Book Reviews

Models of the Early Universe

The Very Early Universe. G. W. GIBBONS, S. W. HAWKING, and S. T. C. SIKLOS, Eds. Cambridge University Press, New York, 1983. vi, 480 pp., illus. $49.50. From a workshop, Cambridge, England, July 1982.

Until very recently, modern theories of cosmology could not intelligently describe that tantalizing first millisecond after the big bang. Now physicists are soberly talking about the first 10^{-35} second. What has changed is that there has been a revolutionary synthesis of cosmology with particle physics. Most of the new work is expertly summarized in *The Very Early Universe*, a collection of 28 papers by participants at a Nuffield workshop.

A number of observed features of the universe have long escaped explanation. Why is it so smooth on the large scale, when insufficient time has elapsed since creation for homogenization (the "horizon problem")? Why is the gravitational energy of the universe approximately balanced with its kinetic energy of expansion, so long after the big bang (the "flatness problem")? Why are there about a billion photons for every proton in the universe? Where are the large number of predicted magnetic monopoles? How did galaxies begin forming, and when? There are other questions. Most of them can be swept under the rug by assuming various and special initial conditions. The papers included in *The Very Early Universe* attempt to provide less embarrassing explanations.

Many of the papers hinge upon the inflationary universe model (1981), nicely reviewed in a contribution by Alan Guth. A false vacuum at the grand unified theory (GUT) epoch ($t \approx 10^{-35}$ second) introduces into Einstein's equations a dominant "cosmological constant," which converts the conventional power-law rate of expansion into an exponential. In the ensuing period of anomalously rapid expansion, causally connected and smooth bits of space stretch to enormous proportions, the curvature of space flattens out to near zero, and the effective distance between magnetic monopoles increases beyond the scale of today's observable universe.

So far so good, but the gradually forming bubbles of true vacuum (today's universe) are too clumpily distributed in this model, and, upon colliding with each other, thermalize the energy released from the bubble walls at a temperature too low for baryon production or nucleosynthesis. A seeming remedy to these problems is the new inflationary universe model (1982), reviewed in mathematical detail by A. D. Linde. The key idea here is to postpone bubble formation until substantial exponential expansion has occurred, so that the entire observable universe fits cozily into a single bubble. A Coleman–E. Weinberg potential with a vanishing second derivative at the origin does the trick. However, this special mathematical property, which allows the GUT Higg's field to roll slowly toward the true minimum of the potential, requires fine tuning of the effective mass parameter of the potential. Whether this fixed-up version of the theory is more palatable than the original is a matter of taste. A number of investigators have converged upon another, perhaps fatal, deficiency in the new inflationary universe theory: the calculated amplitude of density perturbations (leading ultimately to galaxy formation) is too large by about 10^5.

Some investigators have faith that new supersymmetric theories (SUSY's) of particle physics can lead to more natural and workable inflationary epochs. Such a theory is outlined in a paper by Paul Steinhardt. SUSY's, which rest fundamentally on the idea that every fermion has a boson partner, may also possibly solve the "mass hierarchy problem": why is there such an enormous difference between the masses of GUT particles (10^{15} GeV) and those in the laboratory (1 GeV)? A worry repeated often by Frank Wilczek, and sufficiently serious to place everything on tenuous footing, is the lack of any explanation of why the cosmological constant today is at least 108 orders of magnitude lower than it was at the time of the GUT phase transition.

Still, most people now believe in an inflationary scenario of some kind. A clear and astronomically testable prediction of any such model is that the ratio of gravitational energy to kinetic energy of expansion should be virtually one today. Other astronomical facts of life are reviewed in the papers of Wilczek and Martin Rees.

All of this—the excitement, the confusion, and the optimism—comes through in the book. It is a technical book, but several of the review papers should be partly comprehensible to outsiders and are not much out of date. In any case, this is important stuff. Physicists, still high from some recent spectacular successes with partially unified theories, are now set on going all the way: a single theory, with perhaps one free parameter, that explains all the forces and particles of nature and how the universe began to boot.

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Limnology in the Tropics

Lakes of the Warm Belt. COLETTE SERRUYA and UTSA POLLINGHER. Cambridge University Press, New York, 1983. xii, 569 pp., illus. $89.50.

Lake Chad. Ecology and Productivity of a Shallow Tropical Ecosystem. J.-P. CARMOUZE, J.-R. DURAND, and C. LÉVÊQUE, Eds. Junk, The Hague, 1983 (U.S. distributor, Kluwer Boston, Hingham, Mass.). xvi, 575 pp., illus. $137. Monographiae Biologicae, vol. 53.

Lakes in the tropics offer extraordinary variety to the limnologist, and therefore the opportunity to test and expand perspectives largely derived from experience in higher latitudes. Though the scientific potential of tropical waters is far from realized, intensified research during the past 20 years has improved our understanding. The majority of investigations, however, remain largely descriptive and emphasize biological and, to a lesser extent, chemical features; very seldom is geophysics considered. The most comprehensive studies in Africa (for example, those of Lakes Chad, George, Chilwa, and Nakuru), the central Amazon, and southern India bear the stamp of the International Biological Program with its emphasis on biological productivity. Construction of reservoirs (for example, at Lakes Kariba, Volta, and Brokopondo) fostered monitoring programs primarily concerned with fisheries.

Lakes of the Warm Belt is an ambitious attempt to summarize our knowledge of a large subset of tropical and subtropical lakes. The book is divided

into three parts. The first three chapters are intended to provide a general introduction to the geological, climatological, and hydrological features of the so-called warm belt, the region between about 30°N and 30°S. The bulk of the book is a description of aquatic ecosystems in South and Central America, Africa, the Middle East, Southeast Asia, and Australia. The final four chapters are intended to identify characteristic limnological conditions in lakes of the warm belt and to draw comparisons with temperate ecosystems.

Serruya and Pollingher provide an encyclopedic compilation of information available as of 1981. Their treatment is successful to the extent that most lakes or lake districts are described within the bounds of a careful, if not exhaustive, literature review. Lakes of ecological interest with an extant literature that are omitted by Serruya and Pollingher include lakes on the Galápagos Islands, the alpine tarns on Mt. Kenya and Ruwenzori, the Momela lakes (Tanzania), Lake Bosumtwi (Ghana), the Cameroon crater lakes, Lake Sibaya (South Africa), and inland waters of Sri Lanka. These omissions are balanced by the inclusion of major river systems, a welcome addition to a book emphasizing lakes. However, the litany of geographic, physical, chemical, and biological facts provided for each lake or river tends to give the book the air of an annotated bibliography. More serious problems stem from the minor but recurrent factual errors, statements unsupported by evidence, and uncritical acceptance of published information. At least 20 such incidences occur in a 25-page section on the Amazon.

The frequency and extent of vertical mixing play important roles in the ecology of lakes. Serruya and Pollingher argue that for lakes in the warm belt mixing is more a function of wind and rain than of net radiation and air temperature. They emphasize the need for more information on processes that affect circulation, such as convective cooling and motions within the hypolimnion. In fact, as we learn more about the importance of the transparency of the lake and of day-to-day variations in solar radiation as factors influencing stratification, it is becoming apparent that the generalization that variations in net radiation are of minor concern in the tropics is premature.

Analyses of major solutes constitute one of the richest sets of data available for tropical waters. In a too-brief chapter Serruya and Pollingher only touch upon most of the key biogeochemical factors that determine the chemical composition of natural waters. More disappointing is the lack of adequate discussion of nutrients and productivity. Although few investigators in the warm belt have measured supply rates of nutrients or responses of phytoplankton to experimental enrichment, sufficient data are available to evaluate the fertility of tropical waters.

"*Victoria amazonica* in a varzea lake near Alenquer at middle water." [From *Lakes of the Warm Belt*; photo courtesy of H. Sioli]

Although the diversity and distribution of aquatic organisms are especially fascinating in the tropics, the synthesis of the species compilations from numerous lakes is a formidable task. As a first step, Serruya and Pollingher provide useful tables that list common species of plankton and regions where the organisms occur. Their succinct and insightful descriptions of the contrasting food webs in the Amazon floodplain, Lake George, and the pelagic waters of Lakes Kinneret and Tanganyika are provocative examples of the value of combining population and ecosystem investigations.

Lake Chad, one of Africa's largest expanses of freshwater, lies in a basin of internal drainage on the southern fringe of the Sahara. From 1964 until 1978 a multidisciplinary team of French limnologists sponsored by ORSTOM (France's Office of Overseas Scientific and Technical Research) conducted a study of Lake Chad with the objectives of describing the lacustrine environment and the biomass and productivity of the biota. The researchers aspired to arrive at some general conclusions because Lake Chad shares biological and hydrological features with other large African wetlands (such as the Okavango delta and Nile's Sudd). Carmouze, Durand, and Lévêque have edited a thorough treatment of the ORSTOM project at Lake Chad. Fourteen scientists, all of whom are well acquainted with the lake, contributed to the book. It is well illustrated with numerous figures and some photographs and is documented with many tables. A primary strength of the research is the careful identification and quantification of the species inhabiting the lake. Such data are necessary, but in an environment as complex as Lake Chad they are very difficult to obtain. There are considerable differences between the northern and southern basins and among the major habitats, and, in addition, a severe drought midway through the study drastically altered the lake and further increased the problems of adequate sampling.

The book begins with four chapters devoted to the physical, chemical, and climatological features of the lake. As historical background to the modern lake, Servant and Servant's contribution on paleolimnology is terse to the point of being cryptic and would be improved by the inclusion of Maley's palynological results, some discussion of the activities of prehistoric humans in the area, and an

overview of how the evidence from Chad contributes to our understanding of the Quaternary in tropical Africa. The freshness of Lake Chad's waters perplexed even the early European explorers because they expected and usually encountered saline waters in semi-arid closed basins. Carmouze provides a hydrologically and biogeochemically sound explanation for the low salinity of the main body of Lake Chad. The heart of the book is nine chapters that concern the biota and its responses to falling water levels. Six chapters are devoted to the distribution and abundance of the macrophytes, phytoplankton, zooplankton, zoobenthos, fish, and animals associated with macrophytes, and three concern the productivity of the phytoplankton, zooplankton, benthos, and fish. Conspicuous omissions are measurements of macrophyte productivity as well as information on bacterial activity or the periphyton. In fact, the bacteria and periphyton of tropical lakes remain the least studied components of these ecosystems. Three additional chapters attempt to describe the trophic linkages. Although rich in detail, these 12 chapters are shy of integration and synthesis; exceptions are Saint-Jean's treatment of zooplankton and Lemoalle's examination of phytoplankton production. Almost all the literature cited is specific to Lake Chad. The concluding chapter abstracts the book into a succinct summary and contrasts Lake Chad with Lake George (Uganda). However, the discussion is limited to biomass and production values and offers scant insight into ecosystem functions that would help extrapolate the wealth of information about Lake Chad to other wetlands in semi-arid regions.

To the extent that *Lakes of the Warm Belt* and *Lake Chad* are representative of limnological research on tropical lakes, several conclusions are apparent. Although the continuation of descriptive studies founded upon careful taxonomy and sampling is essential, experimental testing of well-formulated hypotheses is definitely required. Conspicuous gaps in information concern the role of bacterial activity in nutrient recycling, the influences of land use on nutrient supply, and, in turn, how nutrient and food web dynamics interact to effect water quality and harvestable resources. The intensifying exploitation of tropical inland waters makes the need for such research especially urgent.

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Creative Personages

Springs of Scientific Creativity. Essays on Founders of Modern Science. RUTHERFORD ARIS, H. TED DAVIS, and ROGER H. STUEWER, Eds. University of Minnesota Press, Minneapolis, 1983. x, 344 pp., illus. $32.50.

Springs of Scientific Creativity contains 12 papers on major figures in the growth of the exact sciences from the time of Galileo and Newton to that of Michael Polanyi and John von Neumann with emphasis on 19th- and early 20th-century figures. The papers are unified by their biographical focus and by an emphasis on scientific style. Only about half of them explicitly focus on the notion of creativity that gives the book its title. Another four make bows in that direction by appending concluding remarks on creativity to papers that are largely anecdotal accounts of the research programs of the traditional "founders" chosen for treatment.

Thomas Settle's little gem of a paper about experiments on falling bodies described by Galileo and his predecessors in 16th-century Italy makes not one direct reference to "creativity." But it deserves to be read by a wide audience of physicists, general science students, and historians and psychologists interested in science. (I wouldn't dream of disclosing his strategy and spoiling everyone else's pleasure.)

Most of the remaining papers are curiously old-fashioned in their approach. They are unabashedly hero-worshiping in tone; they freely attribute the old 19th-century romantic characteristic of unanalyzable "genius" to their subjects; and they seem to agree about little except that creativity is a characteristic of individuals and that, though it may be described in particular cases, it is something that cannot be bound by rules.

The authors seem to be aware of the recent psychological literature on scientific creativity. Stanley Goldberg, writing on Einstein, at least cites some of it before he asserts that "creative thinking has always been a mystery [and] it must remain so" (p. 233), and others refer to cognitive styles, tolerance for frustration, and the bringing together of divergent traditions in creative acts. But most are implicit advocates of Francis Galton's Victorian theory of hereditary genius. (C. W. F. Everitt goes back four generations in the Clerk and Maxwell clans.) Only Everitt attempts to bring psychoanalytic insight to bear on the issue of creativity, offering some fascinating but highly speculative comments on Maxwell's relationship to his parents, his masochistic streak, and his extraordinary tenacity in carrying out "painful" calculations.

Paradoxically, it is Thomas Hughes, the author who most self-consciously draws from romantic literary analyses, who offers the most interesting analytic suggestions regarding creativity. He develops an imaginative comparison of the creativity of Elmer Sperry with that of Thomas Mann's fictional composer, Adrian Leverkühn. Like his colleagues in this volume, Hughes denies that we can find a "method of creativity" or that creativity can be "managed" in any traditional sense. But instead of dropping the issue there, he draws suggestions from Sperry and Mann that invite us to view creativity as a form of social deviance and that therefore locate some necessary but not sufficient conditions for creativity in the domain of *social* psychology.

In spite of the fact that the book won't offer many new insights for the professional psychologist who works on scientific creativity or for the professional historian of modern physics, it offers a very nice introduction to the current biographical tradition in the history of science; so I would have no hesitation about handing it over to a bright and curious student of physics who wants to learn about the mythic figures of that discipline. All of the papers are gracefully written, and all can be read by a general scientifically literate audience.

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Environmental Errors

The Deer Wars. The Story of Deer in New Zealand. GRAEME CAUGHLEY. Heinemann, Auckland, New Zealand, 1983 (U.S. distributor, ISBS, Beaverton, Ore.). viii, 187 pp. + plates. $17.95.

We are all aware that heavy browsing by herbivores leads to soil erosion. Right? Not necessarily, says Graeme Caughley. He recounts what happened when deer were released in the 19th century in New Zealand and spread through the mountain forests.

From the beginning of the present century it was accepted that New Zealand forests had evolved in isolation, protected from serious herbivore damage. Naturally, deer were viewed as wholly destructive—at best they prevented regeneration of forest, at worst they were the