E. Bessey's, pioneered a new kind of quantitative plant ecology in the late 1890's. When they applied their method of "quadrats" (counting and mapping all the plants within a five-meter square) at intervals all across Nebraska, they were able to show that the distribution of species varied much more widely and gradually than was discernible to casual observers. Clements and Pound thus concluded that the Great Plains were much more diverse than had been reported by Europeans unacquainted with the region. From this methodological innovation, Clements, a philosophical idealist, moved (for reasons that Tobey explores in a long chapter) on to the more controversial idea of considering whole formations as an organism striving toward some predestined "climax." According to Tobey this view dominated ecological circles into the 1930's, even though H. C. Cowles of the University of Chicago for a time championed an alternative, more "mechanistic" kind of plant ecology.

In chapter 5 Tobey shifts from this intellectual history of ideas and personalities (which he condemns as outmoded in his introduction) to a quantitative study of the 535 publications on plant ecology between 1895 and 1955 that were listed in various bibliographies (mostly *Biological Abstracts* and its predecessors). He then focuses on the 58 persons (including five women) who wrote three or more of these books and articles. Data on them support what he has prepared us to expect—24 held doctorates from the University of Nebraska (compared with eight from Chicago and 12 from elsewhere), and many published with each other, cited each other (of the women only Irene Mueller was cited more than the minimum), and worked chiefly in certain academic departments (most often the University of Nebraska at Lincoln and Kansas State College at Fort Hays). From all these data Tobey maps the rise and then fall (the "life cycle") of the field and asserts that it all conforms strikingly to recent models suggested by Thomas S. Kuhn, Diana Crane, and Derek J. DeS. Price of how ideas spread and publications multiply.

Yet Tobey is too eager to confirm his elders' models and does not press on to extend or modify them for this at least partially applied science. For instance, though he admits in his methodological appendix that both U.S. Department of Agriculture (USDA) and agricultural experiment station publications "were regularly used by grassland ecologists" (p. 223), he relies on bibliographies that omitted them and makes no attempt to correct for this distortion, even though the link between agricultural and "pure" botany is central to his story and we are told repeatedly that it was Nebraska's agricultural problems from the 1890's through the 1930's that underlay and justified much of the plant ecology. Then, too, seven of the 53 items that were most often cited in the 535 publications (that were in the bibliographies) were USDA and experiment station reports.

This tendency to stick to the growth curves that fit the model and not to explore the interactions between "botany" and "agriculture" further is most serious in the last chapter, which is still the freshest and most interesting, since it deals with "saving the prairies," or the plant ecologists' valiant but futile attempts to stem the devastation brought on by the Great Drought of 1933–41, when dust storms almost blew Fort Hays away. This crisis changed the field and its practitioners dramatically. No longer could idealists stand back and let the prairies change themselves. Human intervention was necessary after all. Before long the Taylor Grazing Act of 1934 created a new branch of the USDA devoted to "range management," and even Clements, earlier considered a biological "conservative" for resisting the mathematicization of the field in the 1920's, became a liberal-to-radical New Deal reformer advocating still greater federal planning to save the Dust Bowl. But rather than seeing range management as a new vista for economic botany, Tobey is prepared by the subsidence of his bibliographical growth curves to see it all as failure and exhaustion of the old plant ecology; and rather than giving John Weaver of Nebraska, who we were told in the introduction was "the leading scientist of the second generation" (p. 3), his due, Tobey minimizes all this later work as mere intellectual "technology" (p. 218). Although Tobey claims to be telling the history of the grasslands plant ecologists and up to a point he does so as well as anyone is likely to, in the end his model runs away with the story and we are left with a most un-Clementsian anticlimax. The "life cycle" analogy is too restrictive here, unless it allows for a posthumous ("Lazarus"?) phase for all a specialty's activities after it is officially dead.

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Atomic Spectroscopy

The Theory of Atomic Structure and Spectra. ROBERT D. COWAN. University of California Press, Berkeley, 1981. xviii, 732 pp., illus. $45. Los Alamos Series in Basic and Applied Sciences.

The field of atomic spectroscopy is currently experiencing a resurgence of interest owing on the one hand to its applications in astrophysics, plasma physics, and other fields and on the other hand to the development of new experimental tools to probe atomic structures. One example of the latter is the use of tunable lasers to study highly excited atoms in the presence of strong external electric and magnetic fields. Another is the use of synchrotron radiation to probe with increasing detail the inner shell structure of rare earth, actinide, and other heavy atoms.

The theoretical foundations of atomic spectroscopy were given in a classic 1935 book, *The Theory of Atomic Spectra* by Condon and Shortley. It served the physics community for decades and is still useful today. The development of powerful techniques of tensor analysis by Racah in the 1940's has prompted a number of authors to write books on the theory of atomic spectra from this more modern point of view. The most recent of these books is that of Robert D. Cowan. His gives probably the most practical detail of all the recent books on the subject; it will therefore prove invaluable to those who plan to carry out numerical calculations and will be useful generally to all who wish examples of how well modern theoretical calculations compare with experimental data.

Cowan has made his career as a theorist in the field of atomic spectroscopy, and his book contains much of the wealth of practical experience he has acquired. The book is based on lectures he gave at Purdue University in spring 1971 and at the University of New Mexico in spring 1972. Though Cowan has greatly expanded the lectures, the book is still intended for possible use as a graduate-level textbook. Thus, all of the theory is developed from an elementary point of view, and there are suggested exercises at the end of many sections of the book. Though the theories of antisymmetric N-electron wavefunctions, irreducible tensor operators, radiative transitions, and so on are all included, the emphasis is on the actual numerical calculation of atomic energy levels. Flow charts of computer programs, detailed comparison with experimental data, ex-

tensive tabular material in the appendixes, and much advice on numerical procedures make this book especially useful.

Cowan's book treats topics in an amount of detail that is not easily found outside the research literature. For example, anyone who has ever studied atomic structure knows Hund's rule, which states that for a given configuration the lowest energy term is the one with the largest value of S having the largest value of L. Most books give the rule and explain its plausibility. Cowan gives a critique of it. He writes:

> With the limited amount of experimental evidence available at that time, Hund thought the above relations to be quite general. Although they are now known to be misleading more often than not (note the two points of disagreement in Fig. 4-4), they are still sometimes invoked in an attempt to predict the lowest term of a complex configuration. *Hund's rule* can safely be applied only to configurations with a single open subshell or with one subshell plus an s electron, and then only in the restricted form: *The lowest-energy term of a configuration* l^w *or of* l^ws *is that term of maximum S which has the largest value of L* [pp. 124–125].

Cowan then compares this restricted rule with experimental evidence and discusses its plausibility.

Other topics treated in similarly useful detail are the numerical solution of the Hartree-Fock equations and the complications and instabilities that can occur (sections 7-5 and 7-6), the use of nonorthogonal basis states in atomic structure calculations (section 13-2), and the effects of cancellation on theoretically calculated oscillator strengths (section 14-15). The theory of continuum wavefunction normalization is treated very satisfyingly for students: all the limiting procedures used to obtain the end result—which are glossed over in most quantum mechanics textbooks—are spelled out (section 18-3).

Three topics of current interest are discussed in the last chapters of the book. Chapter 19 reviews highly ionized atomic spectra, of interest, for example, in plasma physics. Chapter 20 discusses rare earth and transition element spectra, which are of interest because of their unique properties associated with the filling of f and d subshells. Chapter 21 discusses statistical distributions of atomic energy levels and applications of the theory in analyzing plasma spectra.

Despite the size of the book, Cowan omits many topics that are now subfields of atomic structure theory. Thus no discussion is given of group theory, accurate methods for treating few-electron atoms, or accurate methods for treating electron correlations in many-electron atoms. Rather Cowan has chosen to emphasize less powerful but more straightforward theoretical procedures that permit the theorist to analyze a broad range of experimental spectral data. In its emphasis on comparing theory with experiment Cowan's book is probably closest in spirit of any of the modern books on atomic spectroscopy to Condon and Shortley's classic work.

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Ethology: A Reiteration

The Foundations of Ethology. KONRAD Z. LORENZ. Revised version of the German edition (Vienna, 1978). Translated by Konrad Z. Lorenz and Robert Warren Kickert. Springer-Verlag, New York, 1981. xviii, 380 pp., illus. $21.95.

More than anyone else Konrad Lorenz is the intellectual architect of ethology. In the 1930's he labored to reclaim behavior from the perennial philosophical and methodological struggles between the vitalists and mechanists. In these days of computerized observational methods, sophisticated experiments, and sociobiological theory we often do not appreciate the struggle that was required to wrest the study of animal action from mystical instincts, reflex machines, and, somewhat later, the simplicities of laboratory behaviorism and biologically naïve environmentalism.

Unintimidated by then current dogma about conditioned reflexes and brain mechanisms, Lorenz brilliantly combined the ideas of others (especially Charles O. Whitman, Oskar Heinroth, Jacob von Uexküll, Erich von Holst, and Wallace Craig) along with his own insightful observations to construct a scientific approach that was clearly articulated, intellectually stimulating, and, most important, did not sacrifice the complexity and diversity of animal behavior on a barren altar of scientific rigor. Naturally, to simultaneously take on several opposed and entrenched ways of thinking ("ideologies" in this book) was not easy, and the difficulty was compounded by the advent of World War II just as Lorenz's seminal papers of 1935–39 were beginning to gain recognition in the English-speaking world. Physics performed by former enemies may be readily appreciated and accepted; theories of behavior, even of animals, strike too close to cultural myths to be readily evaluated objectively.

While containing echos of his subsequent books, this work primarily represents the assertive, aggressive Lorenz of the pioneering papers of the 1930's. Lorenz admits that the book does not represent the current field of ethology. His aim is to introduce modern workers to the often ignored indispensable core of ethological knowledge and how it was obtained. Like his earlier writings the book is based largely on personal observations and the studies of friends, colleagues, and students. Lorenz provides us his view of the style, as well as the substance, of classical ethology.

The book consists of three major parts, following a forthright introduction by Theodore Bullock, an ingenious short preface, and an "introductory history" that is required reading for everyone interested in placing Lorenz and early ethology in the proper intellectual and scientific context. Here we learn, for example, about the timely and crucial theoretical support provided by the physiological demonstrations of von Holst. The book itself is dedicated to Niko Tinbergen, who provided ethology with an essential experimental methodology.

Part 1, headed Methodology, consists of four chapters. We are treated to Lorenz's approach to thinking in biological terms, the contrast with the physical sciences, and the role of reductionism, teleology, and teleonomy. Then we move to methods of observation, yet not methods in the mechanical sense. We go back to the very nature of perception itself, to the intuitive grasp of "wholes," to the respective virtues of studying wild and captive animals, to unobtrusive experimentation, and, of course, the deprivation experiment. Lorenz tells us of the faults of atomism, explanatory monism, and operationalism. A lengthy chapter on the comparative method follows, where the emphasis is on phylogenetic reconstruction and behavioral homologies.

Part 2, the longest, is entitled Genetically Programmed Behavior. Here we find a complete résumé of Lorenzian ethology. There are detailed explications of fixed action patterns, releasers, centrally coordinated movements, and a new, refined "hydraulic" model. There are long discussions of the stimulus in the innate releasing mechanism, orientation processes such as taxes and kineses (phenomena that have lost favor in modern ethology texts but are having renewed importance in the study of insect behavior), and problems of motivation. This section of seven chapters ends with a discussion of displacement behavior.

In the '60's Lorenz devoted much at-