theme, nor are there many ideas here that haven't been aired before, so the work must be judged by other criteria.

Much space is devoted to retrospective reviews of methodology and complicated arguments concerning the interpretation of data. *Drosophila* workers are now turning increasingly to more direct methods to calibrate quantitative results derived from mosaic analysis. W. Janning's review of gynandromorph fate-mapping includes a thoughtful discussion of the limitations of these maps. Although the maps are self-consistent and referable to the blastoderm stage, the number of nuclei represented by a distance on the map is still ambiguous. The issue is germane to the way the blastoderm is segregated into determined subpopulations of cells. K. Illmensee's single-cell transplant technique should provide a direct approach to this issue, but his chapter in the book includes few new results.

The question of how to estimate primordial cell numbers is also taken up by J. R. Merriam, and peripherally by several others. Unfortunately, nothing definitive emerges, for none of the authors addresses all of the relevant considerations. E. Wieschaus draws attention to the large variance in the size of the population of clones labeled at the same stage of development. How best to calculate cell numbers at this stage will depend on the sources of the variation, and a proper treatment must await deeper theoretical analysis. Merriam emphasizes the important point that data on clone size must be collected with a prior knowledge of the pattern of clonal restriction in the system concerned, and most existing data have not been collected in this way.

Wieschaus, Merriam, and A. García-Bellido and P. Ripoll all review the evidence for the idea that determination takes place via a series of compartmentalization events. I find García-Bellido and Ripoll's attempt to integrate this idea with models of pattern formation based on the regulative behavior of disk fragments unconvincing. In fact, the volume precludes a satisfying clash of ideas on this aspect of the subject by excluding a serious review of the disk regeneration literature.

C. Tokunaga presents an analysis of pattern mutants in mosaics that is often acute. The analysis reveals a conceptual difficulty that involves a task that in Curt Stern's time seemed to have been accomplished, namely, the separation of pattern mutants into those with local or global effects. Since the discovery of compartment boundaries and the recognition of mutants that abolish them, one can no longer make the familiar argument based on autonomy. Tokunaga's critical reevaluation of her early results should stimulate others to rethink their conclusions. The results will provide evidence pertinent to the hypothesis that compartment boundaries represent the limits of regulative fields. But, once more, a conceptual reformulation of the problem would no doubt be of value at this point.

After these technicalities there are two refreshing chapters on mammalian systems, by R. L. Gardner and by A. McLaren, and the book ends with a lucid review of *Drosophila* behavior genetics by J. Hall. Though the book isn't a milestone, it marks a step along the way, with signposts indicating the direction of future developments. Workers in the field will find it helpful, but as an introduction it lacks perspective and would be heavy going in places.

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Early Thermodynamics

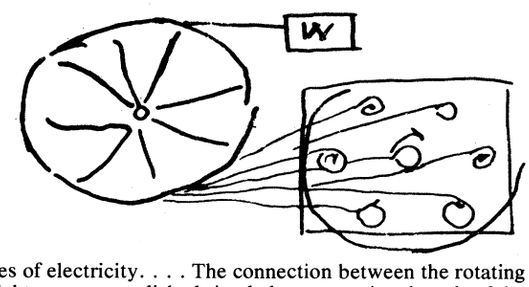
James Prescott Joule and the Concept of Energy. HENRY JOHN STEFFENS. Dawson, Folkestone, Kent, England, and Science History Publications (Neale Watson), New York, 1979. x, 174 pp., illus. $20; prepaid, $16.

The efforts that led to the formulation of the laws of thermodynamics occupied physics and chemistry in the first half of the 19th century. Recent accounts of the history of those efforts have tended to neglect James Prescott Joule, seen usually as an ingenious experimenter who added nothing to the conceptual development of thermodynamics.

Steffens forces us to modify this view by a careful study of Joule's research, his relationship with William Thomson, and his place in the development of thermodynamics. Steffens traces the course of Joule's research, leading from concern with a purely engineering problem, the improvement of the electric motor, to investigation into the nature of heat. Much of Joule's skill went into designing sensitive instruments with the use of the latest theories. The book is a study of the interdependence of instrumentation and theory and Joule's efforts to develop absolute standards of resistance and conduction before others had begun to even define the concepts. By 1843 Joule was also able to measure temperature with unprecedented accuracy. Part of his struggle for the recognition of his work was necessitated by his contemporaries' disbelief in the accuracies he claimed.

By 1844 Joule's work appeared in major scientific journals, but his contemporaries were skeptical. They were partly justified. Many of Joule's conclusions were based on premature speculations, each paper built on all his previous ones, and he assumed his readers had read and accepted the earlier results and ideas—not a good strategy for winning acceptance of novel approaches to the art of experiment or of novel scientific ideas. Joule probably would have continued to labor on the fringes of the scientific community but for his meeting with William Thomson in 1847 at the annual meeting of the British Association. By this time Joule had developed the concept of the transformation of heat into work, and Thomson immediately recognized the concept as conflicting with the caloric theory and Carnot's theory of the heat engine.

While Steffens's assessment of Joule's place in the development of the first law, including his undoubted use of Mayer's work in 1844, seems correct, his account of Thomson's struggle to resolve the conflict between Joule's work and Carnot's theory and of Thomson's role in the development of thermodynamics is



"Re-drawn sketch from Joule's laboratory notebook linking the vis viva of the rotation of the atmospheres of electricity about atoms to the lifting of a weight." The sketch, made by Joule in 1847 in preparation for a lecture, "represented the macrocosm by means of a weight suspended by a string over a large pulley wheel. The microcosm was represented by the seven atoms, with their rotating atmospheres of electricity. . . . The connection between the rotating atmospheres and the lifting of the weight was accomplished simply by connecting threads of the string to the rotating atoms. . . . This sketch remained unpublished, and Joule did not use it in his lecture, obviously considering it a bit too direct an answer to a complicated mechanical as well as philosophical problem." [Reproduced in *James Prescott Joule and the Concept of Energy* from E. Mendoza, *Manchester Memoirs*, vol. 105, No. 2, p. 10 (1962–63)]

less satisfactory. Thomson was far less sure of the validity of Carnot's theory between 1847 and 1850 than he appeared to be in print, and his objections to the mechanical theory of heat were philosophical and deep. Until they were resolved he would not publish on the mechanical theory, and he was beaten to this prize by William Rankine and Rudolf Clausius. Clausius's work is also not given its due by Steffens.

Despite these reservations this is a nice study in what it takes to be an "ingenious experimenter" and shows us that as much imagination and skill must go into the design and development of experiments as into theory.

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Microbiology

Pesticide Microbiology. Microbiological Aspects of Pesticide Behaviour in the Environment. I. R. HILL and S. J. L. WRIGHT, Eds. Academic Press, New York, 1978. xx, 844 pp., illus. $73.65.

In considering how the effects of applied xenobiotic compounds can be adapted to and regulated, priority is often given to the visible effects of xenobiotics on plants and animals. Less attention is focused on interactions of pesticides with microorganisms, although such interactions, by upsetting biological equilibrium or by forming unexpected compounds through metabolic activity, may have a more serious and permanent environmental influence.

Pesticide Microbiology is successful in summarizing the research done before 1976 on microbiological aspects of pesticide behavior in the environment. It can be considered an important reference source and will be useful for both the beginner and the expert. However, one must be rather critical about the organization of the book, since a chapter on microbial transformation of pesticides (I. R. Hill) overlaps with chapters on the microbial degradation of insecticides (F. Matsumura and H. J. Benezet), herbicides (R. E. Cripps and T. R. Roberts), and fungicides, fumigants, and nematocides (D. Woodcock).

Most of the contributions on the transformation of the various groups of pesticides are well written and provide a good perspective of such issues as the value of experimental designs and the possibility of extrapolating laboratory experiments to field conditions. The latter issue, which is discussed from various viewpoints, is important, for the complexity of natural environments—especially of soil—has always presented numerous methodological problems to research workers investigating the in situ metabolic activities of the endogenous microflora. In spite of statements like "Microbial cultures grown in nutrient media, perfusion columns and soil suspensions do not provide data of relevance to agricultural conditions," most of the results reviewed in the book are obtained from laboratory, not field, experiments.

I. R. Hill and D. J. Arnold describe in one chapter the techniques used for the study of pesticide transformation in the environment by the pesticide manufacturing company for which they work, but very few findings of this type of research appear in the literature. Unquestionably the research that private industry does not publish causes a considerable gap in any summary of pesticidal fates in the environment.

The sections dealing with the effect of pesticides on various organisms differ greatly in their thoroughness. The chapter "Pesticides and the micro-fauna of soil and water" by C. A. Edwards contains considerably less information than the two elaborate and very carefully assembled chapters on pesticide effects on soil microorganisms by J. R. Anderson. The critical evaluation and extensive tables included in these two chapters may well be the most comprehensive in the literature.

The introductory chapters covering microbiological aspects of the soil, plant, aquatic, air, and animal environments do not provide an adequate framework for the subjects discussed in the book. In general, students, for whom the first chapters are apparently designed, can hardly afford the book, and experts will not find these chapters very informative.

There is justification for a book on pesticide microbiology, and this one provides valuable and comprehensive information on the subject. As indicated by the editors in their preface, however, interactions of microorganisms with pesticides in ecosystems are unlikely to be clearly defined or isolated from the influence of other factors controlling the fate and activity of pesticides in the environment.

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Biosynthetic Products for Cancer Chemo-

(Continued on page 1423)