# Mathematical and Computational Biology FAQs

## Why should I choose Mathematical and Computational Biology?

We are now able to generate very large and complex datasets – as well as mathematical models – to explore fundamental biological questions. To be able to analyse these datasets and models, biologists need to be equipped with the correct analytical tools. The core aim of Part IB Mathematical and Computational Biology is to provide an applied and rigorous course focused on practical use of statistics and computing in modern biology, underpinned by mathematics and mathematical modelling. This includes computer programming: practical classes in the first four weeks will concentrate on an introduction to the programming language Python, with no prior knowledge assumed. Python will then be used intensively throughout the course. Via our exciting blend of lectures (both theoretical and computational) and practical classes – supplemented by example sheets to discuss in supervision, as well as longer mini-projects - students will develop a strong background in modelling, statistics, fitting models to data, algorithms, simulation, bioinformatics, "big data" and computer programming. The course is not tied to any one single application area, but instead furnishes students with a comprehensive suite of quantitative and computational skills that will be useful at Part II, Part III and beyond (in paid employment as well as in research).

## What topics will I be learning about?

The course will be divided into five blocks – each lasting half a term – as follows:

Block A. Introduction, which will cover:

- introduction to Python and the Jupyter Notebook computing environment.
- data visualisation,
- stochastic models,

Block B. Bioinformatics, which will cover:

- sequence alignment and homology detection,
- DNA and RNA sequence analysis,
- phylogeny

Block C. Foundations, which will cover:

- likelihood and Bayesian methods,
- linear algebra,
- linear systems analysis.

Block D. Systems, which will cover:

- Analysis of biological systems in discrete and continuous time,
- Stochasticity and fitting models to data,
- Analysis of time-resolved data

Block E. Data Science, which will introduce principles of clustering and classification.

## What teaching is provided?

Like all Part IB courses, there will be three hours of timetabled lectures per week. However, while two of these lectures will be very similar to those in other subjects, and will

concentrate upon introducing new theory, the other lecture each week will be a computing lecture, showing how this theory can be implemented on a computer. Lectures will also be supplemented by a three-hour weekly practical class, allowing further practice in computational techniques. Part of the time in practical classes will be devoted to allowing you to work on a portfolio of mini-projects, running through the Michaelmas and Lent terms. These are formally assessed and allow you to engage with more extensive/detailed analyses. And of course, like the mathematics course you studied in Part IA, example sheets of questions will be provided for discussion in supervisions (although in Part IB some of these questions may require computer programming to answer).

## What are the practical classes like?

The practical classes revolve around the analysis of real datasets from across biology. The practical classes will be an opportunity to apply what they have been learning on different complex datasets.

## What subjects do I need to have done in Part IA?

There are no constraints here; absolutely any combination of Part IA NST subjects is acceptable. You just need to be interested in learning more about how mathematics and computing can be used to analyse and better understand large datasets and models. Both Part IA NST Mathematics and Mathematical Biology are therefore suitable preparation for this course, and this is not only a course for mathematical geniuses. However, we recommend that you obtain a mark of 55% or higher in whichever mathematics option you did study. Since this course is a sequel to Part IA Mathematical Biology, knowledge of certain topics covered only in that course will be assumed. Full details of recommended vacation work for those who studied Part IA NST Mathematics – which will consist of watching recorded lectures from Part IA Mathematical Biology and attempting example questions –will be provided before the summer. This will be the equivalent of up to 12 lectures or so, and will be supported by a catch-up supervision in the first week of Michaelmas.

## Do I need to already be able to program?

No! Many lecturers on this course are involved in first year teaching and realise – while programming is taught in both Part IA NST Mathematics and Mathematical Biology – that computing is not the major focus of either course. We also realise that programming in Mathematical Biology teaches R rather than Python. We will teach Python entirely from scratch. All that is required on your part is a willingness to learn, and a degree of enthusiasm about doing so (i.e. while you do not have to have mastered programming in Part IA, if you absolutely hated the computational work, this might not be the course for you!).

## Which departments are involved in the course?

The course is led by the Genetics department, but lectures also come from Pathology, Plant Sciences, PDN, Veterinary Medicine, Zoology and Psychology. This includes various lecturers who currently teach on the Part IA Mathematical Biology course, and so have a good understanding of the level of mathematics that many of you will start with.

## How is the course assessed?

The course will be assessed through a combination of examinations and assessed practical work. Overall, the assessment is a 50:50 split between knowledge/understanding, and practical skills and implementation. Specifically:

- 50% of the final mark will be taken from a 3 hour theory/essay paper sat in June;
- 10% from a 3 hour computer examination, also sat in June, focusing on implementation/practical use of the computational methods and techniques;
- 30% from write ups of two mini-projects (each worth 15%) carried out in Lent term.
- 5% from the practical ticks indicating satisfactory learning at practical classes, based on confirmation of completion of Python notebooks.
- 5% from satisfactory practical attendance records.

## What other Part IB subjects would work well with MCB?

The only hard constraint is that this course cannot be combined with either Earth Sciences B or Physics B, due to a timetable clash. In terms of other biology options, this course links well with all options, ranging from cellular to ecological. The only constraint is that combining this course with History and Philosophy of Science and only a single experimental subject might constrain your options at Part II, and should be thought about very carefully.

## What Part II (and Part III) options does MCB lead to?

The skills taught in this course will be useful for – and will enhance your understanding of at least some topics in – all Part II options, ranging from cell biology (e.g. Part II Genetics or Biochemistry) to ecology (e.g. the Ecology stream of Part II Plant Sciences or Zoology). The increased fluency in computational work and data analysis will be particularly useful if you intend to offer a research project at Part II. Part IB Mathematical and Computational Biology also provides a particularly good training for anyone intending to study Part III Systems Biology.