

shortcomings is in order to prevent this review from becoming lopsided. Careful perusal reveals only six typographical errors (none critical) in the entire book. There appear to be no errors of fact, but some of the footnotes (see pages 106 and 268) are moderately confusing. The important term "contravariant" appears on page 123, long before it is defined or explained, and neither it nor "covariant" are adequately explained. The listing of "cosmological facts" on pages 218-19 is excessively cursory and somewhat confusing, and the poor dimensional notation (for example, "km/sec/megaparsec," which should read " $\text{km sec}^{-1}\text{Mpc}^{-1}$ ") only accentuates the confusion.

The collection of problems at the end of the book is excellent, though some of the harder problems may strain the capacity of even the most brilliant undergraduate. Finally the index is quite short, but I could find no fault with it whatsoever.

In summary, Rindler's *Essential Relativity* should become a household word among undergraduate science students. Only the appearance of a better text at this level can displace it from its rightful place on the bookshelves of the scientifically inclined, and we have yet to see that better text.

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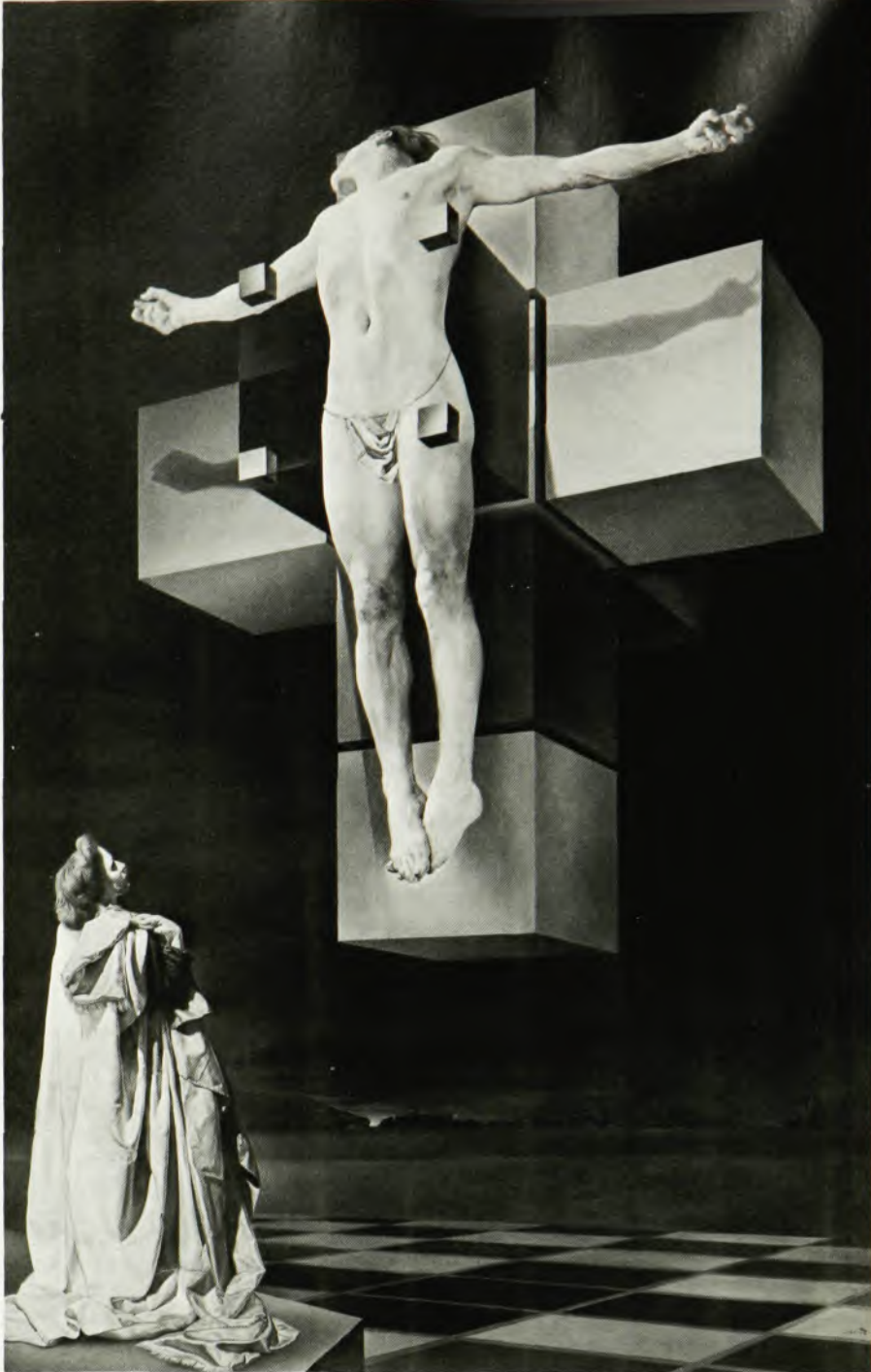
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Behind Appearance: A Study Of Relations Between Painting and Natural Sciences in This Century

By C. H. Waddington
256 pp. MIT Press, Cambridge, Mass., 1970. \$25.00

The author of this book, Conrad H. Waddington, is professor of animal genetics at the University of Edinburgh. He also has a host of friends within the art world and is, in addition, a frequent visitor to the art galleries and museums. It is from this interest and knowledge of the arts that the author draws his ideas about painting. As might be expected, his theory extols science in claiming that painting and science share a common tendency toward probing *behind appearance* into the underlying structure of things and that science has consciously and unconsciously affected the work of many painters.

The book, in addition to expounding this theory of painting, also contains a well written account, intended for scientists, of the mainstreams of modern



Salvador Dali's "Crucifixion." (Courtesy of the Metropolitan Museum of Art.)

art since 1960 and a somewhat historical and slightly technical explanation, intended for artists, of the important scientific discoveries in biology and physics. In essence, the author has attempted to write a book for both artists and scientists about art as viewed through the author's scientific eyes.

Waddington has an ability to write such intricately involved sentences and paragraphs that it is extremely difficult at times to unravel his ideas and theories. The real fun in reading his book is in this unraveling and in attempting to understand just exactly what he might have meant. Although some readers might enjoy this "do-it-

yourself" approach, it does make reviewing somewhat difficult. But reviewing we must!

In my opinion, this book is best described as a confusing melange of unintentionally misleading information and deeply imbedded contradictions. The author chides artists for using scientific terminology falsely and misleadingly in explaining their art. But Waddington then presents confusing information about such scientific things as the fourth dimension and quantum mechanics. Worse yet, he too falls into the trap of using pseudoscientific gibberish in artistic explanations, for example, "The scientific 'true reality' with

which Mondrian was acquainted finds its expression in terms of energy which operates in a bare space-time continuum, from which all trace of personality, or of the 'secondary qualities' revealed in human perception, have been banished." And as an example of scientific mystique: "[The Schrödinger equation] dealt with waves of a special kind referred to as *psi-waves*." As what must be considered a colossal oversight, no mention is made of Salvador Dali's magnificent and ingenious painting of Christ on the cross in which the cross was deliberately and knowingly painted as a projection of a four-dimensional hypercube.

The author is against the atomic bomb and claims that a number of artists "have responded to the horror of the atomic bomb." So anti-atomic bomb is the author that he attacks scientists working on the bomb as scientists who "placed their services as technical experts at the disposal of the political governments of their countries," and he further ostracizes them from "the community of natural scientists." I would strongly suggest that the author spend a little time in studying and understanding the vast scientific, technological and political aspects of the atomic bomb along with the histories of such men as J. Robert Oppenheimer. A book on art should not be an open

forum for a political speech against the atomic bomb and 20th-century technology as being the cause of Man's present dismal state of existence. Artists throughout history have been depicting Man's dismal state of decadence and lack of morality.

A quote that I consider a particular gem is:

"Looking at paintings, or experiencing other kinds of art, especially kinds which are not too immediately transparent but which demand some attempt by the spectator to enter into the experience of the artist's creative process, is one of the best ways for a scientist to loosen the joints of his psyche, to 'roll the bones' of his ideas, and give himself a chance to dredge up from the obscure internal depths something, which will probably have not the slightest obvious connection with the work of art he has been contemplating—but which may be fresh enough to be worthwhile."

The final inescapable conclusion about the book is that it is disorganized and confusingly written and expresses a strange mystical conception of both science and painting. The book, however, if not taken too seriously, is great fun to read and to ponder.

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The Nature of Physics: A Physicist's Views On the History and Philosophy Of His Science

By Robert Bruce Lindsay

212 pp. Brown U. P., Providence, R. I., 1969. \$7.50

This volume contains the mature reflections of a well known physicist who, in his own way, has come to grips with the philosophical and historical aspects of physics that have been his professional concern for about 40 years. The essays here presented are mostly new but lean heavily upon articles published since 1928.

R. Bruce Lindsay approaches his investigation of the nature of physics by examining the method that physicists have employed to study human experience. Essentially this involves the description and creation of experience and the enlargement of these two aspects of experience by understanding (that is, by the construction of theory).

In reflecting on these matters it is crucial to recognize, he emphasizes, that experimentation is not merely controlled sense perception. It also produces experiences new to man. "Experimentation may be described as the creation of experience." What is not clarified satisfactorily (for example on page 20) is that the terminal or theory stage of the method of physics is not so

neatly to be set apart historically from either scientific description or experimentation. Rather, as we learn more about "the nature of physics" from our historical studies (by posing philosophically significant questions) we discover that the interaction of the imaginative, intuitive, logical and operational components of theoretical and experimental physics are significantly linked together in one way or another.

An examination of the key to understanding (theorizing about) physics is given in the main part, which deals with the structure of physical theory and the special philosophical problems encountered in physics.

It is fair to say that Lindsay's position relative to theory appraisal is a compromise between the positivistic criterion of success and the absolutely unfettered and free invention of constructs and postulates. Accordingly, he accepts the somewhat tentative and arbitrary character of physical theorizing as the price the physicist has to pay for the freedom to create, imaginatively, those constructs and postulates that, in his bones, he feels to be essentially correct. Yet he knows they must be presented undogmatically to his colleagues for critical examination. To sum it up: "The

physicist who invents a new theory will use all the weapons in his arsenal to justify its plausibility ... [and he will demand] the right to continue to exploit a theory if he feels confident that it is an ingenious idea and if it helps him understand a certain domain of experience. In the last analysis we come back to faith in the value judgments of clever and imaginative people."

Who is clever, and what is imaginative? These are questions that belong to the psychology of the scientific behavior of creative individuals—concerning which our author suggests that we know, as yet, next to nothing. I believe that he is right. But we can not afford to restrict our attention, as philosophers or historians, to the testimony of scientists who offer an account of the circumstances surrounding their own moments of creativity. Mostly they do not exist; and when they do, the evidence can be risky. I see no convincing reason for not examining such questions with the help of insights provided by the psychological, physiological and sociological study of group behavior. Not unless scientists are some kind of special breed. Not unless science is a discipline with a method exclusive to itself. I seriously doubt that an analysis that limits itself exclusively to the logical structure of physical theories can, in fact, tell us very much about what a physicist does when he claims to be doing physics.

In this work Lindsay is very hard on rigid operationalism because it seems to rely on ultimately valid and verified explanations of physical experience. Such a naive realism disregards the lessons of the history of physics and ignores "the frightful speed with which new physical experience is being created on a grand scale." Our author is even harder on Eddington's idealistic epistemology than on the kind of Bridgman operationalism that leads to confirmed realism. He seeks refuge, then, as a philosopher of physics, on the side of Poincaré's conventionalism. For he argues that, even if we were to be persuaded that all human knowledge about experience is created by the mind, "it seems reasonable to suppose that as the creation of experience multiplies, the methods the mind uses to cope with it will change." That is, we shall never quite know by performing mental gymnastics alone or by carrying out experiments alone which theoretical constructs in physics will be the most satisfactory. We must simply, through the creation of experience and with flexibility of thought, settle for those constructs that we deem most convenient.

Lindsay's excursions into the history of physics are noteworthy mainly as an index of the kind of history of science that preoccupies a physicist or a physicist turned philosopher. He holds, cor-