using the same amount of time to travel (expenses paid) to various meetings.

If an international competition in the writing of advanced scientific texts does develop, it would have a healthy effect on the field.

ARTHUR V. TOBOLSKY
Department of Chemistry,
Princeton University

Museum of Microstructures

Interpretation of Metallographic Structures. William Rostoker and James R. Dvorak. Academic Press, New York, 1965. viii + 226 pp. Illus. $10.

"The book is an organized presentation of specimen microstructures, each chosen for its clarity of illustration and each or in groups forming the pretext for some discussion of interrelation between physical metallurgy and metallography." So the authors describe their intent, which is very satisfactorily achieved. There are some 139 photomicrographs illustrating chapters discussing polycrystalline structures, crystallization, solid state transformations, diffusion and transport processes, and quantitative metallography. The photographs (culled from years of materials development at the Illinois Institute of Technology Research Institute) range between good and excellent, both on the basis of metallographic technique and significance. They represent relatively exotic materials, but they were selected to show the universality of the physical principles of structure and are accompanied by a good discussion of the factors responsible for the particular shapes that occur. The sections on liquid-metal penetration and on diffusion and transport illustrate many important phenomena not commonly covered in metallurgical texts.

The book does not have the balance that would enable one to recommend it as an introduction to metallography, but it is a very useful museum of well-labeled specimen types for suggestive comparison with structures encountered in postmortem examinations and in the study of new types of materials. It is a well-made book, although the proofreader (?) has left errors in the simple equations for interface equilibrium angles and for grain shapes.

The rhythmic layering in chemically deposited nickel (see cover of this issue of *Science*) is strikingly uncrystalline and will be more familiar to fanciers of agate than to metallurgists with ordinary experience. Indeed people of any profession, or of none, will enjoy the structures as abstract art forms, and they will find suggestive analogies with biology, sociology, and virtually every field of knowledge and experience, for everything sensed or thought depends on some relationship between units and interfaces in structural hierarchies that are not unlike those here made visually manifest by the behavior of imperfect microcrystals interacting with each other.

CYRIL STANLEY SMITH
Massachusetts Institute of Technology, Cambridge

Note

The Year Book of the Royal Socity of London, 1965 (Royal Society, London. 351 pp. $3.15), provides a list, including addresses and professional affiliations, of the Fellows and Foreign Members of the Society and a separate list of those elected to membership in 1964. Among the other information provided is the Society's Calendar for 1965 and lists of its committees and boards, medals, lectures, and publications.

BIOLOGICAL AND MEDICAL SCIENCES

Biopsychology Comes of Age

Ernst Mayr recently wrote that "Typological thinking is unfortunately a disease that is highly resistant to all treatments. All we can hope for is to immunize the young against it, but whether we will be able to cure any of those afflicted with it is rather doubtful" (private communication, 1963). **Genetics and the Social Behavior of the Dog** (University of Chicago Press, Chicago, 1965. 468 pp., $12.50) by John Paul Scott and John L. Fuller is an important book, if not a great one. It is important because to my knowledge it represents the first systematic and methodologically sophisticated experimental analysis of behavior *not* cast in the typological mode of thought that has so long plagued the behavioral sciences. Scott and Fuller think in terms of populations and speak the clear language of modern evolutionary biology to present behavior-genetic analyses of individual and breed differences in the behavioral development of the polytypic species *Canis familiaris*.

Their theme is the role of heredity in the development of behavior. They provided puppies with an environment designed like a well-run school, then trained and tested the young from several breeds and attempted a partial Mendelian analysis of two breeds having the longest reproductive isolation. Throughout the highly readable account of 13 years of work we learn much about dogs and their long association with man.

The six chapters of section 1 lay the groundwork. The first, "A school of dogs," outlines the study and what follows. The second chapter, "Dogs, wolves, and men," discusses the origin of *C. familiaris* and its relationship to its congeners *C. dingo, C. lupus* (wolf), *C. latrans* (coyote), and *C. aureus* (jackal), then covers geographical distribution, fossil and prehistoric evidence, and evidence from comparative anatomy, physiology, and genetics. This chapter also presents a fascinating survey of historical evidence for man's role as selective agent shaping the

evolution of the five breeds studied—African basenjis, beagles, cocker spaniels, Shetland sheepdogs, and fox terriers. The third chapter, "The social behavior of dogs and wolves," deals with the choice of the behavior pattern as "a natural unit" of behavior study, with Scott's valuable contribution to behavioral taxonomy in which functionally related patterns are grouped into nine behavioral systems, and with the modification of wolf behavioral systems in the cladogenesis of dog breeds. One table elegantly classifies 103 behavior patterns into Scott's nine systems and compares dogs with what is known about wolves, coyotes, and foxes with respect to each behavior. The fourth chapter examines the major stages—neonatal, transition, socialization, and juvenile—in the development both of sensory and motor capacities and of individual and social behavior patterns.

The fifth chapter, "The critical period," deals with "a special time in life when a small amount of experience will produce a great effect on later behavior" (p. 117) for ". . . a young animal automatically becomes attached to individuals and objects with which it comes into contact during the critical period" (p. 147). The close of this period of maximum susceptibility to socialization follows the appearance of the startle response to sound and the accompanying development of fear. They see it as being of fundamental importance in primary socialization and common to many vertebrates and invertebrates. Since its publication in *Science* [**138**, 949 (1962)] this critical period concept "extrapolated from embryology to . . . behavior" has been criticized because "what the young animal may attain in behavior at any phase of ontogeny depends upon the outcome of earlier development in its every aspect"; furthermore, "the degree of equivalence between . . . [socialization to human handlers] and the ontogeny of interaction among species mates may prove to be appreciable, but it has not been determined" [Schneirla and Rosenblatt, *Science* **139**, 1110 (1963)]. It is unfortunate that such difficulties are not now considered explicitly. The sixth chapter covers the development of social relations between mother and offspring, between littermates, and between young dogs and human handlers of both sexes.

The next two sections are devoted to data and analysis. Here it becomes clear that this most ambitious and thorough behavior-genetic analysis to date will doubtless be the forerunner of a more thorough study of many species. About 500 "pure"-bred and testcross puppies were observed over their first year of life in some 30 major testing situations, each yielding from 5 to 40 scores. Following another short chapter on methodology, the remaining three chapters of the second section report numerous breed differences in emotional reactivity, trainability, and problem solving. Many lucid accounts show the pervasiveness of emotional traits. These and others provide excellent examples of the complexity of the interactions (both behavioral and genetical) that are revealed by the multivariate approach.

In the third section the critical reader will see revealed in greater detail than has ever appeared outside my *Drosophila* studies why our knowledge is still so incomplete. For didactic convenience we use the Mendelian language as if there were only a small number of recombining genes. The unreality of our oversimplification becomes painfully transparent when we consider the behavior genetics of this species with 39 chromosome pairs, a juvenile period longer than a year, and a rich behavioral repertoire. If one calculates (apparently the authors have not) how many animals have to be produced in Mendelian experiments to have even a remote chance of observing recombinant genotypes, the magnitude of the requisite experiments soars to astronomical proportions as the species chromosome number increases. Our repeated failure (called the "Tryon effect," p. 264) to observe Mendelian segregation in F_2 generations is no accident!

A key question that motivated the present study has no answer: Over and over again we are told that the authors were interested in "the effect of heredity upon behavior" (p. v), in "the genetics of behavior" (p. vi), in discovering "the influence of hereditary differences upon behavior" (p. 24), and that "Our primary purpose . . . was to discover . . . the effects of heredity upon behavior and we chose the dog . . . for demonstrating the magnitude of such effects" (p. 383). However stated, this is the old familiar, yet forever unanswerable, nature-nurture question, or search for the heritability of a trait. As was so often clearly stated (then forgotten) in Fuller and Thompson's *Behavior Genetics* (Wiley, New York, 1960) "heritability is a property of populations and not of traits." It means that the magnitude of "the effects of heredity upon behavior" can never be measured as a constant analogous to the speed of light.

The final section considers implications for the art of dog breeding, evolution, and "social genetics." The tremendous practical value of this work is attested by Pfaffenberger: "Results speak for themselves. Fourteen years ago . . . only nine per cent of the dogs . . . could . . . become responsible Guides [for the blind]. In 1958 and in 1959 all the dogs who had been bred and developed by the new knowledge were as good or better than the best dogs . . . in 1946. Even with our much stricter requirement 90% became Guide Dogs. It was our good fortune . . . [that] Scott had started the study of puppies . . . prior to my assignment, and that I met him and his associates who have given us so much wonderful help" (*The New Knowledge of Dog Behavior*, Howell Book House, New York, 1963, p. 6). The contrast with the history of "egregious failures" reported by the Brelands [*Am. Psychol.* **16**, 681 (1961)] after their attempts during a 14-year period to apply the simplistic ideas of behaviorism is painful indeed.

". . . one of the basic problems of psychology [is] that no . . . explanation of behavior is complete without heredity. . . . [and] one of the basic problems of biology [is that]. . . . No theory of evolution of animals is complete without a consideration of behavior" [Scott, *Am. Zool.* **4**, 167 (1964)]. Scott and Fuller's book is the first to deal simultaneously with the relations between the heredity and the behavioral repertoire of a genus, on the one hand, and the relations between the behaviors and the evolution of that genus, on the other. If this volume is carefully studied by the generation now in training, and if they appreciate what it accomplishes and what it fails to accomplish, great progress will be made in the exercise of our generation's responsibility to educate them and "to immunize the young" against the plague that has been typological thinking.

JERRY HIRSCH
Department of Psychology,
University of Illinois, Urbana