By revealing *ex post facto* the credentials of scientific arguments which have succeeded, he is able to delineate for us all what sorts of considerations might very well guide the problem solver through his labyrinthine scientific jungles. Hempel seeks to clarify for us the logical features of anomalies—the conceptual background of "the unexpected." With the sure virtuosity of a master logician he delineates how it is that observation-series can confirm a hypothesis, or disconfirm it. He undertakes to reveal how ensembles of data can corroborate theories, or can serve ultimately to render them useless in further inquiry. Sundry logical problems connected with the philosophy of probability punctuate his book on many pages. And without his illuminating contributions to our understanding of the function of *hypotheses* we should be poorer in analysis than we are at the moment.

Granted, these concerns are all centered on what might be called "the logic of the finished research report." And why not? Finished research reports are not themselves all of a piece. They can be distinguished from each other by virtue of the degree to which one is well made, while the others are not. One may rest its conclusions on observation and upon data logically aligned and inferentially bound to the terminus of its argument. Another may derive its strength from models and analogy. It is notorious how many research reports fail by being weak in both these respects. Any practicing scientist who would refuse the reflections of a serious logician at this stage of his inquiry would not be behaving reasonably. There are other interests for philosophers of science; "the logic of the scientist perplexed" might identify one such area. But this is not Hempel's forte, and in the groves of Academe it is still possible for a man to write books about what he pleases—and we are fortunate that this is the case when a philosopher like Carl Hempel chooses to write.

Thus, activities on the scientific battleground are of many different kinds. Some scholar could be interested in studying the attitudes of researchers before and while winning scientific encounters. Such a scholar would be concerned with the psychology of discovery—as were Wertheimer, Hadamard, and Polya. The thought processes of discoverers would be the focus here. Or perhaps it is the rational strategies invoked during such encounters that capture the imagination of philosophers. Contributors to this area of inquiry would be Toulmin, Peirce, and Whewell, among others. "Good reasons for entertaining as-yet-unestablished hypotheses" would be the watchword here. Still others will address the necessity of coming to understand what conceptual moves must be made in order for the scientific terrain, once achieved, to be related and integrated with the larger logical geography of the scientific enterprise. Such scholars will set out the logical justification for such new territories being adjudged properly acquired, with claims on them fully and justifiably established. "The logical underpinning of scientific knowledge" is the motto here. In this department of inquiry names like those of Carnap, Tarski, Reichenbach, and Hempel are the ones to be reckoned with. And this comports well with *dramatis personae* within the scientific epic itself. There are those whose discoveries came in a flood of inspiration—the Rutherfords, the Poincarés, the Kékulés, and the Keplers. There are also those whose unprecedented work at the frontiers was supported by brow-breaking initial arguments of considerable cogency—the Clerk Maxwells, the Newtons, and the Galileos. And, finally, there are those whose great and necessary contributions consisted in fortifying, strengthening, and holding the scientific ground already won by scholars in the vanguard. These are the Eulers, the Laplaces, and the Lagranges. The philosophical concern of Carl Hempel lies parallel to this camp. For the distinguished productions of his life, and of this present book, are tied to questions of justifying the arguments, eliciting the criteria, and exposing the inferential structure of those areas of knowledge that have become the glorious legacy of the scientific endeavor.

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## A Theory of Instruction

The battle for the souls of American schoolchildren continues. The weapons have been a little research, a lot of rewritten curricula in mathematics and science, and an assortment of books on education by people who were not, before the crusade, professionally interested in the education of children in elementary and secondary schools. Jerome S. Bruner of Harvard's Department of Psychology and Center for Cognitive Study has brought together a little group of essays—**Toward a Theory of Instruction** (Harvard University Press, Cambridge, Mass., 1966. 176 pp., $3.95)—that are gracefully written, lucid, and, uniquely among contemporary commentaries on education, never shrill. Bruner sketches out a theory of human development and a theory of instruction, he writes of education as a product of cultural evolution and of cultural evolution as a course of study for children, he rehearses strong opinions about the relation between English style and thinking and about the nature of "the will to learn," he presents some beguiling observations on children with learning blocks, and, despite the range that he covers, he manages a certain thematic unity.

Two basic ideas hold the essays together. Bruner believes that the instruction of children requires a continuing conversation on the relation between intellectual development and pedagogy, a conversation between the psychologist of development and the teacher. By the way, the psychologist is seen as valuable in educational reform not only because he can describe patterns of human growth and carry out research on motivation but also because of his "lively sense of what is possible." The second theme that unifies Bruner's wide excursions is his enthusiastic commitment to Rational Man. In the days of Vietnam and New York subways it is heroic to suggest that "much of the intrusive nonrationality about us . . . derives from our [nonsymbolic] operations upon experience" as though symbolization in natural language, number, or logic had ever been a guard against nonrationality. So too with the child's desire to learn. Curiosity seems "among the most reliable of the motives" and "the will to learn is an intrinsic motive, one that finds both its source and its reward in its own exercise." Bruner's optimism dips only once: in writing about children who have blocks to learning, he reminds us of "the imperiousness of our drives and the demands of powerful, nonrational, and indocile unconscious mechanisms."

*Toward a Theory of Instruction* is not a technical book, and Bruner disarms the critic by putting down his own essays—". . . too little data, too little systematic observation, too sparce an arsenal of analytic tools." Nonetheless, Bruner raises issues of great consequence and, coming at a time when

we are trying to define our society by defining our children, *Toward a Theory of Instruction* will influence lay and professional talk about education for some time. Two programmatic essays, "Patterns of growth" and "Notes on a theory of instruction," contain Bruner's central principles. In the first, he treats of the child's response to his world in three modes—the *enactive* in which "an object is what one does to it," the *iconic*, in which "images develop an autonomous status," and the *symbolic*, when language becomes "an instrument of thinking." This scheme, which owes a great deal to Piaget and to Werner, permits Bruner to discuss the several ways in which a child may solve the "same" problem and leads him to a conclusion of what education is fundamentally about—"providing aids and dialogues for translating experience into more powerful systems of notation and ordering." Bruner comes closest to the classroom in his essay on instruction. He maintains that a proper theory of instruction requires statements about predisposing conditions for learning (he emphasizes guided exploration), statements about the structure of a body of knowledge (he makes revealing comparisons of different methods of representation), statements about the sequence of materials presented to the child, and statements about the quality of rewards and punishments administered (Bruner sees intrinsic reward as incomparably more effective than grades or praise dispensed by the teacher). Bruner discusses these requirements in a general form and then in application to the teaching of quadratic equations to young children. The argument is plausible and the application ingenious. Unfortunately, Bruner's enthusiasms and his remarkable ability to call up apt illustrations blur the essential distinction between the convictions of a gifted teacher and a serious theory of instruction. The conversation between developmental psychologist and teacher has hardly begun.

*Toward a Theory of Instruction* is valuable in part because it represents speculation in the middle range—between too-grand generalization and laboratory detail. It presents the best case yet made for carefully planned and concurrent evaluation of curricular innovation. It speaks for all school children in arguing for playfulness and personalization in teaching. It is a virtuous book that will offend only the crustiest members of the educational establishment.

An important question remains unanswered at the end of *Toward a Theory of Instruction*. What should we do now? Bruner is indefinite about his intended audience but however it be defined—parents, teachers, psychologists, or citizens—the audience receives no obvious call to action. Bruner closes *diminuendo* when he urges us to "have the courage to recognize what we do not understand and to permit ourselves a new and innocent look" at the problem of instruction.

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## Sources of Science Reprint Series

William Harvey has been rediscovered again. The tercentenary of his death, which was celebrated in 1957, served as the focal point for new editions and new translations of Harvey's work. In the past decade the very rapid growth of the history of science and history of medicine has given great impetus to new scholarly efforts. Not only was the *De motu cordis* retranslated, together with a volume of Harvey's letters on the circulation of the blood, but a series of previously unpublished Harvey manuscripts were brought together by the British medical archivist, Gweneth Whitteridge. More recently, two separate translations of Harvey's manuscript "Anatomical Lectures" were prepared, one by O'Malley, Poynter, and Russell, the other by Whitteridge.

Although Harvey has been the subject of several recent biographies, all of them have been fairly thin studies, and, surprisingly enough, none have shed much new light on the life and work of the great physiologist.

It is against this background of activity that the Johnson Reprint Corporation has reissued the 19th-century volume, **The Works of William Harvey** (Johnson Reprint Corp., New York, 1965. 750 pp., $25) in their Sources of Science Series. Robert Willis, who translated and edited the original printing for the Syenham Society as one of their translations of the writings of great physicians, did a creditable job by anyone's standards. And, although there have been corrections and emendations by the later editors and translators of Harvey, none of these have been so significantly better as to fully displace the work of Willis.

Opening the volume is a brief biography of William Harvey which, in its 80 pages, sets forth the basic outline of Harvey's career. It reflects its author's desire to add to the medical literature a "life of Harvey by one who had maintained a familiarity with anatomy and physiology."

The full text of the *Anatomical Disquisition on the Motion of the Heart and Blood in Animals* is presented together with the two public defenses addressed to John Riolan. Various of the anatomical letters are also included.

There is no doubt in my mind that this edition of Harvey's works is important primarily because it contains the full text of the *Anatomical Exercises on the Generation of Animals*. This lengthy embryological treatise of Harvey's has not been reproduced nor re-edited in English in the past hundred years. The original Sydenham edition of the works has been out of print for a long time, and it is therefore a pleasure to welcome this volume of Harvey's studies on generation and development. Students will now be able to have before them the full corpus of one of the 17th century's great biologists. The inclusion of the embryological treatise permits a much better understanding of Harvey's roots in the past, as well as of his experimental advances, than is available to those who read only the very spare and experimentally organized study of the motion of the heart and blood. It is too bad, however, that no scholar has yet undertaken a new translation and editing of Harvey's work on generation; historical scholarship during the past century has added much to our understanding of the role of Aristotelian thought in the 17th century, and this, in turn, permits a far better understanding of Harvey's own work.

But, having praised this new publication, I can only bemoan the fact that its price, $25, places it beyond the reach of the student and the private scholar and suggests that only the library with a good budget can afford to purchase it. In this day when so many more students are becoming interested in the historical development of science, it is a shame to reprint classics in prohibitively expensive editions.

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