Soaking up the limelight

Systema Porifera: A Guide to the Classification of Sponges
edited by John N. A. Hooper & Rob W. M. van Soest
Kluwer Academic/Plenum: 2002. 1,810 pp. $595, £398, E625

Lorraine Berry

Sponges are "among the most successful life forms that have ever existed, with an estimated 15,000 species alive today", according to the editors of this new work on their classification. The study of sponges has provided information about fundamental biological issues, including the biosynthesis of chemicals, totipotency (the ability of a cell to differentiate into other cell types), the evolution of eukaryotic immunology, and cellular theory. Sponges are also a source of therapeutic drugs, and can serve as biomarkers of pollution and proxies for palaeoclimatic change.

Nomenclature problems have plagued sponge taxonomists for over a century, however. The classification of sponges is complicated by their plasticity of form. They lack recognizable organs, cell types often migrate, and detritus (including skeletal parts called spicules from other sponges) can be incorporated, transforming the sponges beyond recognition. As a result there are many synonyms, which are difficult to reconcile with species descriptions (from different authors at different localities at different times) and with type material that is dispersed among museums around the world.

Systema Porifera attempts to resolve the higher systematics of the phylum Porifera, incorporating spongiomorphs such as the Archaeocyatha, 'Stromatoporoidea' and 'Sphinctozoa', which previously resided in other phyla. The book represents the work of 45 researchers, who took 7 years to re-evaluate and define the 2,100 nominal genera. It also provides a review of the taxonomic literature, creating an invaluable database of sponge biodiversity and a platform for the future development of sponge systematics.

Interest in sponges has been growing since the 1960s, when the discovery of bioactive metabolites (used to synthesize compounds with antibiotic and other biomedical properties) caught the attention of drug-development agencies. Since then, the number of recognized species of sponge has doubled, and today they are studied by several hundred researchers in various institutes around the world. This increase has led to an explosion in the discovery and documentation of species, which until now was dispersed in journals and monographs. *Systema Porifera* provides an important service by drawing information from these disparate sources together and updating it.

The editors are well qualified to do this because of their work on the rich sponge faunas of the Indo-Malay Archipelago. John Hooper has also revised the systematics of Australasian sponges, and Rob van Soest has concentrated on sponges from the north-eastern Atlantic and the Caribbean. Together they have done an excellent job, making *Systema Porifera* interesting and accessible to a wider scientific audience than pure sponge taxonomists.

Descriptions of each class, order and family of sponge are organized under a series of uniform subheadings, making information easy to locate. Bibliographies are comprehensive and include many recent reviews. The authors discuss the history of nomenclature and classification, and recognize the possibility of future taxonomic changes, highlighting the fact that sponge science is still evolving.

Most sections contain an identification key for families and genera — something never previously attempted for Porifera — although I would recommend, as the editors suggest, referring to the *Thesaurus of Sponge Morphology*, edited by Nicole Boury-Esnault and Klaus Rützler (*Smithsonian Contributions to Zoology* **596,** 1–55; 1997), to use them. Some diagrams and electron micrographs in *Systema Porifera* are a bit small, although enlarging them would have further increased the size of this already enormous — but invaluable — book. ■

Lorraine Berry is in the Department of Invertebrate Zoology, Royal Belgian Institute of Natural Sciences, Rue Vautier, Brussels B-1000, Belgium.

Hanging on: some 15,000 species of sponge, including *Leucetta chagosensis* shown here, are alive today.

Universal building blocks

The Road to Galaxy Formation
by William C. Keel
Springer: 2002. 230 pp. E99.95, $109, £60

Carlton Baugh

Galaxies are the building blocks of the Universe. Understanding the origin of these vast agglomerations of stars, gas and dust is one of the main challenges facing cosmologists today. Our ideas about the physical processes responsible for shaping galaxies have matured rapidly over the past decade, in response to the staggering advances in astronomical technology over this period.

The advent of 10-metre ground-based telescopes, the success of satellite-borne instruments such as NASA's Hubble Space Telescope, and the opening up of the electromagnetic spectrum far beyond the optical region have revolutionized our view of the Universe. We can now observe galaxies that are so far away that the time it takes light to travel from them is a significant fraction of the age of the Universe. This means that we see these objects as they appeared when the Universe was just a billion or so years old. The task confronting theoreticians is daunting: to explain the formation and evolution of galaxies over more than ten billion years of cosmic history. It is certainly time for a book devoted to setting out the available clues as to how galaxies are made.

William Keel's book outlines the two competing theories of galaxy formation: the 'monolithic collapse' and the hierarchical scenario. The former is a throwback to the 1960s, when it was first suggested that galaxies were born in some violent episode in the early Universe. The discovery of galaxies with seemingly elderly stellar populations at high redshifts (which correspond to a time when the Universe was relatively young) gives credence to the monolithic picture, with the result that this simple model has stubbornly refused to die.

The hierarchical scenario, on the other hand, attacks the problem from the opposite direction. In this model, galaxies are built up by repeated mergers of smaller fragments. In this case, there is no single epoch of galaxy formation, but rather a steady build-up of stars. This model is appealing because it is set in the context of a model for the formation of structure in the dark-matter component of the Universe. Models in which the mass of the Universe is dominated by weakly interacting particles known as cold dark matter, and which also have a significant cosmological constant or dark-energy component, are receiving impressive support from measurements of the cosmic microwave background radiation and the Hubble diagram of distant supernovae. However, this evidence is circumstantial: dark matter has not been detected in the laboratory, and there is no convincing theoretical explanation of dark energy.

Keel's own research has covered a wide range of topics, which is reflected in the richness and variety of subjects covered in this book. It is refreshing, in a market dominated by theorists, to come across a book on galaxy formation written from an observational perspective. After all, any model of galaxy formation, no matter how appealing from a theoretical point of view, is eventually judged by how well it describes what is actually out there.

In a book of this length it is impossible to cover in detail all of the most exciting advances of the past few years. Consequently, the discussion of Lyman break galaxies — the first significant population of galaxies to be identified at high redshift — is rather brief in view of the tremendous impact that these objects have had upon the subject. Also, galaxies that are detected by their emission at submillimetre wavelengths (which occurs when the dust that they contain is heated by starlight or by material falling into a central black hole) receive little attention until the final chapter. The book provides a flavour of the physics of galaxy formation, rather than a rigorous review of the theory. Readers who require a comprehensive theoretical briefing could turn instead to *Cosmological Physics* by John Peacock (Cambridge University Press, 1999) or *Cosmology*, 2nd edn by Peter Coles & Francesco Lucchin (Wiley, 2002).

Nevertheless, *The Road to Galaxy Formation* should prove to be a handy primer on observations of galaxies for graduate students, advanced undergraduates and theoreticians who feel too shy to visit a telescope. A particularly useful feature is the bibliography at the end of each chapter, which contains a brief résumé of selected research papers and will no doubt be invaluable to newcomers to the field who need guidance in selecting further reading from a burgeoning literature. ■

Carlton Baugh is in the Department of Physics, University of Durham, South Road, Durham DH1 3LE, UK.

Science in culture

Leonardo lifts off

A wing designed by Leonardo da Vinci proves to be aerodynamic.

Martin Kemp

Leonardo da Vinci is famous, among other things, for inventions that did not work, or rather that could not have worked in his own era. He was, as the cliché has it, a man ahead of his time. But like many clichés, this obscures rather than clarifies. Although he was undoubtedly productive as a 'jobbing' engineer, his grand, visionary projects, such as the flying machine and the tank, blended genuine aspirations with bouts of visual boasting directed at prospective patrons.

The brilliance and practical limitations of Leonardo's more extravagant visions have recently been vividly demonstrated in the project to build a flying machine undertaken by ITN Factual for Channel 4 Television in Britain. I was called in as their consultant, to work with Skysport Engineering of Bedfordshire in England, which specializes in the resurrection of early aircraft.

The brief was to construct something that would actually fly, but with the minimum of deviation from Leonardo's own designs, in detail and in spirit. We were determined to use nothing that he did not or could not have envisaged. The great *uccello* (bird) that he envisaged in the 1490s, with its flapping wings, had no chance of flying, so we favoured the gliding mechanisms to which he later resorted.

Our construction was based on a series of Leonardo's bat-like designs, which combined large spans with skeletal lightness (at least in terms of the materials available to him). Leonardo's concept was based on his conviction that nature's own inventions operated with no insufficiency and no redundancy in the context of natural law. Deciding to remake nature on its own terms, he worked on the principle that the aspiring aviator should not literally imitate a bird but should create a mechanical body that works analogously, in conformity with the causes behind natural effects. It is this approach that places the flying machine in much the same category as the *Mona Lisa*, that most synthetically contrived of portraits (*Nature* **389,** 799; 1997).

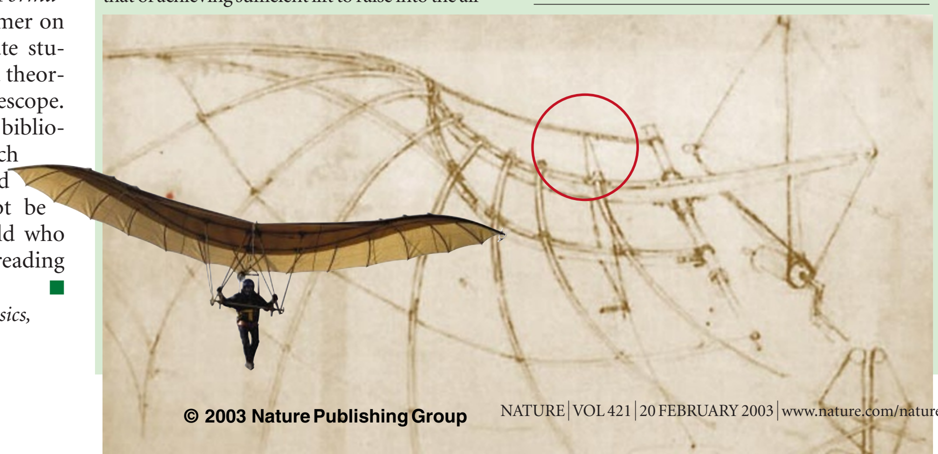
The problem that we faced, like everyone else who has attempted to fly Leonardo's machines, was that of achieving sufficient lift to raise into the air the relatively heavy materials available to him. Our breakthrough came with the observation of a detail on a sheet in the Biblioteca Ambrosiana in Milan that had appeared insignificant to my eyes. The Skysport engineers saw it differently. Near the lateral rib adjacent to the pole at the inner margin of the wing, they noticed a looped line that passes over the front edge (circled in red, below). The rear of the loop is labelled "*panno*" (cloth). What this detail said to the engineers was 'leading edge' and 'aerofoil' — the necessary features for lift-off.

However, Leonardo had no sense of the dynamic laws that underlie modern aerofoil design, which involve compression beneath the wing and rarefaction above. During his many hours watching birds wheeling on currents of air, fish swimming in streams, and boats tacking against the wind, he never doubted that water and air (both of which are fluids) behave in the same way. He did not pay attention to the fact that air, unlike water, is compressible, and had not considered such a possibility. But he had observed the robustness of the leading edge of a bird's wing and the relatively broad and blunt heads of some fish, which told him that air or water needed to pushed strongly out of the way.

The Milanese wing design achieved triumphant lift-off high on the Sussex Downs on a breezy autumn morning about 500 years after it was drawn. In the version that flew, Leonardo's wing design was doubled up, and we omitted the windlass, which was intended to adjust the angle of the wings but would have served no useful purpose. Also added was a leonardesque tail for stability and a somewhat less leonardesque A-frame for the intrepid pilot.

A new formula is needed to replace the cliché. Leonardo, with extraordinary visual inventiveness, envisaged more of the potentiality of his period's science and technology than any of his contemporaries. And, like many highly original inventors, he needed his slice of luck to come up with the right answer for the wrong reasons.

Martin Kemp is in the Department of the History of Art, University of Oxford, Oxford OX1 2BE, UK.



Winging it: a flying machine based on plans by Leonardo da Vinci has been flown. The red circle shows the loop that indicates the leading edge.

H. THOMPSON/CHANNEL 4

BIBLIOTECA AMBROSIANA