BOOK REVIEWS

A Model of Variability

The Evolutionary Biology of the Threespine Stickleback. MICHAEL A. BELL and SUSAN A. FOSTER, Eds. Oxford University Press, New York, 1994. xii, 571 pp., illus. $98 or £65.

Because the study of variability lies at the heart of evolutionary biology, species that exhibit considerable variation across their geographic range are of special interest to comparative biologists interested in understanding evolutionary patterns and processes at the species level. Few vertebrates match threespine sticklebacks (*Gasterosteus aculeatus*) in the extent of geographic variation in morphology, behavior, and ecology, and the nature of this variation makes this species an especially well-suited model for many types of evolutionary studies. Threespine sticklebacks have been recognized for years as a species particularly amenable to biological study, and the scientific literature analyzing sticklebacks extends from the 1750s through the dawn of modern behavioral biology (in which the threespine stickleback featured prominently) to recent populational and morphological studies of variation. Even since the publication of this book, threespine sticklebacks have been featured in *Science* (4 November 1994, p. 798, and 6 January 1995, pp. 30–31) for their utility as a model system for studying the evolutionary process of character displacement.

Threespine sticklebacks are generally held to be a species complex composed of many distinct populations (some of which actually may be separate species) distributed in the Northern Hemisphere in coastal marine and associated freshwater habitats. Within these areas, stickleback populations may be exclusively marine, be restricted to freshwater, or may migrate from marine to freshwater habitats during their lives. Threespine sticklebacks are not naturally found in the central continental areas of North America, Europe, or Asia. Many stickleback populations, especially in northern freshwaters, are small, isolated groups that may have invaded these habitats at various times following the last glaciation during the past 15,000 years. As this geographic pattern would suggest, many freshwater stickleback populations are highly fragmented, and this pattern is likely to have resulted from multiple freshwater invasions from the ancestral marine population. The fragmentation of stickleback populations has resulted in considerable divergence in many aspects of behavior, ecology, and morphology. For example, among populations breeding season varies between 50 days and one year, lateral bony plates and fin spines range from being well developed to absent, and there is extensive variation in body coloration.

Variation among threespine-stickleback populations is nicely introduced by Bell and Foster in their introductory chapter to this book, and they use this chapter to provide a useful overview of stickleback biology. The topic of variability is also explored in detail in several other chapters, and an especially complete treatment of life history variation among populations is provided by J. A. Baker, who draws on a synthesis of many studies worldwide in an attempt to draw general conclusions about the patterns and causes of variation. This chapter will be of special interest to workers on life-history theory, as many features of reproductive biology are examined in relation to geography and ecology. Baker's chapter also is the most successful in its effort to synthesize data and extract general patterns of variation. McPhail's chapter highlights several Canadian populations that have been used as a model system for the study of morphological divergence and speciation and documents the remarkable distinctions between lake and stream populations and between benthic and limnetic sticklebacks.

Gasterosteus aculeatus. Photo by Glenn M. Oliver; Visuals Unlimited

One major theme that emerges from this book is the complex history of stickleback evolution and our lack of knowledge about this history. Because the divergence among populations is relatively recent, the phylogenetic history of populational differentiation has been difficult to elucidate. This is a severe handicap to future progress, as the interpretation of so many patterns of ecological and behavioral differentiation depends on phylogenetic data. Indeed, with even basic questions as to the number of species represented within the threespine-stickleback complex unresolved, Buth and Haglund's admonition (p. 84) that phylogenetic research could "end our application of the vague concept of 'complex' to this taxon" is well taken. Indeed, several chapters suffer considerably from attempts to discuss the evolution of stickleback characteristics when historical information on the direction of character change is lacking.

Despite the difficulties that arise from a lack of phylogenetic data, threespine sticklebacks possess outstanding features for ongoing studies in evolutionary biology. In addition to numerous practical features such as the amenability of breeding to observation in situ, the most outstanding feature of sticklebacks is the numerous repeated invasions of relatively isolated freshwater habitats. Comparative biology often suffers from the lack of replicated natural experiments, and sticklebacks offer a profusion of such cases. With a more complete phylogenetic framework, further analyses of the genetic bases of variation in ecology and behavior, and the application of more consistent methodologies for data collection across populations, research on threespine sticklebacks will contribute substantially to the exploration of many fundamental issues in evolutionary biology.

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Astronomical Venture

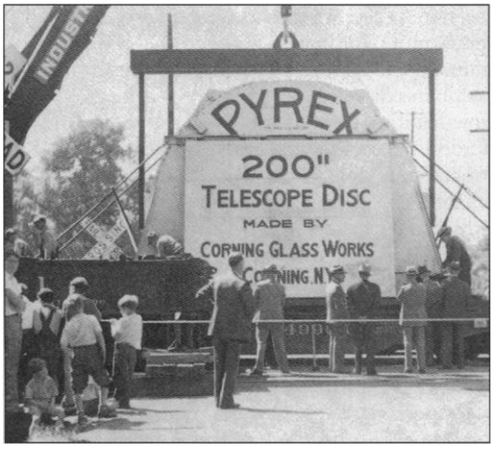
The Perfect Machine. Building the Palomar Telescope. RONALD FLORENCE. HarperCollins, New York, 1994. x, 451 pp. + plates. $27.50.

The construction of the 200-inch telescope on Mount Palomar near San Diego was an epic struggle filled with comedy and tragedy

and with false starts and triumphs, culminating in an instrument that remained the biggest and best of its kind for decades. As Ronald Florence puts it, this mammoth project, like the 100-inch Mount Wilson telescope that preceded it, was on the scale of a battleship with the precision of a microscope, all designed to cradle and aim an ounce of silver (or aluminum in the case of the 200-inch) to catch a bit of starlight. Helen Wright has described the hero of the story, George Ellery Hale, in her recently reprinted biography *Explorer of the Universe* (1966; AIP Press, 1994), and Donald Osterbrock has approached the story from the angle of both Hale and G. W. Ritchey in his *Pauper and Prince* (University of Arizona Press, 1993). The originality of Florence's book lies in the concentration on the telescope itself: the extraction of $6 million from J. D. Rockefeller's International Education Board in 1928; the abortive attempt by General Electric over the next three years to build a fused quartz mirror; Corning's success (on the second try) in 1934 at building a ribbed Pyrex mirror, almost swept away by flood during the annealing process; the cross-country trek from New York to California to the cheers of throngs of citizens; the 11-year, 180,000 man-hour task, interrupted by World War II, of grinding and polishing the mirror to an accuracy of a few millionths of an inch; the innovative design of the mounting, telescope structure, dome, and instruments on a scale never before achieved; the many adjustments after first light in 1947, when some critics still predicted the telescope would never work; and finally the dedication of the instrument in 1948 and its transfer to fully operational status in October 1949.

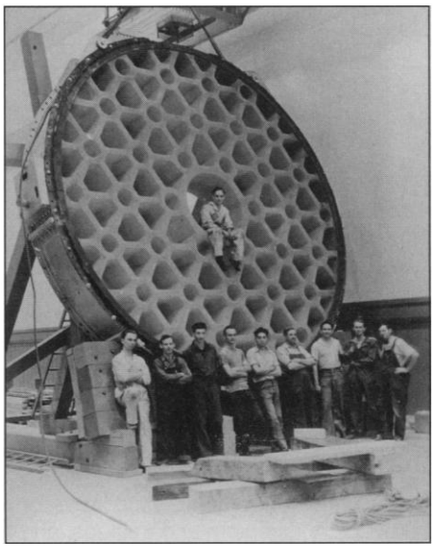
A few other books have described the building of the telescope, but no one has succeeded in describing so colorfully the details of the work and the personalities who undertook it against all odds. Florence describes how Hale himself had long suffered from a condition characterized by "a ringing in his ears and an agonizing headache, then physical exhaustion, a tingling in his feet, frantic excitement, insomnia, indigestion, spastic colitis, and the sensation that his mind was whirling out of control," not to mention visions of a little man who offered unwanted advice. Despite all this, Hale managed a significant research career in solar astronomy, was responsible for building the 40-inch Yerkes refractor (1897) and the 60- and 100-inch Mount Wilson reflectors (1908 and 1917), cofounded the California Institute of Technology, and founded the *Astrophysical Journal*, among other accomplishments. And he is only one of the many personalities brought to life in this volume.

Unfortunately, well written as it is, the book suffers from the serious flaw that some of its facts are plain wrong. To take only one episode, by way of background the first two chapters describe the Great Debate between Harlow Shapley and H. D. Curtis on the size and structure of the universe, which took place in Washington in April 1920, sponsored by the National Academy of Sciences. Florence repeatedly states that the debate happened in April 1921 (even making that date the title of his first chapter). He describes in colorful detail the cars arriving at the portico of the Smithsonian Castle for the event. However, the debate took place in the main auditorium of the Smithsonian's Natural History Building (where in April of this year another debate will be held to mark the 75th anniversary of the event). And Florence has Einstein in the audience, though Einstein did not make his first trip to the United States until 1921. It is one thing to quote a wrong date occasionally; it is quite another to build two chapters around that erroneous date, especially when the facts are well known from primary and secondary sources, some of which the author cites. More generally, these errors do not inspire confidence in the author's detailed account of the building of the 200-inch, details that are in many cases taken from archives and less easily checked. The book is therefore more successful as a historical novel than as history. In history, as in science, clarity of expression is laudable, but it is no substitute for accuracy.



The disk for the Mount Palomar telescope arrives at Pasadena. [From *The Perfect Machine*; California Institute of Technology Astrophysics Library]

The shortcomings of this volume should not diminish the importance of the dramatic story of Palomar—a story repeated (with a less successful ending) with the completion of the 6-meter telescope in the Soviet Union in 1975 and now being played out on many fronts as telescopes vie with one another for their grasp of starlight. A veritable boom of 6- to 10-meter telescope–building is currently under way, using a variety of new technologies. Already the 10-meter segmented mirror of the Keck telescope on Mauna Kea has surpassed both Palomar and the Russian 6-meter, with even larger mirrors on the way, including the innovative spin-cast honeycomb mirrors. Decades from now, these achievements will also have their stories told, it is to be hoped with both the color of the science writer and the accuracy of the historian.


The disk on its storage easel after being unloaded in Pasadena. [From *The Perfect Machine*; Mel Johnson]

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Small Bodies in Space

Asteroids, Comets, Meteors 1993. A. MILANI, M. DI MARTINO, and A. CELLINO, Eds. Published for the International Astronomical Union by Kluwer, Norwell, MA, 1994. xxxiv, 503 pp., illus. $147.50 or £100 or Dfl. 250. From a symposium, Belgirate, Italy, June 1993.

The average attention span for an individual on a given subject is said to be about 20 minutes. This explains why I fall asleep in seminars; why Haydn wrote the Surprise Symphony; and why I recommend the book *Asteroids, Comets, Meteors 1993*. This book is a compendium of review talks each of