Looking for Planets

Planetary Systems. Formation, Evolution, and Detection. BERNARD F. BURKE, JÜRGEN H. RAHE, and ELIZABETH ROETTGER, Eds. Kluwer, Norwell, MA, 1994. xii, 486 pp., illus. $217 or £148.50 or Dfl. 380. From a conference, Pasadena, CA, Dec. 1992. Reprinted from *Astrophysics and Space Science*, vol. 212, nos. 1–2.

A few decades ago, it was a serious scientific question whether any star other than our sun possesses planets or whether life exists elsewhere in the universe. The anthropic principle renders our own existence irrelevant to either problem. The question of life is unresolved, but there are good reasons to suspect that planets are commonplace. We now have a good general understanding of how a star forms by the collapse of a rotating cloud of gas and dust, leaving some of its mass and most of its angular momentum in a disk-shaped nebula. Observations from ground and space have resolved such nebulae orbiting young stars. The raw materials are there, and it takes only a small leap of faith to conjure planets from them, even if details of their formation are obscure. Filling in those details requires comparisons—do other systems of planets resemble ours in numbers, sizes, and orbits, or are very different arrangements possible?

A cloud of dust, with its large surface area, is easily detected, but once grains collect into a planet it is lost in the glare of its star. Finding it becomes a challenge both technical and financial; NASA's response includes sponsorship of a series of conferences on this topic. This volume contains proceedings of the first of these. It has the usual faults of conference proceedings; the contributions are noticeably uneven in quality and reflect the interests of their authors, without comprehensive overview. One notable omission is reference to classical astrometry with ground-based telescopes to search for wobbles in a star's position due to a planet's gravitational pull. With this exception, the 47 papers give a fair snapshot of the current status and future directions of the search.

There is roughly equal division in the volume among theory of planetary formation, accounts of observations, and descriptions of present and projected instruments and techniques. Most of the observations are merely of circumstellar dust and gas. There is as yet only one unambiguous detection of planets outside our solar system, orbiting a most unlikely primary—a neutron star. The star is a pulsar, and the extreme regularity of its radio pulses allows detection of motions due to the gravitational tugs of two planets, closer to their star and a few times more massive than Earth. The three lucid contributions on the discovery and properties of this system are arguably the best part of the book. Still, these pulsar planets give no insight about planets of ordinary stars. We do not know whether they are survivors of the supernova that created the neutron star or were formed from the debris of that explosion. Here too comparisons might constrain the origin of such systems, but continuing searches have found no other pulsars with planets.

Vignettes: Adventurer's Intellections

Characterized by one recent commentator as "an American original," Gideon Lincecum, born in Georgia in 1793, was a westward explorer, adventurer, and practitioner of botanical medicine. In his later years, spent in Texas and Mexico, Lincecum wrote several memoirs of his life and activities that have now been brought together by Jerry Bryan Lincecum and Edward Hake Phillips under the title *Frontier Naturalist: The Life and Times of Dr. Gideon Lincecum* (Texas A&M University Press). Interspersed with Lincecum's accounts of his travels, observations of wildlife, hunting techniques, relations with the Choctaw and Chickasaw Indians, and medical practices are ruminations showing his interest in science, some of which are excerpted below.

I had [Erasmus Darwin's] "Botanic Garden" and the "Temple of Nature," all occupying a plane of thought so far above anything I had before seen . . . that I felt strongly attracted to, and very much desired to know more about the man. So I got up as good a letter as I could, in which I expressed my sentiments towards him and his valuable works, gave him a short sketch of my origin, present condition and eager aspirations. . . . In about three months his very polite, friendly, and most interesting reply came. . . . It changed my crude notions in almost everything. . . . It showed me also that the sun of science had arisen already, and before its effulgent rays, the witches, ghosts, angry gods, and frightful devils of antiquity would soon have to fly to the mountains or somewhere else for protection. And even now, be my intellectual status on the plane of progressed thought what it may, it is attributable to the impulse given by that letter.

Regarding marriage, I had read the works of Dr. [Benjamin] Franklin. He advised early marriage. This agreed perfectly with my semi-civilized humanity, and the influence of the controlling animal developments. The advice of the old teacher at that stage of my being seemed quite reasonable and right. I did so, and thereby in course of time, demonstrated the fallacy of the Franklin theory. That is, as far as such an organism as I possess is a test. I was utterly incompetent to the duties and responsibilities of domestic life. I, however, made out to worry through it without calling for help. My ten living (lost three) children were grown, married and settled off on ample homes long ago, and they are sustaining themselves pretty well. But they are, in their mental aspect, not above fair to good middling; and the mischief that I have done them by bringing them into a world that is full to the brim with the same sort, and to myself, by placing a clog on the pursuits that nature had fitted me for, is great.

. . . Having settled my numerous brood, I found my domestic responsibility ceased. I have since been free and could pursue that which seemed to please me best. But it was no go. The train of philosophic thought had been long since broken. . . . The faculties and powers for scientific scrutiny were blunted and no longer capable of producing reliable ultimates.

The instinctive action ceases exactly at that point in the chain of progressive development where the brainy viscous—the organized brain structure begins. All above that point, be it copious or scant, great or small, much or little, is all clearly attributable to the varying degrees of the reasoning faculty, to the quantity and quality of organized brainy matter.

But let us leave this world-pestering topic, and return to where we left Ned dripping wet from having swam the San Antonio river. . . .

Any evidence of a planet around a main-sequence star is subtle indeed. The gravitational pull of such a planet may change the star's radial velocity by a few meters per second, or (for a nearby star) its position by a thousandth of an arc second. If the planet's orbit is fortuitously aligned, a transit in front of the star may dim its light by about a percent for a day or so at intervals of years or decades. These effects are barely within the measurement capabilities of ground-based instruments, which must retain precision and consistency for years. Space-based observations are more feasible, at least from a technical standpoint. The contributors describe a wide variety of ingenious techniques. Few, if any, can be contemplated by NASA in its present financial straitjacket. Indirect detection, no matter how convincing, cannot compare with the appeal of an actual picture of an extra–solar-system planet. To obtain one requires a space-borne telescope of larger size and better optics than Hubble. There are several descriptions of such instruments, but cost estimates are conspicuously absent. Surely the funding will be harder to find than the planets themselves.

The larger the planet, the easier it is to detect by any method. Evaluations of detection techniques and search strategies tend to assume optimistically that giant planets are abundant. Among the theorists, G. Wetherill raises the disquieting suggestion that Jupiter and Saturn might be exceptional. His study of the orbital evolution of comets shows that gravitational perturbations by these planets prevent most short-period comets from entering the inner solar system. Without this barrier, Earth would have had hundreds of times more cometary impacts over its history, frustrating the evolution of life. Wetherill's result revives a form of the anthropic principle—if we owe our existence to the presence of giant planets, there is no assurance that they are typical stellar companions. A lack of "Jupiters" around other stars would make the search for planets much more difficult.

The discovery of a single planet, or system of planets, about another star would be an exciting event. Still, the examples of the pulsar planets and our own solar system show the limitations of uniqueness. Real understanding will come only with the discovery and characterization of multiple examples, allowing meaningful comparisons. A search program that can accomplish such a goal will not fall under NASA's rubric of "faster and cheaper." It remains to be seen if the commitment is there.

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Traits Related to Fitness

Ecological Morphology. Integrative Organismal Biology. PETER C. WAINWRIGHT and STEPHEN M. REILLY, Eds. University of Chicago Press, Chicago, 1994. viii, 367 pp., illus. $65 or £51.95; paper, $22.95 or £18.25. Based on a symposium, San Antonio, TX, Dec. 1990.

In 1983, Stevan Arnold formalized an emerging conceptual framework for evaluating the evolutionary importance of morphological and physiological traits. By combining laboratory and field studies of the relationship of morphology to organismic performance with field measurements relating performance to fitness, Arnold suggested a path-analytic method for integrating organismic studies of function with evolutionary analyses of natural selection. Arnold's insight connected functional morphology and physiology with mainstream evolutionary biology and helped stimulate a field of evolutionary physiology. *Ecological Morphology* provides a timely and up-to-date summary of the progress made in this field subsequent to Arnold's proposal.

This book has many appealing aspects, starting with the fact that the editors and most of the authors are younger researchers. As illustrated by Garland and Losos's encyclopedic chapter on squamate reptiles, an impressive body of empirical work has developed on the relationships among morphology, performance, and fitness. Losos and Miles provide a fine overview of the conceptual issues and methodological difficulties involved in analyzing morphological and physiological adaptation in a phylogenetic context, a theme that appears in many chapters. Travis gives an insightful discussion of the challenges of demonstrating the adaptive nature of phenotypic plasticity, focusing on the interesting dichotomy between discrete and continuous plasticity. Wainwright reviews the relationships among morphological variation, performance, and resource use and makes the important point that, in the absence of evidence of the ecological importance of maximum levels of performance, the emphasis placed by functional morphologists and physiologists on maximal performance may be misguided.

As in most collective volumes, the contributions are not well integrated. For example, Norberg's adaptive interpretations of wing design in bats pay little attention to the comparative cautions described by Losos and Miles; in turn, Losos and Miles do not address how comparative methods can best address the ubiquitous morphological plasticity documented by Travis in the next chapter. Ricklefs and Miles nicely document how morphology is often a useful predictor of ecological characteristics, but they also skirt the issue of plasticity. In fact, these juxtapositions provide a service, as they highlight some profitable directions for future research.

Although *Ecological Morphology* provides a good overview of recent advances in evolutionary functional morphology and physiology, it suffers from three limitations that in part reflect shortcomings of the field in general. First, the book contains few nonvertebrate examples: the only discussion of insects comes in Bradley's brief chapter on osmoregulation in mosquitoes; plants and marine invertebrates make substantive appearances only in Denny's summary of his studies of wave-swept shores. Second, there is little discussion of the genetic bases and genetic architecture for variation in morphology or performance, which limits considerably the evolutionary conclusions that may be drawn from these studies. Third and most fundamental, there is a curious lack of ecology (as opposed to evolution) here. Emerson, Greene, and Charnov's chapter provides the most notable exception: by combining biomechanical analyses and foraging theory, the authors derive some intriguing predictions about the morphological scaling of predator-prey interactions. Ricklefs and Miles review multivariate analyses of species packing and community structure. Beyond these contributions and Wainwright's brief discussion of resource use, there is little in the book of direct interest to population and community ecologists. The irony here is that, as initially envisioned by Hutchinson and MacArthur, the study of ecological morphology relates the morphological characteristics of species to patterns of resource use, competition coefficients, species diversity, and other issues central to population and community ecology. In the absence of a compelling conceptual and analytical framework that integrates functional morphology and ecological interactions, analogous to that provided by Arnold for evolutionary studies, "ecological morphology" is likely to remain primarily evolutionary in the near future.

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