food production, or bio energy sources. For the next generation, plants will become the focus of key global issues: how to feed an additional 2-3 billion mouths, drive forward an economy currently trading on past sunlight, and maintain biodiversity in the face of climate change. Almost half of our Part II students trained in Plant Sciences over the last few years went on to do postgraduate research at Cambridge or elsewhere. The fact that a significant proportion of those went on to departments specializing in biochemistry or environmental sciences, as well as Research Institutes, emphasizes the breadth and depth of the training we give. The remainder took a variety of posts in, for example, agriculture, school teaching, environmental assessment, management, publishing, law, and industry.

### **Psychology**

Teaching is provided in three broad sections:

- A. Cognitive and Experimental Psychology
- B. Behavioural and Cognitive Neuroscience
- C. Social Psychology, Developmental Psychology, and Individual Differences.

Candidates for the Psychology Option study material across all three sections. The Cognitive Neuroscience Option enables students to specialise in sections A and B. The lecture courses on offer in each area may vary slightly from year to year. Students will have been introduced to some of these topics in the Natural Sciences Tripos courses: Part IA Evolution and Behaviour, Part IB Experimental Psychology or Part IB Neurobiology, or in the Medical and Veterinary Sciences Tripos courses: Part IB Neurobiology and Human Behaviour.

Teaching is also provided on statistics and experimental design; these skills are examined by compulsory questions in Paper 1. Paper 1 also tests the candidate's ability to relate and integrate information from different branches of the subject, and includes questions on conceptual and historical issues in psychology. Papers 2-4 test the three sections (A-C) described above; candidates taking the Psychology option sit each paper, answering three questions on each paper. Candidates taking the Cognitive Neuroscience option sit three papers on sections A and B only. Within these constraints, there is ample scope for students to pick courses that match their interests. Students typically study about half the range of subjects on offer.

There are no practical classes. Instead, each student conducts an experimental research project, under supervision, over two terms, and submits an independent written report. A dissertation - an

extended critical review of an area of the psychological or cognitive neuroscience literature other than that of the project - may also be submitted. The Tripos mark is based on the project report (20%), and Papers 1 to 4 (20% each). For students submitting the optional dissertation, the dissertation may be used to replace the lowest second class (or above) mark from the written Papers 2, 3 or 4.

Almost all those admitted to the course will have taken Part IB Experimental Psychology in the Natural Sciences Tripos, or Part IB of the Medical and Veterinary Sciences Tripos. Students may transfer from either the Philosophy Tripos or Politics, Psychological and Behavioural Sciences Tripos. Any other student may transfer, but would normally be required to devote two years to the Part II course. For those who have met the examination requirements for NST IB Experimental Psychology and NST Part II Psychology (excluding the Cognitive Neuroscience option), the degree received is recognised by the British Psychological Society as conferring 'graduate basis for registration', an essential prerequisite for postgraduate training and practice in certain professional branches of psychology.

## **Zoology**

The courses are arranged in modules from which students select two in each of the first and second terms. Eight modules are offered in the Michaelmas Term and seven in the Lent Term. Students may take one of the following courses offered by the Departments of Plant Sciences and Genetics: Dynamics, History, and Future of Vegetation; and Evolutionary Genetics, instead of one of the modules listed below. The third term is kept free for reading and seminars, though there are a few non-examinable lectures on aspects of Human Biology.

In the Long Vacation between Part IB and Part II, students are encouraged either to attend a ten day field course or to engage in some other approved biological work or to carry out a laboratory project.

### **Michaelmas Term Modules**

Topics in Vertebrate Evolution: The major features of evolution from fishes to birds are reviewed, using the evidence of both fossil and living forms. The functional significance of structural changes is explored, giving emphasis to controversial issues and problematical forms. Practical work is based on exquisite material from the Museum research collections.

Conservation Science: This interdepartmental course, taught with Plant Sciences, aims to provide an understanding of why wild nature is currently in decline, why this matters, and how biology coupled with disciplines such as economics, can be harnessed to identify potential solutions.

Population Biology: This course aims to provide an integrated understanding of key issues in population biology, spanning population dynamics, population genetics, and evolutionary dynamics. The course aims to introduce analytical thinking in population biology and this involves applications of theory; we focus on real-world case studies and not mathematical details.

Neural Mechanisms of Behaviour: The aim of the course is to examine a central problem in animal biology, namely how does the nervous system process information about the environment, integrate the information with past experience, and then generate an appropriate behavioural response.

Behaviour: Individual variation is the raw material for evolution. This course examines the evolution of animal behaviour by focusing on how individual differences in behaviour arise.

Cell assembly and interactions: Is an interdepartmental course taught with PDN. Cells are highly organised and dynamic structures. The module explores how the architecture of the cell is constructed and how cells interact with each other and their environment.

From Genome to Proteome: This interdepartmental course, taught with Biochemistry, considers approaches used to study the control of gene expression in eukaryotes..

Development: Patterning the Embryo: Is an interdepartmental course taught with PDN. It is the first of two complementary modules (with Development: Cell differentiation and organogenesis) which can also be taken on their own. Our aim is to explore a fascinating biological question: how does a single cell, the fertilized egg, have all the information to make an animal?

#### Lent Term Modules

Mammalian Evolution and Faunal History: Mammalian Evolution and Faunal History considers the structure, function, mode of life, relationships, and basic systematics of mammals (and mammal-like reptiles): the faunal history of Tertiary and Pleistocene mammals: and the nature of microevolutionary change.

Responses to Global Change: This interdepartmental course, taught by Plant Sciences, aims to develop an understanding of how the environment, especially the climate, is changing and how the living world is responding. This course explores changes in birds, plants, water and nutrients with lectures given by people who work for conservation organisations, and ecological consultants, as well as academic ecologists.

Behavioural Ecology: The aims of this course are to show how evolutionary theory can explain how life history patterns and behaviour vary, both between species and within a species, in relation to ecological conditions and social competition.

Applied Ecology: With ever increasing pressure on finite resources the world faces very serious environmental problems. This brand new course is about what ecological science can do to help. Sometimes we must accept that undesirable changes will occur, but ecologists often have the knowledge to give advice on how to minimize the harm.

Genetics, Development and Animal Diversity: Genomes contain a rich record of the history of life on earth. This module will show how information contained in genome structure and gene sequences can be used to understand the processes of evolution, and to infer phylogenetic relationships.

Development: Cell Differentiation and Organogenesis: This is the second of two complementary interdepartmental modules in Developmental Biology, taught with PDN. This module will examine a second phase of development: cell differentiation and organogenesis. The two courses can be taken together or on their own.

#### Cell cycle, signalling and cancer

This interdepartmental course, taught with Biochemistry, focusses on the understanding of cancer as a disease of cell proliferation. It first considers fundamental cellular processes including cell cycle progression, DNA damage repair, signalling and apoptosis. It moves on to focus on the understanding of cancer at a molecular and cellular level, and concludes with an outlook towards therapeutic strategies.

### **Biological and Biomedical Sciences**

The aim of Part II Biological and Biomedical Sciences (BBS) is to provide a rigorous and intellectually challenging alternative to a single subject biological Part II subject, for both third year Natural Scientists and Medical and Veterinary Science students. NST Part II BBS allows students to maintain some breadth in their study at Part II, rather than specialising in a single subject, and requires the submission of a dissertation rather than a practical laboratory-based research project. Each candidate must take a Major and a Minor subject and a dissertation. The dissertation topic may be proposed by the candidate or chosen from one offered by the relevant Department and should be not more than 6,000 words, on a subject associated with either the Major or Minor



subject. The dissertation must be prepared in accordance with the guidelines issued by the Faculty Board.

Further details and a link to permissible combinations of Major and Minor subjects can be found at: <http://www.biology.cam.ac.uk/undergrads/nst/bbs>

## Physical Sciences

The aim of Part II Physical Sciences is to allow students to continue to develop a broader knowledge of the sciences than a Part II single subject may provide. The NST Part II Physical Sciences course is also designed for students who have decided on a career more suited to a broad scientific background and have concluded that a more research-oriented single subject Part II would not meet their needs.

Each candidate takes one Half Subject chosen from the following:

- Chemistry
- Physics
- Geological Sciences

and a Part IB subject from the Tripos that they have not previously studied and a dissertation. More information is available at:

<http://www.natsci.tripos.cam.ac.uk/students/third/physicalsciences>

## Part III

Structure: <http://www.natsci.tripos.cam.ac.uk/subject-information/part-iii>

Further details: <http://www.natsci.tripos.cam.ac.uk/students/fourth>

## Astrophysics

This course leads to a M.Sci. degree and is mainly intended as preparation for graduate studies in astrophysics, although the high level of mathematical rigour means that graduates are also highly attractive to employers in other sectors. Lecture courses are taken mainly from the wide selection of astrophysics courses taught, often by Institute of Astronomy (IoA) staff, as part of the Part III Mathematics course and from a few courses offered in Part III Physics. Students normally take four lecture courses for examination although they often attend a wider range of lectures for interest.

Although many of those taking Part III Astrophysics will have taken Part II Astrophysics, the fact that most Part III Astrophysics and Part III Mathematics lectures (and examinations) are the same, means that for interested Part II Mathematics students of sufficient standard, Part III Astrophysics is an alternative to Part III Mathematics. The main difference is that Part III Astrophysics students take one less lecture course (and examination), but undertake a more substantial project, instead of the essay. It is also possible for mathematically able students who have taken Part II Physics to take Part III Astrophysics (at the discretion of their Director of Studies and of the IoA), provided they have taken the Lent Term option in Astrophysical Fluid Dynamics. Students contemplating the route from either Part II Maths or Part II Physics into Part III Astrophysics should be aware that, in the case of over-subscription, priority will be given to suitably qualified students who have done Part II Astrophysics.

Astrophysics courses typically offered in Part III Mathematics (these change from year to year) include Astrophysical Fluid Dynamics, Structure and Evolution of Stars, Stellar and Planetary Magnetic Fields, Galaxies, Physical Cosmology, General Relativity, Black Holes, and Accretion Discs. Further details of the courses may be found at the Faculty of Mathematics. Examinations are the same as those taken by students taking Part III Mathematics. Part III Astrophysics students may also offer the Part III Physics courses "The Physics of the Earth as a Planet" and "Particle Physics". Further details of the courses may be found at the Department of Physics. Examinations are the same as those taken by students taking Part III Physics.

A major component of the Part III Astrophysics course is the research project (accounting for one third of the marks) which is supervised by staff at the IoA over the Michaelmas and Lent Terms. This provides undergraduates with a unique opportunity to get to the cutting edge of astronomical research and the resulting dissertation often contains work of publishable quality. Projects often either involve the analysis of astronomical data or the running of computer simulations. In addition, students develop their communications skills through giving an oral presentation on their project.

Further details are available at <http://www.ast.cam.ac.uk/teaching/undergrad/>

## **Biochemistry**

The Part III Biochemistry course is followed by undergraduates who have successfully completed the Part II Biochemistry course having met the set criteria in Part IB and Part II in order to be accepted for the 4-year course. The course allows students who wish to become professionals in the molecular biosciences to pursue a two-term research project during their fourth year, together with continuing advanced teaching in lectures and discussion groups. Success in the course leads to the award of the M.Sci. degree.

The individual research project is conducted in the laboratory of the supervising member of staff and chosen from an extensive list. With prior approval by the Course and Projects Organisers, projects may be undertaken in other parts of the University, such as the Gurdon Research Institute, the Systems Biology Centre, the Babraham Institute, Cambridge Institute for Medical Research, Department of Clinical Biochemistry (Institute of Metabolic Science), Department of Clinical Veterinary Medicine, MRC Dunn Human Nutrition Unit, MRC Molecular Biology Laboratories, Hutchison/MRC Research Centre, Unilever Cambridge Centre for Molecular Informatics or the Department of Chemical Engineering and Biotechnology. The experimental work will start at the beginning of the first term and be written up as a dissertation (8,000 word limit, excluding footnotes and bibliography) by early in the third term. For many of the Part III class the project is the highlight of their degree as well as providing a real insight into the world of research.

In two Part III research symposia, students present 20 minute reports and answer questions on their project at the beginning of the second term and at the beginning of the third term. Production of these presentations is an excellent training for postgraduate and business careers. The research environment is reinforced by a series of seminars on "Scientific Method and Experimental Design" and "Landmark Papers in Biochemistry".

The training also includes Journal Clubs and advanced lectures. Weekly biochemical discussion sessions amongst other students and members of staff continue through the year. The third term is, as for Part II, otherwise free to devote to examination preparation through the departmental-based group supervisions, specialist supervisions with individual lecturers and self-guided supervision. At this stage, four-year students graduate with the BA and M.Sci. degrees.

There are opportunities for students who satisfactorily complete the Part III course in Biochemistry to proceed to doctoral degrees by research, in Cambridge or elsewhere; the Department is well equipped for research on a wide range of biochemical topics.

## **Chemistry**

Part III (the fourth year) is intended for those who wish to pursue a career in research; it leads to graduation with an M.Sci. Degree. The fourth year will be quite different from the previous three years, which have in a sense been a preparation for this final year. There are just two components to the fourth year: a major research project, occupying all of the first and second terms, and a wide selection of research-oriented lecture courses from which a free choice can be made. Students will write up an account of their research project (about 5000 words) and in addition there will be end-of-year examinations.

## **Earth Sciences**

This course offers a full geological education up to the active research level. It is intended for students planning a career, further training or research within Geological Sciences, or for other students wanting the intellectual challenge of an advanced course in the Earth Sciences.

Part III will have a core in the form of a seminar series on topical research areas in the subject in the first term. In the second term there will be a choice of options across a wide spectrum of the subject. Field-based training during the Easter break is an essential part of the course.

There will be a research project carried out in the first term which may be based on fieldwork or Industry placements (typically conducted during the preceding Long Vacation), or a laboratory work and/or data analysis.

More details of the coursework and course requirements can be found at <http://www.natsci.tripos.cam.ac.uk/subject-information/plll-folder/geosci>

## **History and Philosophy of Science**

This course gives students with relevant experience at Part II the opportunity to carry out focussed research in History and Philosophy of Science. It provides students with the opportunity to acquire or develop skills and expertise relevant to their research interests, and enables them to develop a critical and well informed understanding of the roles of the sciences in society. The course is intended for students planning a career in the subject and will provide the requisite research skills to enable them to prepare a well planned and focussed PhD proposal.

HPS Part III will have a core in the form of a weekly seminar which will be examinable by means of 2 essays. In Michaelmas term students will work on a Critical Literature Review, and at the end of Lent term they will submit a Research Paper. In the second part of Lent term and the first half of Easter, students will contribute to the weekly seminar by presenting their own work in progress, and discussing the issues that arise from it, on the dissertation which they will submit at the end of the Easter term.

Entry to Part III will depend on obtaining at least a class II.i standard in NST Part II History and Philosophy of Science. Students who have not taken NST Part II HPS will be treated on a case-by-case basis.

The detailed entry requirements can be found at: <http://www.natsci.tripos.cam.ac.uk/students/fourth>

## **Materials Science**

This course is intended for students who wish to follow careers as professional scientists in industry or academic research.

The aims and objectives of the course differ from Part II, since it is largely focussed on highlighting the latest developments in the subject. Many of the lecture courses concern cutting-edge topics and provide a natural springboard for future research, which could be undertaken in industry, research institutes or academia. While the course is certainly not exclusively for those planning a research career, it provides a valuable insight into advanced study of the subject. There are 3 compulsory lecture courses, concerned with experimental techniques, and there is then a choice of module courses, covering a wide range of advanced topics. A major component of the course is the individual research project, undertaken within one of the research groups in the Department in the Lent term. Among extra-curricular activities organised by the Department are programmes of visiting speakers and an opportunity to spend the summer after the course pursuing a research project in a university or research institute in continental Europe. (Some of these are also available in earlier years of the Tripos.) The course leads to the M.Sci degree. Being awarded this degree counts (uniquely within the Natural Sciences Tripos) as an accredited qualification towards Chartered Engineer (CEng) status.

## Physics

This course is intended as preparation for professional work as a physicist in industry or academic research. Entry is restricted to candidates who have attained a specified standard (currently Class 2.i) in Part II Physics, or who have attained a specified standard (currently equivalent to Class I) in Half Subject Physics of Part II Physical Sciences, and students with a 2.i in the Part II Astrophysics course or in Part II Mathematics. The fourth year course presents physics as a connected subject of considerable flexibility and applicability. All students undertake a substantial project. The possibility exists of undertaking industrial work during the previous Long Vacation for credit in the Tripos. Lecture courses in the first two terms provide more advanced treatments of major areas of physics and are selected to reflect broad areas of current interest. It is also possible to take courses in each of the first and second terms from an approved selection of those offered in Part III Mathematics.

In the first term students read three or more courses selected from eight or more options, including those from Part III Mathematics. These cover major areas and in each of them physics is presented as a connected discipline drawing upon the material of the first three years to take the topic to the frontiers of current research. Examples of course titles are Particle Physics, Relativistic Astrophysics & Cosmology, Advanced Quantum Condensed Matter Physics, Quantum Condensed Matter Field Theory, Soft Matter, and Physics of the Earth as a Planet.

In the second term students chose three or more courses from a menu of about a dozen. Sample subject areas are Astrophysics, Field Theory, Information Theory, Particle Physics, Semiconductor Physics, Soft Condensed Matter, Medical Physics and Biological Physics. Students may also choose the Entrepreneurship course, which can be substituted for one Minor Topic: it is taught by the Judge Business School and assessed through coursework. Additionally students may choose 'Interdisciplinary Topics' from amongst those offered across Part III of the NST. Each Interdisciplinary Topic replaces one Minor Topic. Students are also able to choose the subject Nuclear Power Engineering taught in Part IIB of the Engineering Tripos, again in place of one Minor Topic.

Most courses are examined at the start of the term following that in which they are given, but there is a final examination in General Physics for all Part III students, held shortly before those graduating proceed to their B.A. and M.Sci. degrees. The examinations for the Interdisciplinary Topics and Part III Maths courses are also held in the main Easter Term examination period.

## Systems Biology

Systems Biology is an integrated approach to the study of living systems. It is quintessentially interdisciplinary with participation of biological, physical, mathematical, engineering and computational sciences. The emerging discipline is concerned as much with the links that connect components of a network as with the components themselves. A major focus is the determination of how the properties of networks arise from all their constituent links. A second strand focuses on the collection of detailed highly quantitative data from smaller systems with the goal of developing predictive mathematical descriptions of systems behaviour. Ultimately these strands will converge to provide accurate mathematical models of biological processes.

Students will take the following modules as part of this course:

- 1) Induction Course: This aims to introduce a group of students from a range of backgrounds in the biological and physical sciences, mathematics, computer science, and engineering to the basic concepts, theories, and modelling and experimental techniques of Systems Biology.
- 2) Data Acquisition and Handling: This module will present the techniques used to acquire data in the various 'omics' approaches (transcriptomics, proteomics and metabolomics), as well as in high-throughput genetics. The module will emphasise the practical aspects of the challenges in dealing with large amounts of data and their experimental limitations.

3) Mathematical Modelling and Analysis of Networks: This module will look at computer-based network modelling and analysis, embodying tools of mathematics, informatics and statistics.

4) Synthetic and Executable Biology: The synthetic biology approach will be introduced, as will the practice of modelling by simulation using computational techniques. This module will include a focused design project in which the design is evaluated by *in silico* simulation.

In addition to the above courses, which will incorporate lectures and practical classes, students will be required to attend two seminars per week during term, and carry out a research project in Michaelmas and Lent.

February 2016