vestigators of materials at cryogenic temperatures.

Dietrich's valuable contribution will provide a taste of the potential that is available in the marriage of cryogenics and electron optics. Anyone interested in electron optics and in particular high-resolution or high-voltage electron microscopy should be stimulated by this tightly written and exciting introduction to the subject.

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The Key to the Universe

N. Calder
198 pp. Viking, New York, 1977. $14.95

When the reporters wanted to follow the triumphs of space technology, they knew the calendar of the events exactly. Major events were programmed years in advance. The 1969 Moon landing was programmed to the hour, years ahead of time. With the aid of the television cameras one could make the technological history happen in front of the eyes of all mankind. Why not, then, follow in the same manner the discovery of a major kind of event in the field of elementary-particle physics? After all, the necessary props of the high technological drama are there: giant accelerators, hordes of people, exotic equipment, computers and so on. Major research centers of the US and Europe, such as Fermilab, SPEAR, Brookhaven, and CERN, know their schedules of experiments with ponderous precision. One only has to direct several TV crews to the most promising experimental set-ups, and *Eureka*! "One small particle per microsecond, one giant heart-beat for mankind." The recent drama in the discovery of the new ψ/J particle at Stanford and Brookhaven appeared to promise a repeat. A similar new drama of discovering the "Naked Charm" offered an opportunity to be duly recorded on magnetic tape. This could be a television first: a scientific discovery and the drama surrounding it would be captured forever. To quote the writer of this book, Nigel Calder, former editor of *New Scientist*, winner of the UNESCO prize for the Popularization of Science, and producer of the NET–BBC TV program "The Key to the Universe:" "This book and the associated television program was intended to lay before the public the splendid fruits of recent research into the working of the universe."

In that sense both the TV program and the book have failed. The drama of instant distant discovery, the elusive moment of scientific exuberance, smiles, handshakes, champagne, did not happen. The discovery of Naked Charm squeeked in timidly after months of careful analysis and re-analysis of data recorded on magnetic tapes almost a year earlier at the SPEAR electron colliding rings.

But both the two-hour TV program and this book—*The Key to the Universe*—are an enormous success. Starting with the most elementary concepts, Calder introduces the reader to the up-to-date and most novel ideas of elementary-particle physics and astrophysics. The language used and the explanations given are always very simple, understandable, and sometimes novel. From the chapter "Electricity as the Life Force," followed by "Alchemy of the Weak Force," leading to the strong interactions called "Sunfire," one gets readily immersed into the "Color Force" and the problems of "Freedom and Slavery among the Quarks." In the unique newspaper style, resembling in some way the Walter Cronkite "You Are There" format, the readers are introduced to all of the modern ideas of high- energy physics. This is best illustrated by reading the synopsis of the fourth chapter on Charm: "Another quark needed; Caution at Brookhaven; Champagne at Stanford; the Possibly Charmed Gypsy; the Marks of Charm; Signs of Relief; Charmed Universe; Still More Particles?; The Ultimate Decay; The End of the Road?"

In this mixture of explaining new concepts and ideas, personalities and life histories of researchers, research laboratories and localities, Calder competently and steadily leads you toward the goal: the modern cosmology. Before the reader grasps the enormity of compaction, a 3/8-inch black circle stares at him as the only symbol on an empty page, this being the size of the black hole into which the whole Earth has collapsed. The reader is introduced to exploding black holes, the first split second, the Big Bang, and after. Is this a palpable key? Any new idea throughout the book, no matter how complex or abstract, when introduced for the first time is explained in simple language or reduced to some simple concepts. The illustrations in the book are excellent, and the photographs and text in the margins contribute to the readability of the book.

Sometimes the simple explanations, lacking the rigor of mathematics or even being somewhat misleading oversimplifications, can offend the purist. As an example: ". . . and while Mother Nature blinked almost anything could happen provided it is quick enough," is given on page 24 as an explanation of the principle of uncertainty. But such spots are rare and are far apart and always given in the context of other reiterated explanations.

This book can be highly recommended to a very broad spectrum of readers. At one end of the spectrum would be an intelligent, science-oriented high-school student, and at the other end the well informed particle physicist. To the first the book would provide insight and inspiration to learn more about particle physics and astrophysics. To the second it is the best synopsis of high-energy physics' status of ideas of 1976–1977 and the most current gossip of the field. To quote Calder himself: "Detailed accounts of parts of it [the book] are to be found in scientific magazines . . . and in learned journals such as *Physical Review Letters*, *Physics Letters*, *Nature*, and *Reviews of Modern Physics*, but almost always using a more technical vocabulary than I have permitted myself." A historian of science is well advised to read this book too. It accurately portrays an era in the 1970's that may be later described as the "dawn of new discoveries," or more sarcastically as the "peak in government spending in the area of basic research."

Lastly, this book should be compared to the TV program bearing the same title. It is not the script of the TV broadcast. While the two-hour broadcast contains many "live" pronouncements of the main characters of the drama such as Abdus Salam, Steven Weinberg, Gerard t'Hooft, Murray Gell-Mann, Sheldon Glashow and Richard Feynman (not in the order of appearance), the book is strictly Calder. The impact of the live performance may be of a more lasting duration, but it lacks the cohesion of this well-organized book. To this reviewer it appears, however, that the poignancy and deep message of the closing moments of the TV program are missing from the book. The closing remarks of the TV program were issued by a young, brilliant astrophysicist, Stephen Hawking; his words barely discernable because of severe neuromuscular disease handicapping the young man: "The mind will triumph over matter."

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An Introduction to Biophysics

C. Sybesma
278 pp. Academic, New York, 1977.
$19.50

This book fulfills the needs for an introductory one-term course in biophysics for students in the physical sciences at the college sophomore or junior level. The approach is such that the book would probably be less appealing to undergraduate biology majors. After two chapters of introductory material, there are sections covering molecular structure, molecular interactions, bioenergetics, the biophysics of the sensory systems and theoretical biology. One appendix is a useful summary of the elements of equilibrium thermodynamics; another ap-

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Uneå University, Sweden

"I would recommend the book to any major scientific library." — **David P. Stern,** *Science*
Nobel Foundation Symposium, Volume 30.
369 pp., 1975, $25.00

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pendix covers the elements of quantum mechanics, in a form that is unfortunately too brief either for those familiar with the topic or for those meeting quantum theory for the first time.

The author understands that biophysics is a field that is as yet not well defined. He heads his first chapter with a well known statement from Kenneth S. Cole: "Biophysics includes everything that is interesting and excludes everything that is not." For a scientist with a solid background in the physical sciences and an interest in biology, that is not an unreasonable definition. It does suggest the limitations in what can be done in the way of producing a text in biophysics. A reader might want to find a text in biophysics that covers the area in a systematic way, such as would be expected from a text on physical optics, for example. This would be a worthy goal, but the author of the present work has had no more success in this direction than have the authors of several similar books that have appeared over the past five years.

Bearing this limitation in mind, the text has real qualities: The material is clearly presented and the book is reasonably well illustrated. The topics covered include many of interest to biophysicists today. It looks as though it would be easy to use in class, and I think the students would get some idea of the reason "Casey" Cole defines biophysics as "everything that is interesting . . . ."

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Structural Stability, the Theory of Catastrophes, and Applications in the Sciences

P. Hilton, ed.
410 pp. Springer-Verlag, New York, 1976. $14.40

Singularity Theory and an Introduction to Catastrophe Theory

Y.-C. Lu
199 pp. Springer-Verlag, New York, 1976. $12.00

Does "Catastrophe Theory" help us understand Nature? This question is currently the subject of a controversy in the pages of magazines from *Newsweek* to *Science*, from *Scientific American* to *Synthèse*. The books under review originated at a Battelle Conference held in Seattle in 1975 and provide an overview of some of the achievements that proponents of catastrophe theory claim for their work as well as background on the mathematics of the subject.

The essence of catastrophe theory is easy to state: Suppose some discontinuous natural phenomenon is observed; that is, as a function of time, space, magnetic field or some other variable, a property of a system undergoes radical change. Then one accounts for the discontinuity by assuming that some variational principle determines the state of the system and that as an external parameter (time, space, etc.) varies, the minimum that the system occupied initially goes out of existence and the system will change until its properties correspond to those of a distant surviving minimum.

But catastrophe theory goes beyond this. One might have supposed that minima can come and go (as external parameters are varied) in arbitrary ways. They don't. If only four external parameters are varied, then the famous theorem of R. Thom states that generically (meaning, roughly, except for special circumstances such as symmetries) there are only seven different patterns of appearances and disappearances of minima. The upshot is that discontinuous phenomena manifested as functions of space and time can appear in only this limited variety of ways.

To return to the opening question of this review, I think some appreciation of what catastrophe theory does and does not do can be obtained by considering the following questions. What greater understanding of Nature is gained through the use or appreciating of

- vector analysis?
- the abstract concept of "group"?
- Schrödinger's equation?
- the Born–Oppenheimer approximation?
- Feynman diagrams?

This list is intended to suggest that scientific progress can take many forms: the prediction of specific numbers, the simplifying of calculations that could be performed in other ways and the unification of diverse concepts.

I believe that the answer to my opening question is in the affirmative, but that the main contribution of catastrophe theory will be in the conceptual unification of diverse phenomena rather than in the prediction of experimental data. Much of the current conflict revolves about specific applications, but I think everyone agrees that there are *some* topics (such as the study of caustics) where catastrophe theory ideas apply. (For an interesting recent paper on caustics see M. V. Berry and J. F. Nye, *Nature*, **267**, 5 May 1967, page 34.)

How useful catastrophe theory will be for other topics, such as embryology or the propagation of nerve impulses, has yet to be seen. My own experience in applying the theory to phase transitions has been mixed. To describe phase transitions as catastrophes, the best I could do was come up with something resembling mean-field theory, but on the other hand a slightly unexpected prediction for tricritical phase transitions turned out to be correct. However, one should not knock mean-field theory (more than one Nobel Prize has been won for it). For phase transitions mean-field theory was there before catastrophe theory suggested it; however, if the theory inspires the discovery of a useful variational principle in some other area, it will have accomplished a good deal.

The books under review reflect some of the problems of the theory. Although ostensibly devoted to catastrophe theory, P. Hilton's book also includes applications of other mathematical methods (such as bifurcation theory) to various scientific problems. Of the catastrophe theory applications, none in this book falls within the bounds of traditional physics. One paper I found stimulating is that by J. Guckenheimer in which he discusses the Zhabotinsky (chemical) reaction. Strangely, the major qualitative feature of this reaction (connected with wave propagation) does not seem to follow from the exact solution of any equation. Guckenheimer speculates that this feature may only be an asymptotic property and motivates the guess by considering the role of asymptotic expansions in optics. Catastrophe theory lurks off at the sidelines in this paper, and while there is no place in the paper where Guckenheimer could state ". . . and we now use a theorem of Thom to show that . . .", still ideas from this theory play a role in the author's description of his motivations and speculations.

Articles by C. Zeeman and others on buckling beams, on prison riots and on various biological applications are currently the subject of hot debate, and rather than get into the thick of that battle I shall content myself with two remarks. First a scientific comment: Caustics in optics are generally acknowledged to be catastrophes, but in fact they do not represent an application of Thom's theorem because that theorem applies only to finite dimensional "state" spaces. Whether this point is merely technical I do not know; T. Poston's article takes up this question. I'd also like to comment on a human side to the controversy. Zeeman and many of his colleagues sometimes take a playful attitude toward science, and seem to feel that the process of exploration is itself worth reporting. This is reflected in the autobiographical character of some of the articles and the admittedly tentative ideas put forth. Contemporary science often rejects this approach—try to publish in *Physical Review* that you made some discovery on caustics while tilting a glass of milk in the Detroit airport! Nevertheless, I think that if really exciting steps are to be made in science, people have to risk sounding silly. Not only should speculation be encouraged at