

CORBIS



Predictive power: mathematician A. N. Whitehead anticipated disappointment.

Mathematicians are in short supply in the United States. Potter Wickware examines how the federal agencies plan to boost the numbers.

"The study of mathematics is apt to commence in disappointment," wrote the mathematician A. N. Whitehead in 1911, and, as if to corroborate this gloomy view, young people in the United States are turning away from the mother of the sciences. Between 1992 and 1999 the proportion of US citizens among full-time maths graduate students at the nation's top universities dropped by 26.5%, according to statistics from the National Science Foundation (NSF). Exacerbating matters, today, fewer than half of the graduate students in maths programmes across the United States are US citizens, down from 75% in the 1970s, according to American Mathematical Society data.

Strangely, the decline in interest comes just as a rich crop of theoretical and applied problems is bursting into bloom. Opportunities are abundant in cryptography, data mining, nanosystems, communications networks, materials and imaging. Physics continues to exert a strong influence on maths, with string theory revealing connections between algebraic and differential geometry. And as biology moves from a descriptive to a quantitative science, an entirely new frontier is opening up, both in physiological modelling and in new imaging systems (see "Biostatistics booms", opposite).

A decade ago, the combination of an economic recession and an influx of Russian and Chinese mathematicians made for a bleak hiring picture, but today the jobs are there, says Jim Maxwell, who tracks maths demographics at the American Mathematical Society, in Providence, Rhode Island. The current unemployment rate among new maths PhDs is 3–4%, down from over 6% in 1999. Salaries in top academic departments in 2000 ranged from \$50,000 to \$55,000 for assistant professors, \$65,000 for associates, to \$101,000 for full professors. Of the roughly 850 PhDs who enter the job market in the United States each year, about 60% take their first job in academia.

The diminishing appeal of maths to the current generation

Spooky maths

The US National Security Agency (NSA) is probably the largest employer of mathematicians in the United States. Its main mission is to make classified information impenetrable to prying eyes. A preoccupation with ciphers and keys leads to emphasis on algebra and number theory, but lots of work is also done in other areas such as signal analysis, probability theory and statistics, according to Jim Schatz, head of the agency's mathematical research group.

"We have an extremely rich set of problems here," says Schatz, who explains that restrictions on publishing in a mostly classified environment are not the constraint they might seem. There

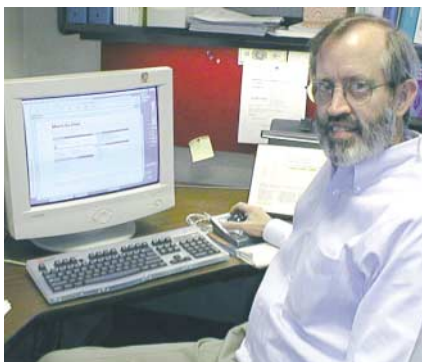
are hundreds of mathematicians in the NSA, far more than in academic settings, so readership for a typical paper is wider than in the world at large, he says.

The NSA hires about 50 mathematicians a year, about two-thirds of them PhDs. "This is a very significant percentage of US citizen maths PhDs, and we are incredibly worried about the shrinking pool," says Schatz.

To help counteract the flagging numbers of mathematicians being produced, the NSA augments the National Science Foundation's efforts with early career grants to help build the maths community. Currently about 180 grants a year, each averaging \$20,000, are being funded. P.W.

Booming business: Jim Maxwell believes that job prospects are good for US mathematicians.

AMS



is partly traceable to the rise of computer-science departments, which draw off those who otherwise would have majored in maths. "The dotcom world was a fantastic temptation," says Philippe Tondeur, director of the NSF's Division of Mathematical Sciences. "People with modest skills got hired without realizing how short the shelf-life of their knowledge was. With maths the skills don't go out of date."

To reverse the trend, the maths establishment is mounting an urgent if somewhat belated response. The NSF, the main patron of maths research in the United States, wants to increase its budget for maths from this year's \$120 million to between \$400 million and \$500 million by 2007. Programmes to support mathematicians at the graduate, postdoc and early career levels have been brought into place, with grants



The Mathematical Sciences Research Institute (above, left) balances pure and applied maths in class (above).

and stipends destined to rise in number and value. Central to the NSF's support for maths are three institutes, at Berkeley, Minneapolis and Los Angeles. Unlike the Institute for Advanced Study at Princeton, where the departments are staffed by permanent faculty, the NSF-supported maths institutes rely on 'soft' money rather than endowments and have a continually changing mathematical cast of characters.

Berkeley's Mathematical Sciences Research Institute (MSRI) dates from 1982. It has a budget of \$5 million, 70% of which comes from the NSF, with contributions from corporate partners such as Pfizer and Hewlett-Packard making up the balance. The MSRI aims for a 2:1 mix between pure and applied work, although Joe Buhler, its deputy director, is quick to point out that these terms inconveniently blur into one another. For example, number theory, once the epitome of pure maths, is now the source of many commercially important applications for computer security (see "Spooky maths", opposite).

In Minneapolis, the Institute for Mathematics and its Applications (IMA) takes a somewhat different tack, focusing on problems from industry such as networking, computational complexity and optimization. Fadil Santosa, associate director for industrial programmes, says industry is under-appreciated as a well-spring of maths jobs, naming companies such as Microsoft, Schlumberger and IBM as organizations that have maths departments. The IMA has a budget of \$3.5 million from all sources, including about \$2.2 million from the NSF.

The newest NSF-supported maths centre, the Institute for Pure and Applied Mathematics at the University of California, Los Angeles, opened its doors this year with a five-year budget from the NSF of \$12.5 million. According to its director, Tony Chan, the institute aims to bring mathematics to new problems in the sciences. Recent programmes have been concerned with functional genomics, stochastic processes in biology and modelling of crystallization. Programmes in finance and economics focus on risk management, arbitrage, derivatives pricing in energy



Philippe Tondeur says maths skills do not date.

markets and catastrophe insurance. A third area of interest is the mathematics of image processing.

Continuing the trend of broadening the presence of maths in the scientific world, as many as four new NSF-funded institutes are in line to be created, according to Tondeur, with proposals being reviewed now. In contrast to the existing institutes, the new arrivals are likely to have more closely defined mandates, such as statistics, large data sets and imaging.

Potter Wickware is a science writer in San Francisco.

Mathematical Sciences Research Institute

♦ <http://www.msri.org>

Institute for Mathematics and its Applications

♦ <http://www.ima.umn.edu>

Institute for Pure and Applied Mathematics

♦ <http://www.ipam.ucla.edu>

Biostatistics booms

Biostatistics, which is concerned with clinical-trials design and management, is booming. Demand for biostatisticians is driven by a range of issues including new drugs and therapies, testing of alternative medications, HIV/AIDS research and cancer, all fuelled by increased funding from the National Institutes of Health.

"We can't turn people out fast enough to fill the need," says Alex MacKenzie, who coordinates the biostatistics programme at the University of Washington, Seattle.

Most graduates in biostatistics are employed at universities,

or in research at pharmaceutical companies and medical research institutes. Starting salaries are \$45,000–50,000 at the masters level, and \$60,000–70,000 for PhDs, with those on the industrial side getting a moderate premium above their academic peers, says MacKenzie.

About 20 students a year graduate from Washington in biostatistics, up from six or seven a decade ago.

"Our graduates typically get flown out for interviews, are wine and dined, competed for, and usually can pick and choose among offers," says MacKenzie. **P.W.**



Fadil Santosa sees industry as a well-spring for maths jobs.



Tony Chan: aiming to bring maths to bear on science.