grandparents and numerous uncles are described in detail at the beginning of the book, his son Igor is mentioned only as being born. The beautiful Barbara, whose inimitable and imaginative verses are scattered through the volume, is given two paragraphs, one of them devoted mainly to a joke about Gamow's showing a policeman their wedding license instead of his driver's license.

However, Gamow was a thorough and methodical man (in spite of all appearances), and the reviewer has no doubt that the book would have been more complete if he had lived longer (he was still working on it at the time of his death). Anyway, it is very good reading as it is.

There are some revealing passages. Gamow's discovery of the mechanism of alpha decay was made in Göttingen in the summer of 1928 (and simultaneously by Gurney and Condon, as he states). He explains that although Göttingen was then full of the feverish activity of applying the new quantum mechanics to atomic and molecular problems, he did not get much involved in that (and decided to try instead to apply the new theory to the nucleus), for two reasons: First, there were far too many people engaged in that activity and he "preferred to work in less crowded fields." Second, "any new theory is almost always expressed in a very simple form, [but] within only a few years it usually grows into an exceedingly complicated mathematical structure. . . ." The same attitude appears in his complete lack of enthusiasm for the doctoral thesis topic (on the adiabatic invariants of a pendulum) that had been assigned to him in Leningrad; he found it boring. The idea of the mechanism of alpha decay occurred to him in Göttingen while he was reading an article by Rutherford, which contained an explanation that did not appeal to him. He says, with evident pride, "Before I closed the magazine, I knew what actually happens in this case." He valued simple ideas and simple explanations of things. His description of Friedman's work on cosmology emphasizes that Friedman's improvement of Einstein's cosmology involved deleting a term from Einstein's equation (the cosmological term) rather than adding new terms.

Gamow had a constant flow of original ideas (a sizable fraction of them were good ideas, and he abandoned the others quickly). It would seem that, in order to keep these ideas flowing, he studiously (though possibly subconsciously) avoided becoming involved in what he considered to be uninteresting complications. He surely *could* have learned to spell (in English, German, and in Russian) if he had wanted to, and this reviewer has seen him use mathematics (correctly) when he wanted to. But, by and large, he shied away from any subject when original ideas were no longer important and technical elaborations were accumulating instead.

If this interpretation is correct, it may partly explain Gamow's relative isolation in Boulder during his last decade. There were many good nuclear physicists and astrophysicists there, but apparently they did not seek out Gamow, nor he them. It may be that nuclear physics and astrophysics, in both of which he had played dominant roles, no longer appealed to him when million-dollar computers, elaborate theories, and volumes of data were involved. So, instead, he began to work in biology—in a part of biology where original ideas could still count. Unfortunately, this reviewer cannot assess his contributions there.

Other familiar Gamow characteristics are also evident in the book, such as his complete lack of both vanity and unnatural modesty and his complete lack of acrimony: situations that would have brought anger from others just brought jokes from "Geo." One can hardly imagine a more interesting world line to read about.

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The Causation of Behavior

Animal Behaviour. A Synthesis of Ethology and Comparative Psychology. ROBERT A. HINDE. Second edition. McGraw-Hill, New York, 1970. xviii, 876 pp., illus. $15.50.

Ethology has been generously endowed with general books by its leading practitioners, such as Eibl-Eibesfeldt, Klopfer, Manning, Marler, and Tinbergen. Robert Hinde's volume, in a revised and expanded second edition just four scant years after the first, remains in the ascendant. It is a perceptive scientist's analysis of some of the central questions about animal behavior. Although far too long and difficult to be used as a one semester's introductory text, this volume should be virtually mandatory reading for students of behavior beyond that level.

The volume is organized around the three major topics of causation, ontogeny, and evolution of behavior. It cannot, however, be considered a complete exposition of behavioral studies, for it gives little attention to behavioral problems at the population level. For instance, social systems are virtually ignored, as is much of animal communication. The chapter on evolution and behavior pays as much attention to the aid that ethology can render to taxonomy as it does to the actual evolution of behavior. Nowhere is there an analysis of how traditional behavior originates or how it is transmitted within populations. And the few pages devoted to the adaptiveness of behavior and its role in the creation and maintenance of species are more for the sake of completeness than analysis. This is, then, a book about the behavior of individual organisms.

The greater part of the volume is concerned with sifting the vast literature on what the Old World ethologists term the causation of behavior: its integrated control by environmental stimuli and internal physiological mechanisms. Hinde's *modus operandi* is to ask a question, such as whether coordinated movements are controlled by environmental stimuli, proprioceptive feedback, or endogenous central nervous mechanisms. He may take one or many chapters to frame an answer, weaving as he goes the warp of ethology with the woof of psychology. Often, the answer is not simply a choice among the alternative hypotheses but, rather, a documentation of the diversity of answers that pertain to different organisms and different behavioral patterns.

In tackling the various problems of causation—complex movements, the organization of perception, factors that produce selective attention and perception, internal drives, changes in motivational states, spontaneity of behavior, and the conflict of simultaneously activated patterns—Hinde introduces in passing many of the older ethological concepts rendered superficial by his synthesis. The chapter on animal orientation seems misplaced in these discussions, and the classification of motivational systems does not clearly enough dissect functional from physiological categories. Nor does the treatment of problems such as perception seem as penetrating as the treatment of problems on which Hinde himself

has worked: conceptions of drive, waning of responsiveness, and behavior in conflict situations. Hinde's thorough criticisms of unitary drives have done more than any others to remove the vague motivational concepts from ethology and to replace them with operational approaches to the assessment of internal processes that help to structure overt behavior. Despite some unevenness in treatment, Hinde's synthetic view on the dynamic control of behavior is the best in print.

The remaining third of the book is devoted primarily to an inquiry into the nature-nurture controversies of behavior, and should serve to bury much of the past nonsense written on the subject. Hinde tries to show why the dichotomy of behavior into "instinctive" and "learned" patterns or components is not useful—indeed, why the ever more subtle viewpoint of genetic and experiential components of information leads to sterile controversy. These things he does by concentrating upon the interactive processes between developing organism and changing environment, although one regrets that more behavioral genetics did not find its way into the text. Hinde does not merely avoid the sterility of learning theory, but attempts to place learning phenomena in their rightful role of furthering the development of adaptive behavior.

A behaviorist asserted recently that first editions should be allowed to fade away because subsequent editions are at best spotty patch jobs that lose the coherence and freshness of the original effort. Hinde's revision loses nothing—rather it gains significantly through additional evidence, more careful organization, and clear exposition.

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On the Course of the Biology of Man

Changing Patterns. An Atypical Autobiography. MACFARLANE BURNET. Elsevier, New York, 1969. x, 282 pp. + plates. $8.50.

Biographies of leading scientists provide valuable insight into the frequently fortuitous manner in which fundamental discoveries have been made and general theories propounded. They reveal the peculiar and unpredictable sequences of events that shape the destiny of older sciences, the ontogeny of newer ones, and the careers of those who pursue them. Autobiographies, especially by one's contemporaries, though more susceptible to bias, can be much more informative and interesting, since they provide "inside" accounts of what it's like to work in a particular field and may provide hints toward achieving better performance for fellow scientists. How many of us have wondered why Dr. "X" has been so much more successful than we have in making original contributions in the laboratory, gets so many more invitations to give important lectures and prestigious addresses, and in addition finds time to produce stimulating reviews and books on a variety of subjects and to perform a full share of administrative and other duties?

Those who know Sir Macfarlane Burnet will recognize that in *Changing Patterns* he has written an extremely honest, as well as readable, analytical account of his 50 years' highly productive life as a medical scientist, during which time his own laboratory achievements and scholarship have exerted a tremendous impact on the development of virology, epidemiology, immunology, oncology, gerontology, and molecular biology. His career has been collinear with a period of fantastic achievement in the conquest of infectious disease, a period in which, for the first time, physicians have had the means to exert a significant influence on life expectancy.

Through Burnet's eyes and from his vantage point in Australia, we review the exciting changes in the scientific aspects of medicine and approaches to biological research, due in part to greatly increased funding, that have come about during his career, and we are made party to his views about the impact of science, especially biological science, on human affairs of the future.

The book presents, in a well-organized manner, accounts of many events connected in some way with the author's career: for instance, his early contribution as a bacteriologist investigating a tragedy attending a campaign of immunization against diphtheria in 1928, and the curious way in which such an unlikely animal as the ferret, happening to be available at the National Institute for Medical Research in London in 1932, provided the urgently needed susceptible host species for influenza studies. Burnet tells much of his work on poliomyelitis, but it was his account of the activities and beliefs of that once legendary but now forgotten nurse from Australia, Sister Kenny, who restored hope to victims of polio, that held my attention.

Another project, which was close to the heart of the ecologically minded Burnet and in which he participated as a consultant, was the deliberate introduction of myxoma virus into Australia as a means of reducing the rabbit population. An outbreak of severe encephalitis, with fatalities in children, in an area in which rabbits were dying by the thousands threatened to cause a public outcry against the undertaking. This was happily averted by the demonstration that the viruses involved in the two species were different and that the inoculation of volunteers, including Burnet himself, with myxoma virus had no ill effects, and the ultimate success of the project was resounding.

Repeatedly we find anecdotes revealing the author's interest in epidemiology, none more interesting than his account of his visit with W. N. Pickles, a paternal medical practitioner in an English country district who, in pursuing old-fashioned epidemiology as a hobby, made important observations concerning influenza and hepatitis.

Burnet is saddened by the realization that the transformation of pneumococci by DNA terminated the heyday of medical bacteriology, the field of his early endeavors and the one that introduced him to immunology. This discovery heralded the new science of molecular biology, which was partly his child. Burnet admires molecular biology as an intellectual achievement, as he does the hydrogen bomb, but has grave misgivings about both on the grounds that they lack present or even potential usefulness to man and can do harm through accident or misuse—a molecular biologist monkeying around with polio virus might produce an appallingly dangerous variant. He expresses great cynicism about the often-voiced opinion that advances in molecular biology will afford means of preventing cancer and of replacing defective genetic units in the human genome with good ones; he sees no conceivable way in which knowledge of protein synthesis and the genetic code could be applied to human benefit, believing that the complexity and order of the human genetic apparatus put it beyond approach at the chemical level.