concerned about opening up to a larger instead of a more restrictive pool of applicants? The all-important reason, says Kane, is diversity of ideas. "Everybody brings their own experience to science. People's life experiences and cultural antecedents are different, sometimes radically so, and these will affect choice of research problems. The result will be an expansion of creative breadth."

How to bring about the necessary changes? Shirley Malcom, director of education and human resources for the American Association for the Advancement of Science, and an adviser to President Bill Clinton on science issues, stresses that increased support must be provided from pre-college through to faculty stages. Structural change in higher education must include stronger emphasis on changing introductory science courses, increased interaction between students and professionals — as well as professors — career advice and mentoring, and undergraduate research opportunities. □

*Potter Wickware is a science writer in Oakland, California, USA. e-mail: wick@netcom.com*

# In defence of small science

**Frederick Sachs**

It's 1904. Einstein gets three grants. Annus mirabilis becomes annus satisfactory. It seems obvious, from our present perspective, that for Einstein to write and administer a collection of grants would have destroyed his creativity. The US National Institutes of Health (NIH), however, supports many researchers who are principal investigators of four, five, six or more research grants. Have these grants been awarded without concern for the applicant's scientific creativity? What peer-review committees (called study sections) make these awards? Although giving many grants to one person probably doesn't often result in bad science (although a lack of supervision leading to fraud may be an issue), the real penalty is the loss of ideas. We are giving funds to provide predictable new life at the expense of the unexpected[1].

Given a fixed NIH budget, one person can only get their research funded at the expense of someone else. For every grant awarded to someone who already has other NIH grants, one or more people are dismissed. Instead of multiple grants requiring less money because they build on the infrastructure of pre-existing grants, the average value increases with the number of grants held by one person[2,3]. Needless to say, the losers are most likely to be beginners who do not have an existing laboratory to generate preliminary data. A competitive NIH grant submission has about a 90 per cent chance of getting rejected[4,5], and this high probability encourages smart young people to leave research.

In 1986, more than 96 per cent of grant awards in the category reserved for first-time applicants went to people under 36 years of age. By 1993, this proportion had fallen to less than 29 per cent (ref. 5). In 1994, 38 per cent of all first-time awards went to people between 36 and 40 years old[6]. This trend is bad for science. Biology has made its greatest advances from the ideas of young independent investigators. The shortage of funds has its greatest effect on those who are not 'in', as shown by that ground-breaking study[7], done in Sweden, showing that women needed vastly superior credentials, equivalent to two or three extra publications in *Nature* or *Science*, to have the same chance as men of getting a postdoctoral fellowship (see page 204). The study showed that men who were not associated with members of the peer-review committees were also treated unfairly.

There is no reason to believe that the United States is different. In 1995, 45 per cent of PhDs in biomedical sciences (US citizens in US universities) were awarded to women, but less than 8 per cent of all research-centre grants were awarded to women[6,8]. How many women seek funding? Not as many as men, if the Federation of American Societies for Experimental Biology can be taken as representative of the funded biomedical research community[9]: women constitute only about 13 per cent of its membership.

The NIH appears to be making an effort to maintain balanced reviews: its study sections contain on average 20 per cent women. Coincidentally, about 20 per cent of research projects are awarded to women. The presence of a male majority on study sections, however, could be a significant factor in rating proposals from women. This is particularly important now because the number of female graduates is up from 25 per cent in 1975 to 45 per cent in 1995.

How many grants should a person control? A random search of the CRISP database (http://www.nih.gov/grants/award/crisp.htm) shows at least one principal investigator on 11 different grants, some of which are large programme project grants. Because CRISP is not relational, it is not possible to identify the real grant winners. CRISP also has no information on whether a principal investigator is a co-principal investigator on any other NIH grants, a recipient of grants from other sources, or has any administrative or clinical duties — or even for how much the grants are funded.

The principal investigator with 11 grants, however, has less than half a day to work on each one during a five-day week. This assumes no travel, and no institutional obligations. Should this level of commitment be encouraged while other applicants are consigned to the trash? If we give someone US$2 million a year to perform a clinical study, should we give them six more research grants (NIH lists some people as principal investigators on seven such grants[2])? Should we add to that grant supply some training grants that pay for students to work on these projects? In large laboratories most training is done by other students and fellows, not laboratory directors. In compiling data on multiple grants, I received no responses to questions about justification for funding from some of these successful principal investigators. Perhaps they were too busy.

The publicly funded research enterprise is short of money to support independent investigators. Where should it come from? As things stand, it can come either from an increased NIH budget or from a redistribution. (A large increase in funding from Congress seems unlikely, and in any event, given present funding policy, an increased budget would lead to more money going to currently funded investigators.) If, instead, the NIH were to limit the number of grants and to decrease the overhead rates for multiple grants from the same principal investigator, there could be significant changes without a decrease in the number of funded labs. Limiting the number of grants to two for each principal investigator would provide funds for 3,000 new principal investigators. One thing is clear: the NIH must act now to stop the loss of promising young investigators. □

*Frederick Sachs is in the Department of Biophysical Sciences, State University of New York, Buffalo, New York 14124, USA.*
*e-mail: sachs@fred.med.buffalo.edu*

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# "Invasion of dragons" needed

**Helen Gavaghan**

"Nature herself prescribed to the woman her function as mother and housewife and that law of nature cannot be ignored… without grave damage which… would especially manifest itself in the next generation." So wrote Max Planck in 1897. It would be hard to find a more discriminatory statement.

Planck was hampered by the social and scientific mores of his time, but what of the prospects for women in physics in our more enlightened days? They consistently fare less well in the physical than the biological sciences where, argued Gerhard Sonnert and Gerald Holton of Harvard University in *The*




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*American Scientist* (January–February 1996), "the gender gap has all but disappeared". In a study of men and women in physics, maths and engineering, Sonnert and Holton found there was a significant gap between academic ranks attained in the United States. The gap was particularly pronounced in younger scientists.

Although the situation is slowly becoming more equitable (women account for 15 per cent of PhDs in the United States compared with 3 per cent 30 years ago), the disparity between the numbers of women and men succeeding in physics persists.

In the July 1997 issue of *Physics and Society*, for example, Jolanta Lagowski and Janis McKenna found that 18 per cent of those receiving a bachelor's degree in physics in Canada were women; 13 per cent of all PhDs in physics went to women and 5 per cent of faculty staff were women. Only 2 per cent of tenured physics faculty members were women. The authors collected responses from 40 institutions, and of these 80 per cent had one or no women faculty members in their physics departments. Nearly half of the 40 institutions had no women faculty members in physics. The figures, say Lagowski and McKenna, are similar to those in the United States but worse than in Europe. In France, Italy and Turkey, 23 per cent of physics faculty members in 1991 were women.

Although Lagowski and McKenna do not attempt to explain the differences they found, D. Elizabeth Pugel in an article in the same issue explores the stages from birth in the development of a physicist. A sociological approach highlights four factors in the nurturing of a scientific outlook: parental behaviour, toy selection, and the wider relationships of the child and the adolescent.

For nearly 30 years, researchers have noted that most people allow infant boys greater freedom than girls to crawl around exploring their surroundings. Stereotyping follows, which can, of course, be reinforced by the toys that parents select. Pugel points out that the selection of dolls that purportedly enhances social skills is not a bad thing in today's large collaborative teams of physicists. The problem occurs when these social skills are perceived as drawbacks by others.

Some school teachers, says Pugel, are still of a generation in which a science education for girls was not particularly emphasized. Even if they do teach science to young children, women teachers may be intimidated by science and provide poor role models. Few, if any, women physicists have the public status of Einstein or Oppenheimer.

Nevertheless, young girls do become physicists, even though the data show them trapped firmly beneath the glass ceiling. In the July 1996 issue of *Physics and Society*, Howard Georgi, former chairman of the physics department at Harvard University, wrote of senior faculty meetings at Harvard: "I was appalled by the old-boys-club atmosphere that oozed from these gatherings, and I began to feel that an invasion of dragons was needed to shake up the country club."

Georgi believes that women often seem outwardly less sure of themselves than men. Initially, he found that this diffidence made it difficult for him to communicate as effectively with women as with male students. He also consistently discovered that women graduate students were more talented than was suggested by their entry examinations.

This point, argues Georgi, suggests the need for an affirmative-action programme — an unfashionable view both in academic institutions and in the law courts (see *Nature* **376,** 288; 1995 & **384,** 97; 1996). Thus if there is reason to suspect that woman or 'minority' students are better than their applications suggest and an interview reveals them to be as capable as the best white male students, then there is a case for affirmative action. Of those women that do gain faculty positions, Georgi argues, "We are still shoehorning women into a programme that works well for men but not for women and then trying to deal with the problems that arise." Georgi concludes: "You have to be an optimist and keep trying... Things are getting better, but always more slowly than we would like." □

*Helen Gavaghan is a freelance science and technology writer based in Hebden Bridge, UK.*

## Equality not taken for granted

The response across the world could be measured on the Richter scale after the revelation that the Swedish medical research council (MRC) exercised prejudice in its allocation of research fellowships (A. Wold and C. Wennerås, *Nature* **387,** 341–343; 1997).

Six months later, the implications are still being discussed in the newspapers and on radio and TV. But has anything really changed? Most definitely yes, say Agnes Wold and Christine Wennerås, the authors of the *Nature* Commentary. The MRC has finally accepted that it had been acting unfairly, and has changed its procedures. And some research councils in other countries – for example, the United Kingdom (see Breen, G. *Nature* **389,** 326; 1997) – are checking their own procedures.

Wold and Wennerås had to fight hard to convince Sweden's MRC that it had a problem. They began their investigations into its peer-review system two years ago, but were hampered by its lack of cooperation. The research council's belief in its system of meritocracy was unshakeable, says Wold. She and Wennerås had to get court orders to force the MRC to make documents available. Their analysis of the peer-reviewers' reports showed that in 1995 (the only year they were able to study), a woman applying for a postdoctoral fellowship had to be two-and-a-half times more productive than a man to rate the same scientific competence scores by referees. The analysis revealed that connections to any of the reviewers, independent of gender, helped bump up competence scores.

Wold believes that the MRC was genuinely unaware of the prejudices it was harbouring. Women reviewers were not significantly fairer than men, she says, when it came to estimating the skills of their own sex.

After the *Nature* article was published, the MRC began its own studies into possible prejudice in its allocation of project money, which it says it intends to publish. Although it found no evidence that the scientific competence of women had been misjudged, it did find that it allocated smaller grants to women than to men with identical competence ratings.

Jan Nilsson, vice-secretary of the MRC, says that he and the MRC's subcommittees which had advised on grant distribution were shocked by the revelation. "It came as a complete surprise. We had a fair system for grading scientists but transforming the grading to size of grant proved – unexpectedly – to be less rigid". The MRC has already corrected this tendency, he says, and the size of grants allocated this autumn were based only on competency scores. This proves, says a delighted Wold, that there is no truth in the adage that "things can only change slowly because they have been like this for hundreds of years".

Wold is intolerant of attempts to personalize the issue of discrimination. Discrimination is simply about prejudice, she says, and has nothing to do with family status, self-esteem, or any other fantasized female attribute that some claim contributes to women being taken less seriously. "It is a purely statistical problem and making it personal serves only to lower standards of discussion." Wold has now raised the discussion to a level that has brought tangible results. **Alison Abbott**

## Careers and recruitment in *Nature*

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