contain extensive reviews, but others report original research results. Papers on floral rewards and cues review extensive information on such intriguing traits as buzz-pollination (the fastest mechanism of pollen collection), dummy anthers, stigmas as electrostatic pollen collectors, oils as rewards for pollinators, colors as perceived by an insect's eye, and patterns of sugar constituents in nectar (high sucrose in long-tubed flowers and high hexose in open flowers). All mention the lack of information on how different types of rewards or cues influence pollinators. Intraspecific variation in rewards due to genetic or environmental effects emerges as a major topic that remains to be explored.

Pollinator behavior and species interactions are covered mostly in reports of specific research studies. The importance of competition among plants for pollination remains controversial, but an emerging consensus here from studies of natural populations is that it is quality of pollen, more commonly than number of pollinator visits, that limits seed set. Carpenter and Ford both suggest that bird-pollinated plants may seldom be pollinator-limited. Waser presents some exciting new data showing flip-flops in flowering phenologies of two unrelated plant species that share hummingbird pollinators. This is the only good example of character displacement between unrelated species due to pollinator sharing, although Waser's studies also suggest that the phenomenon is due to selection from interspecific pollen transfer and not from competition for pollinator visits. In contrast, in agricultural systems competition among plants for honey bee visits recurs as a major problem for obtaining hybrid seeds in crops. Selection for male sterility in flowers is often accompanied by reduced production of nectar and fragrance, and this is often correlated with changes in floral cues that are discriminated by honey bees. Varieties that provide lower rewards are visited less often and seed set is reduced. The editors have done a great service by including two reviews of the extensive agricultural research on pollination and plant breeding that will bring this information to the attention of other ecologists.

The number of new research studies reported here is a tribute to the growth and vitality of pollination biology. Such studies on natural populations report on pollen tube competition and timing, the maintenance of pollinated flowers to increase pollinator attraction, staggered phenologies that promote intraspecific bee movements within tropical tree species, and possible floral mimicry between two plant species. As one might expect, a major conclusion that arises from reading this book is that plant-pollinator systems are complex with many fascinating but often poorly known components.

Although this book will be of the most direct value to pollination biologists, it should open up the possibilities of using plant-pollinator systems to study many basic problems in ecology and evolution. Its influence will certainly be felt as an influx of information into many different areas of research.

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The Structure of the Universe

Relativistic Astrophysics. Vol. 2, The Structure and Evolution of the Universe. YA. B. ZEL'DOVICH and I. D. NOVIKOV. Gary Steigman, Ed. University of Chicago Press, Chicago, 1983. xxxiv, 718 pp., illus. $65. Translated from the Russian edition (Moscow, 1975) by Leslie Fishbone.

Cosmology is a speculative field. There are few facts on which to base a theory. As one proceeds to probe earlier and earlier epochs of the universe, the data become sparser and sparser. Finally, one is left, almost literally, with hot air.

As it happens, the cooled relic radiation from the fiery beginnings of our universe was discovered in 1965 at microwave frequencies by Arno Penzias and Robert Wilson. They verified one of the great predictions of modern physics, second in cosmology only to the prediction of the expansion of the universe itself. Georges Lemaître deserves much of the credit for this latter idea, but the trail was clearly blazed several years earlier, in 1922, by the Soviet scientist Alexandre Friedman. It was Friedman's discovery of the expanding universe models, due to a much regretted oversight of Einstein's, that heralded the emergence of Soviet cosmology into the mainstream of modern physics.

Ya. B. Zel'dovich and I. D. Novikov are worthy inheritors of this tradition. Both have played major roles in developing the theory of the large-scale structure of the universe. Novikov recognized that the fireball radiation might be measurable a year before its serendipitous discovery. Both authors are well known to Western cosmologists.

Their latest book provides a thorough account of cosmic evolution. Its scope ranges from the earliest instants of the big bang to the formation and clustering of galaxies. Its level is appropriate for beginning graduate students, and it provides a broad introduction to much of modern cosmology. Some knowledge of general relativity is required, but not at a very sophisticated level. Not surprisingly, it highlights contributions by the authors and their Soviet colleagues, but it also gives a fair account of results obtained in the West.

One theme that pervades the book is the need to confront cosmological theories with observation. The microwave background radiation has been a source of continuing employment for aspiring cosmologists. The seed fluctuations from which galaxies emerged must have left telltale traces in the apparently uniform background radiation. Apart from a variation over 180° that is associated with the motion of our galaxy, no trace of anisotropy is seen in the radiation to within one part in 10^4. A race is now under way between forthcoming Soviet and U.S. satellite experiments to measure the radiation fluctuations, which according to the cosmologists must ultimately be detectable.

The Zel'dovich and Novikov book provides a detailed description of how such fluctuations arise. Once there were no stars, no galaxies; matter was everywhere a homogeneous soup. But it could not have been completely uniform, otherwise structure would not have evolved by the present epoch. The gravity field of the seed fluctuations in the matter slightly perturbed the fireball radiation, much as a light ray from a distant star is slightly deflected by close passage to the sun.

Such a history of minuscule deviations from uniformity is a conservative view of our past. A radical view is that the universe originated from an extreme state of chaos and nature provided a suitable filter. Zel'dovich and Novikov tell us how the cosmic background radiation constrains such hypotheses. Exotic possibilities remain for the first second of the universe. One can imagine a universe collapsing in one direction yet expanding in another, rather like a tube of toothpaste when squeezed, only to periodically reverse this behavior. As long as such bizarre behavior eventually dies away, there need be no contradiction with the observable universe.

Gravity waves could be one surviving manifestation of primordial chaos. Such waves manifest themselves by generating a transient acceleration of any object in their path. Cosmological gravity

waves are expected to have wavelengths well beyond the scale of any terrestrial detector; indeed galaxies themselves could respond to megaparsec-long waves. Perhaps the random to-and-fro motions of galaxies could be induced by such waves. This would require a very considerable mass fraction of the universe to be present in this exotic form of energy, and one can learn in the book under review how such exotic possibilities are constrained by the harsh reality of observational cosmology.

Along with such fascinating speculations, Zel'dovich and Novikov provide a thorough grounding in the basics of the hot big bang theory. For the translation the 1975 Russian edition has been considerably improved and updated by the authors in close collaboration with Gary Steigman and Kip Thorne. The long history of the book shows, in that recent developments involving grand unification symmetry breaking, baryon creation, and inflation are omitted. A more serious fault is the number of typographical or mathematical errors in the equations, along with inconsistencies in notation. But the persevering student will be well rewarded. The book provides a first-rate introduction for the reader who wishes to explore the origins and evolution of the large-scale structure of the universe.

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Books Received

History of Science

Astronomical Cuneiform Texts. Babylonian Ephemerides of the Seleucid Period for the Motion of the Sun, the Moon, and the Planets. O. Neugebauer. Springer-Verlag, New York, 1983. Three volumes. xl, 512 pp., and viii, 256 pp., illus. $88. Sources in the History of Mathematics and Physical Sciences 5. Reprint, 1955 edition.

Le Développement de la Géologie de Langue Française dans Ses Relations Internationales des Origines à la Mort de Cuvier (1832). Laboratoire d'Ethnobotanique, Muséum National d'Histoire Naturelle, Paris, 1982. 147 pp. Paper, 90 F. *Histoire et Nature*, Nos. 19–20. From a symposium, July 1980.

Encyclopedia of Antique Scientific Instruments. John FitzMaurice Mills. Facts On File, New York, 1983. 255 pp., illus., + plates. $35.

Hensing, 1719. An Account of the First Chemical Examination of the Brain and the Discovery of Phosphorus Therein, Set Against the Background of Europe in the 17th and Early 18th Centuries. A Source Book in the History of Neurochemistry. Donald B. Tower. Raven, New York, 1983. xvi, 407 pp., illus. $38.

History and Philosophy of Science. Selected Papers. Joseph W. Dauben and Virginia Staudt Sexton, Eds. New York Academy of Sciences, New York, 1983. viii, 168 pp., illus. Cloth or paper, $33. Annals of the New York Academy of Sciences, vol. 412. From meetings, 1979–1981.

Knowledge and Society. Studies in the Sociology of Culture Past and Present. A Research Annual. Vol. 4, Current Perspectives on the History of the Social Sciences. Robert Alun Jones and Henrika Kuklick, Eds. Jai Press, Greenwich, Conn., 1983. xii, 292 pp. $45.

Maxwell on Saturn's Rings. Stephen G. Brush, C. W. F. Everitt, and Elizabeth Garber, Eds. MIT Press, Cambridge, Mass., 1983. xiv, 199 pp., illus. $25.

Nineteenth-Century Scientific Instruments. Gerard L'E. Turner. Sotheby Publications, London, and University of California Press, Berkeley, 1983. 320 pp., illus. $60.

Patrick Matthew and Natural Selection. Nineteenth Century Gentleman-Farmer, Naturalist and Writer. W. J. Dempster. Paul Harris, Edinburgh, 1983. 156 pp. + plates. £8.95.

Roger Bacon's Philosophy of Nature. A Critical Edition, with English Translation, Introduction, and Notes, of *De multiplicatione specierum* and *De speculis comburentibus*. David C. Lindberg. Clarendon (Oxford University Press), New York, 1983. lxxxii, 420 pp., illus. $84.

State of the Art. A Photographic History of the Integrated Circuit. Stan Augarten. Ticknor and Fields, New Haven, Conn., 1983. xvi, 79 pp. $17.95; paper, $9.95.

Statistical Physics and the Atomic Theory of Matter. From Boyle and Newton to Landau and Onsager. Stephen G. Brush. Princeton University Press, Princeton, N.J., 1983. x, 356 pp. $45; paper, $14.50. Princeton Series in Physics.

Telescopes, Tides, and Tactics. A Galilean Dialogue about the *Starry Messenger* and Systems of the World. Stillman Drake. University of Chicago Press, Chicago, 1983. xx, 236 pp., illus. $22.50.

The Uses of Science in the Age of Newton. John G. Burke, Ed. University of California Press, Berkeley, 1983. xxii, 204 pp. $22.50. Publications from the Clark Library Professorship, UCLA, 8.

General History

Architecture and the Crisis of Modern Science. Alberto Pérez-Gómez. MIT Press, Cambridge, Mass., 1983. xii, 400 pp., illus. $30. Revised translation of the Spanish edition (1980).

The Electrical Workers. A History of Labor at General Electric and Westinghouse, 1923–60. Ronald W. Schatz. University of Illinois Press, Urbana, 1983. xvi, 281 pp. + plates. $22.95. The Working Class in American History.

Kikkoman. Company, Clan, and Community. W. Mark Fruin. Harvard University Press, Cambridge, Mass., 1983. xvi, 358 pp., illus. $30. Harvard Studies in Business History 35.

Mystical Bedlam. Madness, Anxiety, and Healing in Seventeenth-Century England. Michael MacDonald. Cambridge University Press, New York, 1983. xviii, 323 pp. Paper, $14.95. Cambridge History of Medicine. Reprint, 1981 edition.

Princes and Peasants. Smallpox in History. Donald R. Hopkins. University of Chicago Press, Chicago, 1983. xx, 380 pp., illus. $25.

Probability and Certainty in Seventeenth-Century England. A Study of the Relationships between Natural Science, Religion, History, Law, and Literature. Barbara J. Shapiro. Princeton University Press, Princeton, N.J., 1983. x, 348 pp. $35.

Revolution in Time. Clocks and the Making of the Modern World. David S. Landes. Belknap (Harvard University Press), Cambridge, Mass., 1983. xx, 482 pp. + plates. $20.

Speaking for Nature. How Literary Naturalists from Henry Thoreau to Rachel Carson Have Shaped America. Paul Brooks. Drawings by the author. Sierra Club Books, San Francisco, 1983 (trade distributor, Random, New York). xvi, 304 pp. Paper, $8.95. Reprint, 1980 edition.

Stagecoach East. Stagecoach Days in the East from the Colonial Period to the Civil War. Oliver W. Holmes and Peter T. Rohrbach. Smithsonian Institution Press, Washington, D.C., 1983. viii, 220 pp., illus. $17.50.

The Structure of American Medical Practice, 1875–1941. George Rosen. Charles E. Rosenberg, Ed. University of Pennsylvania Press, Philadelphia, 1983. viii, 152 pp. $22.50; paper, $9.95.

Which Road to the Past? Two Views of History. Robert William Fogel and G. R. Elton. Yale University Press, New Haven, Conn., 1983. viii, 136 pp. $14.95.

Animal Groups

Amphibians and Reptiles of New England. Habitats and Natural History. Richard M. DeGraaf and Deborah D. Rudis. Drawings by Abigail Rorer. University of Massachusetts Press, Amherst, 1983. viii, 85 pp. $14; paper, $6.95.

Birds of North America. A Guide to Field Identification. Chandler S. Robbins, Bertel Bruun, and Herbert S. Zim. Illustrated by Arthur Singer. 2nd ed. Golden (Western Publishing Company), New York, 1983. 360 pp. $10.95; paper, $7.95.

Birds of Prey of Britain and Europe. Ian Wallace. Paintings by Ian Willis. Oxford University Press, New York, 1983. viii, 88 pp. $15.95.

Blue Butterflies of the *Lycaenopsis* Group. J. N. Eliot and A. Kawazoé. British Museum (Natural History), London, 1983 (U.S. distributor, Natural History Books, Woodland Hills, Calif.). 309 pp., illus., + plates. $63.

British and Other Freshwater Ciliated Protozoa. Part 2, Ciliophora: Oligohymenophora and Polyhymenophora. Keys and Notes for the Identification of the Free-living Genera. Colin R. Curds, Michael A. Gates, and David McL. Roberts. Published for the Linnean Society of London and the Estuarene and Brackish-water Sciences Associaton by Cambridge University Press, New York, 1983. viii, 474 pp., illus. $69.50. Synopses of the British Fauna, No. 23.

British Polyclad Turbellarians. Keys and Notes for the Identification of the Species. Stephen Prudhoe. Published for the Linnean Society of London and the Estuarine and Brackish-water Sciences Association by Cambridge University Press, New York, 1983. viii, 77 pp., illus. $24.95. Synopses of the British Fauna, No. 26.

A Catalogue of the Araneae Described between 1940 and 1981. Paolo M. Brignoli. P. Merrett, Ed. Published in association with the British Arachnological Society by Manchester University Press, Dover, N.H., 1983. xii, 755 pp. $90.

Check List of the Lepidoptera of America North of Mexico, Including Greenland. Ronald W. Hodges *et al.*, Eds. Classey, London, and Wedge Entomological Research Foundation, Washington, D.C., 1983. xxiv, 284 pp. Paper, $88.

Fishes of Wisconsin. George C. Becker. University of Wisconsin Press, Madison, 1983. xii, 1052 pp., illus. $75.

Garden Birds of the World. Michael Chinery. Illustrated by Maurice Pledger. Dodd, Mead, New York, 1983. 108 pp. $19.95.

Handbook of Canadian Mammals. Vol. 1, Marsupials and Insectivores. C. G. van Zull de Jong. Illustrated by Brenda Carter, C. H. Douglas, and E. van Ingen. National Museum of Natural Sciences, Ottawa, 1983 (U.S. distributor, University of Chicago Press, Chicago). 210 pp. Paper, $19.95.

Mammals of the Northern Great Plains. J. Knox Jones, Jr., *et al.* University of Nebraska Press, Lincoln, 1983. xii, 379 pp., illus. $32.50.

The Mollusca. Academic Press, New York, 1983. Vol. 3, Development. xx, 352 pp., illus. $39.50. Vol. 4, Physiology, Part 1. xx, 523 pp., illus. $65. Vol. 5, Physiology, Part 2. xx, 500 pp., illus. $62.

Revision of the African Whiteflies (Aleyrodidae), Mainly Based on a Collection from Tchad. Rosita M. Bink-Moenen. Nederlandse Entomologische Vereniging, Amsterdam, 1983. 211 pp., illus. Paper, $25. Monografieën van de Nederlandse Entomologische Vereniging, No. 10.

Saltwater Fishes of Texas. A Dichotomous Key. Edward O. Murdy. Bland Crowder, Ed. Illustrations by Janice D. Fechhelm. Texas A&M University Sea Grant College Program, College Station, 1983. vi, 220 pp. Spiral bound, $7.

The Sierra Club Handbook of Whales and Dolphins. Stephen Leatherwood and Randall R. Reeves. Paintings by Larry Foster. Sierra Club Books, San Francisco, 1983 (trade distributor, Random, New York). xviii, 302 pp. $25; paper, $12.95.

Treatise on Invertebrate Paleontology. Part G, Bryozoa, Revised. Vol. 1, Introduction, Order Cystoporata, Order Cryptostomata. R. S. Boardman *et al.* Geological Society of America, Boulder, Colo., and University of Kansas, Lawrence, 1983. xxvi, 626 pp., illus. $48.

Vanishing Eagles. Philip Burton. Illustrated by Trevor Boyer. Dodd, Mead, New York, 1983. 140 pp. $25.

Anthropology and Archeology

Adaptive Responses of Native Amazonians. Raymond B. Hames and William T. Vickers, Eds. Academic Press, New York, 1983. xvi, 518 pp., illus. $49. Studies in Anthropology.

Advances in Archaeological Method and Theory. Vol. 6. Michael B. Schiffer, Ed. Academic Press, New York, 1983. xiv, 359 pp., illus. $37.50.

Advances in World Archaeology. Vol. 1. Fred Wendorf and Angela E. Close, Eds. Academic Press, New York, 1982. xxxii, 372 pp., illus. $37.50.

Archaeological Hammers and Theories. James A. Moore and Arthur S. Keene, Eds. Academic Press, New York, 1983. xviii, 312 pp., illus. $32.50. Studies in Archaeology. From a symposium.

Archaic Hunters and Gatherers in the American Midwest. James L. Phillips and James A. Brown, Eds. Academic Press, New York, 1983. xviii, 349 pp., illus. $45. New World Archaeological Record. From a symposium, Chicago, Oct. 1980.

Boreal Forest Adaptations. The Northern Algonkians. A. Theodore Steegmann, Jr., Ed. Plenum, New York, 1983. xii, 360 pp., illus. $49.50.