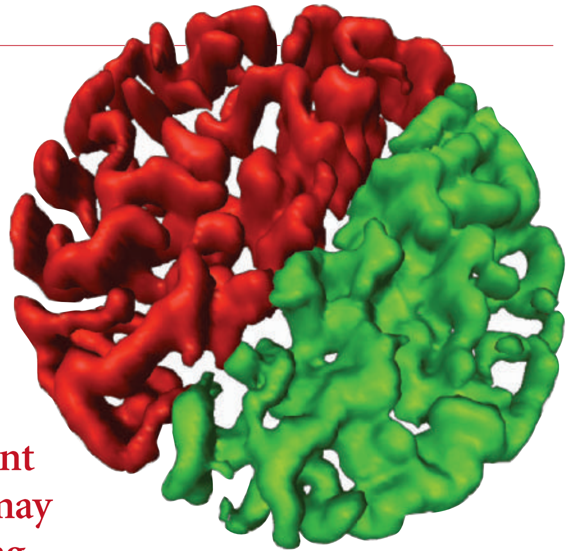
All systems go



If you can reassemble an organism from its component parts then a wealth of jobs may await you, says Hannah Hoag.

Many biologists were lured into research by the promise that, one day, they would understand how an organism worked. Over the years, they have broken cells down into their constituent parts, identifying genes and proteins and their interactions. Systems biology aims to put the organism back together again from these newly identified parts, and to predict its behaviour in nearly any situation.

Once restricted primarily to the United States, the job market for systems biology is now growing in Europe and Japan. Spacious new institutes, increased funding and a glut of positions for both experimentalists and theoreticians are providing a boost for the field — although mathematicians, physicists and engineers are receiving a warmer welcome than biologists.

Investigators commonly assume that scientists with a quantitative background will fare better in systems biology. The data deluge from fields such as genomics and proteomics is best handled by those who can work with numbers in meaningful ways. In fact, a multidisciplinary background is more appropriate. "It is not much use to hire the perfect mathematical modeller who has never heard of DNA or cells," says Roland Eils, who heads a theoretical-bioinformatics group at the German Cancer Research Center in Heidelberg.

Biologists eager to join the field will need experience in mathematics or physics, but the ability to communicate may be most important. "A systems biologist has to be able to understand two languages: the exact language of mathematics and the fuzzy language of biology, which is more descriptive and cryptic," says Eils.

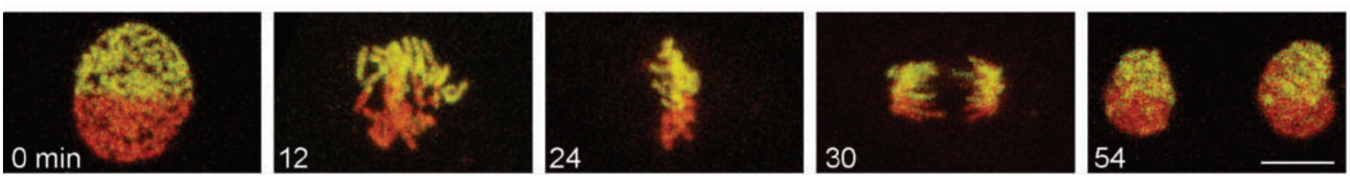
Industry spin-offs exist in systems biology, but they remain small and tend to hire only a few researchers each year. The greatest concentration of jobs is in universities, or in institutes that straddle the line between academia and industry. In 2003, Harvard Medical School launched a systems-biology department, which will recruit more than 20 full-time faculty members. The school is the only one in the United States with a department-level systems-biology programme.

Elsewhere, multidisciplinary biocentres, both real and virtual, are the norm. Leroy Hood pioneered the movement in 2000 when he established the Institute for Systems Biology in Seattle, Washington (see *Nature* **407,** 828–829; 2000). He was the first to sever investigators' traditional ties to a university, a move he believed was essential to foster interdisciplinary relationships.

THE PRICE OF FREEDOM

Although researchers may benefit from such autonomy, most consider project funding to be inadequate. Many of the larger grants have allowed new institutes to be built, but few grants address the large-scale nature of systems-biology projects. "Right now, funding is a challenge," says Steve Wiley, director of the Biomolecular Systems Initiative at Pacific Northwest National Laboratory in Richland, Washington, who says that he has stitched together funding from the US Department of Energy, the National Center for Research Resources and numerous little grants to "fill in the gaps". This patchwork of government grants, trusts and private donations can make it tough for an institute to launch a robust systems-biology programme.

But scientists remain optimistic. In the United States, the National Institutes of Health (NIH), the National Science Foundation (NSF) and the energy department are increasing their funding of systems biology. Under the NIH's long-term funding plan, for example, $7.4 million will be spent on initiatives, including two to four new centres. The NSF has earmarked $4 million for quantitative systems-biology research in 2004 for the first of three years.



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Nuts and bolts: these microscopy images showing how chromosomal material is split during cell division have been used to generate a mathematical model of the process.

Wiley, however, is concerned that systems-biology programmes are growing faster than the funding agencies' award structures. There is no way that a systems-biology programme could be funded by a single, investigator-initiated grant, he says.

The Japanese government, meanwhile, has provided funding for the Kitano Symbiotic Systems Project, and the recently launched Solution Oriented Research for Science and Technology Project. Hiroaki Kitano, who founded both groups, says that they are approaching systems biology from both the silicon and the cellular sides. They are working on two computer tools — systems biology mark-up language (SBML) and systems biology workbench (SBW) — that should make research more efficient, says Kitano. He hopes to hire a few experimental researchers this year.

Europe's foray into systems biology has long lagged behind the United States and Japan, but European researchers are at last receiving some government support. Germany is doing most: both national and regional governments have recently unveiled systems-biology programmes. The education ministry will put €20 million (US$25 million) into a national programme dedicated to the liver cell. "We decided to go with one model system that will have the most relevance for the pharmaceutical and biotech industries," says Eils. With an anticipated 78 federally funded positions to be filled by the end of the year — many at postdoc or faculty level — Germany may become the destination of choice for international researchers.

The German regional programme, boosted by the private support from the Klaus Tschira Foundation, will distribute €1.5 million annually among five centres, including the University of Heidelberg, the European Molecular Biology Laboratory, also based in Heidelberg, and the German Cancer Research Center, each of which will see a new research group established later this year. In 2007, the groups will move to the Bioquant research network centre, a newly proposed institute to be affiliated with the University of Heidelberg.

Keyed in: researchers at the German Cancer Research Center discuss a computer model of cell processes.

SAFE HAVEN

In Britain, the Manchester Interdisciplinary Biocentre is scheduled to open in 2005. The institute will be the first large-scale centre of its kind in the country. The £35-million (US$64-million) initiative has had large contributions from the charitable organizations the Wellcome Trust and the Wolfson Foundation. More than 500 staff, including up to 85 investigators, will pool their talents to study systems biology from the nano to the macro levels (see *Nature* **425,** 430–433; 2003).

John McCarthy, the academic coordinator of the biocentre, sees its role as providing a haven for researchers. "A lot of people with a quantitative background don't want to move into a traditional mainstream biology department because they won't have the right environment to develop what they are working on," he says.

Finland and the Netherlands are also entering the fray. The Academy of Finland and the country's national technology agency, Tekes, have jointly funded SYSBIO, a €10-million, four-year systems-biology and bioinformatics programme that will include about 50 positions, mainly for PhD and postdoc students. Dutch universities, including the Free University of Amsterdam, are beginning to collaborate with one another and with multinational companies, such as Unilever, to develop drugs, to understand diabetes and sleeping sickness — and to brew a better beer.

The flurry of job openings provides people interested in systems biology with international opportunities. "I am absolutely certain that we will rely on international applications," says Eils. "We don't have enough people here in Germany to fill these positions." Whereas the popularity of molecular-biology programmes has blossomed in the United States, it is the opposite in Europe, where graduates are more likely to have degrees in physiology and cell biology. Theoretical mathematicians from Eastern Europe, where molecular biology remains strong, may find themselves being wooed by US institutions.

But Eils suspects that interest will shift again and the tide will turn in a few years. "If we wait for another five years, we will have more people, especially in the field of biology, with additional training in the theoretical side," he says. "It's already happening." ■

Hannah Hoag is a freelance science journalist based in Montreal, Canada.

Web links

MIT Computational and Systems Biology Initiative
▸ **csbi.mit.edu**

Bio-X, Stanford University
▸ **biox.stanford.edu/index.html**

Institute for Systems Biology, Seattle
▸ **www.systemsbiology.org**

Pacific Northwest National Laboratory
▸ **www.sysbio.org**

Department of Systems Biology, Harvard Medical School
▸ **sysbio.med.harvard.edu**

Lewis-Sigler Institute for Integrative Genomics, Princeton University
▸ **www.genomics.princeton.edu**

Molecular Sciences Institute, Berkeley
▸ **www.molsci.org**

IBM Research
▸ **www.research.ibm.com/FunGen**

Manchester Interdisciplinary Biocentre
▸ **www.mib.umist.ac.uk/Overview**

Free University of Amsterdam
▸ **www.vu.nl/home/index.cfm**

German Cancer Research Center, Heidelberg
▸ **www.dkfz.de/ibios/index.jsp**

University of Stuttgart Systems Biology Group
▸ **www.sysbio.de**

Systems Biology and Bioinformatics, Academy of Finland
▸ **www.aka.fi/sysbio**

Lilly Systems Biology, Singapore
▸ **www.lsb.lilly.com.sg**

Kitano Symbiotic Systems Project
▸ **www.symbio.jst.go.jp/symbio/index.htm**