powerful constraints as income, information, and the distribution of a technology. "The sensibility of users," he tells us, "can thus operate only within narrow social and cultural limits" (p. 18). That would seem to be a serious qualification.

Still, *America Calling* does serve to remind us that "technology" is not always and everywhere an indivisible behemoth controlling modern life. Different technologies have different meanings in different circumstances. People can even use them on occasion, as may have been the case with the telephone, for the "maintenance, even enhancement, of past practices" (p. 272). Free will flows, even if only within narrow channels.

American Calling is a potpourri of sociology and social history. It offers little in the way of meaningful comparisons with other societies except Canada, if that counts as other. There are eight appendixes on method and data, as well as separate sections of notes, of bibliography, and of illustrations, making it difficult for the reader to integrate those materials with the text. The text is sometimes breezy, sometimes ponderous, often repetitious. The author freely mixes bits of data, theory, and speculations from many places and time periods. This is not a book notable for its analytical or methodological rigor. Here social science meets journalism, and the dress is casual. The results are often fascinating and sometimes surprising, if not altogether satisfying.

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Collapsed Stellar Objects

High-Energy Radiation from Magnetized Neutron Stars. PETER MÉSZÁROS. University of Chicago Press, Chicago, IL, 1992. xiv, 531 pp., illus. $98; paper, $39.95. Theoretical Astrophysics.

The study of collapsed stellar objects (white dwarfs, neutron stars, and black holes) is a cornerstone of modern high-energy astrophysics. Neutron stars in particular have been objects of intense research since the discovery of radio pulsars in 1967. It is remarkable that most of the theoretical literature on neutron stars also dates from this period. Theoretical physicists had already recognized by 1932 that a star several times more massive than the sun might, after exhausting its nuclear fuel, undergo a supernova explosion and collapse to a degenerate neutron core: essentially a stellar mass, compressed within a sphere whose radius is only about 10 kilometers. However, perhaps because of the exotic nature of these objects, many astrophysicists doubted that neutron stars could actually be formed in nature, and if they did exist it was expected that they might be difficult to detect.

These doubts quickly vanished in the late '60s as it became apparent that neutron stars provided a natural (and essentially the only viable) model of pulsars. Soon afterward, neutron stars were also identified as the sources of pulsed x-ray emission observed from numerous binary-star systems. For most of the past decade they were also considered the most likely sources of the mysterious gamma-ray bursts (sporadic flashes of gamma rays scattered over the sky, which have not yet been identified with known celestial objects). To date over 500 radio pulsars and more than 30 binary x-ray sources have been discovered. In several cases neutron stars have also been detected as optical or gamma-ray sources, including some reported observations at TeV and even PeV energies. Most of these discoveries have generated at least as many theoretical puzzles as they have resolved.

In view of the continuing rapid growth of both the observational and the theoretical literature on neutron stars, it is not surprising that only a few authors have ventured to write textbooks or monographs on the physics of these objects. Peter Mészáros has provided a noteworthy contribution to the available theoretical books that in several ways complements the treatments found in *Black Holes, White Dwarfs, and Neutron Stars* by Shapiro and Teukolsky and *Theory of Neutron Star Magnetospheres* by Michel. In particular (and in spite of some misleading statements on the back cover) Mészáros is primarily concerned with electromagnetic processes in the magnetospheres of neutron stars, as opposed to the physics of their internal structure and evolution. Though his first and last chapters provide some background on these topics, he does not attempt the detailed treatment found in Shapiro and Teukolsky. On the other hand, he presents a more complete discussion of the physical processes underlying magnetospheric phenomena than can be found in either of the works cited above.

Some other comparisons may also be in order. Shapiro and Teukolsky's book was designed as a textbook, with explicit derivations of most fundamental results and problem sets. Mészáros has produced a monograph, with no problem sets and much less effort to be self-contained. His book, like that of Michel, seems most suitable as a professional reference. His treatment differs from Michel's, however, in that he clearly separates the discussion of fundamental physical processes in neutron star magnetospheres from surveys of specific models of pulsars or other sources. Moreover, Mészáros tends to cover the physics at a more advanced level, with few fundamental preliminaries. It is in fact surprising that he suggests his intended audience should include beginning graduate students and even advanced undergraduates. The general level, at least in the first half of the book, seems rather to exclude all but advanced graduate students and researchers in the field.

As a professional reference work, however, the first six chapters are uniquely valuable for their systematic coverage of plasma effects, radiation transfer, and quantum electrodynamics in strong magnetic fields. Mészáros treats most of these topics in considerable depth and provides a compendium of many useful results. Readers with strong backgrounds in classical electrodynamics, plasma physics, and quantum mechanics (including relativistic quantum electrodynamics) should be able to follow his development of the theory, although there are numerous annoying misprints in the equations and even occasional verbal glitches in the text.

The second half of the book is devoted to discussions of astrophysical settings in which neutron stars have apparently been detected. Mészáros devotes complete chapters to accreting x-ray sources in binary systems, isolated pulsars, gamma ray bursters, and the controversial extremely high-energy sources. He states in his introduction that this material is likely to become outdated more rapidly than the first half of the book, and recent observations of gamma-ray burst sources in particular have already proven him correct. Results accumulated since 1991 by the Burst And Transient Source Experiment (BATSE) on the Compton Gamma Ray Observatory (CGRO) have revealed an isotropic but inhomogeneous burst distribution (with a paucity of weaker and presumably more distant sources), which seems to rule out galactic neutron stars as source candidates (except perhaps for a very extended halo population). At present the jury is still out on the true nature of burst sources, but many of the neutron star models discussed by Mészáros are now more doubtful than they appeared to be just a year ago.

Ongoing observations by CGRO, the Roentgen Satellite (ROSAT), and other detectors will almost certainly force similar revisions of the other specific models Mészáros describes. It is also quite possible that many aspects of the current models will survive. In any event, researchers should find that this book will have lasting value as a comprehensive reference on the underly-

ing physical processes responsible for the radiation emitted by neutron stars.

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Palynology

Pollen and Spores. Patterns of Diversification. S. BLACKMORE and S. H. BARNES, Eds. Clarendon (Oxford University Press), New York, 1992. xii, 391 pp., illus. $120. Systematics Association Special Volume 44. From a symposium, London, March 1990.

This volume commendably attempts to put palynological research into the context of biodiversity studies. Although the book largely falls short of this goal, the editors do make a more realistic appeal for palynologists to go beyond mere static descriptive work by striving to interpret and analyze their data as part of broader systematic studies, and this aim is met in many of the chapters. In accordance with this intent, the book has three major themes: ontogenetic processes that give rise to morphologic diversity, systematic analyses of extant plants, and the fossil record of diversification through geologic time, the latter two of which have become entangled because of the increased use of both fossil and extant taxa in rigorous cladistic analyses.

With regard to ontogeny, several chapters consider developmental data in the context of a phylogenetic "survey." In one of these, Gabarayeva reviews patterns of three aspects of pollen wall development among several "primitive" angiosperms. (The term "primitive" should have been clarified; in my view it should refer only to character states, not taxa.) Gabarayeva's most interesting conclusion is that, as evidenced by careful developmental and chemical studies, endexine is present in at least several "primitive" angiosperms, perhaps refuting the oft-cited hypothesis of its secondary evolutionary origin in the flowering plants. Other chapters on ontogeny are oriented more toward describing underlying cellular or subcellular processes. Heslop-Harrison and Heslop-Harrison give a nice review of aspects of the structure, chemistry, and function of apertural intine in relation to pollen tube growth. The examples they cite point out the diversity of intine stratification and demonstrate some interesting correlations of structure with function, such as the outer, resistant pectic layer of *Eucalyptus* serving as an apparent adaptation to drought and heat stress. In another chapter, Knox and Ducker describe plant sperm cells, beginning with a thorough historical survey and ending with recent advances in descriptions and technique. Although the authors do not adequately address the "evolution of gametes" from a phylogenetic perspective, they do review recent findings on male gametes in angiospermous systems, including evidence for the "male germ unit" as a structural entity, sperm cell size or organelle dimorphism and predetermination, and sperm surface protein receptors and motility.

Paleobotanical contributions to the volume include the description of spores isolated from sporangia of several rhyniophytes of the Silurian period by Fanning *et al.* In addition to aiding in stratigraphic identification of palynomorphs, these *in situ* observations of spores with macrofossils (some newly described) could become particularly significant in analyses tracing the early evolution of land plants from "bryophyte" ancestors. In another chapter Gray summarizes our knowledge regarding fossil tetrahedral spore tetrads from the mid-Ordovician period, clarifying a past misinterpretation of morphology and suggesting a possible evolutionary transition between spore tetrads and early trilete spore monads. Gray emphasizes the significance of these tetrahedral spore tetrads in understanding land plant evolution, as they represent microfossil remains of a land flora that evolved some 40 to 50 million years prior to the first Silurian land plants known from macrofossils.

Heterospory has widely been accepted as the first step in seed evolution, on the basis of the sequence of structures appearing in the fossil record. Chaloner and Hemsley critique an alternative hypothesis that has been suggested by some authors: that endospory and retention of homosporous spores preceded heterospory. From their study of wall ultrastructure of megaspores from early free-sporing and seed fossil plants, the authors conclude that the evolution of seeds directly from homosporous ancestors was unlikely because the megaspore exine of at least some early seed plants is as thick as or thicker than that of early heterosporous plants, a primitive retention of non-seed heterosporous plants. Friis *et al.* discuss the morphology of stamens and *in situ* pollen of mid- to late-Cretaceous angiosperms. General trends include the evolution of a laminar filament-connective (in some Magnoliidae), formation of a clear differentiation between filament and connective, loss of the apical connective appendage, and evolution of strictly longitudinal dehiscence (from laterally valvate dehiscence) in Rosidae and Dilleniidae.

The determination of evolutionary polarity of pollen characters is addressed in a chapter by Zavada. One quibble with terminology is that his use of the term "outgroup method" to denote the commonality principle has, from my perspective, been defunct for some time; what Zavada terms "parsimony method" is what most systematists today just call "outgroup comparison," in which parsimony serves as a logical foundation. In any case, Zavada does a good job in applying outgroup comparison (based on parsimony) to assess the polarity of a number of pollen features in the angiosperms, utilizing several unresolved, non-angiospermous outgroups. Interestingly, he concludes that information from dispersed fossil pollen (especially pre-Cretaceous angiosperm-like pollen) may actually obscure phylogenetic relationships because it introduces additional variation in the unresolved outgroups, rendering some previously inferred polarities ambiguous. However, this limitation may be overcome by the use of additional characters and a greater number of taxonomic units (including dispersed pollen taxa) in an explicit phylogenetic analysis, in which outgroup interrelationships are better resolved. An example of such an explicit analysis is that of Doyle and Hotten, who provide a careful, detailed evaluation of early angiosperm pollen morphology and ultrastructure within a phylogenetic context. In part on the basis of a previous study (by Donoghue and Doyle), the authors place various fossil pollen types within one or another of five major angiosperm lineages, by correlation with modern forms or by hypothesizing evolutionary gradation series. Although considerable ambiguity regarding angiosperm relationships remains, this study exemplifies the insight that may be gained in studying fossil pollen in terms of a cladistic framework.

The chapters on systematic studies of extant taxa include some standard papers plus some with intriguing new approaches. An exciting methodology for quantifying variation in pollen sculpturing is presented by Vezey *et al.* The authors measure ultrastructural parameters from numerous scanning electron micrographs (using a video-interfaced image analysis system) and analyze the data using UPGMA. This study may serve as a model for quantifying data and more carefully justifying discontinuity of pollen character states in systematic studies. Finally, Cox *et al.* describe an interesting computer simulation based on three-dimensional random-search theory. Their mathematical predictions conform to the occurrence of filiform pollen grains in subsurface water-pollinated angiosperms.

In summary, this book would be worthy of selective reading to many, particularly those interested in development, land plant phylogeny, and application of new palynological techniques.

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