Mate now, meal later

Sex with a female preying mantis can end in death. From *Food Chain: Encounters Between Mates, Predators, and Prey* (Aperture, $29.95, £20), photographs by Catherine Chalmers.

the egg, the reverse is not so clearly the case (although males can run out of sperm). Therefore, if a female mates with more than one male, it will be to each male's advantage to inseminate more sperm than if the female were monogamous.

The reason is simple. Fertilization is often a lottery, and the males with the most tickets (sperm) are most likely to win. Consequently, in species in which females are especially promiscuous, males have particularly large testes, which produce extremely high numbers of good-quality sperm: males of the polyandrous chimpanzee have testes that are 16 times the size of those of the far less promiscuous gorilla.

And the story gets a lot more bizarre. The copulating male redback spider places itself on the female's jaws, and hence is eaten, apparently because, by becoming a meal, he prolongs copulation, extends the female's delay in remating, and hence diminishes the chances of a rival mating with her.

Chemicals in fruitfly semen, some similar to spider toxin, induce egg production in females, and delay subsequent mating with another male. Probably as an unfortunate side effect, they also reduce her lifespan. But as long as she has bred by then, and she will have done, her shorter life is of no cost to the male. And in a lovely experiment to show that the toxicity of the fruitfly's semen is a competitive consequence of the female's promiscuity, when females and males are bred monogamously for a few generations, the semen ceases to be toxic.

It is a fruitfly that holds the record for the longest sperm known. The fly itself (*Drosophila bifurca*) is just 1.5 millimetres long, a normal size for a fruitfly. But its sperm is six centimetres long — yes, centimetres. The picture of the male fly surrounded by several coils of its sperm is one of the more memorable among a number of startling pictures in the book.

Females have evolved adaptations both to improve their chances of being promiscuous and in response to adaptations in males. Some promiscuity is forced on females. Competing bedbug males go as far as to inject sperm through the female's abdominal wall in attempts to beat other males to her ova. Her response in the battle to gain control is, it seems, to develop pads of tissue under the cuticle that look as if they absorb and kill the sperm. Finally, take the rove beetle, an otherwise ordinary insect. The male inseminates the female with a bag of sperm which, once inside her body, extrudes a tube into her sperm store. The end of the tube expands into a bulb, forcing out sperm from previous males. The bulb is then pierced by two 'teeth' that extrude from the female's store, releasing the new male's sperm, a lovely story of co-adaptation between the sexes.

I have only two regrets about the book. One is that the index is so sparse, as seems to be the case for too many books nowadays. The other is that, although human promiscuity and its consequences are discussed, 'human' does not appear in the index, not even in the special index of animal species mentioned in the text. The omission is a pity. The book not only corrects some misapprehensions about human promiscuity, but is engagingly enough written for many readers initially interested only in humans to carry on reading. Whole-animal biology needs more appreciation than it receives, and where better a place to start than in an expertly guided walk on the wilder side of reproductive adaptations? ■

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Misplaced nostalgia for a bygone era?

Between Politics and Science: Assuring the Productivity and Integrity of Research
by David H. Guston
Cambridge University Press: 2000. 213 pp. £35, $54.95

Daniel S. Greenberg

Science in the United States has its own legend of paradise lost, a descent from a halcyon era of political faith in the honesty and productivity of science to a latter-day regime of distrustful oversight and utilitarian demands.

David Guston, assistant professor of public policy at Rutgers University in New Jersey, has produced a skilfully argued and provocative formulation of the American experience. He postulates that, starting around 1980, the federal government's relationship with science has shifted from benign and distant delegation of authority to assertive micromanagement. Central to this change, he contends, was the erosion of a tacit 'social contract' that had congenially bound the parties since the Second World War. In the words of an unnamed government official, the contract provided that "the government will give scientists money to do what they want to do; in return, scientists will try to work on things that are going to be good for ... the people whose money they're spending".

However, "by the early 1980s", says Guston, "the United States decided it could no longer rely entirely on the scientific community to have integrity and be productive all on its own. The political patrons found flaws in the premises of the social contract for science."

Guston attributes the change to doubts that science was serving the nation's economic needs, and to public revelations of scientific misconduct. The government responded with measures to ensure scientific integrity and to encourage technology transfer from government-financed basic research.

Focusing on what he describes as a representative segment of the science–government relationship, Guston observes that the National Institutes of Health established an Office of Scientific Integrity and an Office of Technology Transfer. Congress reserved a portion of science budgets for the programme of Small Business Innovation Research. Other measures provided money and incentives for researchers to think commercially.

Precursors of change, according to the author, occurred in the early 1970s, when Congress and the Nixon White House actively supported applied research at the National Science Foundation. The big difference in the 1980s, Guston asserts, was a shift from macro- to micromanagement through the creation of formal mechanisms at the boundary between science and government, to ensure integrity and technology transfer. The new environment even "empowers whistle-blowers who can publicize information about the failures of scientific integrity". The government still trusts the scientific community, Guston acknowledges, but the "boundary organizations" embody the principle of "trust but verify".

The tale as told is accurate, and the analysis of the shifting relationship between patron and beneficiary persuasive. But, as a science-policy journalist who has continuously observed science–government relations long before and long after the changes at the boundary two decades ago, I find Guston imposes too much order on an amorphous landscape, that he confuses congressional bombast and posturing with tangible effects, and uncritically accepts the mythology of a long-ago Eden in government dealings with science.

In the context of an American economy that spends more than $225 billion a year on research and development, the few under-

staffed, under-financed government outposts set up to promote productivity and integrity play scant roles in scientific affairs. Government itself has receded to a junior partnership in the research economy, providing about 25% of national R&D expenditures.

The misconduct follies played out on Capitol Hill in the 1980s — the so-called Baltimore case and the contention over Robert Gallo's role in identifying the AIDS virus — were the pet project of one powerful House member, John Dingell, and did not come from a groundswell of political concern. Few other legislators seemed interested in scientific misconduct. After the Republicans took control of the Congress in 1995, misconduct disappeared from the legislative agenda. It has reappeared with the recent outbreak of concern over ethical corner-cutting in gene-therapy trials. The Office of Research Integrity in the Department of Health and Human Services has been headed by an acting director since 1996 — scarcely a sign of political approbation for its work. Whistle-blowing is not conducive to career advancement, empowered or not.

As for the social contract, it can just as easily be argued that it never existed, or that, if it did, it persists to this day relatively intact, perhaps even expanded from its original terms. Ironically, these are particularly congenial and trustful times in science–government relations compared with the presumed nirvana of the pre-1980s. Congress today is gung-ho over a rapid doubling of the budget for the National Institutes of Health, based largely on naive faith in that agency's productivity.

Guston's use of language falls victim to academic opacity: "the dissemination model of the second period of Devine, *et al.* remains predicated on the univariate nature of the appropriability model of the first period." Nonetheless, a dogged reading yields fresh insights into the complexities of the American experience in the relations between science and government. ■

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Turning the key to an adolescent talent

In Code: A Mathematical Journey
by Sarah Flannery, with David Flannery
Profile Books: 2000. 292 pp. £14.99

John L. Casti

Sarah Flannery is a teenager in County Cork, Ireland. She is also the creator of a coding scheme for information transmission that dramatically extends our ideas of how best to compress information. How could a completely typical Irish teenager astound the world of mathematics in this way? *In Code* is a first-hand account of the answer.

Sarah's father, mathematics teacher David Flannery, plays the Henry Higgins to Sarah's Eliza Doolittle. The Flannery household, rather ordinary by most standards, is quite unusual in one way: the presence of a large blackboard in the kitchen, on which Flannery senior would write challenging mathematical puzzles for his children to ponder. So, from the time she was a toddler, Sarah was continually exposed to logical thought processes and the thrill of discovery. That's one piece of the answer to her success, a mathematically friendly home environment where the fact that she is a child and a woman played no role in discouraging her from developing a native talent for mathematical thinking.

As Sarah's story continues, we find her taking educational enrichment courses taught by her father at the local college. By the account given in the book, these courses are rather extraordinary in the way they challenge the students to think through the logic behind various mathematical problems. Thus, the principles involved in finding answers are arrived at in a kind of Socratic process of dialogue and discovery.

During the development of her novel coding scheme, Sarah takes the reader through a sequence of science competitions, first in Ireland, then abroad, at each stage of which her project wins a major prize. The ultimate project is a code that improves upon the standard RSA coding scheme used around the world to compress and send information. Sarah's scheme, the technical details of which are not presented in this book, provides an alternative that is considerably faster than the RSA procedure, and thus has the potential to send information far more efficiently — and cheaply — than previously thought possible.

The success of Sarah's coding method in science fairs around the world brings her fame, minor fortune and lots of publicity — including a front-page write-up in *The Times* of London. It also brings innumerable offers from entrepreneurs, software houses and others of that ilk, who promise riches beyond her wildest imagination if she will enter into a commercial arrangement with them to further develop and market her work. To her credit, Sarah refuses all these blandishments, and tells the world that she intends to present her work publicly, essentially giving the code away for free.

But there is a fly in the ointment. As mathematicians scrutinize Sarah's work, they discover a security flaw in the scheme. While the flaw in no way invalidates the mathematical basis of the code, it does prevent it from being used as a public-key cryptosystem. This, in turn, destroys the code's commercial value. *Sic gloria transit mundi.* Sarah remains undaunted by this development, and we read of her admirable aplomb in shrugging off the tarnishing of her achievement by this blemish. 'Who cares?' she seems to say. Much mathematical work is less than perfect. But it is still regarded as a contribution to progress.

In Code is a wonderfully moving story. While at times it reads a bit too much like a gushy teenager's diary (which it is), the book contains a wealth of interesting information on mathematical puzzles, coding methods, elementary number theory and algebra. It is also well worth noting, however, that it can be profitably read by anyone; no knowledge of mathematics, codes, number theory or anything else is needed. In fact, the book does an exemplary job of walking the reader through a set of graded puzzles aimed at developing mathematical intuition, followed by a first-rate, gentle introduction to codes, deciphering and cryptosystems. So don't be put off by the fear that this is a book on some mathematical genius that you won't understand. It is just the opposite; it's a book about the thrill of the mathematical chase, and how it is a game that anyone can play.

The book also gives a fascinating account of how a gifted teacher like Sarah's father, David, can help nurture and develop the mind of a very bright — but far from genius-level — teenager such as his daughter, and inspire that mind to creative heights one would believe possible only of bona fide geniuses. Sarah's story should serve as an inspiration to all young people, especially young women, who might be contemplating a life in mathematics. I recommend it highly as summer reading not only for teenagers, but for anyone interested in the human spirit and its boundless capacity for innovation and imagination. ■

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