tions, and a broader point of view than the preceding analytical method of least squares.

Other analytical methods for period analysis are considered. The Laplace transformation, differential and difference relations, and the method of exhaustions are included.

Finally, a discussion of physical aids to period analysis—including physical concepts such as momentum, resonance, and interference; and mechanical and optical devices—serves to complete the discussion of methods of application to practical problems.

There is collected in this book a sound treatment of the basis of the period analysis of empirical functions together with detailed discussions of methods of applying these in practice.

Anyone engaged in such period analysis or interested in a sound discussion of fundamentals will find this book very useful.

HOWARD EMMONS

The Axiomatic Method in Biology. By J. H. Woodger. Cambridge, University Press, 1937. 10+174 pp.

We have here the first attempt to build a system of biology on the basis of abstract logic. The book will probably be harder reading than the author (reader in biology at the University of London) realizes—save for those few who are versed both in Russell's symbolism and in fundamental biology. Nonetheless, its writing was a task well worth doing, and one which has been done excellently. It discusses biology with precision of statement and reliability of reasoning, and clearly shows the conceptual unity underlying a number of basic branches. It emphasizes the wisdom of R. A. Fisher's remark: "I can imagine no more beneficial change in scientific education than that which would allow each (mathematician and biologist) to appreciate something of the imaginative grandeur of the realms of thought explored by the other."*

In justification of the undertaking, Woodger quotes A. N. Whitehead: "There are an indefinite number of purely abstract sciences, with their laws, their regularities, and their complexities or theorems—all as yet undeveloped." And in the preface, which calls the book an experiment, he says: "In every growing science there is always a comparatively stable, tidy, clear part, and a growing, untidy, confused part. I conceive the business of theoretical science to be to extend the realm of the tidy and systematic by the application of the methods of the exact or formal sciences, i.e. pure mathematics and logistic."

Almost the whole substance of the book is given in the symbolic statement of axioms, definitions, and theorems. As a concession to the laity, most statements are also explained, more at length, in words. Some 250 symbols are used, mainly taken from the *Principia Mathematica* or introduced for their biological usefulness; the list of these symbols constitutes, in fact, the only index.

The ten undefined signs can be interpreted as "part of," "before in time," "organized unities," "related by a succession of divisions and fusions," "cell," "male," "female," "whole organisms," "environment," "genetic properties." The most important derived concept is that of a "hierarchy," a relation (xRy) which is one-many and asymmetrical, has just one beginner and, as possible terms y, those to which this

* R. A. Fisher, *The Genetical Theory of Natural Selection*, p. ix.

beginning stands in the relation R or a power of R. Thus we might have a species, a man, a cell, or a gene within a cell, together with all its descendants.

More general is the "*dend*," which allows both many-one and one-many relations, so that there need be neither a unique beginner nor a unique final term. The noun "δένδρον" is of course the source. In particular we have "*zgdend*" and "*cpdend*"—dendra, respectively, of cells (including gametes which, by fusion, yield zygotes) and of cell-parts (in particular such "continuous" or essential parts as chromosomes and genes). Cytology is further developed by a treatment of A-pairs—abstractly defined pairs, exemplified by allelomorphic pairs of genes in the same cell.

Genetics, naturally the next topic, is well outlined—some of the concepts are Mendelian classes of zygotes, A-classes of gene-pairs, a-classes of genes, in each case classes of genetically related objects. The probability calculus of heredity is briefly developed. Woodger points out that Mendelian theory cannot take account of the "discontinuous" components of a cell—those, such as the cytoplasm, which are not certainly transmitted to all descendants of a cell.

Of embryology and taxonomy Woodger does not pretend to give more than a sketch. A requisite in a logical study of the former would seem to be a clear distinction between embryo and adult. The author sets the division at the instant after which no further structural complexity develops. But, as structural complexity is one of the undefined concepts, and is not even furnished with adequate axioms, we gain little. There is, however, a careful description of various phases of the development of an organism. In taxonomy Woodger distinguishes between varieties, species, and larger groups, substantially on the basis of sterility and epochs of differentiation, those distinctive features which fit most readily into his present theory.

Of course this book is but a beginning of the axiomatic treatment of biology. For one thing, it holds to topology, avoiding metric statements of size, duration, spatial separation. Again, it restricts definitions to typical cases, which are by no means universal. Cell division is always taken to be a one-two relation. "A woman who gives birth to identical twins does not stand in the relation of sexual parenthood to either twin in the sense here defined." Likewise, continuous components of zygdendra are forbidden to divide in precisely the second "generation" before a gamete. As this, though typical, is not universal, a mathematician might well prefer to say "precisely the nth generation."

There have been mistakes in biological reasoning in the past. The reviewer would be glad to have cases cited in which the existence of Mr. Woodger's calculus would have prevented errors.* Once mastered by biologists, it may well help them to more rapid, reliable reasoning in the future.

E. S. ALLEN

Introduction to the Theory of Fourier Integrals. By E. C. Titchmarsh. Oxford, Clarendon Press, 1937. 10+390 pp.

The theory of Fourier integrals, although originating as early as that of Fourier series, has not been adequately treated in monograph form until recently, when "introductions" to the subject were published by Bochner, Wiener, and Zygmund (a chapter in his excellent book on trigonometric series). The method of Fourier trans-

* Cf. R. A. Fisher, loc. cit., p. 7: "It is a remarkable fact that had any thinker in the middle of the nineteenth century undertaken, as a piece of abstract and theoretical analysis, the task of constructing a particulate theory of inheritance, he would have been led, on the basis of a few very simple assumptions, to produce a system identical with the modern scheme of Mendelian or factorial inheritance."