natural world (not merely predictions but explanations—see p. 10) is a characteristic way in which man and man alone tries to understand his environment. The grammatical rules of human language enable us to form sentences which *predicate*, that is, which communicate cognitive information (and not merely an emotion or a signal). This is a second activity that is unique to the human mind: the ability to say things about physical and human nature which have universal references, and which are not bounded by the domination of the immediate environment. And human beings are alone (on present evidence) in the capacity to *paraphrase* a message, so that the same content can be conveyed in subtly different forms—a third fundamental effect which makes poetry possible, and gives it a status as remarkable and species-specific as science.

These are three features of human language, but they are not peculiar to language: they are peculiar to man—they are projections into language of the whole human personality. But when Simpson comes across such connections he always puts them aside. For example, he writes, "One of the enticing side tracks to which I can point here but which I cannot follow far is a relationship between language and ethics" (p. 113). With this ominous remark, which firmly separates the discussion of man the speaking animal from that of man the ethical animal, I turn to the essay on "Biology and Ethics."

The essay on ethics is a sober and reasonable analysis of previous attempts to set up either an evolutionary or a naturalistic ethic, for example by Julian Huxley and by C. H. Waddington. Simpson rightly criticizes these attempts because they do not sufficiently take account of the special nature of man. But in fact what he has to say shares the same fault: it treats man as a unique creature because he is the only "ethicizing" animal, but it fails to connect the existence in all cultures of ethical rules with other universals of culture. He does draw attention to the importance of human foresight as a gift which plays a part in ethics (p. 146). But he does not extend the notion of foresight to that inner creation of a generalized future, a domain for strategy rather than tactics, which characterizes the human imagination. Here again he seems unable to get beyond the concept of man as a problem solver, to the concept of man as a creator of open or unbounded futures which have to be controlled in spite of the high uncertainty they contain. It is in the balance of these concepts that the conflicts between individual and society have to be resolved, and that biological and social trends have to be matched. But Simpson evades dealing with such conflicts: "I cannot here discuss the nature of these two factors in human evolution or the relationship between them" (p. 145).

In an earlier essay Simpson rightly complains that in the past "philosophy of science" simply meant "philosophy of the physical sciences" (p. 45). But the unexpected discovery that has to be faced by those of us who want to create a philosophy of biology is that such a philosophy has a different character from the philosophy of physics. A biological system, even a single human being, is not a mechanism that can be isolated, or whose parts can be treated as separable. Something more is asked of philosophy in biology than an extension of the traditional analysis of the modes of scientific reasoning. And it is not even a question of making sure that one group of cells is seen in the context of another. The behavior of an organism, and of man above all, is an expression of gifts which are internally connected and intertwined, so that they all project into every activity. The coherent analysis of these connections is a new problem in the philosophy of science.

Simpson has in the past shown a subtle appreciation of the coordination of an organism, in his analysis, for instance, of species in evolution. But in the crucial essays in this book he fails to bring the same sense of inner unity to the study of two gifts of man which, in my view, most require it. Language and ethics are universals of culture in all human societies. It is understandable that linguists and philosophers of ethics should treat them in isolation; but it is precisely the business of the philosophical biologist to trace in them expressions of the total human makeup. Their philosophical content is that they particularize a central issue in epistemology: the special ability of man to modify both his physical and his social environment by a progressive process of understanding.

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Astronomical Manual

Observation in Modern Astronomy. DAVID S. EVANS. Elsevier, New York, 1968. xiv + 274 pp. + plates. $14.

The tone for this unique book is set in the author's preface: "There is a need for a kind of manual for the student who aspires to be a working astronomer, or the physicist who wants to know what goes on in observatories" and "many recruits to the astronomical profession have a very limited experience of optical observational practice." The book is indeed written to benefit the professionally inclined student or the dedicated amateur. Evans was for many years the Chief Assistant of the Royal Observatory at the Cape of Good Hope, and in this capacity he was deeply involved in problems of the measurement of fundamental time and star positions. He contributed significantly to the measurement of stellar radial velocities and proper motions. He was engaged in photometric research by photographic, photoelectric, and spectroscopic techniques. In this book he explains how he did it all—and the student who reads the book will be ready to go to work for himself. Evans's training was in astrophysics, with the emphasis on good Oxford physics.

I like the first two, long chapters best of all. The first deals with "Astronomy of Position," a subject in which Evans is truly a master, also one that remains a closed book to many younger astronomers. My only criticism is that I wish he had been more precise in some definitions. For example, I looked in vain on pages 24 to 26 for a precise definition of ephemeris time, a most significant concept and one that is difficult to grasp for most students. In spite of this reservation, I intend to urge all my students to study this chapter with care. The second chapter deals with "Measurement and Analysis of Stellar Radiation." It is comprehensive and excellent. I only wish that it were more up to date. There is, for example, no reference to the techniques and potential of astronomy in the infrared. The radio spectrum is deliberately ignored—which I for one regret. I wish that in these early chapters Evans had spent more time describing techniques for the adjustment of optical telescopes and of stellar spectrographs, both problems with which he is well acquainted.

Personally I do not care especially for the presentation of the universe of

stars and galaxies in the second part of the book. It is clear that chapters 3 through 7 were written between 1960 and 1965, and no references to major papers and books published since 1965 are found in the bibliography. Astronomy has moved so fast in recent years that much of Evans's story seems out of date in content and in emphasis. His treatment of the spiral structure of our Galaxy and of galactic rotation are off the beam. Horizontal branch stars are not even mentioned, and the description of stellar evolution and star formation is of early 1960 vintage. The sections on the Star Clouds of Magellan are scanty and incomplete, and some of the presentation is careless: plates 34a and 34b present the Large Magellanic Cloud in two different orientations, one with south at the top, the other with north at the top.

The strength of the Evans book—and its uniqueness—lies in the first chapters, where the author takes the young student step by step into the fascinating world of precision observation of the heavens by optical techniques. Evans is now permanently a professor of astronomy at the University of Texas; the Texas students have a master teacher to introduce them to the field of precision astronomical observations.

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Crystal Spectroscopy

Optical Properties and Band Structure of Semiconductors. DAVID L. GREENAWAY and GÜNTHER HARBEKE. Pergamon, New York, 1968. xii + 160 pp., illus. International Series of Monographs in the Science of the Solid State, vol. 1.

Optical spectroscopy and quantum theory have had a particularly close alliance in the development of modern physics, witness the early and productive partnership between atomic and molecular spectroscopy and the emerging quantum theory. The spectroscopy of crystals is a late bloomer in the family of spectroscopy. It suffices to say that it has now come of age, and, not surprisingly, the same close relationship to quantum theory characterizes the new field as well. The key elements in the growth of crystal spectroscopy have been the development of experimental techniques to measure optical constants over a broad range extending from the infrared to the far ultraviolet, the development of tractable theoretical techniques for calculating the band structure of crystals, and the development of the conceptual framework for relating the observed spectra to the calculated band structure. Needless to say, theory and experiment have leaned heavily on one another at various stages of this development.

Solid-state physicists will welcome this short and well-organized monograph as a convenient compendium of the spectroscopic results and analysis in terms of band structure for a large class of crystalline materials. Non-solid-state physicists and those who are entering the field will find this monograph a lucid introduction.

Readers who are familiar with Moss's *Optical Properties of Semiconductors* (Academic Press, 1959) will note a similarity in approach, level, and format. The two books complement one another nicely, since Moss treats mainly the optical effects arising from free carriers and band edges and the current book concentrates on the structure and analysis of the more complicated spectra arising from the higher bands. All of the machinery for producing and interpreting the spectra is described in concise and conceptually clear sections with a minimum of mathematical prolixity. Thus there is a chapter on the optical constants and dispersion relations and another on the experimental techniques for the visible and ultraviolet. There is a very short, in fact too short, chapter on the quantum theory of interband transitions, the classification of critical points, and applications of group theory with a slight reference to the theoretical methods for calculating band structures. The main body of the text, and the part most useful to workers in the field, is a compendium of the experimental results and analysis for a large class of materials including most of the well-known semiconductors and some of the insulators. The effects of deformation are discussed, as well as the contributions of excitons to the spectra. The authors conclude with discussions of other experimental techniques that have been applied to band structure analysis, such as the piezo- and electro-optical modulation techniques, the photoelectric effect, and energy-loss phenomena.

The authors might be criticized for trying to say too little about too much. In the eyes of the reviewer this is no fault. The monograph eminently succeeds in what it attempts: to serve as a compendium of the results scattered through the literature with a skeleton outline of this vital new field. For those who want more detail, ample references to the literature are included.

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Festschrift

New Pathways in Inorganic Chemistry. E. A. V. EBSWORTH, A. C. MADDOCK, and A. G. SHARPE, Eds. Cambridge University Press, New York, 1968. xxxiv + 392 pp., illus. $13.

This book has been prepared by a group of former students of H. J. Emeléus in honor of his 65th birthday. After a brief biographical preface and a complete list of Emeléus's scientific publications, each of the 14 authors describes the work he and his students and colleagues have done. The book is a fitting tribute to Emeléus, illustrating as it does the great influence he has had on inorganic chemistry.

One might suppose that since all of the authors were trained in the same school of chemistry, the subject matter of the various chapters would show a strong dependence upon the work done in the Cambridge laboratory. Such dependence, however, is not apparent. Even in the four chapters describing research on compounds of fluorine, it is evident that the authors have departed widely from the work they did as graduate students.

It is difficult to categorize the contents of the various chapters briefly, for some of them cover a fairly wide range of material. Suffice it to say that 4 of the 14 chapters are concerned chiefly with fluorine compounds, three specifically with coordination compounds, two with nonaqueous solvents, one and part of another with silicon compounds, and one each with organometallics, derivatives of gallium hydride, and the solid state. The chemistry of mercury, germanium, tin, lead, and several of the transition metals is the subject of extensive discussion. Aside from that in the chapters on metal-metal interactions in paramagnetic clusters and defect aggregation chemistry, the material discussed is largely descriptive rather than theo-