Bringing bioinformatics to schools

BRINGING BIOINFORMATICS TO SCHOOLS

Biological research has become rapidly more data-driven and digital, and university researchers in Scotland have designed workshops for schools that combine biology and computing

Rapid advances in technology over recent decades have changed the nature of life sciences research. Biologists are increasingly required to develop and use computational tools to work with and interpret biological data. Genomic sequencing, in particular, has led to the generation of such large data sets that computers are essential for their storage, management, and analysis. Almost all areas of the life sciences benefit from knowledge of DNA and protein sequences — including evolutionary biology, cancer biology, ecology, animal breeding, and conservation, to name but a few. Bioinformatics is an interdisciplinary field that combines aspects of biology, computer science, mathematics, and statistics. The field experienced rapid expansion in the mid-1990s, driven largely by the Human Genome Project, and is now an essential element of modern biology. This has generated demand for interdisciplinary researchers with strong computational skill sets.

Despite this need, biology education has failed to keep pace with advances in research. In schools, computing is often taught in isolation from other sciences, and its importance in biological research has not yet been fully realised. This leaves biology pupils unprepared for the computational component of higher education and subsequently, research in the life sciences. The 4273π Bioinformatics at School project aims to address this issue by designing and delivering curriculum-linked, hands-on bioinformatics workshops combining biology and computing for secondary school pupils.

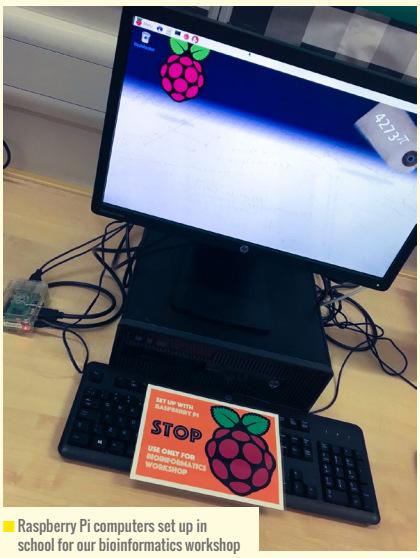
At the present time, our project has reached 166 schools and colleges across Scotland through in-class workshops and teacher CPD. Although our primary focus is Scotland, our open educational resources are used internationally (elsewhere in the UK, Mexico, Argentina, India, USA, Finland, Brazil, China, the Netherlands, and Saudi Arabia). All of our resources are freely available at **4273pi.org**.

Our workshops

We use biological case studies based on DNA sequences as an entry point to engage young people with computer science. We have two workshops, one for senior biology pupils (aged 16 to 18) (**helloworld.cc/workshop1**) and one for pupils at an earlier stage (aged 13 to 16) (**helloworld.cc/workshop2**). The senior

GETTING STARTED WITH BIOINFORMATICS

- Bioinformatics is an ideal field for collaboration between science and computing teachers. Work together through our workshops to engage pupils with the different skills and knowledge required, or develop your own case studies. Lesson plans can be found on our website: **4273pi.org/teacher-resources.**
- Make use of the free, publicly available online biological databases (see our introductory videos at **helloworld.cc/4273videos**). These databases are accessible on any device with internet access, e.g. laptops, tablets, and smartphones.
- Use case studies that support the curriculum but that also represent everyday scenarios, e.g. health.
- Encourage active learning and working in pairs.
- Use research-grade, freely available bioinformatics software for Raspberry Pi, e.g. the command line version of the NCBI sequence database search tool, BLAST. Thanks to work by the Debian Med project and others, many of these are available as Debian packages that can be installed on Raspberry Pi OS using apt-get.



Raspberry Pi computers set up in school for our bioinformatics workshop

Resource package for teachers attending our current series of free online CPD events

workshop introduces the Linux command line. For many pupils and teachers, this is their first experience of command line computing. In order to provide the Linux operating system and the tools required to perform bioinformatics at the command line, we bring Raspberry Pi computers to schools. These are preinstalled with all required software and files, and do not require internet or school network access.

Secondary school science curricula vary across the world. In Scotland, bioinformatics is included in the senior level biology syllabus; however, our workshops also incorporate other key topics covered in most secondary school biology courses, such as DNA sequencing and evolution. Our senior workshop uses a gene involved in vitamin C biosynthesis as a case study to explore mutations and nutrition, and our junior workshop uses DNA barcoding to investigate food fraud. Both use freely available online research resources: the National Center for Biotechnology Information (NCBI) database and its BLAST tool. These can be accessed on any device with an internet connection.

Bioinformatics is interdisciplinary by nature, so we have also trialled our senior workshop with computing classes. We ran a joint session with a computing class and a biology class, in which pupils worked through the exercises in pairs comprising one computing pupil and one biology pupil. We are continuing to develop our workshops to maximise their applicability across subjects. Bringing bioinformatics to computing classes provides a real-life example of the power of computing in research — for example how bioinformatics algorithms and biological databases can be used to investigate biodiversity and the evolutionary relationships of species. These case studies provide a practical insight into the significant role computation plays in modern biology, and demonstrate how pupils' skills can be used in this field.

> BRINGING BIOINFORMATICS TO COMPUTING CLASSES DEMONSTRATES THE POWER OF COMPUTING IN RESEARCH

Engaging more girls with computing

In Scotland, around 66 percent of biology pupils identify as female, in contrast to only around 16 percent of pupils in computing classes (**helloworld.cc/SQA**). This disparity exemplifies the startling gender inequality associated with computer science in the UK and many other countries. Therefore, targeting biology classes with our computational workshops allows us to reach an audience not necessarily engaged with computing. We also conduct whole-class visits during the school day to avoid the potential audience bias and exclusion that may occur through self-selection for extracurricular activities. Importantly, feedback from pupils showed that there were no significant differences in enjoyment and usefulness of our workshops between the genders (**helloworld.cc/workshop3**).

Pupil and teacher feedback

Evaluation of feedback from teachers and pupils has highlighted several key elements that underpin the success of our workshops. For teachers, a strong link to the curriculum is important. Bioinformatics is used across many areas of life sciences and so it is possible to create case studies that cover specific areas of the curriculum. Many pupils in both age groups reported that they enjoyed working in pairs or small groups to complete activities. We believe this creates a collaborative and relaxed environment when learning a new subject, as well as being good preparation for further studies and work. Feedback also shows that using case studies provides real-life context to abstract scientific concepts, making the activities feel more relevant to both pupils and teachers.

Our project aims to highlight the key role that computing plays in modern biological research. Computing is far from an insular subject, and our bioinformatics workshops offer pupils and teachers the opportunity to gain practical experience in this interdisciplinary field. (HW)

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