Cardiff University

MSc in Bioinformatics - MSc in Genetic Epidemiology & Bioinformatics

http://bbu.cardiff.ac.uk/html/training/msc.htm

What is Bioinformatics?

Bioinformatics applies principles of information sciences and technologies to make the vast, diverse, and complex life sciences data more understandable and useful. It involves, research, development, or application of computational tools and approaches for expanding the use of biological, medical, behavioural or health data, including those to acquire, store, organise, archive, analyse, or visualise such data.

Why do our course?

- Students are taught by specialists within three different schools (Biosciences, Medicine and Computer Sciences) who are all involved in world class research.
- We offer the only UK course with a significant statistics component.
- Students are taught together rather than being streamed based on analytical/computational or biomedical background.
- Students are fully embedded in a local research group during their projects.
- Opportunities for PhD study after the MSc.
- CRUK Masters Bursary Award Scheme for students committed to a career in cancer research (available to UK and EU students, and overseas students in some cases).
- Guaranteed University Accommodation

What do you need to know before you start the course?

We are looking for students who have:

- A computer background with experience or with a degree.
- A degree in a biological science and an interest in computers or statistics.

We will teach you what you don't know.

What we will teach you?

- Three introductory courses on computers, statistics and postgenomic bioscience
- Two intermediate courses on computing and statistics with a case study project
- A choice of advanced courses on a range of topics
- A research project carried out in collaboration with a local research team

Where will you go with your Masters degree?

- Pharmaceutical and Biotech Companies
- Public Institutions
- Bioinformatics and IT Companies
- PhD Study

What is Bioinformatics?

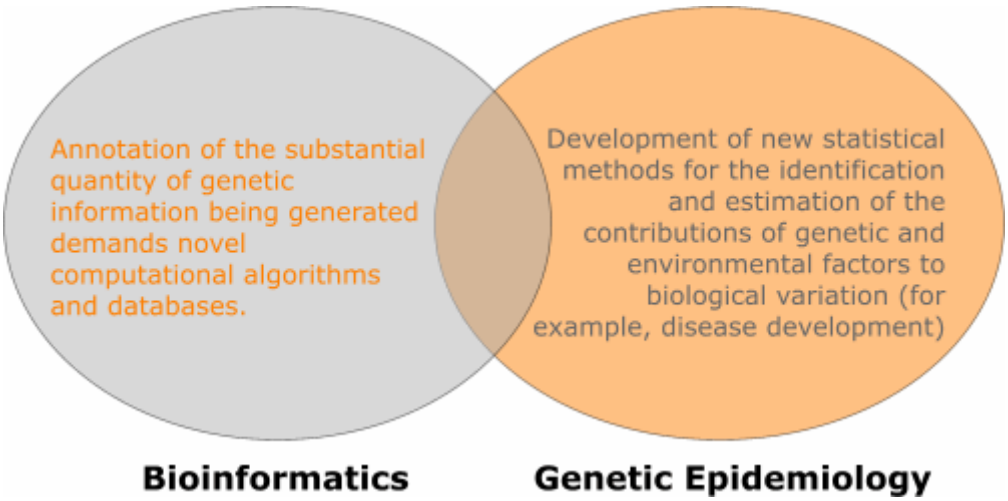
Completion of the human genome signified a step change in life sciences from the consideration of biological components in isolation to approaches that attempt to profile global change and provide the base for true systems biology. Technical developments such as molecular genetics, transcriptomics, proteomics and metabolomics provide the analytical base to support this advance but demand novel statistical and computational skills. In this post-genomic era, bioinformatics is rapidly developing and it is essential that current and future researchers learn the most up-to-date applications and approaches. Post-genomic applications demand a level of informatic skill beyond that previously employed in biosciences. Bioinformatics derives knowledge from computer analysis of biological data. These can consist of the information stored in the genetic code, but also experimental results from various sources, patient statistics, and scientific literature. Research in bioinformatics includes method development for storage, retrieval, and analysis of the data. Bioinformatics is a rapidly developing branch of biology and is highly interdisciplinary, using techniques and concepts from informatics, statistics, mathematics, chemistry, biochemistry, physics, and linguistics. It has many practical applications in different areas of biology and medicine including: sequence analysis, genome annotation, computational evolutionary biology, measuring biodiversity, analysis of gene expression, analysis of gene regulation, analysis of protein expression, analysis of mutations in cancer, prediction of protein structure, comparative genomics, modelling biological systems and high-throughput image analysis.

What is Genetic Epidemiology ?

The main aim of genetic epidemiology is to use statistical methods to identify the locations of genes influencing risk of disease. A secondary aim is to quantify the contribution of such genes to disease risk. The recent wealth of genetic information that has become available (for example: HapMap <http://www.hapmap.org>) has made large-scale genome-wide genetic studies feasible (for example, the Wellcome Trust Case Control Consortium <http://www.wtccc.org.uk>). Efficient design, analysis and interpretation of such studies is of crucial importance, for which a knowledge of genetic epidemiology is essential. There is considerable potential (as yet mainly untapped) for using other sources of biological data (as mentioned above) to inform genetic studies. Combining bioinformatics & genetic epidemiology is thus likely to become increasingly important.

Individuals with the necessary multidisciplinary training are currently in demand to aid the future understanding and interpretation of the large amounts of available data.

The Cardiff University Bioinformatic and Genetic Epidemiology course aims to provide the training to meet this demand.



Why do our course?

Bioinformatics is a fast growing subject with a very wide range of methods, skills, abilities and knowledge associated with it. The Cardiff University MSc course aims to teach you what you need to know to solve almost any problem.

There are a number of MSc Bioinformatic courses taught in the UK, some of which specialise in specific topics. While the Cardiff course gives an excellent generalised grounding in Bioinformatics we offer a number of specialised modules. In particular, a basic grounding in statistics forms a central part of the course and ours is the only UK course with a significant statistics component. Students can chose to specialise in statistics and genetic epidemiology and will then go on to obtain an MSc in Genetic Epidemiology and Bioinformatics.

Our students come from an number of different academic and industrial backgrounds, but all students are taught together rather than being streamed based on analytical/computational or biomedical background. This allows students to learn from and support one another.

Students are taught by specialists within three different schools (Biosciences, Medicine and Computer Sciences) who between them have a broad sweep of knowledge and experience.

All the academic staff who teach on the course are involved in cutting edge research in bioinformatics or genetic epidemiology. Research projects in the form of Case Studies (150 hours work) and research dissertations (3 months work) are carried out in close collaboration with either course staff or academics in other fields of study in various departments within Cardiff University.

We have been awarded a number of Masters Bursary Awards by Cancer Research UK for students committed to a career in cancer. See our website for details:
http://bbu.cardiff.ac.uk/html/training/CRUK_CANCER_BIOINFORMATICS_BURSARIES_IN_CARDIFF.pdf

An MSc in Bioinformatics or Genetic Epidemiology is the perfect grounding for further study for a PhD in a range of subject areas. Cardiff University is a major research establishment and our MSc graduates are much sought after.

Why study in Cardiff?

The city of Cardiff offers an excellent location in which to study. Students at Cardiff benefit from the combination of a small, friendly, inexpensive city with the cultural and recreational amenities of an ambitious and progressive capital city, including the National Sports Stadium, the Millennium Centre - home to the Welsh National Opera, the National Museum and Art gallery.
With a population of 327,500, Cardiff does not suffer from overcrowding. Students in Cardiff lead a busy life, both with their academic studies and the social and cultural activities that take place.
Lively, elegant, confident, cosmopolitan, Cardiff caters for all tastes, offering everything from the excitement of a vibrant city life to the peace and tranquillity of the nearby coast and countryside. The famous Tiger Bay docklands have been substantially transformed into Cardiff Bay, a modern development of homes, shops, offices, visitor attractions and the National Assembly for Wales, all surrounding a huge freshwater lake.

"Cardiff is the up-and-coming cosmopolitan British city, a place jam-packed per square yard with some of the best drinking, dancing and shopping outside London."
Virgin Alternative Guide to British Universities

"The fastest growing capital city in Europe. It boasts beautiful old architecture as well as the major waterfront development at Cardiff Bay, which includes cinemas, restaurants, cafes and museums. Excellent shopping, eating and accessibility."
The Trotman Student Book

"Cardiff is popular with students, offering all the attractions of a large conurbation without such high prices as students experience elsewhere."
The Times Good University Guide

What do you need to know before you start the course?

The normal entry requirement is that students should possess a good initial degree in Mathematics, Statistics, Computer Science, Medicine, Psychology or a Bioscience such as Biology, Molecular Biology, Microbiology etc. Lesser qualifications may be accepted at the discretion of the course director if justification can be demonstrated. Entry may be considered by the course director if other equivalent qualifications or no formal qualification exists but sufficient experience can be presented. Such applicants should normally be over the age of 25 and have a minimum of two years' experience in a position of responsibility relevant to the course.

We find that it is easier for statistics/computer science students to learn the biology required than it is for bioscience students to learn the computer skills. Therefore, students with a psychology/neuroscience, bioscience or medical background need to have reasonably good computational skills and be prepared to work hard to learn programming skills.

Applicants whose first language is not English are required to provide proof of their proficiency in the English language before they can be accepted. Applicants must have satisfied one of the English Language requirements specified by Cardiff University application procedures.

It is intended that all applicants should be able to demonstrate sufficient skills, knowledge and experience in at least one of the three core specialties of statistics, biology or computing and students will be subject to a period of intense study in the other areas during the early part of the course.

All applicants must be able to demonstrate evidence of the following competencies:

Essential:

- Basic knowledge of mathematical and statistical methods (provided by the student's first degree, otherwise to GCSE or equivalent level)
- Basic knowledge of computing (experience with at least one of Windows/UNIX/LINUX/Mac operating systems, word processors, spreadsheets and accessing web-based information)
- Interest in computing, statistics and biology.

Desirable

- Basic knowledge of biology and genetics (at GCSE (or equivalent) level or above)
- Programming ability (practical experience of at least one programming language). This is more important for students who intend to follow the Bioinformatics route than those students who intend to follow the Genetic Epidemiology/Bioinformatics route

English language requirements

The University requires postgraduate students whose first language is **NOT** English to provide proof of their proficiency in the English language and must have satisfied one of the English language requirements no more than 3 years before the proposed date of entry to the University. The following are the most commonly acceptable requirements; for a comprehensive list, please contact the International Office.

- an overall score of 6.5 in the British Council IELTS
- an overall score of 570 in the TOEFL (230 on the computer based marking);

For mature applicants:

- a pass in the Professional and linguistic Assessment Board (PLAB);
- evidence that they have successfully completed a first or subsequent degree entirely in the medium of English for a minimum of one year.

What we will teach you?

The course is based on a combination of lectures, practical sessions and workshops, guided reading and tutorial sessions, in addition to course assignments. The course intends to develop the appropriate complementary skills to provide students with the multidisciplinary genetic epidemiological and bioinformatic skill set required to work effectively in the post genomic era.

The **Core I modules** will enable students to obtain background understanding of biosciences, statistics, and computer science for bioinformatics. These core modules are designed to provide participants from different backgrounds with a working knowledge of subject areas not covered by their first degree. The **Core II modules** cover epidemiology, biostatistics and bioinformatics. By having the option to choose amongst the **Specialist modules** , the student is able to specialise in either genetic epidemiology or bioinformatics thus providing a tailored approach to future career development.

MSc students will undertake a research project which requires the student to examine in-depth issues related to the specialist area of their choice.

In the first term students study three compulsory modules:

An Introduction to Statistical Approaches in Life Sciences

- •The need for statistics and the use of computers in statistics
- •Data types, summary statistics and graphical presentation of data
- •Statistical distributions and their properties
- •Introduction to probability, conditional probability, and Bayes' theorem
- •Random variables and probability distributions
- •Statistical independence and concept of covariance
- •Sampling theory
- •Statistical estimation and confidence intervals
- •Hypothesis testing and relationship between hypothesis test and confidence interval
- •Power of a test and factors that affect it
- •Tests and confidence intervals concerning proportions; Goodness of fit tests
- •One-way ANOVA
- •Multiple comparison issues
- •Studying linear relations hips : simple linear regression

Postgenomic Biosciences

- •Introduction to basic genetics: DNA, RNA, chromosomes, bases, amino acids, proteins, recombination, meiosis.
- •Definition and illustration of the concepts and relationships between genome, transcript, protein and metabolome.
- •Introduction to the concept of systems biology - genome mapping, transcriptomics using macro and micro arrays, proteomics using 2D protein separation and mass spectrometry and metabolomics using spectral techniques such as GC-MS and NMR.
- •he involvement of biological macromolecules within the cellular machine and how they link together within pathways (including metabolic, cell signalling amongst others).
- •Approaches allowing determination of gene/protein function. This will range from protein characterisation through to the production of transgenic model organisms (yeast, nematodes, Drosophila and mice).

Computing for Bioinformatics

- •Basic computing concepts and programming skills most relevant to bioinformatics
- •Java concepts and Java programming
- •Static web pages and writing web pages
- •Simple database concepts
- •Perl programming and accessing databases
- •Choosing between Java and Perl : advantages, disadvantages and appropriateness of use
- •Dynamic web pages: CGI scripts, JSP, etc.
- •Design and examples of bioinformatics algorithms
- •Data structures and their relationship to algorithm design
- •Modelling using UML class diagrams

•Complexity analysis and scalability

In the second term there are three more compulsory module:

•Informatics for 'omic' Biosciences,
•Statistical applications in bioinformatics, genetics and epidemiology
•Case studies in bioinformatics and biostatistics

In the third term students take 3 specialist modules from a choice of 5:

- Genetic Epidemiology (Association Analysis)
- Genetic Epidemiology (Model-based and Model-free Linkage Analysis)
- Protein Bioinformatics
- Machine Learning and Data Mining
- Information Systems in Bioinformatics

In the fourth term, the students undertake a research project and write a dissertation:

The dissertation requires the student to demonstrate his or her ability to undertake a piece of research or a critical review of an aspect of bioinformatics or genetic epidemiology and bioinformatics. The size and scope of the study or review is limited by the time period and by the word limit of 20,000 words. It is expected that the student will use the critical review or research project to generate new ideas or examine aspects of genetic epidemiology and bioinformatics from a different perspective. Innovative application of recognised concepts and applicable models is encouraged and rewarded. It may well be the case that research projects will comprise a significant amount of programming to enable a novel application in bioinformatics to be achieved.

Where will you go with your Masters degree?

Bioinformatics is central to many biological disciplines. Genome sequencing is just the beginning. As we enter the "post-genomic era", information about gene expression, protein structure and function, data from DNA array technology, as well as epidemiological and disease susceptibility data, are all being integrated with genome sequence information. The scale of the data is huge, but the power of integrating different data to get to what you are really interested in is what will enable us to make use of it all. This demands a greater level of informatic skill than previously employed in the biosciences. The availability of individuals appropriately trained in this field is critical to future understanding/interpretation of such data and there is a shortage of individuals with the necessary multidisciplinary training.

Bioinformatics is a relatively new fast-maturing discipline and many people working in the field trained originally in either biological sciences or computing. A growing number have completed a Masters in bioinformatics. Is it easier to move from biology to computers or the reverse? The answer depends on whether you are talking to a computer scientist who 'does' biology or a molecular biologist who 'does' computing. The importance of interdisciplinary scientists cannot be over-stressed and that the young people getting the top jobs in the next few years will be those graduating from truly interdisciplinary programmes. Over and above this the uniqueness of our course means that you can also develop skills in genetic epidemiology as well as bioinformatics.

There are many types of bioinformatics jobs available, so no one background is ideal for all of them. The fact is that many of the jobs available currently involve the design and implementation of programs and systems for the storage, management and analysis of vast amounts of DNA sequence data. Such positions require in-depth programming and relational database skills which very few biologists possess and so it is largely the computational specialists who are filling these roles. This is not to say the computer-savvy biologist doesn't play an important role. As the bioinformatics field matures there will be a huge demand for outreach to the biological community as well as the need for individuals with the in-depth biological background necessary to sift through gigabases of genomic sequence in search of novel targets. It will be in these areas that biologists with the necessary computational skills will find their niche.

There is no such thing as a typical career path in this field. As stated bioinformaticians need to perform two critical roles: develop IT tools embodying novel algorithms and analytical techniques, and apply existing tools to achieve new insights into molecular biology. However, you must remember that although powerful and highly specialised in itself, bioinformatics is only a part of biotechnology. Getting a DNA sequence coding for a new protein does not automatically make it useful. Unless this information is converted into useful processes and products, it serves no purpose. You can not, for instance, have a virtual drug or a virtual vaccine. We need real products. Working in bioinformatics, you'll need analytical skills and attention to detail. You also have to be creative, pulling different strands of data together and able to come up with new ideas to solve problems. Communicating well is invaluable too because you'll be working in a multidisciplinary environment. Often you'll have to mediate between two sets of scientists who speak very different languages.

Jobs come from research institutes as well as industry. Big research institutes in the UK include the Sanger Centre, the European Bioinformatics Institute and the MRC's UK Human Genome Mapping Project Resource Centre, all in Cambridge, as well as the Wellcome Trust Centre for Human Genetics in Oxford. In industry, recruiters have traditionally been the big pharmaceutical companies, such as GlaxoSmithKline, but now smaller companies are using bioinformatics too, as well as other biotech companies, including those involved in agricultural applications, industrial organisms and personal care products. There are also a growing number of "start up" companies appearing in this sector. Because the field is young, there aren't too many senior people around so a career in bioinformatics represents good prospects for quick promotion for the talented individual.

We hope that such exciting career opportunities have further fuelled your interest in bioinformatics!! Studying on these courses will serve to train you in key areas, broaden your horizons and enhance your future job prospects.