# Visiting Students Biochemistry/Biomedical Sciences Pre-Medical Programme

**Biochemistry** is the use of molecular methods to investigate, explain and manipulate biological processes. The study of life at the molecular level continues to undergo dynamic expansion, leading to ever-increasing insights into topics as various as the origin of life, the nature of disease and the development of individual organisms. The Biochemistry Department in Oxford is one of the largest in Europe, and is extremely active in research, with the breadth and excellence of these activities reflected in the scope of the undergraduate courses and underpin the teaching.

**Biomedical science** focuses on how cells, organs, and systems function in the human body; an exciting and dynamic area that is highly relevant to the understanding and treatment of human diseases. Oxford is a highly respected and internationally recognised centre for biomedical research and students will benefit from tuition from leading experts working within a variety of nonclinical and clinical departments. Biomedical Science study at Oxford provides students with an intellectually stimulating education in modern molecular, cellular and systems biology and neuroscience.

**The St Anne's biochemistry/biomedical sciences pre-medical programme offers visiting students the unique opportunity to immerse themselves in studying both of these subjects at Oxford.**

In addition to the general visiting student application requirements **visiting students applying for this programme need to have completed:**

- organic chemistry ideally prior to application, and certainly prior to arrival
    - if you have not yet completed organic chemistry when you apply, please indicate in your application when you will be completing this
- a course/s in biology prior to application

**Study duration:**

You can apply to study on the Biochemistry/Biomedical Sciences Pre-Medical Programme for the Fall Term, Extended academic year, or the academic year, with preference for applicants for the extended academic year.

If joining for Fall Term or the Extended academic year you will participate in the September teaching outlined below and then continue with academic year teaching.

**Courses offered:**

The following courses are offered to visiting students and will include, where applicable, lectures, classes, seminars, tutorials, practicals (labs). Please note courses are only offered in the terms indicated and **depending on your study duration you will need to indicate 8 course preferences from across biochemistry and biomedical sciences from each term**. Subjects do not need to be evenly distributed across the term/s or academic year. Courses and terms can be subject to change and all courses depend on sufficient prerequisite knowledge and tutor availability. Please indicate your preferences on the accompanying tutorial preferences form.

Please note this information may still be subject to change each academic year.

**Extended academic year or Fall Term September teaching**

You will participate in all the following classes, lectures, workshops, and tutorials.

***Classes/Workshops/Lectures:***

Some pre-reading and/or exercises may be required.

- **Scientific writing workshop**
  Covering scientific writing, how to write concisely and effective use of diagrams/figures to convey information.

- **Amino acids and proteins**
  Looking at the properties of amino acids and how this affects how polypeptides can fold.

- **RNA/DNA**
  Looking at the properties of RNA and DNA and how each are suited to their individual roles. Emphasis on the specificity of base pairing, stability, and capacity to participate in chemical reactions.

- **The protein toolbox**
  Looking at methods to investigate proteins and their functions.

- **The genetic toolbox**
  Covering forward and reverse genetics methodologies and how they can be utilized to understand biological systems.

- **Enzyme kinetics and Statistics**
  Covering how enzymes catalyse reactions, measuring enzyme kinetics, modes/methods of inhibition, and appropriate statistical analyses.

- **Systems neuroscience**
  A brief overview of how neural circuits are organized and how this allows for information processing. Examples of the visual system, spinal cord, and basal ganglia to understand how different types of circuits operate and how these might go wrong in disease states.

***Tutorials:***

Accompanied by extensive reading and an essay or equivalent workload.

- **Cell Biology**
  An introductory tutorial covering comparing eukaryotic and prokaryotic cells and the implications of their differences on the biological mechanisms that underpin life.

- **Protein structure-function relationships**
  Looking at the relationship between structure and function of proteins using enzymes, haemoglobin/myoglobin, collagen, and membrane proteins as key examples.

- **Membranes and Compartments**
  Looking at the many roles of membranes, including how membranes can function as barriers, how selective permeability is achieved, and how controlled movement of molecules can be utilized by cells. Key examples include nerve signal transduction, epithelial cell nutrient uptake, and control of intracellular environments for regulation of cellular processes.

- **Mutagenesis and Repair**
  Looking at how DNA damage can arise, be recognized, and repaired. How damage can lead to mutations in the genome, how this and the mechanisms of repair can be harnessed to understand biological systems.

- **The Cell Cycle**
  Looking at how transitions between cell cycle phases are governed by CDK-cyclin complexes and how this is controlled with regulated protein synthesis, degradation, and post-translational modification. Also considering how cellular events are linked to the cell cycle, looking at the mechanism of replication and chromosome organization and segregation.

- **Regulation of gene expression**
  Looking at how gene expression can be controlled at the level of transcription, translation and post-translationally in both prokaryotes and eukaryotes.

- **Cellular Neuroscience**
  Looking at how neurons conduct electrical signals through action potentials and communicate through chemical synapses. Understanding how morphology and different receptors might affect the function of neurons.

***Fieldtrip:***
**Trip to Diamond Light Source**
Guided visit to Diamond Light Source, the UK's national synchrotron science facility, including a trip to a fragment screening lab. Students will learn how the synchrotron works and how the beamline generated is used to solve biological problems such as understanding protein structures.

## Academic Year Teaching

**Biochemistry** is taught in blocks and a typical week may be divided between lectures (typically eight to ten a week), tutorials and classes (1 to 3 a week), and practicals/other activities (averaging 1 full day a week).

**Biomedical sciences** is typically taught in a combination of lectures (approx. 5 per week) and tutorials (1-2 per week), some with practical classes as well. Depending on your course preferences you may also attend lectures, seminars, and tutorials in a specialist area.

To assist with academic understanding and credit transfer to your home institution we have allocated suggested unit/s to all biochemistry and biomedical science courses.
Each unit roughly equates to:

- 1 unit courses – up to 8 lectures, 1 or 2 tutorials
- 2 unit courses – up to 16 lectures, 2 - 4 tutorials
- 3 unit course – up to 24 lectures, up to 6 tutorials

and these guidelines are neither completely comprehensive nor a maximum amount of teaching that may be undertaken with a course.

Visiting students on this programme will generally participate in approximately 5/6 units of teaching per term, and this may not be evenly distributed across the terms.

**All visiting students must take either *TB1 – how to isolate and characterise a gene* from biochemistry OR *Immunology and Microbiology* from biomedical sciences, both of which are offered in Michaelmas term. Please indicate which of these you wish to take on your tutorial preferences form.**

## Michaelmas Term

**Biochemistry courses:**

**TB1 - How do I isolate and characterise a gene? 2 units**

In this toolbox we explore genetic and molecular biology techniques that are concerned with understanding what a gene is, and how genes are identified and manipulated. By the end of this block, you will understand how genes and genetic pathways are defined in both genetic and molecular terms and you will have gained experience in yeast and phage genetic techniques, gene cloning and manipulation, as well as in some of the bioinformatic tools that are used to investigate genes.

**TB2 – How do I purify a protein? 2 units**

In this toolbox we explore techniques required for the expression and purification of proteins. This includes prediction methods, expression methods, purification methods, how to assess protein quality, and identification of binding partners.

**CC1 – How do cells do chemistry? 1 unit**

This block aims to describe how cells use enzymes to carry out chemical reactions with speed and specificity. It also describes how enzymes can be evolved to perform new chemistry and applied industrially. We will look at mechanisms enzymes use to speed up reactions, how to determine the speed of enzyme function, how different inhibitors can block reactions, why and how certain metal ions are used by cells, and how enzymes not found in nature can be designed, evolved, and used beyond the laboratory.

**MP1 – How do chemicals move across membranes? 1 unit**

This block aims to introduce you to the problems that organisms face in terms of getting small and often charged entities across membranes and how these are generally solved. Much of this is solved by membrane proteins like channels, transporters, and pumps. We take a mainly structure-based view of this topic, asking how does the structure link to the function?

**IT1 – How is DNA packaged in the cell? 1 unit**

This block aims to explore how DNA is packaged in cells and how chromatin can support and influence genome function. We will investigate how DNA is packaged into the nucleoid in prokaryotes and chromatin in eukaryotes, what defines the nucleosome landscape across the genome, how chromatin is organised and modified, how chromatin influences chromosomal processes like gene expression, how chromatin is assembled and functions at centromeres and telomeres, the macroscale structural organisation of chromosomes in cells, and features of sex chromosomes and chromatin-based dosage compensation.

**MP2 – How are proteins processed? 1 unit**

All cellular pathways and process rely on post-translational modification of proteins. This block explores the mechanisms that underpin the three main types of PTMs: phosphorylation, ubiquitination, and glycosylation. By then end of this block you will understand how the

enzymes that control these PTMs work and in some cases how they are themselves regulated. You will also explore the consequences of such PTMs.

**IT2 – How do cells divide? 1 unit**

This block covers how CDK-cyclins create different cell cycle stages and feedback control of the cell cycle. We will study Mitosis, including how chromosomes are segregated and the spindle assembly checkpoint, Cytokinesis, and how the cell cycle is dysregulated in cancer.

## Biomedical sciences courses:

**Immunology and Microbiology – 3 units**

Including and introduction to infectious diseases, bacterial form and function, bacteria pathogenesis, antibiotics and resistance, preventing bacterial infections, neutrophils, macrophages, acute inflammation and fever, adaptive immunology, innate immunity, virology, and latent infection.

**Receptor and System Pharmacology: Relevance for diseases and drug discovery – 2 units**

Including and introduction to quantitative receptor pharmacology, the pharmacology of cell signalling, how the body handles drugs, pharmacology of cell growth and cancer, infectious diseases, antibiotics and antiviral agents, drug target identification and validation, mechanism of action of general and local anaesthetics, pharmacology of pain, peripheral neuropharmacology, drugs and the heart, drug action in neuromuscular transmission, pharmacology of blood pressure control, pharmacology of kidney transporters and diuretics, and pharmacology of diabetes and obesity.

**Cellular Pathology – 2 units and continues into Hilary term**

Including neutrophils, macrophages, acute inflammation and fever, adaptive immunology, autoimmunity, transplantation, tuberculosis, chronic inflammation, prions and amyloid, atherosclerosis, arterial thrombosis, venous thrombosis, cancer biology, inflammation.

**Developmental Biology – 2 units and continues into Hilary term**

Control of cell growth, cell differentiation, embryology, axis formation, signalling in development, non-mammalian models of development, transgenic technologies in mice, morphogen gradients, patterning structures and organs, Drosophila embryonic patterning, homeotic genes, mouse early embryonic development, and regeneration.

**Integrative Systems Biology – 2 units and continues into Hilary term**

Including: regulation of potassium, long term control of blood pressure, physiological changes during exercise, control during exercise, pharmacology of fluid balance, regulation of plasma pH, physiology at high altitude, pharmacology asthma, body systems inn anaesthesia, atherosclerosis, venous thrombosis, and general anaesthesia.

**Auditory Neuroscience – 1 unit**

Including the nature of sound, spatial hearing, periodicity and pitch, auditory scene analysis, hearing and speech, development, learning and plasticity, hearing aids and cochlear implants.

**Hilary Term**

**Biochemistry courses:**

**CC2 – How do cells make energy? – 1 unit**

This block covers the principles of Chemiosmosis, proteins/complexes/biochemical reactions that generate ionmotive gradients and Oxidative phosphorylation by the human mitochondrial electron transport chain.

**TB3 – How do I get a protein structure? – 1 unit** *(TB2 is a pre-requisite for this course, and you must include TB2 in your preferences if you wish to take TB3)*

This block aims to provide an understanding of the principles and methodology underpinning structure determination by X-ray crystallography, cryo-electron microscopy, and nuclear magnetic resonance, including structure refinement.

**TB4 – How do I visualise events in the cell? – 1 unit**

This block aims to illustrate the importance of microscopy in modern research, particularly biological sciences. It will demonstrate how various microscopy techniques are differentially suited to a range of challenges and illustrate the design concepts that underpin development of new or improved imaging modalities.

**MP3 – How are macromolecules moved around cells? – 1 unit**

This block covers the principles of protein transport. Looking at vesicular trafficking, it will cover secretion, endocytosis, molecular mechanisms, and regulation. It will also examine the biogenesis of integral membrane proteins

**MP4 – How does cell signalling work? – 1 unit**

This block explores cell signalling and examines the roles of receptors such as RTKs, GPCRs, and other receptors, signalling for cell growth, cross talk in signalling pathways, bacterial signalling, and methods to study signalling pathways.

**CC4 – Life without light and oxygen – 1 unit**

This block aims to develop an understanding of the basic principles behind a wide range of metabolic pathways found in bacterial systems. You will be able to place these pathways within ecological and environmental context and appreciate the microbial community and population effects.

**CC3 – How do cells use energy stored in proton gradients? – 1 unit** *(CC2 is a pre-requisite for this course, and you must include CC2 in your preferences if you wish to take CC3)*

The aims of this block are to investigate the principles of membrane electrochemical gradients, the major ways in which energy stored in membrane gradients is harvested, and how membrane proteins couple transmembrane ion flux to other catalytic activities, such as ATP synthesis or flagellar rotation.

**IT4 – How is DNA copied and maintained? – 1 unit**

The overall aim of this block is to provide detailed insights into how the genomes of organisms are copied and maintained. By the end of this block, you should have gained an understanding of how DNA is replicated, how cells orchestrate a response to DNA damage and coordinate DNA repair with other process including the cell cycle. You should also understand how cells can compensate for loss of certain DNA repair mechanisms and how an understanding of these relationships can be exploited therapeutically.

## Biomedical Sciences courses:

**Endocrinology – 2 units**

Including: regulation of calcium, cell signalling, homeostasis of iron, the hypothalamus, control of appetite, neuroendocrine control of the thyroid, pituitary, stress response, diabetes, oxytocin, vasopressin and behaviour, gut hormones and appetite, thyroid control of metabolic rate, control of growth, malnutrition, and obesity.

**Genes Circuits and Behaviour – 1 unit**

Including how genes influence behaviour, genetic mapping of behaviour, genetic dissection of neural circuits, mouse as a model system, olfactory circuits and behaviour, and aggression/emotion behavioural circuits.

**Neural codes: Modern questions and directions in neuroscience – 1 unit**

Correlation versus causation in neuroscience. Can we use AI to understand the brain? Are neural oscillations an epiphenomenon? Connectomics: are neural connections the way to understand brain function? Decrypting neural codes: are spike rates or spike times more important? Should we be hunting for "grandmother neurons" in the brain? And Brain-machine interfaces: current applications and future directions.

**Neuropharmacology – 1 unit**

Pharmacology of glutamate transmission, monoamine neurotransmitters, pharmacology of inhibitory transmission, atypical chemical messengers, drugs and treatments of mental illness, neuropharmacology of recreational drugs, and neurotoxic mechanisms.

**Second messengers and Cascades – 1 unit**

Including: families of cell surface receptors, G proteins, the second messenger concept and adenylyl cyclase system, calcium signaling, nitric oxide and cGMP signaling, signaling through enzyme coupled receptors, the inositol lipid pathway, kinases, and phosphatases.

**Sleep and Circadian Neuroscience – 1 unit**

Including: An introduction to sleep physiology, circadian and homeostatic regulation of sleep, brain oscillations during sleep, neurobiology of NREM sleep, neurobiology and regulation of REM sleep, genetics and phylogeny of sleep, sleep and metabolism, and functions of sleep.

**Cellular Pathology – 2 units and starts in Michaelmas term**

See Michaelmas term

**Developmental Biology – 2 units and starts in Michaelmas term**

See Michaelmas term

**Integrative Systems Biology – 2 units and starts in Michaelmas term**

See Michaelmas term

## Trinity term

## Biochemistry courses:

**TS1 – What are the principles of the immune response? – 1 unit**

This block will explore the basic concepts of how immunity is induced and regulated following an infection. It will examine how immunity evolved and detail the knowledge that can be obtained by comparing immune systems of different animals both closely related as well as evolutionary distant. It will identify the basic building blocks that are needed in the induction

of innate and adaptive immunity and where and how the interjection of innate and adaptive responses happens in jawed vertebrates.

**IT3 – How are genes expressed? – 1 unit**

This block addresses key concepts in gene regulation. It will cover the mechanisms of transcription by RNA polymerase and mechanisms of translation by the ribosome, both in bacteria and eukaryotes, and examine how these processes are regulated by looking at the key elements of genes, operons and transcripts that are the focus of regulatory mechanisms in bacteria and how these compare to mechanisms used in eukaryotes to control transcription, the processing of transcripts and translation.

**MP5 – How do cells communicate in tissues and populations? – 1 unit**

This block examines the role of the extracellular matrix and its effects on cell behaviour. It examines the roles of Fibrillin and TGFb signalling, Collagens, and Notch signalling and its role in cancer.

**TB6 – How do I understand protein interactions? – 1 unit** *(TB2 and TB3 are pre-requisites for this course, and you must include TB2 and TB3 in your preferences if you wish to take TB6)*

This block examines how we can investigate protein interactions. It covers molecular mechanics and force fields, molecular dynamics, NMR for dynamics, and how to integrate structural information.

**TB5 – How do I understand protein dynamics and integrate structural information? – 1 unit**

This block aims to give you a basic sense of how python works and to use this to explore how molecular dynamics simulations are performed, what they can tell you and how MD is complementary to other forms of structural biology. You will learn how to read simple python code, interpret molecular dynamics simulations results, initiate a molecular dynamics simulation, and how various strands of structural biology can be combined in an integrated manner.

**TS2 – What is cancer? – 1 unit**

This block examines how cancer arises, examining both oncogenes and tumour suppressor genes. It also explores the mechanism and role of apoptosis.

**CC5 – How are defence and attack linked in bacteria? – 1 unit**

This block covers the major biogenesis pathways of the cell envelope, the mode of action of common antibiotics and bacterial resistance mechanisms, outer membrane protein structure and function including the biogenesis machine BamA, the biochemistry of interbacterial competition, Coarse grain and molecular dynamics simulations of the bacterial cell envelope and what they tell us, and explores bacterial competition, cooperation, and warfare.

## Biomedical sciences courses:

During Trinity term there are few biomedical sciences courses as most students undertake a lab-based research project which it may also be possible for visiting students to join (see below). You may also be able to attend third year lectures, but tutorials are not offered in these topics.

## Additional possible options:

**Literature Review project**

Under the guidance of a Tutor students will complete an extended essay (typically 5000 words),

which reviews the primary literature in a field of their choice. This project and topic selection would begin in September and independent progress is ongoing throughout the academic year, culminating in a presentation and essay. If you are interested in this option and already have a research area in mind, please specify it and include brief additional information as may be helpful to your personal tutor.

*This option will need to be discussed with your St Anne's personal tutor once you arrive in Oxford. Tutor availability for specific topics cannot be guaranteed.*

**Data Analysis and Interpretation (Michaelmas, Hilary, and Trinity terms)** – 4 tutorials
Considers how to analyse and interpret biochemical data from a range of sources, considering the limitations of conclusions that can be drawn, and planning subsequent experiments with appropriate controls to address the key questions. Students will also consider how findings are presented to the wider scientific community through peer reviewed journals, posters, and conference talks.

**Lab research project**
Students join a research project in one of the University's research labs. Projects may begin at different times of the year depending on a student's interest and lab availability. Students are required to produce a written account of their research (approx. 5000 words) and give a talk in College on their work. If you are interested in this option and already have a research area in mind, please specify it and include brief additional information as may be helpful to your personal tutor.

*This option will need to be discussed with your St Anne's personal tutor once you arrive in Oxford. Projects and availability of lab space cannot be guaranteed.*

**History of Science (Michaelmas) and Philosophy of Science (Hilary) – lectures + 4 tutorials in each**
*- there may be some flexibility by prior arrangement to schedule tutorials in Trinity term*
The History and Philosophy of Science is designed to give students from science and medicine the tools needed to address ethical, philosophical, and policy-focused questions that accompany scientific work, and which embody the urgent problems facing us today. The course provides students with an introduction to contemporary issues and research within the history and philosophy of science, and also takes up larger questions concerning science denialism, the nature of evidence, science policy, and social and cultural influences on scientific practice.

**Medical Ethics (usually Trinity term) – usually 4 tutorials**
*- there may be some flexibility by prior arrangement to schedule tutorials in a different term*
Investigates ethical issues arising from medicine and medical care and topics could include beginning and end of life; the doctor-patient relationship; social inequalities in health care; private versus public healthcare; public health and policy; disease of the 21st Century, etc.