with the search for security in a free society, entitled "Program comparisons: Sweden and the United States."

These two books are well written in different styles, informative, and even exciting in different ways. The exciting message they convey is that Sweden does have something to teach Americans as well as other developed nations. The lesson is especially poignant in America, the present *primus inter pares* of the world's powers. No society has bet more heavily than America on the public forum—free public education plus mass media plus social science; but it still seeks the payoffs that are already visible in Sweden.

DANIEL LERNER
Center for International Studies, Massachusetts Institute of Technology, Cambridge

Assault on the Citadel

The Ghost in the Machine. ARTHUR KOESTLER. Macmillan, New York, 1967. xiv + 384 pp. $6.95.

The Ghost in the Machine is a book about psychology and evolution and genetics and the brain sciences and even a bit about sociology and history and philosophy. It takes a brave man to write such a book. But Koestler is, after all, knowledgeable in the history and philosophy and substance of science, and the fact that he dares write of matters scientific with wit and style and occasional brilliance does not make it any easier to categorize him as a popularizer who does things once-over-lightly. Indeed, many scientists reading *The Ghost in the Machine* will probably be pleased by all sections minus one. The one section that will evoke the least enthusiasm will be the one where the reader's particular specialty is under discussion. This is not, however, meant as a snide criticism of Koestler—for the fault lies not all in Koestler. No one of the life sciences is in short supply of blemishes; Koestler seeks out these vulnerable spots, and when he finds them, he attacks. He is no mean polemicist, and when he attacks, he hurts.

At the very outset of his argument Koestler announces his targets:

> The citadel of orthodoxy which the sciences of life have built in the first half of our century rests on a number of impressive pillars, some of which are beginning to show cracks and to reveal themselves as monumental superstitions. The four principal ones, summarised in a simplified form, are the doctrines
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> a) that biological evolution is the result of random mutations preserved by natural selection;
>
> b) that mental evolution is the result of random tries preserved by 'reinforcements' (rewards);
>
> c) that all organisms, including man, are essentially passive automata controlled by the environment, whose sole purpose in life is the reduction of tensions by adaptive responses;
>
> d) that the only scientific method worth that name is quantitative measurement; and, consequently, that complex phenomena must be reduced to simple elements accessible to such treatment, without undue worry whether the specific characteristics of a complex phenomenon, for instance man, may be lost in the process.

Let me illustrate Koestler at work (confining [illegible] SCIENCE, VOL. 160 throughout this review, to his treatment of psychology, which occupies about half the book). To begin with, and with his pen sharpened to a stiletto point, Koestler goes after the behaviorists. Now those of us who are psychologists of the nonbehaviorist persuasion cannot, of course, completely disassociate ourselves from our benighted brethren—many of them are our respected colleagues. And even if we feel (as I do) that behaviorism (the paleo-form of Watson or the neo-form of Skinner) is one of the greatest of catastrophes that have befallen our science—even so we cannot but squirm uncomfortably when he introduces his discussion of experimental psychology with a quotation from Swift's account of his *Voyage to Laputa*: "He had been eight years upon a project for extracting sun-beams out of cucumbers, which were to be put into vials hermetically sealed, and let out to warm the air in raw inclement summers." We continue to squirm when Koestler tells the world that "There is hardly a self-respecting psychological faculty in the Western world without some white albino [*sic*] rats disporting themselves in so-called Skinner boxes, invented by that eminent Harvard authority. The box is equipped with a food tray, an electric bulb, and a bar which can be pushed down like the lever of a slot machine, whereupon a food pellet drops into the tray."

We look over our shoulder in embarrassment to see whether any of our scientific colleagues are also reading when Koestler quotes Harlow in 1953 to the effect that "a strong case can be made for the proposition that the importance of the psychological problems studied during the last fifteen years has decreased as a negatively accelerated function approaching an asymptote of complete indifference."

And we hardly have the heart to fight back (or even to complete filling out our latest grant-request form) as he ends his chapter castigating a psychology which "lives on specious analogies derived from the bar-pressing activities of rats. The record of fifty years of ratomorphic psychology is comparable in its sterile pedantry to that of scholasticism in its period of decline, when it had fallen to counting angels on pinheads—although this sounds a more attractive pastime than counting the number of bar-pressings in the box."

Clearly, insofar as I am my brother psychologist's keeper, I am not going to be pleased with Koestler On Psychology; and clearly part of my displeasure derives from the truth of much of what Koestler has to say. But having said that, I have said only part of what needs saying. For part of my irritation with Koestler on psychology, and by far the larger part, derives from Koestler's unfair and unscholarly job. Koestler is guilty of some of the most grievous sins of the polemicist. He overstates, he understates; he selects data, he neglects data. Koestler to the contrary, "academic or 'experimental' psychology, as it is taught at the great majority of our contemporary universities," is not restricted to counting bar-pressings in the box, or to adumbrating in talmudic arguments (in midwestern accents) upon behavioristic themes. To argue this way,

as Koestler does, is a grotesque exaggeration. The vast bulk of modern academic psychology—even at Harvard and even at Yale—is far and away and beyond the ken and concerns of Skinner and Hull. I am not here arguing that Koestler is flogging a dead horse. I quite agree with him that behaviorism is not a dead nag, that its neighings and its whinnyings are still heard in the land; but I am asserting (and in the process am doing violence to a metaphor) that by far the largest part of psychology is a horse of quite a different color, indeed of many splendid different colors. Koestler tells us that he is seeking, in this book, to make a contribution toward a "true science of life." That is a most noble purpose. But why then neglect almost all of psychology? Why neglect such areas as psycholinguistics, personality research, brain and behavior research, the modern and very much refurbished research in verbal learning, cognitive psychology, social psychology —all of which are taught at the great majority of our contemporary universities and almost none of which has even distant kinship with behaviorism?

And so we both stand at fault. Those chapters which we will find less than delightful will be chapters in which Koestler has found us out in our foolishness, but in which he attacks us unfairly and with something less than the scholarliness we might expect from him. I strongly suspect that the geneticist and the evolutionist would testify similarly regarding Koestler's treatment of their sciences.

Koestler's book, for a psychologist at least, has other failings. After demolishing the cracked pillars of our unwisdom, he turns to construction. And here he has much to say. But many of the true things he has to say—about behaviorism (in a chapter titled "The poverty of psychology"), about the mind-body relation (in the chapter from whose title he has taken the name for his book), about the problem of units of analysis in science (where he coins a most useful word, "holon," to substitute for a number of words originally employed by the Gestaltists), or about neurological theories of emotion (The Three Brains)—have been said too often to sound new, even on Koestler's clever tongue. Many of the new things he has to say—especially about the cause and cure of the self-destructive tendencies in man—seem just too simple to be true, even with his long (300 pages) buildup and preparation for the denouement. The ability to integrate our emotional urges with our intellectual ones—the lack of which today threatens our very survival—will come, he believes, only when biochemistry discovers the Pill which will bring about a "state of dynamic equilibrium in which thought and emotion are re-united, and hierarchic order is restored." I miss (and am surprised to have to say this of Koestler) a more sophisticated discussion of the political, economic, psychological, and sociological supports which would be necessary if his Pill is to solve modern man's predicament. As his conclusion now stands one might (and no doubt many will) accuse Koestler of having written a book of science with a science-fiction ending in which a naive Better-Living-Through-Chemistry doctrine is presented as a solution to all our international ills.

And yet, as I reread the last few paragraphs which I have just written, I feel that I have done Koestler's book an injustice. His book is better than I make it sound. And I think I know the reason why. It is because I have reviewed the book Koestler thought he had written, rather than the book I enjoyed reading. Koestler believes that in his examination of psychology and genetics and evolution and the brain sciences he was picking up the "loose ends, the threads of ideas trailing in the fringes of orthodoxy . . . to weave them into a comprehensive pattern in a unified frame." If this was Koestler's objective, then I must judge his effort a failure. There are too many lacunae, too many solutions on too abstract a level, too much selection of data-to-fit to call this a "unified frame" for serious scientific theorizing, speculation, and research. I cannot agree with the blurb on the book's jacket (for which, of course, I do not hold Koestler responsible) that Koestler's thesis "is certain to provoke controversy and debate for years to come."

But if we read Koestler's book not for what he thought he was writing, but for what valuables we can find in it, then I can wax much more enthusiastic about it. I am tempted to say that Koestler has written a good book despite himself. For we have here a collection of lucidly written and compelling critical and speculative essays on the many-faceted life sciences. Of how many books can it be said that no chapter bores? Even the irritating chapters and even those with the oft-told tales provoke thought and, at the end, have profited the reader. And of how many books can it be said that again and again the reader is forced to stop and puzzle and speculate about matters which he had thought already to have been settled to his satisfaction long, long ago? (Reread the four "monumental superstitions" quoted at the beginning of this review.) Koestler has written a frequently unsettling and, therefore, a lively and interesting book which the scientist can read with profit, but above all—and that is so rare—with pleasure.

DAVID KRECH
Department of Psychology,
University of California, Berkeley

The Biological Uses of a Venerable Concept

Optimality Principles in Biology. ROBERT ROSEN. Plenum, New York; Butterworths, London, 1967. xii + 198 pp., illus. $9.75.

The concept of optimality has become familiar to most scientists, largely because of its central importance in operations research, or systems analysis. In this context, one seeks to maximize or minimize one or more dependent variables through appropriate selection of variate values for independent variables. Because of the great importance of this problem in many areas of science, a formidable body of mathematical techniques has been developed for dealing with it. As Rosen points out, optimality also has a venerable history in physics, as for example in Fermat's principle of least time, Maupertuis's principle of least action, and Hamilton's principle. Since the most powerful central concept in biology, evolution through the survival of the fittest, is in effect an optimality principle, it is surprising that a comprehensive effort to apply optimality to biology has awaited the arrival of this interesting little book. Rosen has made such an effort, and if the ideas he presents are extended and applied with sufficient ingenuity, some of the ultimate consequences may be very important indeed.