Ever since Minkowski published his famous paper on space and time in 1909 there have been two ways of looking at relativity—the old kinematical way, with constant reference to measuring-rods and clocks, and the Minkowskian way, in which the geometry of the four-dimensional continuum dominates. Prof. Möller definitely favours the former. He writes: "On the whole, the epistemological significance of the four-dimensional representation should not be exaggerated" and "... it must be emphasized that such a representation is quite formal". But of course he cannot get on without the space-time continuum, which is introduced in Chapter 4 with these cautionary remarks. There are even space-time diagrams on pp. 96, 152, 168; but they are queer diagrams—topologically incorrect representations of space-time, since the axes of (x_1', x_4') should be both inside (or both outside) the axes of (x_1, x_4) (cf. Fig. 1 in Minkowski's paper in "The Principle of Relativity", p. 78 (London: Methuen, 1923)).

It seems to me that the book would have been better if Prof. Möller had been more sympathetic to the Minkowskian way of looking at things. When the head begins to swim with contracted rods and slowed clocks, the best antidote to confusion is a simple space-time diagram. Thus, in Chapter 8, which leads to the general theory of relativity through the "principle of equivalence", it would be good to recognize that the ends of a short rigid measuring-rod are simply adjacent world-lines with a constant normal separation between them. But having recognized this, and remembering how Herglotz's masterly treatment of rigid-body motions (*Ann. d. Physik*, 31, 393; 1910) restricts such motions, one cannot but be surprised at the simple dogmatism of Prof. Möller's treatment of that thorny problem—the rotating disk. If a second edition of the book gives him an opportunity to revise Chapter 8, I hope he will use it to give the reader a clearer idea of the concept of rigidity in relativity.

J. L. SYNGE

EXPERIMENTAL EMBRYOLOGY OF BIRDS

The Epigenetics of Birds

By Prof. C. H. Waddington. (Cambridge Biological Studies.) Pp. xvi+272. (Cambridge: At the University Press, 1952.) 35s. net.

PROF. C. H. WADDINGTON'S choice of the title of his new book is eye-catching and stimulating if for no other reason than that the word 'epigenetics' connotes in the minds of many embryologists a variable and changing spectrum of meanings. The author's rather broad use of this word as a name for "The science concerned with the causal analysis of development" may be somewhat surprising and unfamiliar to most embryologists, particularly, because such usage would seem to leave little room for ideas about the alternative, 'preformistic' causal aspects of development. Nevertheless, as one reads through the book it becomes apparent that 'epigenetic' is being used in a sense sufficiently broad to include both the interactive (inductive) and segregative (localizational) mechanisms of the developmental system. However, since Prof. Waddington's major concern is not the presentation of a general thesis of avian development (although his title might suggest it), we have little concern with the inevitable semantic

difficulties which result from the use of the word 'epigenetics'.

The central purpose of the book, as the author states in the preface, has been to review the literature of experimental embryology of birds from 1930 up to about 1950. The book is fortunately much more than a simple review, for the author has frequently interjected his own evaluation and interpretations along with his description of the results and interpretations of the various workers in the field. Moreover, he has done this in a commendably objective and undogmatic way. His warnings about the making of interpretations of data accumulated by experimental methods and procedures that do not specifically warrant them should be accepted as a healthful shaking-up in our thinking about the mechanisms of bird development, regardless of whether all of us agree with his interpretations in particular instances (for example, interpretation of the organization of the uncubated chick blastoderm as a "single entity" on the basis of the results of studies of the uncubated duck blastoderm). One of the major contributions of the book is the comparison and critical evaluation of the many and sometimes conflicting results of the German, French, English and American workers—an analysis which has not been made previously in anything like as thorough a fashion.

The plan and order of presentation of the subject-matter follow in the main those of developmental chronology, beginning with an introductory chapter on technical methods and proceeding through a discussion of our knowledge of endoderm, primitive streak and embryo formation on to problems of organ system formation in later stages. The main emphasis has been devoted to such general problems as germ-layer interaction and primitive streak organizer (induction) activities. Special chapters deal briefly with a comparison of bird development with that of other vertebrates, biochemical mechanisms, feather development and pigmentation and with certain genetic effects and their phenocopies.

In the final and one of the most thought-provoking chapters in the book, the author has summarized the status of our knowledge of the "development of the epigenetic organization of the chick". This amounts in large part to a presentation and evaluation of our information about the regulative capacities of the early embryo. Among a number of valuable suggestions for future lines of attack is a most interesting one concerning the physiological mechanisms which underlie the processes of localization (or "segregation"). It is true that most of our information concerns the inductive (cell or tissue interactive) mode of differentiation—perhaps because this is most easily demonstrated experimentally—whereas almost nothing is known about the localizational or "segregative" mechanisms. Prof. Waddington suggests that "they offer to the embryologists of the future a problem perhaps even more important than that of the mechanisms of induction". It is obvious to all, however, that we still know very little about the actual mode of cell-cell interaction; for example, whether this is mediated by cell-cell contact and/or by diffusible substances remains an important problem in developmental physiology.

Embryologists will find this little book quite readable and provocative. It is well illustrated and contains a rather extensive bibliography. Prof. Waddington is to be congratulated for his efforts, which have produced a book both timely and valuable.

NELSON T. SPRATT, JUN.