Fitzwilliam College Online Summer School Programme 2024

Course brochure

Fitzwilliam College, a constituent college of the University of Cambridge, is delighted to offer its own Online Summer School Programme for 2024. Through this programme, participants will experience the world-leading teaching offered at our institution, by the same academics responsible for our own undergraduate students. Reflecting the traditional Cambridge supervisions at the core of our undergraduate courses, our programme will help you develop your academic skills through challenging small-group problem-solving and discussion sessions.

This brochure outlines the range of short courses on offer in July 2024, detailing their core content, any prerequisite knowledge, and recommended reading lists.

I am delighted that Fitzwilliam College can offer you the opportunity to participate in this Summer School Programme. I hope you will enjoy exploring your chosen topic and grow your enthusiasm for learning. We look forward to welcoming you soon to our Summer School Programme!

Dr Peter Bolgar
Director of the Summer School Programme

Contents:

Pathogen evolution through bioinformatics

(Biology, Genetics, Bioinformatics, Microbiology)

Dr Marta Matuszewska

Research Associate, Department of Medicine, University of Cambridge and
Wellcome Sanger Institute, Wellcome Trust Genome Campus

Marta Matuszewska, currently a Research Associate at the University of Cambridge, is an accomplished evolutionary microbiologist specialising in bacterial host adaptation. Holding a PhD in Veterinary Medicine, Marta's research is dedicated to understanding the host range and transmission dynamics of antibiotic-resistant pathogens, with particular focus on *Staphylococcus aureus*. In her current role, she is actively engaged in investigating the biological basis of nasal carriage *by S. aureus*, employing a comprehensive approach that integrates microbiology and genetic epidemiology. Beyond her research, Marta actively contributes to education at the University by leading practical classes in mathematical biology and cell biology. Previously she has supervised undergraduate students in mathematical biology, nurturing the next generation of scientists. Marta also enjoys public science outreach, participating in events such as the Cambridge Science Festival, communicating complex scientific concepts to broad audiences.

Google Scholar: https://scholar.google.com/citations?user=hDJPDIgAAAAJ&hl=en
Cambridge Infectious Diseases Profile: https://www.infectiousdisease.cam.ac.uk/directory/marta-matuszewska
LinkedIn Profile: https://www.linkedin.com/in/marta-matuszewska-b92432131/

Module Structure and Syllabus:

Date and UK time	15th July Monday 9 am - noon	16th July Tuesday 9 am - noon	17th July Wednesday 9 am - noon	18th July Thursday 9 am - noon	19th July Friday 9 am - noon
	Molecular Epidemiology	DNA Structure	Causes and consequences of mutations	Principles of Classification of Micro-organisms	Microbes and Disease
Date and UK time	22nd July Monday 9 am - noon	23rd July Tuesday 9 am - noon	24th July Wednesday 9 am - noon	25th July Thursday 9 am - noon	26th July Friday 9 am - noon
	Bacterial Genomics	Phylogenetics	Phylogenetic Inference	SARS-CoV-2 Pandemic Response	Final Presentations

Molecular Epidemiology: An in-depth introduction to the methodologies and key definitions essential for studying the evolution of pathogens using genomic data. Students will learn the foundational concepts that underpin molecular epidemiology.

DNA Structure: A comprehensive exploration of cell structure, the intricacies of DNA and RNA molecules, and a deep dive into the Central Dogma of biology. This lecture lays the groundwork for understanding genetic information.

Causes and consequences of mutations: A detailed examination of mutations, including their definition, classification into types, an exploration of their consequences on genetic material, and an analysis of the diverse factors contributing to mutagenesis.

Principles of Classification of Micro-organisms: A nuanced discussion on the principles governing the classification of microorganisms, emphasising both phenetic and phylogenetic relationships. Students will gain insights into the taxonomic frameworks that categorise these entities.

Microbes and Disease: An exploration of infectious diseases, covering the spectrum from foodborne and waterborne to airborne diseases. Students will gain a broad understanding of the diverse microbial agents responsible for various health challenges.

Bacterial Genomics: An introduction to the diverse sequencing techniques employed in bacterial genomics. The lecture will guide students through the process of transforming raw sequencing data into a comprehensible genome, providing essential insights into genomic analyses.

Phylogenetics: A deep dive into phylogenetic principles, including real-world examples of phylogenies, discussions on phylogenetic tree rooting and topology, applications in diverse contexts, and a critical examination of potential pitfalls in phylogenetic analyses.

Phylogenetic Inference: Building upon the previous lecture, students will learn the practical aspects of phylogenetic inference. This includes creating alignments, understanding distance matrices, selecting appropriate substitution models, and exploring various approaches to construct phylogenetic trees, such as Neighbour-Joining, Likelihood-based methods, and Bayesian phylogenetic inference.

SARS-CoV-2 Pandemic Response: A special guest lecture by Dr. Christopher Ruis, offering unique insights into his work during the SARS-CoV-2 pandemic response. Students will gain a first-hand understanding of applying mutational spectra and phylogenetics to decipher pathogen transmission patterns.

Final Presentations: The culmination of the course, where students present their comprehensive understanding of molecular epidemiology and pathogen evolution. Each presentation will showcase the application of acquired knowledge and skills, providing a tangible demonstration of the course's impact on the students' analytical capabilities and scientific acumen.

List of prerequisite knowledge:

There is no required prerequisite knowledge for this course, however basic computational skills in Linux and coding are encouraged. A broad familiarity with the items on the list above will greatly enhance your understanding and enjoyment of the classes and good preparation by all students will contribute significantly to the success of the course.

Recommended reading list (optional):

Brown, T. A. (2002). *Mutation, Repair and Recombination*. https://www.ncbi.nlm.nih.gov/books/NBK21114/

Costa dos Santos, G., Renovato-Martins, M., & de Brito, N. M. (2021). The remodel of the “central dogma”: a metabolomics interaction perspective. *Metabolomics: Official Journal of the Metabolomic Society*, *17*(5). https://doi.org/10.1007/S11306-021-01800-8

Crick, F. (1970). Central Dogma of Molecular Biology. *Nature 1970 227:5258*, *227*(5258), 561–563. https://doi.org/10.1038/227561a0

Foxman, B., & Riley, L. (2001). Molecular Epidemiology: Focus on Infection. *American Journal of Epidemiology*, *153*(12), 1135–1141. https://doi.org/10.1093/AJE/153.12.1135

Hall A. What is molecular epidemiology? (Editorial). *Trop Med Int Health* 1996;1:407–8.

Lakhundi, S., & Zhang, K. (2018). Methicillin-Resistant *Staphylococcus aureus*: Molecular Characterization, Evolution, and Epidemiology. *Clinical Microbiology Reviews*, *31*(4). https://doi.org/10.1128/CMR.00020-18

MacPhee, D. G., & Ambrose, M. (1996). Spontaneous mutations in bacteria: chance or necessity? *Genetica*, *97*(1), 87–101. https://doi.org/10.1007/BF00132585

Pitt, T. L., & Barer, M. R. (2012). Classification, identification and typing of micro-organisms. *Medical Microbiology*, 24. https://doi.org/10.1016/B978-0-7020-4089-4.00018-4

Tompkins LS. Molecular epidemiology: development and application of molecular methods to solve infectious disease mysteries. In: Miller VL, Kaper JB, Portnoy DA, et al, eds. Molecular genetics of bacterial pathogenesis: a tribute to Stanley Falkow. Part 1. Retrospective look at early advances. Washington, DC: American Society for Microbiology, 1994:63–73

Office hours: Thursdays, 12.30 pm - 1.30 pm

Special Relativity and Quantum Mechanics
(Physics)

Dr Joao Rodrigues
Director of Studies, St Catharine's College, University of Cambridge
Bye-Fellow, Wolfson College, University of Cambridge

After many years working in Quantum Field Theory and Particle Physics, specifically in the parton structure of the nucleons, I changed my field of research to the climate of the polar regions. In the Polar Oceans Physics Group in Cambridge, I studied how the Arctic sea ice cover has changed in recent decades as a consequence of global warming. I examined sea ice thickness data collected by submarines and satellites and attempted to quantify the dramatic thinning of the Arctic Sea ice. At present, I teach several Physics and Mathematics courses for first-, second- and third-year students in the Natural Sciences and the Mathematical Tripos of the University of Cambridge.

College Profile: https://www.wolfson.cam.ac.uk/people/dr-joao-rodrigues

Module Structure and Syllabus:

Date and UK time	15th July Monday 8 am – 11 am	16th July Tuesday 8 am – 11 am	17th July Wednesday 8 am – 11 am	18th July Thursday 8 am – 11 am	19th July Friday 8 am – 11 am
	The Lorentz Transformation	Relativistic Kinematics	Relativistic Dynamics	Relativistic Optics	Appearance of rapidly moving objects
Date and UK time	**22nd July Monday 8 am – 11 am**	**23rd July Tuesday 8 am – 11 am**	**24th July Wednesday 8 am – 11 am**	**25th July Thursday 8 am – 11 am**	**26th July Friday 8 am – 11 am**
	The historical development of QM	The postulates of QM and simple applications	The EPR paradox and the Bohr-Einstein debate	Bell's Inequality	Final Presentations

The Lorentz Transformation: We highlight the successes and difficulties of the pre-relativistic physics. The latter was very effective in predicting, for instance, the motion of the planets, but Einstein noticed what appeared to be an inconsistency between Newton's dynamics and Maxwell's electromagnetism. This led him to propose a new physical theory and a new transformation law for the coordinates of the same event in two different reference frames. Different observers may assign different times to the same event, a curious feature of what became known as the Lorentz transformation.

Relativistic Kinematics: The fact that time flows at different rates in different systems of reference has interesting consequences. We shall follow a fast-moving interstellar spaceship and compare the magnitudes of time intervals, distances and velocities measured by those in the ship with the corresponding measurements made by observers at rest. In this context, we shall examine in detail the well-known Twin Paradox.

Relativistic Dynamics: We introduce the notions of relativistic momentum and energy and study some examples of the conversion of mass into energy and vice-versa. We derive the famous formula $E=mc^2$ and explore its implications in some physical systems.

Relativistic Optics: The Doppler effect and the aberration of light were known phenomena in non-relativistic physics. We shall assess how Relativity modifies the classic formulas and explore some of the consequences of these changes.

Appearance of rapidly moving objects: When taking a photograph of a moving object, all rays generated at its boundaries arrive simultaneously at the camera. If the object has a non-negligible size, light rays must then leave its surface at different times. In most instances this causes a significant distortion on the appearance of objects that move at speeds close to the speed of light. However, perhaps surprisingly, some objects keep their shape in the photographs.

The historical development of Quantum Mechanics: The first quarter of the twentieth century is often regarded as one of the most productive periods in the history of science. We shall study the ideas of Planck, de Broglie, Heisenberg, Schrodinger, and others which culminated in 1925-1926 with the formulation of the Quantum Theory.

The postulates of Quantum Mechanics and simple applications: We introduce the notion of wave function, quantised energy levels and solve Schrodinger's equation for simple systems. We discuss how the equation can be applied to more complicated systems such as the hydrogen atom.

The EPR paradox and the Bohr-Einstein debate: The new ideas were not accepted without reluctance by some, among them Einstein. In 1935, together with Podolsky and Rosen, he wrote an article in which an apparent paradox suggested that the formulation of Quantum Mechanics was incomplete. We shall discuss their reasoning and the more modern version of the paradox due to Bohm.

Bell's Inequality: Almost 30 years after the EPR argument was formulated, Bell wrote what has been described as one of the most important scientific works of the 20th century, in which it was shown that Quantum Mechanics could not be completed with the so-called hidden variables. We shall have a good discussion of Bell's theorem and some of its variants, namely due to d'Espagnat.

List of prerequisite knowledge:

Newtonian dynamics: - Newton's Laws
- Notions of force, mass, momentum, energy and work

Optics: - The laws of reflection and refraction
- Notion of frequency, period, wavelength

Mathematics: - Elementary techniques of differentiation and integration
- Techniques for solving simple first and second order differential equations (desired but not strictly necessary)

Recommended reading list (optional):

Halliday and Resnick, *Fundamentals of Physics* (Relativity and Quantum Mechanics chapters only);
A Einstein, *The Principle of Relativity*;
R Feynman, *The Feynman Lectures on Physics*, Quantum Mechanics (Chapter 1 only);

Office hours: Thursdays, noon – 1 pm.

Mathematics for the Natural Sciences

(Mathematics)

Mrs Serena Povia
College Teaching Associate at St John's College
Supervisor at Magdalene and Jesus
Involved in Cambridge Admissions for the past 6 years in several colleges
STEMSMART Supervisor

I specialise in teaching Mathematics and Physics at the University level. I have been a supervisor in physics and mathematics for the Natural Sciences course for about ten years. My current teaching commitments are the Physics and Mathematics courses for the first year and the second year of the respective Tripos. I previously taught third-year courses too.

College Profile: https://www.joh.cam.ac.uk/fellow-profile/410

Module Structure and Syllabus:

Date and UK time	**15th July Monday 9 am – noon**	**16th July Tuesday 9 am – noon**	**17th July Wednesday 9 am – noon**	**18th July Thursday 9 am – noon**	**19th July Friday 9 am – noon**
	Differentiation 1	Integration 1 and differential equations 1	Exponentials and Logarithms	Trigonometry and Hyperbolics	Differentiation 2
Date and UK time	**22nd July Monday 9 am – noon**	**23rd July Tuesday 9 am – noon**	**24th July Wednesday 9 am – noon**	**25th July Thursday 9 am – noon**	**26th July Friday 9 am – noon**
	Integration 2 and differential equations 2	Differential Equations 3	Complex Numbers	Differential Equations 4	Final Presentations

Differentiation 1: We introduce differentiation, give some simple example; we introduce sketching simple functions.

Integration 1 and differential equations 1: We introduce integration of simple functions and the construction of differential equations using simple physical examples where possible.

Exponential and Logarithms: We introduce, learn to sketch, and learn to differentiate exponentials and logarithmic functions.

Trigonometry and Hyperbolics: We introduce, learn to sketch, and learn to differentiate several useful trigonometric functions (including inverses and hyperbolics)

Differentiation 2: We introduce product, quotient, and chain rule for differentiation; we introduce implicit differentiation.

Integration 2 and differential equations 2: We introduce integration by substitution and by parts; we introduce the integration of differential equations.

Differential equations 3: We proceed in learning how to work with differential equations, strongly tying it back to physics wherever possible.

Complex Numbers: We need the formalism of complex numbers to solve harder physics problems; we introduce and use the cartesian and polar forms.

Differential equations 4: Simple harmonic oscillator physics requires a different style of solution that will use Complex Numbers.

List of prerequisite knowledge:
GCSE, IGCSE or equivalent qualification. No calculus required as we will cover everything from first principles.

Office hours: Thursdays, 12.30 pm – 1.30 pm

A Hitchhiker's guide to research in Psychology and Neuroscience

Dr Aude Rauscent
Research Fellow, Department of Psychology
Bye-Fellow Homerton College, Fitzwilliam College and Hughes Hall
Director of Studies for Psychological and Behavioural Sciences and Natural Sciences

Dr Katharina Zuhlsdorff
Bye-Fellow and College Teaching Associate, Downing College

Dr Stavros Vagionitis
Research Associate, Welcome – MRC Cambridge Stem Cell Institute and Cambridge Centre for Myelin Repair
Bye-Fellow, Fitzwilliam College

Dr Aude Rauscent is a visiting research fellow at the Department of Psychology, University of Cambridge, and one of the Directors of Studies in Psychological and Behavioural Sciences and Natural Sciences at various colleges across the University. Aude studied at the University of Bordeaux, France, where she graduated in 2008 in Neuroscience and Neuropharmacology. During her PhD, she developed a new experimental model to investigate the plasticity of the central nervous system in the face of environmental or morphological constraints, allowing the maintenance of adapted behaviours. Aude then moved to the laboratory of Professor David Belin at the French Institute of Health and Medical Research, where she investigated the psychological, neural, and cellular mechanisms of individual vulnerability to developing compulsive disorders. Ten years ago, Aude moved to Cambridge University and continued her research on the neurological and psychological mechanisms subserving individual vulnerability to addiction in the CLIC, Cambridge Laboratory for research on Impulsive and Compulsive disorders, in the Department of Psychology.

Dr Katharina Zuhlsdorff is a visiting postdoctoral fellow at the Department of Psychology, University of Cambridge and a Bye-Fellow/Teaching Associate at Downing College. Katharina completed her PhD in the department on the topic of computational modelling of behavioural and neuroimaging data in patients with major depressive disorder and substance use disorder. Specifically, her research focussed on reinforcement learning and its underlying neural basis. Katharina's postdoctoral work has focussed on developing predictive models of dementia and depression using cognitive and MRI data and graph neural networks. This work has included the use of large-scale datasets such as the UK Biobank and Adolescent Brain Cognitive Development studies. Katharina has received awards from the Alan Turing Institute, Foulkes Foundation and the Angharad Dodds John fellowship from Downing College.

https://www.researchgate.net/profile/Katharina_Zuehlsdorff

Dr Stavros Vagionitis is a research associate at the Wellcome – MRC Cambridge Stem Cell Institute and a Bye-Fellow at Fitzwilliam College. Stavros studied Molecular Biology and Genetics at the Democritus University of Thrace, Greece. He then completes a Master's in Cellular and Molecular Neuroscience at the Eberhard Karls University of Tübingen, Germany. Stavros then moved to Munich, Germany, where he completed his PhD, studying the damage and repair of myelinated axons using zebrafish. For his postdoctoral work, Stavros moved to Cambridge, where in the laboratory of Prof. Ragnhildur Thóra Káradóttir he has been studying oligodendrocyte regeneration, myelin plasticity and glial biology using rodent models of multiple sclerosis as part of the Cambridge Centre for Myelin Repair

https://neuroscience.cam.ac.uk/member/sv482/

Module Structure and Syllabus:

Date and UK time	**15th July Monday 9.30 – 12.30 am**	**16th July Tuesday 9.30 – 12.30 am**	**17th July Wednesday 9.30 – 12.30 am**	**18th July Thursday 9 am – noon**	**19th July Friday 9 am – noon**
	Introduction to the fundamentals of psychology and neuroscience Dr Aude Rauscent	The modular and integrative functional architecture of the brain Dr Aude Rauscent	Towards an understanding of the individual vulnerability to develop psychiatric disorders Dr Aude Rauscent	Introduction to computational neuroscience Dr Katharina Zuhlsdorff	Application of advanced neuroimaging techniques Dr Katharina Zuhlsdorff
Date and UK time	**22nd July Monday 9 am – noon**	**23rd July Tuesday 9 am – noon**	**24th July Wednesday 9 am – noon**	**25th July Thursday 9 am – noon**	**26th July Friday 9 am – noon**
	Machine learning methods for neuroscience Dr Katharina Zuhlsdorff	Principles of microscopy in neuroscience Dr Stavros Vagionitis	Fantastic cells and where to find them Dr Stavros Vagionitis	Cellular communication in the brain and beyond Dr Stavros Vagionitis	Final Presentations Dr Katharina Zuhlsdorff

Introduction to the fundamentals of Psychology and Neuroscience: The objective of the first lecture is to introduce the fundamental notions of psychology and neuroscience and to provide an overview of the wide array of the methods that can be deployed in psychology and behavioural science research.

The modular and integrative functional architecture of the brain: In this lecture the students will discover some of the fundamentals of the functional anatomy of brain. They will then become acquainted with the principal neurotransmitter of the central nervous system and what happens if they disfunction.

Towards an understanding of the individual vulnerability to develop psychiatric disorders: In this lecture, the students will be introduced the principle of individual vulnerability to develop psychiatric disorders and the methods used to study the underlying psychological and neurobiological mechanisms.

Introduction to Computational Neuroscience: This part of the course will focus on introducing students to the behavioural and neural mechanisms of learning and models used for quantifying learning such as reinforcement learning models.

Application of advanced neuroimaging techniques: Students will be introduced to a variety of neuroimaging methods such as structural and functional magnetic resonance imaging and magnetic resonance spectroscopy. Their application in psychological and clinical neuroscience will be discussed.

Machine learning methods for neuroscience: This lecture will cover different types of machine learning methods, including linear and non-linear methods. Their use for behavioural and neuroimaging data will be discussed.

Principles of microscopy in neuroscience: Students will get introduced to the basic principles of microscopy and they will be presented with different use cases in the neurosciences, from simple histological staining to more complex live microscopy and super resolution microscopy.

Fantastic cells and where to find them: In this lecture, students will get acquainted with the principles of cellular neuroscience, understanding the functional organisation of the brain at the cellular molecular level and the complex interplay of neurons and glia.

Cellular communication in the brain and beyond: This lecture will discuss the fundamentals of neural function, how excitable cells generate action potentials, their propagation, as well as synaptic transmission. The supportive role of glia in this process will also be highlighted.

List of prerequisite knowledge:

There is no prerequisite knowledge for this course. Strong analytical skills and a keen interest in Psychological and Behavioural Sciences will be particularly helpful. The course will be suitable for students interested in Cognitive, Computational, Behavioural, Cellular Neuroscience, Neuroimaging, Microscopy, Neuropsychopharmacology, and Neurobiology.

Recommended reading list (optional):

Reinforcement learning: an introduction – Sutton and Barto.
An Introduction to resting state fMRI functional connectivity – Bijsterbosch, Smith, Beckmann
(this is to help the students catch up on the prerequisite topics if they were not familiar with a topic)

Office hours:

Dr Aude Rauscent: Wednesday 17th July, 1 – 2 pm
Dr Katharina Zuhlsdorff: Monday 22nd July, 12.30 – 1.30 pm
Dr Stavros Vagionitis: Thursday 25th July, 12.30 – 1.30 pm

Computer Science

Dr John Fawcett
Churchill College, University of Cambridge

Since completing his PhD, John Fawcett has been working in industry alongside lecturing, tutoring, supervising and directing studies in Computer Science at Cambridge. Over more than 15 years, John has seen around 500 students through to graduation. John has delivered courses in summer schools for over 10 years and is active in undergraduate admissions, including as Subject Convenor for the Computer Science undergraduate course. John served as University Senior Proctor in the 2021/22 academical year after being Praelector for 6 years at Churchill.

College Profile: https://www.chu.cam.ac.uk/fellows/dr-john-fawcett/

Module Structure and Syllabus:

Date and UK time	15th July Monday 6 am – 9 am	16th July Tuesday 6 am – 9 am	17th July Wednesday 6 am – 9 am	18th July Thursday 6 am – 9 am	19th July Friday 6 am – 9 am
	Computer Architecture	Operating Systems 1	Operating Systems 2	Starting Processes	Interprocess Communication
Date and UK time	**22nd July Monday 6 am – 9 am**	**23rd July Tuesday 6 am – 9 am**	**24th July Wednesday 6 am – 9 am**	**25th July Thursday 6 am – 9 am**	**26th July Friday 6 am – 9 am**
	Network communication	Graphics 1	Graphics 2	Graphics 3, GPUs and accelerators	Final Presentations

Each of the following will use lecture time to introduce and explain new concepts, followed each day with practical programming exercises: learning-by-doing through scaffolded exercises giving room for learners to solve problems in their own ways.

Computer Architecture: the components inside a computer and styles of interacting with them. Programmed I/O. Interrupts. DMA.

Operating Systems 1: virtual memory for protection between processes. Address translation. Hardware acceleration.

Operating Systems 2: cooperative and preemptive multi-tasking. Scheduling algorithms.

Starting Processes: system calls, fork(), the shell.

Interprocess Communications: understanding Unix pipes, marshalling datatypes into bytes.

Network communication: sockets, server applications, a simple webserver.

Graphics 1: ray-tracing, Phong shading, imperfect and perfect reflections.

Graphics 2: triangularisation, Painters' Algorithm, Z-Buffers.

Graphics 3: texture maps, bump mapping, displacement mapping.

GPUs and accelerators: contrasting CPU pipelines with GPUs, understanding vectorizable workloads, OpenGL/CUDA coding.

List of prerequisite knowledge:
No computer science knowledge is assumed but programming experience is always useful. Later work on graphics assumes knowledge of vectors and basic geometry.

Recommended reading list (optional):
Computer Architecture and Organisation, S.P. Wang, published by Springer. ISBN 978-981-16-5661-3 (e-book 978-981-16-5662-0).

Office hours: Wednesdays, 10.30 – 11.30 am

Elements of Mathematical Economics
(Mathematics and Economics)

Dr Vasileios Kotsidis
College Associate Lecturer, St. John's College

Vasileios Kotsidis uses tools from traditional and evolutionary game theory to analyse social interactions that (potentially) involve strategic motives. His research focuses on the scope and limitations of models based on methodological individualism in interpreting individual behaviour (human or otherwise) as it is manifested in social settings. It spans along three main directions: how individuals think, what they are motivated by, and what the researcher can infer. He obtained his PhD in Economics at the University of Nottingham. His doctorate explored some theoretical aspects of social (strategic) behaviour and investigated its empirical manifestations. He also enjoys practicing karate, studying the philosophy of mathematics, and reading fantasy literature.

Module Structure and Syllabus:

Date and UK time	**15th July Monday 9 am - noon**	**16th July Tuesday 9 am - noon**	**17th July Wednesday 9 am - noon**	**18th July Thursday 9 am - noon**	**19th July Friday 9 am - noon**
	Elements of Mathematics I	Elements of Mathematics II	Elements of Statistics I	Elements of Statistics II	Rational Choice Theory I
Date and UK time	**22nd July Monday 9 am - noon**	**23rd July Tuesday 9 am - noon**	**24th July Wednesday 9 am - noon**	**25th July Thursday 9 am - noon**	**26th July Friday 9 am - noon**
	Rational Choice Theory II	Stochastic Dominance	Dynamic Choice	Information	Final Presentations

Elements of Mathematics I and II: These lectures introduce students to fundamental concepts of mathematics that have useful applications in economics.

Elements of Statistics I and II: These lectures provide the statistical foundations necessary for the analysis of economic processes and relations.

Rational Choice Theory I and II: These lectures introduce a formal theory of choice and examine some applications in economic transactions.

Stochastic Dominance: This lecture discusses conditions under which certain options outperform others, with reference to some key statistical properties.

Dynamic Choice: This lecture discusses formal choice in a temporal setting and examines financial decisions with varying time-horizons.

Information: This lecture investigates the ways in which rational agents can incorporate newly acquired pieces of information into their decision-making process.

List of prerequisite knowledge:
Basic differentiation is necessary and basic integration is desirable.

Office hours: Thursdays, 12.30 – 1.30 pm.

Supramolecular Chemistry: From Principles to Molecular Machines

(Chemistry)

Dr Giulia Iadevaia
Teaching Bye-Fellow at Churchill College, University of Cambridge
Chemistry Laboratory Operations Manager, The Francis Crick Institute, London

Dr Giulia Iadevaia gained her MSc in Chemistry from the Sapienza University of Rome in 2010 after doing her final year project on anion recognition. She got her PhD from the University of Sheffield in 2014 working on cooperative hydrogen bonded systems. She then worked for two years as a postdoctoral researcher in the group of Professor Christopher Hunter FRS, at the Department of Chemistry at the University of Cambridge. She was then appointed as Research Laboratory Manager in the same group and she held the position for six years. Her research focused on the study of supramolecular systems, more specifically on the synthesis and analysis of abiotic analogues of information molecules like DNA. Giulia currently works at the Francis Crick Institute in London, where she is responsible for the science operations and the smooth running of the Chemistry Laboratories.
Over the past 8 years, Giulia has taught a wide range of courses in Chemistry at the University of Cambridge, from all years of the undergraduate curriculum. Since 2021 she has been a Teaching By-Fellow at Churchill College. She is passionate about organic chemistry, in particular about physical organic chemistry and supramolecular chemistry.

College Profile: https://www.chu.cam.ac.uk/fellows/giulia-iadevaia/

Module Structure and Syllabus:

Date and UK time	16th July Tuesday 6 – 9 am	17th July Wednesday 6 – 9 am	19th July Friday 6 – 9 am	20th July Saturday 7 – 10 am	21st July Sunday 7 – 10 am
	Non-covalent interactions		Thermodynamics in supramolecular chemistry	Analytical techniques in supramolecular chemistry	Quantifying interactions and solvent effects
Date and UK time	**23rd July Tuesday 6 – 9 am**	**24th July Wednesday 6 – 9 am**	**26th July Friday 6 – 9 am**	**27th July Saturday 7 – 10 am**	**28th July Sunday 7 – 10 am**
	Molecular recognition: Host-guest chemistry	Self-assembly of molecular structures	Synthesis and applications of molecular machines	Uncovering the inspiration for chemistry	Final Presentations

Non-covalent interactions: Explore various non-covalent interactions used by supramolecular chemists to link molecules, including electrostatics, hydrogen bonding, π-interactions and Van der Waals forces.

Thermodynamics in supramolecular chemistry: Learn about Gibbs free energy, enthalpy, entropy and equilibrium constant and the relationship between these quantities.

Analytical Techniques in supramolecular chemistry: In this session you will be introduced to various techniques, including NMR, UV, and fluorescence spectroscopy, used to identify and analyse the structural and dynamic properties of host-guest complexes.

Quantifying interactions and solvent effects: Learn about scales to quantify the strength of non-covalent interactions such as H-bonding and how to predict the strength of these interactions. Explore the effect of the solvent on these interactions.

Molecular recognition: Host-guest chemistry: We will discuss molecular recognition in supramolecular chemistry, including the design principles behind cation, anion, and neutral guest recognition. Learn about the impact and significance of this field, as exemplified by the Nobel Prize in Chemistry awarded in 1987.

Self-assembly of molecular structures: You will be introduced to the process of self-assembly, where large supramolecular structures are formed/organised through non-covalent interactions, with a focus on examples found in nature such as DNA.

Synthesis and applications of molecular machines: Discuss the 2016 Nobel Prize in Chemistry and the various techniques used to synthesize molecular machines and their applications.

Uncovering the inspiration for chemistry: Discuss inspiring stories of researchers and their impactful discoveries and give an insight into a life of a chemist.

Prerequisite knowledge:
Simple calculations of position of equilibria, equilibrium constants
Basic organic chemistry (reactions that would normally be covered at secondary school-level organic chemistry, familiarity with the meaning of curly arrows desirable but not essential)

Office hours: Saturday 20th July, 11 am – noon, Friday 26th July, 11 am – noon.

Nuclear Science and Technology

(Physics, engineering, materials science)

Dr Miles Stopher

Senior Tutor at Fitzwilliam College, University of Cambridge
Director of Admissions, Department of Engineering, University of Cambridge
Affiliated Lecturer, Department of Engineering, University of Cambridge

Dr Miles Stopher is Acting Senior Tutor at Fitzwilliam College, the Director of Admissions and an Affiliated Lecturer in the Department of Engineering. Previously he was Deputy Senior Tutor and Senior Lecturer of Engineering at Homerton College, Cambridge. He has supervised and directed studies in Engineering for almost 10 years, across a number of colleges at the University, including his alma mater, Jesus College. His research focuses on nuclear reactor design, with particular interest in the design of nanostructured materials for applications in extreme environments, such as the reactor core, radiation damage modelling, hydrogen embrittlement, and the engineering and safety of integral and passive small modular reactors. He lectures Nuclear Materials for Part III materials scientists at Cambridge, An Introduction to Materials Science for Engineers, and Nuclear Materials for Engineers on the MPhil in Nuclear Energy. He has also lectured on nuclear safety for engineers. Miles supervises Part IA and Part IB Mechanics, Materials and Structures to engineering undergraduates at Cambridge. Prior to his arrival at Cambridge, he worked on the design of the Royal Navy's Dreadnought-class nuclear-powered ballistic missile submarines.

Department profile: http://www.eng.cam.ac.uk/profiles/mas251

Module Structure and Syllabus:

Date and UK time	**15th July Monday 9 am - noon**	**16th July Tuesday 9 am - noon**	**17th July Wednesday 9 am - noon**	**18th July Thursday 9 am - noon**	**19th July Friday 9 am - noon**
	Introduction to Nuclear Energy	Fundamentals of Nuclear Science part i	Fundamentals of Nuclear Science part ii	Nuclear Safety and Waste Disposal	Nuclear Reactor Design
Date and UK time	**22nd July Monday 9 am - noon**	**23rd July Tuesday 9 am - noon**	**24th July Wednesday 9 am - noon**	**25th July Thursday 9 am - noon**	**26th July Friday 9 am - noon**
	Fundamentals of Materials Science	Radiation Damage	Nuclear Fuel	Nuclear Cladding and Moderators	Final Presentations

Aim of the course: Nuclear Science and Engineering is an exciting area of research and industrial investment across the globe. From the decommissioning of current reactors to new, advanced fission and fusion reactors, there is huge demand for graduates with the knowledge and skills to work in the nuclear industry. This course will give an overview of the nuclear industry and discuss the many performance, reliability and safety issues within it, ensuring students understand the fundamental concepts of nuclear energy and technology. As such, this course covers topics across Materials Science, Physics, Chemistry and Engineering.

Introduction to Nuclear Energy: Nuclear Energy's role in the global energy infrastructure and strategy to tackle climate change.

Fundamentals of Nuclear Science: Common notation, types of radiation, binding energy, radioactive decay, half-life, and nuclear reactions.

Nuclear Safety and Waste disposal: Regulatory systems, probabilistic risk assessment, waste immobilisation and disposal.

Nuclear Reactor Design: Components, and types of reactor including pressurised water reactors, boiling water reactors, gas-cooled reactors and liquid-metal reactors.

Fundamentals of Materials Science: intrinsic and extrinsic properties, crystallography, microstructures and mechanics.

Radiation Damage: Displacement cascades, dislocation loops and void formation.

Nuclear Fuel: Uranium, plutonium, and future fuel design.

Nuclear Cladding and Moderators: Cladding - steels and zirconium, Moderators – graphite, Zirconium hydride, and liquid moderators.

Final presentations: short student presentations on a topic which has caught their interest. There will be feedback given, and the best presentation will be awarded a prize.

List of prerequisite knowledge:
There are no prerequisites for this course except for basic algebra and trigonometry.

Office hours: Thursdays, noon – 1 pm.

From the Dawn of Time: the History and Archaeology of Humanity

(History and Archeology)

Dr Ben Wiedemann

Fellow in History, Director of Studies in History and Postgraduate Tutor, Fitzwilliam College, University of Cambridge

Bye-Fellow and Undergraduate Tutor, Lucy Cavendish College, Cambridge

Dr Thomas Matthews Boehmer

Research Associate in Classical Archaeology, Faculty of Classics, Cambridge

Bye-Fellow and Director of Studies for Archaeology, Fitzwilliam College, Cambridge

Dr Thomas Matthews Boehmer is a Roman Archaeologist who works on the remains from the northern provinces of the Empire. He is currently part of a project investigating the formation and status of an imperial capital, York in northern England. This will be published as a monograph next year. Thomas combines this with his interests in funerary archaeology, and social change, in northern Europe more generally. He is also an active field archaeologist and co-director of a project that examines the landscape history around a villa at Harpham, East Riding of Yorkshire. At Cambridge, Thomas teaches first-year Undergraduate Archaeology papers on World Archaeology and other courses which relate to empires, their growth and effects; and also supervises Undergraduate dissertations.

Faculty Profile: https://www.classics.cam.ac.uk/staff/dr-thomas-matthews-boehmer
College Profile: https://www.fitz.cam.ac.uk/people/dr-thomas-matthews-boehmer

Dr Ben Wiedemann is a Medieval Historian with a long-standing interest in the Medieval Church and Papacy, and Medieval politics, government and statehood more generally. Ben has written widely about various aspects of Medieval History, focusing mainly on the mechanics of government in the European Middle Ages (c.1000-1500). Ben's first book – *Papal Overlordship and European Princes, 1000-1270* – was published by Oxford University Press in 2022, and examined the practicalities and theory of the pope's position over European secular rules. Ben is primarily interested in the role of petitions – requests from subjects to rulers – in initiating government action, and how Medieval government can hence be seen as more reactive than proactive. At Cambridge, Ben teaches first-year Undergraduate History Courses on Medieval Europe c.1100-1450 and The British Isles in the Middle Ages 800 to c.1500; and also supervises MPhil and Undergraduate dissertations.

Faculty Profile: https://www.hist.cam.ac.uk/people/dr-benedict-wiedemann
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Module Structure and Syllabus:

Date and UK time	**15th July Monday 9 am - noon**	**16th July Tuesday 9 am - noon**	**17th July Wednesday 9 am - noon**	**18th July Thursday 9 am - noon**	**19th July Friday 9 am - noon**
	Introduction: 105 billion People Ever	Introduction: Methods in Archaeology and History	Early Communities: Form and Structure	States: Big and Small	Empires: Boom and Bust
Date and UK time	**22nd July Monday 9 am - noon**	**23rd July Tuesday 9 am - noon**	**24th July Wednesday 9 am - noon**	**25th July Thursday 9 am - noon**	**26th July Friday 9 am - noon**
	Tenacity During Failure: 1 - 1000 CE	Rootling in the murk: 500 - 1000 CE	The 'Light Ages': the World Post-1000 CE	Modernity and 'Progress': 1500 CE to the present	Student Presentations

Aim of the course: Over these ten lectures, students will be exposed to a range of archaeological and historical case studies that expose and undermine neat explanations for how the past is thought about in the present. The focus is global, shifting towards Europe later in the course, but the emphasis will always be laid on how societies across many environments seek to innovate and operate despite the constraints imposed upon them.

Introduction 1 (TMB + BW): The scope and scale of human history is vast, and seems confusing. This introduction to the course ties together general trends, including the manner in which societies agglomerate and organise. Instead of understanding the present as a linear progression from the past, the emphasis will be on key markers that have differentiated various polities through history.

Introduction 2 (TMB + BW): In formulating a view of the past, a wide range of methods and techniques have been utilised by scholars since the 18th century. Segueing between archaeology and history, the session will be spent unpicking the manner in which histories have been interpreted.

Lecture 1 (TMB): During the course of this lecture, the diversity of earlier human community building will be explored. An emphasis will be placed on the creativity and expression that were discovered and expanded upon by a wide range of cultures.

Lecture 2 (TMB + BW): States are a current geopolitical ever-present. However, they have never taken the same form, socially, economically, or politically. By evaluating a range of exemplars, the divergence of past institutions will be thought through.

Lecture 3 (TMB): Empires are often believed to be polities of constant expansion and interconnectivity. The validity of this idea will be evaluated whilst the experience of those within such is underlined. A wide number of examples of imperial ambition and experience are discussed.

Lecture 4 (TMB + BW): There were constant blips in human history. Invasion and plague were often thought to break even the mightiest. Through underlining different kinds of experience, a review will be made of the ways in which societies adapt and change to heed external pressures.

Lecture 5 (BW+TMB): The early Middle Ages saw the end of the unified Roman Empire and the breakup of Europe into smaller areas. Amidst this contraction of political authority, trade and living standards, great changes occurred in religious and societal organisation.

Lecture 6 (BW): Between 1000 and 1500 European states took the form which they would hold for the next thousand years; this period is often seen as the crucible or making of modern Europe. This session will discuss whether modern European states really can trace their origins back to this period.

Lecture 7 (BW): The most recent 500 years have seen enormous increases in life expectancy and living standards; alongside these gains have come other changes, less obviously beneficial. This lecture asks what characterizes the modern age, and whether we really have all benefited.

Session 8 (TMB + BW): Student Presentations.

<u>Office hours:</u> Thursdays, 12.30 – 1 pm