ground the self, and they ground it in the past. The classification of memories in this book provides a thoughtful insight into how this grounding might take place. □

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Seminal work

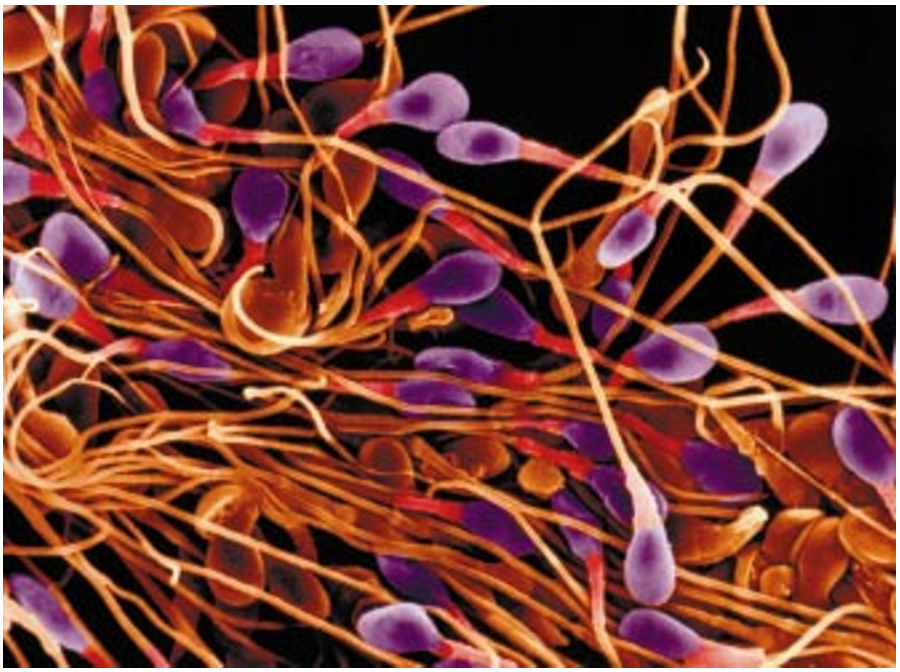
Sperm Competition and Sexual Selection
edited by T. R. Birkhead and A. P. Møller
Academic Press: 1998. 826 pp. $59.95

Mark Ridley

Geoff Parker defines sperm competition as "competition between the sperm from two or more males for the fertilization of a given set of ova". He practically invented the subject in 1970, and research has grown explosively since then. This book describes the state of the art, succeeding the multiauthor review edited by R. L. Smith in 1984.

Since that volume was published, two big new themes have emerged. The first of these is the use of molecular markers to measure multiple paternity within a female's offspring. Paternity was almost impossible to measure in natural populations before molecular markers became available in the 1980s, but we now have bags of data, particularly for birds and mammals.

Birkhead's chapter on birds uses evidence "for over 100 species and the list continues to grow". At a crude level, this evidence is valuable because it shows the extent of 'extra-pair paternity' in apparently pair-bonded birds. Sperm competition is unimportant in genuine monogamists, and the finding (or confirmed suspicion) that up to 60% of broods in apparently monogamous species have more than one genetic father has hugely expanded the range of species in which sperm competition must operate. The same method also features in tests of subtler, deeper hypotheses.



DR DENNIS KUNKEL

Winner took all: a crowd of human sperm no longer jockeying for position.

Second, the development of statistically sound methods for studying cross-species trends has caused comparative work to take off. R. V. Short noticed in 1979 that testis size is larger in chimpanzees, in which females copulate with several males, than in other (one-male-per-female) great apes. Sperm competition will be stronger in the 'multimale' mating system of the chimpanzee, and they have duly evolved larger sperm factories, and pump more of the stuff out. The same relationship between testis size in a species and the number of males that a female copulates with has been rigorously demonstrated in butterflies, fish, frogs (Halliday describes how foam-nesting frogs have larger testes than other kinds), reptiles (probably), birds, marsupials and eutherian mammals, making it one of biology's most general laws. In primates, the interaction with other factors, such as the length of the breeding season, has been traced, and the components broken down, to show that males in species with multimale mating systems produce larger numbers of sperm, store more of it, and in some cases have larger sperm.

Molecular markers have not been used to measure sperm competition in humans, but reverse comparative engineering has. Reverse comparative engineering, however, shows that human testes are on the small side, compared with our relatives, and suggests a monandrous evolutionary history as either monogamists or polygamists with one male per harem.

Research into the mechanisms of sperm competition has given us several pleasing stories to add to the whirring parts and scrapers of the damselfly penis, exposed by Waage in 1979. A male bushcricket, "using a modified subgenital plate", turns the female's reproductive tract inside-out, and then "the female consumes any stored sperm. In this way 85% of stored sperm are removed before the male transfers his spermatophore." A ghost crab "uses a glue-like substance in the seminal fluid to seal in any previously stored sperm and prevent it from fertilising". Simmons and Siva-Jothy con-

New editions

The RNA World, 2nd edn
edited by Raymond F. Gesteland, Thomas R. Cech and John. F. Atkins
Cold Spring Harbor Laboratory Press, $129

Massive Neutrinos in Physics and Astrophysics, 2nd edn
Rabindra N. Mohapatra and Palash B. Pal.
World Scientific Publishing, $48, £33

Foundations of Earth Science, 2nd edn
Frederick K. Lutgens and Edward J. Tarbuck
Prentice Hall, £24.95, $58

Meteorites and Their Parent Planets, 2nd edn
Harry Y. McSween, Jr.
Cambridge University Press, £40 (hbk), £14.95, $24.95 (pbk)

Invertebrate Palaeontology and Evolution, 4th edn
E. N. K. Clarkson.
Blackwell Science, £24.95

The New Solar System, 4th edn
edited by J. Kelly Beatty, Carolyn Collins Petersen and Andrew Chaikin
Sky Publishing and Cambridge University Press, £40, $59.95

The Insects: Structure and Function, 4th edn
R. F. Chapman
Cambridge University Press, £35, $54.95

Universe, 5th edn
by William J. Kaufmann III and Roger A. Freedman
Freeman, $64.95, £26.95

clude for insects that "we are still largely ignorant of the mechanisms by which non-random paternity is generated", which may be true (it almost has to be for insects) but is too modest.

The theory of sperm competition can also be used to make sense of adaptations in individual species. This work ranges from the rigorous to the anecdotal. Parker's update of his model of optimal copula duration in the dungfly — successfully predicting the dependence of copula duration on partner body size — is at the extreme of impressive rigour. The anecdotes, however, can be equally amusing, and at least point to research problems for the future. I liked this juxtaposition: hermaphrodite slugs "frequently lose their penis during copulation. It becomes stuck in the female tract and is bitten off either by the receiver or its possessor... The presence of multiple copulation organs in some free-living flatworms has been interpreted as a way to replace copulatory complexes lost during copulation." And then, despite 250 years of research (reviewed by Baur), we still do not know the function of the "love darts" that certain hermaphroditic snails and slugs may fire into their partners during mating.

A final theme is "cryptic female choice", the idea that females choose among the sperm of different males after insemination. It has captured the imagination of most of the authors, and was championed in a 1996 book by Eberhard (who has a chapter on it here). The consensus is that it is one for the future. Evidence for pollen usage, in the chapter on plants by Delph and Havens, suggests one model system. Or the wonderful experiment on fruitflies by Rice may point the way.

The book is bang up to date, referring to work done as recently as 1997. Topicality may have sometimes been gained at the cost of integration. More than one chapter may allude to the same published work, but none of them explains it fully. Chapters sometimes refer to papers discussed by their authors elsewhere in the book. I'd also question the taxonomic organization, with most chapters being about a particular group. This is not how I subdivide the subject, and it is awkward that one of the most interesting recent studies on a sea squirt receives short shrift, perhaps because that obscure taxon did not deserve a whole chapter. But these criticisms are piffling and my main reaction is to praise the immense achievement.

Two of the chapters — by Gomendio, Harcourt and Roldán on mammals, and by Simmons and Siva-Jothy on insects — are expert minibooks in themselves. The book contains large appendices and tables of data; background reproductive physiology made intelligible for behavioural ecologists; intelligent suggestions for future research; and original analyses which have not been published elsewhere. It is a one-stop first-step guide for anyone wishing to understand, add to, subtract from (critically), or multiply up (synthetically) research on sperm competition, and should be compulsory equipment in any lab that works on sexual selection. □

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Illuminating the past

Lengthening the Day: A History of Lighting Technology
by Brian Bowers
Oxford University Press: 1998. 220 pp. $45, £24.99

Peter T. Fox

Artificial light, like food and shelter, is a necessity for civilized life. Since Prometheus stole fire from the gods, mankind has manipulated light to ward off the dangers of the dark and to extend the hours in which vision-based activities can be pursued. Lighting adequate for such basic needs is readily provided by rather rudimentary technologies: rushes, candles, oil lamps and the like. Making utilitarian light safe, convenient, cool, clean and olfactorily inoffensive at a cost affordable by the masses, however, is a much greater challenge, and has motivated many developments in lighting technology.

Yet light is much more than merely utilitarian. From the Roman era onward, luxury (*luxe*) has been virtually synonymous with light (*lux*). The well-lit environment is a hallmark of personal and societal wealth. Well-balanced lighting enhances our enjoyment of visual arts, theatre, food and the face across the dinner table. Extravagant lighting displays have been crowd-pleasers for as long as there have been crowds. Competition between cities for the most artistic and impressive lighting of public buildings, bridges and roads has been in full sway for more than a century and shows no sign of abating. Thus, luxury has been an equally powerful force behind the lighting industry.

In *Lengthening the Day*, Brian Bowers gives a multi-faceted history of the development of lighting technology. The problems that had to be solved, the personalities of the inventors, the patents awarded, the impact of patents on subsequent developments, and the incremental improvements in the quality of life are thoroughly and entertainingly documented.

All manner of lights — from the gas limelights in theatres of the 1860s, to the first filament bulbs of Swan and Edison, to the latest

Shop around the illuminated clock: from the Roman era onwards, light and luxury have gone hand-in-hand. A well-lit environment still suggests wealth and comfort: an attempt to get us to relax and spend.