knowledge report on tropical forest ecosystems published last year. It is clear that the work by Bormann, Likens, and co-workers in a temperate hardwood forest in New Hampshire is highly relevant to understanding the dynamics of the rather more complex forests of the humid tropics.

In the eighth and final chapter some examples are given of how the Hubbard Brook Ecosystem Study can contribute some answers about environmental impacts and appropriate forms of forest management, as well as help to formulate questions on such issues more precisely. We must await the fleshing out of these suggestive principles in the next volume of the Hubbard Brook series.

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Decoding Nonverbal Behavior

Sensitivity to Nonverbal Communication. The PONS Test. ROBERT ROSENTHAL, JUDITH A. HALL, M. ROBIN DIMATTEO, PETER L. ROGERS, and DANE ARCHER. Johns Hopkins University Press, Baltimore, 1979. xxiv, 408 pp. $20.

Although scientific interest in nonverbal communication dates back a century to Charles Darwin, recent proliferation of research on the topic covers a mere two decades. That brief period has yielded a voluminous and often disorderly body of knowledge. This state of affairs results in part from the wide range of behavior that nonverbal communication encompasses, including how people sound, move, gesture, and touch, how they approach and look at each other, and even how they dress, adorn, and equip themselves. Anthropologists, sociologists, linguists, and psychologists have been among the many who study these topics. It is perhaps not surprising then that this diversity of domain and range of researchers have produced more questions than answers about the nature of nonverbal communication. This book presents the results of seven years of research by a team of social psychologists who have developed a "film test" of nonverbal sensitivity. Their work too produces more questions than answers.

The research grew out of Rosenthal's previous studies of the effects on performance of expectations held by experimenters and teachers, work which suggested that these effects are mediated by nonverbal communication. The investigators believed that being able to measure individual differences in the ability to encode and decode nonverbal behavior would provide some answers concerning the way in which peoples' expectations influence behavior. The Profile of Nonverbal Sensitivity (PONS test) was designed to measure such decoding ability, and the first third of the volume is devoted to a careful description of the development and structure of the test.

The PONS test is a 45-minute film in which a young woman is shown encoding 20 different emotional situations. Each emotional situation is shown 11 different times in 2-minute segments that isolate one of three visual channels (face, body, entire figure) or two auditory channels edited to be content-free or six combinations of these visual and auditory channels. The 20 emotional situations represent positive-negative and dominant-submissive dimensions of behavior. Each of the 220 segments is followed by a pause long enough for the viewer to pick one of two alternative descriptions of what the encoder is doing. The isolation of channels makes it possible not only to describe encoders as more or less accurate but also to derive a "profile" of different decoding abilities.

The first six chapters provide detailed descriptions of the construction of the PONS test and of seven shorter versions of the test that were developed for specific studies. Results are presented bearing on the internal consistency of the PONS (which is high) and the stability of the scores over time (which is modest). The researchers describe the reliability of the test as "reaching the level obtained by standardized group-administered tests of intelligence" (p. 362), a finding likely to satisfy some potential users and to dismay others. The limitations of using a single encoder and posed emotional expressions are recognized, albeit minimized, by the authors. No rationale is offered for the selection of positive-negative and dominant-submissive dimensions of emotion, although the structure of the test with regard to these dimensions is carefully described. Validation is difficult when developing a test of something for which no other good measure exists. The authors show considerable care and statistical sophistication in establishing that the pattern of results presented in the volume constitutes evidence of construct validity for the PONS test.

The test has been given to more than 7000 people in over 200 groups in the United States and other, mainly English-speaking, countries. The last two-thirds of the book presents findings relating the nonverbal sensitivity of these decoders to their gender, age, culture, cognitive ability, personality attributes, various psychological and physical impairments, and occupation. A chapter is devoted to the original question whether nonverbal sensitivity is a mediator of expectancy effects; regrettably few relationships were found and the question remains unanswered. Considering this body of data as findings that validate the PONS test, the results are informative. As findings that add to a fundamental understanding of nonverbal communication, they fall short. This failing arises from the notably atheoretical approach taken to the development of the test and to the selection of samples on which the results are based. The absence of guiding conceptualizations occasionally draws the authors close to the logical fallacy of assuming that identical patterns of correlations reflect identical underlying psychological processes. The determinedly empirical approach presented in the volume makes the interpretation of findings difficult for both the authors and the reader.

In general, the researchers have been thorough and careful in the statistical extraction of relationships from their diverse data. Particularly helpful is their consistent reporting of effect sizes in addition to statistical significance. This provides the reader with useful information on what relationships are large enough to warrant further investigation. In sum, the book provides a complete account of a measure of decoding ability and is a gold mine of suggestive hypotheses that others might pursue. In so doing, they would be well advised to seek answers to the questions raised by the findings in this program of research.

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Developmental Genetics

Genetic Mosaics and Cell Differentiation. W. J. GEHRING, Ed. Springer-Verlag, New York, 1978. xii, 316 pp., illus. $39. Results and Problems in Cell Differentiation, vol. 9.

Genetic mosaics are individuals made of cells of more than one genotype. They have been utilized most extensively in *Drosophila* and the mouse for developmental studies. This volume of ten papers on the subject of genetic mosaics does not have any strong common

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

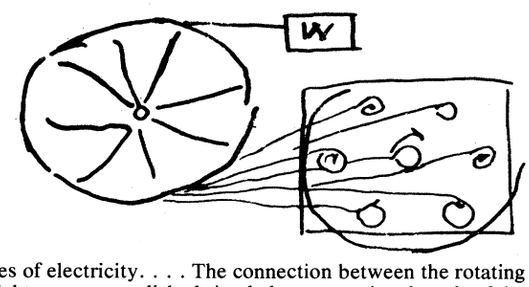
James Prescott Joule and the Concept of Energy. HENRY JOHN STEFFENS. Dawson, Folkestone, Kent, England, and Science History Publications (Neale Watson), New York, 1979. x, 174 pp., illus. $20; prepaid, $16.

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)]