tical distribution patterns of selected organisms. The emergent distribution pattern presented in *Life between Tidemarks on Rocky Shores* is one of tripartite zonation including a supralittoral fringe which contains little more than lichens; a midlittoral zone consisting most importantly of sessile animals such as barnacles, mussels, anemones, and tubeworms; and, finally, an infralittoral fringe usually consisting of algae in temperate regions and ascidians or corals in warmer regions.

It is generally assumed that science proceeds from descriptions of patterns toward an understanding of the mechanisms producing the observed patterns. Ideally the analyses of these mechanisms are based on controlled experimentation, and the synthesis should be sufficiently general to relate to other, similar patterns in nature. The rocky intertidal community is unique among natural communities, as a strong, experimentally based, functional appreciation of its organization is emerging. Controlled experimentation is allowing rigorous definition of the trophic and competitive roles of many populations and of their effects on the growth and regulation of other populations in the community. Unfortunately the Stephensons were little interested in such functional questions, and *Life between Tidemarks on Rocky Shores* contributes little in this direction; it does, however, add valuable comparative observations which facilitate generalization from experimental studies of restricted areas. For example, experimental studies have shown that the asteroids, carnivorous gastropods, and larger barnacles and mussels are functionally important species in the temperate midlittoral zone, and it is satisfying though not new or unexpected to learn that structural parallels occur in many widely separated intertidal communities, suggesting consistency in the functional roles that have been described. Probably the most important long-term contribution of the book is that it will serve as a vehicle by which other functional relationships discovered in the future in restricted areas can be generalized to other similar habitats around the world.

The descriptive value of this book is limited, however, because the Stephensons did not quantify their observations. Since the book describes seashore visits made 25 to 45 years ago, quantification could have provided a basis for comparison with the current status of these shores and thus given insights into long-term population fluxes. In this respect the book fails. For example, the sea otter (*Enhydra lutris*), once considered extinct, has made a remarkable recovery along the central California seashore. Because sea otters decimate populations of mussels, abalones, and sea urchins, they exert a profound effect on the entire nearshore environment. Naturalists have watched the recovery of the otter population with pleasure, but have failed to document community changes, and no quantitative data exist describing the affected habitat before the recovery of the otter population. Because the Stephensons visited Pacific Grove in 1947, one might hope to find in their description a measure of the situation before the otter recovery. Unfortunately, the book describes the abalone as "common" and the sea urchins as "astonishingly abundant," "pavements of thousands of individuals," and occurring in "countless numbers." Not even these rudimentary levels of quantification were achieved when the Stephensons visited the coast of Nova Scotia, which is thought to be strongly affected by the current overexploitation of the lobster population, which by its predation on the urchins is thought to have kept the urchins from overexploiting the kelp previously. Exotic algae, *Codium fragile* in the Atlantic and *Sargassum muticum* in the Pacific, have invaded the coasts of the United States and reputedly displaced native populations; again it is not possible to evaluate preinvasion populations from the relevant chapters. Finally, efforts to evaluate large-scale changes from the photographs lead to frustration, as most of the photographs are not dated and in many cases were taken by other people, so that their dates cannot be deduced from the dates of the Stephensons' visit.

For these reasons the book has restricted scientific value, but still it can be recommended to naturalists interested in nearshore biology. It is carefully written and attractively produced; it makes pleasant reading and is abundantly and lucidly illustrated with clear sketches and appropriate photographs. Perhaps most important, the book is unique as a succinct description of the shores of so many continents, some of which, particularly parts of Africa and South America, are very poorly known. Certainly *Life between Tidemarks on Rocky Shores* succeeds in what must be a main goal of the authors, as any reader will acquire a strong appreciation of unifying distribution patterns in the rocky intertidal community. A reader interested in more detailed descriptions of well-known shores would enjoy *The Ecology of Rocky Shores* by Lewis for the British Isles, *Between Pacific Tides* by Ricketts, Calvin, and Hedgpeth and *Natural History of Marine Animals* by MacGinitie and MacGinitie for the Pacific coast of North America, and *The New Zealand Sea Shore* by Morton and Miller for New Zealand.

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On the Evolution of Life

Exobiology. CYRIL PONNAMPERUMA, Ed., North-Holland, Amsterdam, and Elsevier, New York, 1972. xx, 484 pp., illus. $32. Frontiers of Biology, vol. 23.

The flood of books, symposia, and meetings on exobiology and the origin of life seems unending. Reviewing the latest offering is a little like reviewing the latest recording of *Figaro*—how does Oparin's performance compare with his dramatic introduction of the subject in 1924? and so on. Let me state from the outset that the overall level of production and performance in this collection of articles is excellent. The book would make a splendid introductory gift for the graduate student, and should also give a good deal of nostalgic pleasure to the professional.

The first and longest part of the book is concerned with the evolution of life on Earth. In his introduction, Oparin takes a characteristically comprehensive view of the subject. Then we get down to detail with William Schopf's lucid account of Precambrian paleobiology, that is, the study of very primitive fossil microorganisms. Sylvester-Bradley does a workmanlike job trying to impose some sort of order on the confusing observations relative to juvenile carbon. Gabel and Ponnamperuma are old hands at primordial organic chemistry. Perhaps this is why their effortless performance seems a little dated.

At this point there is a slight surprise. The article by Pullman on electronic factors in biochemistry is unusual in this context, and William Bonner introduces a scholarly chapter entitled "Origins of molecular chirality" instead of the more usual chapter on optical activity. Both of these chapters intro-

duce some unconventional material, and the latter may be particularly relevant for exobiology. After this diversion there are few further surprises. Chapters on the evolution of membranes, proteins, the genetic apparatus, and cells are contributed by Shah, Dayhoff, Woese, and Margulis, respectively.

The second part of the book is concerned with life elsewhere in the universe. Here the subject matter is changing more rapidly, and we do encounter some more recent material. Rasool gives an account of the atmospheres of the planets which was up to date at the time of writing. Chang and Kvenvolden seem about to demonstrate the prebiotic significance of carbon compounds on the moon. If they do not succeed, it is because, as they finally admit, such compounds have no prebiotic significance. Molecules in space are treated by Donn and extraterrestrial life and intelligence by Klein and Sagan, respectively.

What is the cause of this rash of books on exobiology and the origins of life? Unfortunately, I don't have time to answer this interesting question, since I must correct the proofs of my own second book on the subject.

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Ontogeny of Sleep Patterns

Sleep and the Maturing Nervous System. A symposium, Boiling Springs, Pa., June 1970. CARMINE D. CLEMENTE, DOMINICK P. PURPURA, and FLORENCE E. MAYER, Eds. Academic Press, New York, 1972. xviii, 470 pp., illus. $19.50.

Investigators of the maturation of the central nervous system are confronted by an embarrassment of riches: histological, biochemical, and physiological systems develop almost explosively after birth. The brain triples in weight during the first five years as the neonate is transformed from an essentially vegetative organism into a recognizable person capable of extraordinarily complex behavior. The present volume, based on a symposium sponsored in 1970 by the National Institute of Child Health and Human Development, reviews the developing sleep pattern in humans and animals in the context of various aspects of central nervous system maturation. The 19 formal papers are followed by comments initiated by invited discussants, the papers being organized according to the following topics: maturation of neural elements; development of electroencephalogram and activity cycles; reflex patterns and evoked potentials during sleep; and effects of some pathological processes (mental retardation, toxemia, autism) on human sleep patterns. Although the waking EEG has been intensely scrutinized for several decades, study of the sleep EEG in abnormal brain conditions, as exemplified in the last group of papers, has barely begun. It is already clear that sleep abnormalities may be observed where the waking EEG is normal, but clinical application of these findings is not yet possible.

The analysis of neurochemical changes in the maturing central nervous system is subject to various methodological difficulties, several of which are emphasized by Morgane and by Roberts. Biogenic amines, now in enormous vogue, have been invoked as controllers of sleep—noradrenergic systems for active (rapid eye movement) and serotonergic elements for quiet (slow-wave) sleep. In one noteworthy discussion, Shulte presents data squarely inconsistent with the latter possibility. The response to his findings provides yet another example of the dictum that theories are not abandoned because of inconsistent observations, but only when more attractive hypotheses emerge.

Parmalee and Stern provide an authoritative description of postnatal changes in human sleep. At birth (normal term), the infant spends roughly equal proportions of total sleep time in each sleep state—44 percent in active sleep (characterized by irregular respiration, muscle jerks, rapid eye movements) and 37 percent in quiet sleep (regular respiration, absence of body and eye movements). The remainder of sleep is transitional, that is, the defining parameters do not cluster perfectly. After three months active sleep occupies 25 percent and quiet sleep 49 percent of total sleep time; at eight months the respective values are 28 percent and 56 percent. The usual sequence of states in the neonate is waking—active sleep—quiet sleep. As the infant develops, quiet sleep more and more frequently follows waking, and by eight months it does so regularly. Electroencephalographic maturation occurs rapidly over the same period, and the infant achieves most of the distinctive features of slow-wave and REM sleep by the end of the first year.

There are two omissions from the volume that seem regrettable. First, it might have been instructive to include a comparison of milestones in the development of waking behavior and of sleep patterns. Second, a description of the course of sleep patterns after the first few years could have added useful perspective. Marked reductions in total sleep time and in the amount of deep sleep (characterized by high-voltage slow EEG activity) occur during adolescence; these changes should probably be considered maturational. Subsequent developments are best interpreted as the result of "aging": deep sleep continues to decline throughout adult maturity, and in late middle age an increase in awakening becomes apparent. It seems worth emphasizing that these latter changes in sleep EEG represent the most marked age-related alterations in central nervous system physiology measured thus far.

In spite of intensive research during the past decade, we remain ignorant of the biological function of either slow-wave or REM sleep. We are equally unable to specify with confidence the physiological mechanisms that control sleep. This reviewer suspects that the two problems are not separable; an understanding of function may be needed to determine which of several possible systems actually determines the occurrence of sleep.

In the absence of adequate theory, and with so much change going on at once, it would be incredible good fortune were meaningful relations to emerge between sleep and other maturational brain changes on mere empirical inspection. This volume reveals no such fortuitous outcome. Nevertheless, it seems likely that ontogenetic changes furnish an important clue to the function of sleep. The changes in infancy are well described in the book, and other contributions reflect the wide range of disciplines attracted to the challenge of what is becoming a central concern in neurobiology: the nature and function of sleep.

The book is well produced. It includes an index of subjects but not of authors. It provides a fair sampling of current research in several areas of brain maturation.

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