hay-extract nutrient that he put in his sealed swan-necked flasks — still to be seen today, as void of life as a century ago — could have harboured a type of spore that is now known to resist sterilization by boiling; indeed one Henry Bastian attempted much later to rehabilitate spontaneous generation, having inadvertently discovered such spores. So it follows that Pasteur might just as well not have bothered, because seen in retrospect his experiments actually proved nothing. But this will not do: we all know that nothing retards progress so much as the right experiment at the wrong moment. What if atomic weights had been measured too accurately in the nineteenth century? Does this diminish the insights of Dalton and Prout? Or suppose that the viral polymerase that transcribes RNA into DNA had been recognized 20 years too soon. Where then would the Central Dogma be?

Collins and Pinch press the point that science is burdened by intellectual, and indeed social and political, bias (driven, for example, by its votaries' desire for funds). Scientists, if they think about such matters at all, know this well enough. Darwin, in a famous passage, remarked that he had always found it strange how anyone could doubt that observations must be for or against something if they were to be of any use. Eddington — something of a *bête noire* to Collins and Pinch — declared that one should never believe a fact until it had been confirmed by theory. But perhaps G. K. Chesterton got closest to the nub (but in a rather different context) when he wrote: "you can only find truth with logic if you have already found truth without it."

Another theme explored in this book is the hazard of pursuing very small physical effects, which lie beyond the sensitivity of existing instrumentation. Such problems attract a particular scientific type — the men with the staring eyes and the tic. Irving Langmuir in his celebrated lecture on what he called pathological science gave as one of his criteria of the genre that the reported effects were in general at the very verge of detectability and commonly irreproducible. Collins and Pinch have formulated a new law, which they call experimenter's regress: to determine whether an effect exists, a new apparatus has to be constructed, but if it reveals nothing this may signify not that there is no effect but that the apparatus is wanting, and so a vicious cycle is initiated.

This book is designed to open a window on science and its practitioners for beginners and outsiders. It gives, in my view, a distorted view of how science mostly proceeds, but for all that there are many sharp insights, the writing is deft, the stories good and there is not a boring page. The working scientist, disposed to grumble about the rigours of his vocation, can do no better than study the absorbing account of Michelson and Morley's efforts to detect the retardation of light in the luminiferous ether by measuring its velocity along and across the Earth's axis of rotation. The first apparatus had to be moved from Berlin to Potsdam to minimize traffic vibration and even then the interference fringes could be made to vanish by the stamping of a foot 100 yards from the building. The second apparatus, built in Cleveland, Ohio, reposed in a basement and was mounted on a block of sandstone five feet square, floating in a massive trough of mercury; set in motion by hand, it would revolve for more than an hour. But no effect was observed. The negative result acquired its retrospective éclat only after the Theory of Relativity was published and embraced by physicists. Perhaps we should not seek our rewards before the Day of Judgement. □

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# Flying squid and spinning seeds

*R. McNeill Alexander*

**The Biokinetics of Flying and Swimming.** By Akira Azuma. *Springer: 1992. Pp. 265. DM280, £150, $198.*

SQUID swim fast by jet propulsion, using enhanced breathing movements to squirt water out of their gill cavity so as to drive them forwards or back (backwards is faster). That is how ordinary squid travel, but the flying squid of the Indian Ocean also leaps into the air to glide like a flying fish . Most people (including professional zoologists) will be puzzled to identify the

**This ladybird, *Coccinella 7-punctata*, wings its way into John Brackenbury's *Insects in Flight* (Cassell), which was shortlisted for this year's Rhône-Poulenc Science Book Prize.**

subject of the photograph on the cover of Akira Azuma's book — a shoal of squid in flight — and all will be struck by the oddity of these animals. Flying fish have enlarged fins placed like the wings of an aeroplane, but the flying squid has its aerofoils at the extreme ends of its cigar-shaped body, a pair of fins at the anatomical rear end (which travels in front) and membranes stretched between the tentacles of the anterior end (which follows behind).

Azuma reviews the swimming and flight of a remarkable range of organisms, several of them as odd as the flying squid. He discusses the flight of birds, bats, many different kinds of insect, flying squirrels, sycamore seeds and spiders on gossamer, as well as squid. His chapters on swimming deal with the whole range of animal sizes from microorganisms to whales, all shapes of fish, and wind-surfing scallops. But he leaves one with the impression that he is interested in organisms only as problems in theoretical mechanics, that he finds the animals less interesting than the equations.

The initial impression given by the wonderful cover picture is quickly modified when the book is opened: the first ten pages, in double columns, are filled by a list of algebraic symbols. Most pages have a few equations, which are generally neither complicated nor difficult, though readers who do not already know (for example) what a Kármán vortex is had better keep a hydrodynamics text handy.

The strength of this book is its richness as a source of data and equations. Many graphs present potentially useful data that are hard to find elsewhere, such as force coefficients for rectangular and triangular aerofoils of low aspect ratio. And tables present the basic equations for the analysis of (for example) the helical beat of a flagellum, while others give data on the dimensions and performance of (again, one of many examples) spinning seeds.

The weakness of the book is its lack of reference to experimental physiology. There are diagrams of theoretically expected vortex patterns in the wake of flying birds but no illustrations of the actual patterns revealed by experiments with helium-filled soap bubbles. There is a table showing that squid that swim slower than similar-sized fish nevertheless use more energy, but no indication of how this information was obtained.

That said, those of us who research and teach in the field of animal locomotion will refer frequently to this book, and teachers of applied mathematics looking for unusual problems will find it a rich source of ideas. □

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