his discussion of Darwin shows the method at work. Such hypotheses can be successive as well as simultaneous.

Although this, too, has been questioned, Gruber reasonably concludes, with Darwin himself and with other evidence, that Darwin's new insight and the beginnings of his theory of natural selection dated from his reading Malthus in September 1838. Yet the Darwinian theory was not publicly announced in abstract until 1 July 1858 and in reasonably full form, by publication of *The Origin of Species*, until 24 November 1859. Gruber gives as a main reason for this long delay fear of unorthodoxy and of consequent persecution, perhaps not in as severe a form as that suffered by Bruno or even by Galileo (both are mentioned in this connection), but still in a form genuinely dreaded by Darwin as evidenced by a dream, to which Gruber repeatedly refers, which barely permits but hardly seems to require so extreme an interpretation. As another cause of delay Gruber gives Darwin's feeling that his theory was incomplete unless it could explain the origin and transmission of adaptive variations. In Gruber's view this matter was dealt with by changing it from a problem requiring solution for completion of the theory to a premise for that theory. But to the extent that it was ever adopted, that attitude was reached by 1839 at the latest and can hardly have been involved directly in some 20 further years of delay.

There is no doubt that Darwin was concerned about opposition, but I believe that this concern is overstated as fear of persecution. What he was most intent upon was to convince a majority of his scientific peers. He did convince them with his publication in 1859, and it is almost certain that he would have failed, as he realized, if he had published in 1839. His theory in 1838–39, then summarized in terms of heredity, variation, and superfecundity and left at that level in Gruber's discussion, was indeed simplistic and naive in comparison with the elaboration and sophistication of *The Origin*. The progress was due mainly to the intense and productive labor of the intervening years, even though these had no fully overt relationship to evolutionary theory. Furthermore, in 1838–39 Darwin had not really evaded the problem of origin and inheritance of adaptive variation. He still relied heavily on the inheritance of acquired characters, a false hypothesis which he never wholly rejected but on which he relied less in later years.

Darwin was an indefatigable writer, producing not only a large number of published papers, monographs, and books but also thousands of notes and thousands of letters unpublished in his lifetime. Many have since been published, scattered widely in different journals and books, but many are still unpublished. The second book of the present work contains less than is suggested by "Darwin's early and unpublished notebooks" but does include two previously unpublished notebooks from the years 1838–39. They are here called "The notebooks on man, mind and materialism," but by Darwin the first was titled "Metaphysics on morals and speculations on expression" and the second "Metaphysics and expression." Although they are brief, in Darwin's usual way they supplied some materials for later books, scattered through especially *The Origin of Species* (1859), *The Descent of Man* (1871), and *The Expression of the Emotions in Man and Animals* (1872). They are here well annotated by Barrett, with commentaries by Gruber, and they are a useful and scholarly addition to materials for the study of Darwin's early thought. There is also a collection of loose notes, mostly isolated comments on articles and books read in or about 1837–39, also well annotated by Barrett. Other contents of Book Two of the present work are miscellaneous and relatively unimportant, and do not need listing or special comment here. Some involve questionable editorial judgment.

It has not been possible to agree entirely with Gruber's interpretations. It should be added that the application of Piaget's studies of "the formation of intellectual structures in children" to Darwin's mature intellectual creativity, anticipated by Piaget in a foreword to this work, has not been carried far in the text, wisely, as it does not seem really relevant. There are innumerable other points that could be profitably discussed, but it is hoped that this review has now sufficiently indicated the contents of the work and also its stimulating effect for anyone interested in its subject, which must include almost everyone.

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Biological Continuities

On Development. The Biology of Form. JOHN TYLER BONNER. Harvard University Press, Cambridge, Mass., 1974. xii, 282 pp., illus. $10.

This book is essentially a review of reviews. In 259 pages of text, with a minimum of illustrations, Bonner covers the whole vast literature of organismal development, from viruses and microorganisms to mammals and higher plants. He does this "so that the nature of development becomes illuminated by its relation to other themes of biology." Of necessity, therefore, the book is both a synthesis and an analysis. Bonner relates development to biochemistry through comparisons between cycles of synthesis and degradation of macromolecules, similar cycles undergone by certain organelles, and cycles of cell multiplication, including the replication of DNA. He establishes its relationship to reproduction by emphasizing the point that the essence of reproduction is the reproduction of entire life cycles, not just adult phenotypes, and that the molecular information that initiates a new cycle during cleavage and early embryonic development is provided in part by the action of genes at the end of the previous, parental cycle. In drawing connections with inheritance he emphasizes the fact that nuclear DNA provides the pattern of order only with respect to the synthesis of informational macromolecules, particularly the various kinds of proteins. Order at the supramolecular level, although chiefly a consequence of macromolecular order, nevertheless requires the action of processes which operate in the cytoplasm, far from the nucleus, and which are as yet poorly understood.

One of the most illuminating of Bonner's analyses is his tracing of different levels of complexity, from bacteria through unicellular and colonial eukaryotes, and from simple multicellular forms to societies, particularly those of insects. To many biologists, the analogies Bonner draws between simple multicellular organisms and the beginnings of animal societies will be novel and will provide food for thought and further research.

The second half of the book, entitled The Molecular View of Development, emphasizes control mechanisms, rates and timing of metabolic processes, and the localization of substances in different parts of a structurally complex organism. Discussion of the last

topic naturally includes a review of diffusion and other mechanisms by which molecules, macromolecular complexes, organelles, and even cells may be transported; of organismal and cellular polarization; and of the adhesive properties of animal cells. This section is enriched by analogies between differentiation of castes within societies of insects such as termites, differentiation of cells and hyphae in fungi, the truly anomalous situations in cellular slime molds and elaborate uninucleate algae such as *Acetabularia*, and pattern development in unicellular eukaroytes as well as Metazoa such as hydroid coelenterates. Great attention is paid to the complexity and diversity of control mechanisms at the level of cells and of the synthesis and activation of enzymes.

Bonner's approach to these complex subjects is well balanced and reasonably comprehensive. He refers frequently to biological classics such as the work of H. Spemann, H. Driesch, C. M. Child, and T. H. Morgan; but he rightly pays more attention to discoveries made during the past decade as a consequence of the molecular revolution in biology. He does not have any pet theories and refrains from both laudatory and derogatory comments on the work of others. He lets the results speak for themselves. Nevertheless, from time to time the philosophy of a mature and perceptive biologist appears in the form of editorial comments: for instance, "We apparently like mystery; we like to think that what we are doing is just a bit more complicated than the work of others, and we seem to take some pride in this; we gloat over the fact that some aspects of our problems have so far defied explanation."

This book will be useful to young investigators, including beginning graduate students, who are seeking to orient themselves with respect to the complex problems of development at the molecular and cellular level. Teachers of general biology will enjoy a new approach to the subject of development and will undoubtedly find new ways of presenting it to their students, whether or not they agree with Bonner's approach in its entirety. Specialists in the field are likely to find the book disappointingly superficial, but obviously it was not written for them.

There are, unfortunately, some glaring omissions and some topics that are not covered thoroughly enough that their application to problems of development can be fully appreciated. The geneticist will be particularly disappointed at the comparatively slight attention that is given to differential gene action during development. For instance, both puffing in giant chromosomes of Diptera and the action of lampbrush chromosomes during oocyte development of Amphibia are ignored. In view of the dramatic presentation of puffing sequences in a recent (1972) volume edited by W. Beermann, which provides us with the best information we have on the number of genes that must cooperate to produce a single complex cell, and of the extensive research by H. Callan, J. Gall, and E. H. Davidson on lampbrush chromosomes, these omissions are most unfortunate. Another subject omitted is the effects of cellular tensions and pressures in determining patterns of supramolecular organization. This is a key topic for understanding differentiation in plants, as has been demonstrated by Paul Green and others. The properties of membranes are given less attention than they deserve. Perhaps the severest criticism that can be made of the book is that while it orients the reader well with respect to biochemistry and cell biology as applied to development, it neglects to an unfortunate degree the actual and potential contributions of genetics and biophysics.

Recognizing these imperfections, and regarding the book more as a source of ideas and stimulation than of factual knowledge, this reviewer nevertheless feels that Bonner has made a substantial and valuable contribution to the subject of organismal development.

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Selenium

Organic Selenium Compounds. Their Chemistry and Biology. DANIEL L. KLAYMAN and WOLFGANG H. H. GÜNTHER, Eds. Wiley-Interscience, New York, 1973. xviii, 1188 pp., illus. $55. Chemistry of Organometallic Compounds.

Interest in the biology of selenium is likely to remain with us for many years. Compounds of selenium can be very toxic. Selenium is present in the soil in varying amounts and gets into plants, some of which concentrate selenium in their seeds to dangerous levels. Selenium has been suspected of being a carcinogen under certain circumstances, yet it is also an essential trace element. When the selenium content of the soil is low, there may not be enough in the plants produced for the adequate nutrition of farm animals. We have soils in the United States that contain too much selenium and more that don't contain enough. Both situations also exist in the rest of the world. Attempts to understand selenium deficiency were beclouded for many years by the fact that selenium and vitamin E sometimes cure the same deficiency symptoms. But now it is clear that animals need some selenium even when the amounts of vitamin E in the diet are large. It is highly probable that man, also, needs it in his diet. Yet what it actually does in the animal body is still far from being fully understood, and the selenium problem continues to be attractive to investigators.

The volume edited by Klayman and Günther is the latest and largest in a series on the Chemistry of Organo-Metallic Compounds and follows monographs on lead, tin, germanium, iron-group metallocenes, and arsenic, antimony, and bismuth. The new compilation promises to be at least as useful as any of its predecessors. Certainly it is timely. As the authors point out in the foreword, the organic chemistry of selenium has undergone major expansion during the past two decades, after a century of relative neglect during which compounds of selenium were prepared or studied more or less as incidental variants of the corresponding compounds of sulfur.

The chemical chapters make it abundantly clear that chemists have finally been giving the organoselenium compounds the attention they deserve in their own right, and the extensive detail as well as the large number of references cited promises to make this "Handbuch" useful for many years to anyone who has occasion to seek information on organically bound selenium. Incidentally, the 41 contributors to this volume are truly an international group; a great many European authors from both sides of the Iron Curtain are represented.

Although the subtitle might suggest roughly equal emphasis on chemistry and biology, the volume is heavily weighted toward chemistry. The first 12 chapters deal with selenium itself or its organic derivatives, and chapters 14 through 17 deal with physicochemical properties of organoselenium molecules or with analytical methods. Only 186 pages deal specifically with