Online and on course

Professor Geraint Thomas introduces the course he leads, which aims to expand research activity in the life sciences by enabling learners to develop and interpret advanced models for solving complex issues

What was the impetus behind the development of the Systems training in Maths, Informatics and Computational biology (SysMIC) course?

The Biotechnology and Biological Sciences Research Council (BBSRC) has identified that the transition of life science research from a mostly qualitative to a more quantitative and computational discipline is increasingly limited by the capacity and willingness of the workforce to adopt the new approaches that are required. Many highly skilled, experienced and talented investigators lack or have lost the skills required to work with modern computational and mathematical approaches at exactly the time they are needed in order to be competitive. BBSRC decided that the UK bioscience research community should seize the initiative and develop a high-quality, high-calibre training course to remedy the situation. They launched the project with a grant of over £1 million.

Who can benefit from the SysMIC course?

Our aim is not to try to convert bioscientists into mathematicians – that is beyond the scope of our project. Our ambition is to give them sufficient skills to interact more productively with data and the complex systems that data can describe. In addition, we wish our 'graduates' to have a keen eye for exactly when and where it will be most productive to work with mathematical and computational experts, and to then do this in a maximally effective and efficient way. Our learners must be able to read, understand and analyse existing mathematical models and build their own, and clearly communicate their outcomes to other professionals.

Consequently, SysMIC is of immediate use to anyone who believes they can do more with their data, or who wonders if they are working efficiently when approaching the investigation of complex biological problems or systems with behaviours emerging from the combination of parts. It will also be very useful to investigators who believe that their experiments are failing to address the heart of a poorly defined biological problem – mathematics encourages rigour, creativity and the habits needed to make a difficult problem approachable.

SysMIC routinely reaches researchers from BBSRC, Medical Research Council, Cancer Research UK, the civil service and the pharmaceutical industry at all career points, including PhD students, postdocs, fellows, project investigators and group leaders, as well as directors of very large divisions or institutes. SysMIC has also welcomed investigators interested in a wide range of fields, from systems biology and neuroscience to ecology and pharmacology. The message is that almost anyone with imagination and ambition can benefit.

Could you outline the major challenges associated with developing an online learning course?

For traditional universities, the first problem is creating excellent content – it's a big step from the lecture theatre, where misunderstandings can be cleared up on the spot. Online materials need to be exceptionally clear, well written, and able to engage the student without a tutor being present to guide and motivate learning. Worked examples, interactive applets, embedded computer code, quizzes and assessment all have to function flawlessly and without minute to minute support. The SysMIC team did exceptionally well in building the course within 12 months; if we printed out the materials tomorrow, we would have a textbook of over 1,100 pages and many days' worth of videos, interactive exercises and self-assessment tests.

Your professional career has traversed the traditional boundaries between disciplines; you trained as a biochemist, have a degree in mathematics and now specialise in cell biology. Based on your own experiences, how important is an interdisciplinary approach to life science research?

In the future, the major problems of life and clinical sciences will be solved using interdisciplinary teams and networks. A great deal of funding and infrastructure creation is increasingly predicated on this, and where the money flows the research will follow. This explains the need to develop mathematical and computational skills amongst bioscientists so they can function in these teams and make strong contributions to critical projects.

The big teams and networks will need to function efficiently and the key to this will be the packaging and transferring of information between the collaborators and partners; the formulation of questions, exchange of data, generation of insights and project planning and execution will all need to be handled across disciplinary interfaces. The only set of languages dense enough and sufficiently free of ambiguity to entrust this to are mathematical and computational. For maximum impact, every member of the team will need to make

their contributions in a way that all of the other highly skilled experts from different disciplines can make the best possible use of it. This means understanding the points of view, assumptions and techniques of the other disciplines and also – possibly more importantly – their limitations and weaknesses. For life scientists, there is considerable value in expanding their mathematical and computational skills and knowlegde.

How do you see systems biology developing in the future?

The importance of a systems approach was well established in the middle of the 20th Century, but was virtually wiped out by the great wave of reductionism that accompanied the molecular biology revolution and the associated drying up of funds for systems level work. In the first 14 years of the 21st Century, much hard work has been done to salvage, refurbish and improve what remained, and to harness it to the new generations of information and instrumentation. Because of the sheer complexity of the current generation of bioscience problems, the critical role of systems thinking and quantitative approaches will be self-evident from now on.

SysMIC: an interactive distance learning course

A consortium of UK universities has been charged by the **Biotechnology and Biological Sciences Research Council** with the challenge of developing a course to fill the computational and mathematical knowledge gaps within the biology community

Sir Martin Rees, the former President of The Royal Society, once stated that: "The problems of biology are the problems of complexity". Virtually all biological systems are complex and non-linear; thus, in order to reflect real-world biological situations, life scientists must be adept in mathematics and computational biology if they are to build, refine, maintain and share knowledge in this area. The Biotechnology and Biological Sciences Research Council (BBSRC) recently identified these skills as inadequate within the UK bioscience community, and noted that key players in the field would find it increasingly difficult to keep abreast of cutting-edge research and conduct effective interdisciplinary science without this fundamental expertise.

SysMIC THINKING

In response to this issue, the Systems training in Maths, Informatics and Computational biology (SysMIC) consortium was established. It brings together University College London (UCL), the Open University, Birkbeck College and the University of Edinburgh. Led by Professor Geraint Thomas of UCL, SysMIC is a web-based course available to bioscientists that provides learning services in the theoretical and computational components of systems biology. "The ambition of SysMIC is to make a durable, positive impact on the UK's life and clinical research capability by embedding the skills necessary for this approach within the UK bioscience community and elsewhere," explains Thomas. "We aim to foster an expanding, energetic learning community focused on preparing and executing interdisciplinary investigations."

SysMIC consists of three distinct learning modules: basic skills, advanced topics and application, and project work. The modules are delivered using Moodle, an expert virtual learning environment that enables all researchers – from graduate to senior project investigator level – to better understand how to utilise mathematical and computational models to analyse complex biological challenges.

MORE THINKING, BETTER DOING

The team recognises that it is necessary for the UK's biological community to improve its mathematics and computing literacy for one predominant reason: "It is clear that in most research fields – as in most businesses – it is becoming cheap, routine and sometimes trivial to amass vast amounts of quantitative data without thought," Thomas comments. "Winning data is often no longer the major bottleneck in many aspects of bioscience research – the problem now is extracting reliable meaning and obtaining predictive power." To address this issue, the SysMIC team adheres to a 'think more, do less, understand more' approach. They hope this will improve research efficacy and competitiveness in the expanding analytical dimension of bioscience research, and that spending more time thinking about aspects such as mathematics and computing will enable researchers to produce more accurate systems modelling.

GO ONLINE

Thomas and his collaborators decided that an online, self-study learning format would be an appropriate method, as opposed to in-person training: "You can't stop the research engine – projects have a funding life cycle and so re-training and up-skilling must proceed while researchers remain busy researching," he explains. "Also, researchers are widely distributed geographically and the content of SysMIC requires at least modest computational literacy at the start. This tends to select for independant, well motivated self-starters who can install and operate software competently; just the sort of people who will benefit from the course." SysMIC aims to ensure that information from the course becomes deeply embedded and understood, and encourages researchers to go on to discover new techniques and approaches for themselves. These are benefits that accrue naturally during e-learning courses taken over extended periods of time; for this reason, the course runs over several months, rather than in a shorter, more intensive face-to-face training period.

Of course, the e-learning format requires that researchers studying through SysMIC demonstrate a desire to learn, the discipline to manage their time, and a capacity for self-directed learning. However, this does not mean that learners are completely isolated; online

SysMIC

SYSTEMS TRAINING IN MATHS, INFORMATICS AND COMPUTATIONAL BIOLOGY

OBJECTIVE

To allow students from all levels of research activity and seniority to grasp the power of mathematical and computationally driven model building to clarify biological problems of great complexity.

PARTNERS

University College London (UCL)

Birbeck College

The Open University

University of Edinburgh

FUNDING

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tutorials, discussions and problem fora ensure both teachers and students come together and actively participate in the learning programme. Beyond this, SysMIC holds one- and two-day workshop sessions and also organises live interactive video classes – a mixture of learning tools the team believe is fundamental to SysMIC's success.

PERPETUAL PROGRESS

SysMIC is in a constant state of development. Presently, one exciting project underway is Industrial SysMIC – a version of the course that can be used by bioscience industries. Similar to SysMIC, the project features bespoke modules, and identifies support and delivery patterns relevant to this group of learners. Encouragingly, the team has already confirmed two international pharmaceutical companies on the course. Indeed, the course is fostering a reputation abroad by reaching out to European students and forming relationships with university consortia in China. International collaboration is important to the researchers, who understand that the issue of lacking computational and mathematical knowledge also impacts countries outside the UK.

Another development the team hopes to roll out in the coming months is to implement a version of the course that can be taken using powerful, flexible programming languages such as Python. "This would allow learners to identify which computational skills they would primarily like to develop and provide a smooth route into the other language using familiar learning materials," Thomas elaborates.

Moving forward, the team's long-term goal is to build up SysMIC to become the foundation for a much greater knowledge environment that graduates can visit even once their course is complete for perpetual, updated, relevant information on skills, techniques and data.

EMBRACING FUTURE UNKNOWNS

To date, the group has had some excellent feedback, using five instruments to measure its success: sign-up rates, completion rates, forum activity and comments, assignment grades, and module exit questionnaires. Through continuous feedback, the SysMIC consortium has been able to learn as it develops, transforming unforeseen challenges or issues into learning opportunities. They consider this to be key to their ongoing success. For instance, when SysMIC was launched, the level of demand was significantly higher than expected. The team scaled up the initiative accordingly, and the course now takes almost 700 students per year – and this number is growing annually. In another unexpected twist, over 40 per cent of expressions of interest in SysMIC has so far come from outside the BBSRC community. The team hopes to expand this further.

Moving forward, the next challenge for the team will be gaining a sustainable footing, both in terms of funding models and personnel. "11 of the 14 proposed next-generation flagship doctoral training partnerships to be established by BBSRC have already adopted SysMIC, giving us committed demand through to 2020. We are therefore looking forward to establishing something durable yet flexible," Thomas concludes.