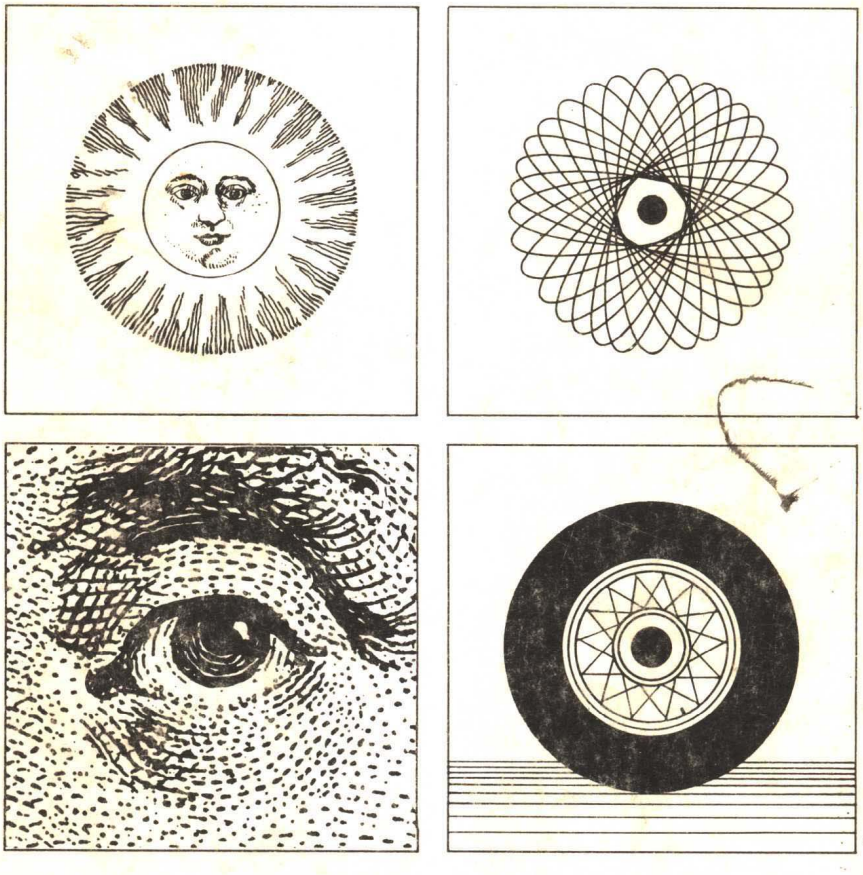
Perspectives in the History of Science and Technology



Edited by DUANE H. D. ROLLER

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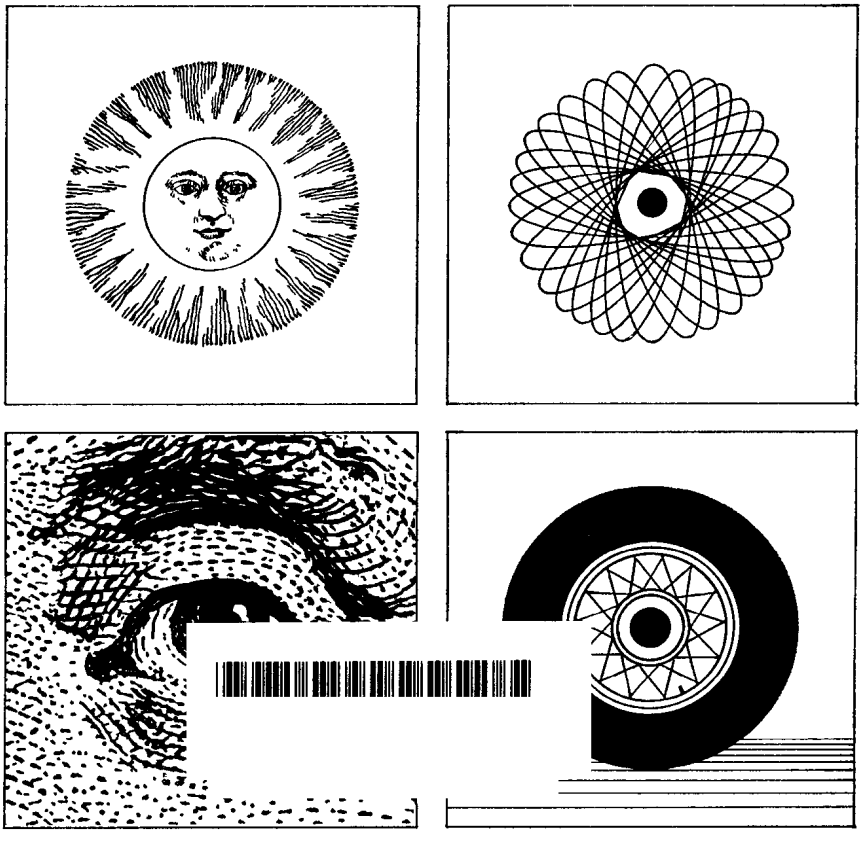

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Perspectives in the History of Science and Technology

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FOREWORD

The history of science is a new branch of history, a child of the twentieth century. Professionally trained historians of science are a product of the last two decades. As a consequence, this new and rapidly growing field of inquiry is as yet ill-defined.

With a few notable exceptions, nineteenth-century historians were not interested in the history of science, and the first impetus to its study came from individuals trained in one of the sciences. Some of these were teachers who felt that the history of their science offered pedagogic value in their teaching. Others were retired scientists who turned to a search for their own origins and intellectual roots. A few among these learned the techniques of the historian for study of the past; they became the founders of the field of the history of science.

The circumstances of its origin caused the history of science to be regarded as a portion of science, history being merely a tool for the study of the past of science. And knowledge of that past was largely organized in terms of the modern branches of science.

Within this general structure the tendency has been to focus attention upon the achievements of individual scientists. In part this was due to a nineteenth-century heroic view of history; in part it was because those who regarded the history of a science as a pedagogic aid in the teaching of that science wished to display its notables as exemplars to students. Reference materials are largely organized in terms of people, and the source materials for the history of science have seemed to consist almost entirely of manuscripts and publications by individual scientists. And, finally, the having of ideas is widely regarded as the prerogative of the individual.

In its earlier stages, then, the history of science tended to be accounts of the work of individual scientists of the past, grouped according to modern divisions of science.

The history of technology never has seemed as alien to historians

as did the history of science. It is technology that has produced the most visible monuments of the past, and social and cultural historians have long been aware of the impact of technology upon the societies and cultures they study. To be sure, there have been written histories of individual branches of engineering and of specific types of machinery, as well as studies of the works of individual engineers. But there has never been in the historical study of technology the kind of isolation from the culture that appeared in the history of science and that tended to regard science as a body of "organized positive knowledge" whose practitioners piled new truths upon old ones in a steady progression toward obtaining total knowledge.

The second half of this century has seen drastic changes in the study of the history of science. A new breed of professional historians of science has appeared on the scene, and a considerable number of professional historians have turned their attention to the history of science as well as the history of technology. The arrival of these scholars trained in history has predictably produced changes in the history of science, for their motivations are largely historical rather than scientific. Although the source materials remain the writings of individuals, there is a growing tendency to spread beyond the confines of the writings of the scientist and to examine the culture which produced him. Although studies of individual scientists remain an essential portion of the history of science, many historians now group the results of such studies in terms of the history of an idea or a point of view or an era, rather than in terms of a twentieth-century science.

All of these aspects of the study of the history of science and technology are displayed in the papers and commentaries comprising this volume. They were originally presented at a symposium at the University of Oklahoma April 8–12, 1969, during the Inaugural Year of the ninth president of the University, J. Herbert Hollomon. The Midwest Junto and the Society for the History of Technology joined the University in sponsoring the symposium. Rather than attempt organization of the symposium around some scientific or historical "theme," it was decided to ask historians of science and technology to speak on subjects of their own choosing. Two other specialists in the same area of research prepared and presented commentaries on each paper, based upon advance copies. Eight presentations and sixteen commentaries comprised the Symposium and are now published here.

In addition, the volume contains two other papers which were given at the time of and in conjunction with the Symposium, one the

Rosetta Briegel Barton Lecture, by Professor Ihde, the other the Phi Alpha Theta Lecture of Father Clark.

These twenty-six papers and commentaries by distinguished historians of science and technology offer a cross-section of research and attitudes in these fields in the seventh decade of the twentieth century.

DUANE H. D. ROLLER

Norman, Oklahoma

The paper on which this book was printed bears the watermark of the University of Oklahoma Press and has an effective life of at least three hundred years.

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Perspectives in the History of Science and Technology

The Kuhnian Paradigm and the Darwinian Revolution in Natural History

By John C. Greene, The University of Connecticut

THE PUBLICATION OF Thomas Kuhn's *The Structure of Scientific Revolutions* in 1962 was an important milestone in the development of the historiography of science. It was the first attempt to construct a generalized picture of the process by which a science is born and undergoes change and development. The main stages of development envisaged by Kuhn's model may be summarized as follows:

1. A pre-paradigm stage in which the natural phenomena that later form the subject matter of a mature science are studied and explained from widely differing points of view.

2. The emergence of a paradigm, embodied in the published works of one or more great scientists, defining and exemplifying the concepts and methods of research appropriate to the study of a certain class of natural phenomena, and serving as an inspiration to further research by its promise of success in explaining those phenomena.

3. A period of normal science conducted within a conceptual and methodological framework derived from the paradigmatic achievement, involving actualization of the promise of success, further articulation of the paradigm, exploration of the possibilities within the paradigm, use of existing theory to predict facts, solving of scientific puzzles, development of new applications of theory, and the like.

4. A crisis stage of varying duration precipitated by the discovery of natural phenomena that "violate the paradigm-induced expectations that govern normal science" and marked by the invention of new theories designed to take account of the anomalous facts.

5. A relatively abrupt transition to a new paradigm brought about by the achievements of a scientific genius who defines and

exemplifies a new conceptual and methodological framework incommensurable with the old.

6. Continuation of normal science within the new paradigm.

Professor Kuhn's examples of the formation and transformation of paradigms are drawn entirely from the history of the physical sciences, but he gives us no reason to believe that his analysis is not applicable to the sciences generally. It may be worthwhile, therefore, to examine the developments leading up to the Darwinian revolution in natural history to see to what extent they fit the pattern of historical development described in Kuhn's book.

Perhaps the best way to begin the investigation is to ask: When did natural history first acquire a paradigm? When did it arrive at a state characterized by "research firmly based upon one or more past scientific achievements that some particular scientific community acknowledged for a time as supplying the foundation for its further practice"; achievements "sufficiently unprecedented to attract an enduring group of adherents away from competing modes of scientific activity," yet "sufficiently open-ended to leave all sorts of problems for the redefined group of practitioners to resolve"?

This is not an easy question to answer. On the whole, however, it seems that such a condition cannot be said to have prevailed in natural history until the emergence of systematic natural history in the late seventeenth century, its embodiment in the publications of John Ray and Joseph Pitton de Tournefort, and its apotheosis in the works of Carl Linnaeus.

Aristotle and Theophrastus had laid the foundations of scientific zoology and botany two thousand years earlier, but their achievements cannot be said to have given rise to a continuing tradition of research based on their precept and example. The herbalists cannot be said to have been continuing the Theophrastian tradition, nor can Pliny, Albertus Magnus, Gesner, and Aldrovandi be said to have been the continuators of Aristotle in the same sense that Brisson, Jussieu, Candolle, Cuvier, Lamarck, Hooker, and Agassiz were continuators of the tradition established by Tournefort, Ray, and Linnaeus. Doubtless the Aristotelian achievement was profounder, broader, and in some ways more fecund than that of the founders of systematic natural history, but it did not, like theirs, give rise to and dominate an enduring tradition of scientific research of the kind Kuhn has in mind when he speaks of normal science.

It may be objected, however, that systematic natural history as practiced by Ray, Tournefort, and Linnaeus, was not a science in

Kuhn's terms because it did not explain anything, but only named, classified, and described natural objects. This objection raises the difficult problem whether science can be defined in absolute terms; that is, in such a way that the definition is valid for all sciences in all periods of history.

Kuhn himself seems to favor a loose, relativistic concept of science that would allow for the fact that every great scientific revolution involves some redefinition of the nature and aim of science. He tells us that no man is a scientist unless he is "concerned to understand the world and to extend the precision and scope with which it has been ordered." On the other hand, he stresses the importance of respecting "the historical integrity of that [older] science in its own time." With respect to the acceptance and rejection of paradigms he asserts that "there is no standard higher than the assent of the relevant community," and he rejects flatly the view, which he attributes to Charles Gillispie, that "the history of science records a continuing increase in the maturity and refinement of man's conception of the nature of science."

It would seem, therefore, that whatever the ultimate truth about the nature of science may be, no objection to the scientific status of systematic natural history can be drawn from Kuhn's book. Systematic natural historians were concerned to understand the world and to extend the precision and scope with which it was ordered. They considered themselves scientists and were so considered by their contemporaries, including the physical scientists. True, they did not consider it their business as natural historians to explain the origin of species, but neither did Newton consider it his business as a natural philosopher to explain the origin of the solar system.

Like Newton, Ray and Linnaeus took for granted a static concept of nature that regarded all the structures of nature as created and wisely designed by an omnipotent God in the beginning. This assumption of the permanence and wise design of specific forms and of the basic structures of nature generally was an essential feature of the paradigm of systematic natural history, integrally related to the belief that the aim of natural history was to name, classify, and describe.

By every criterion laid down by Kuhn there was a paradigm of systematic natural history. Emerging from the scientific achievements of Ray, Tournefort, and Linnaeus, it involved commitments on all the levels—cosmological, epistemological, methodological, etc.—mentioned by Kuhn. Embodied in manuals and popularizations, articulated with increasing precision, communicated by precept and example, celebrated in prose and verse, it dominated the field of

natural history for nearly two hundred years and helped to prepare the way for a far different, far more dynamic kind of natural history. To this extent, then, we can say that Kuhn's model of scientific development seems to fit fairly well with what is known concerning the emergence of systematic natural history as a science of nature.

Having established, at least to our own satisfaction, that natural history first acquired a paradigm in the Kuhnian sense through the work of Ray, Tournefort, and Linnaeus, we next inquire when this paradigm may be said to have been supplanted by a different one. Here it seems generally agreed that the publication of Charles Darwin's *Origin of Species* was the decisive event in the transition from a static, taxonomy-oriented natural history to a dynamic and causal evolutionary biology. Whatever the exact nature and causes of the Darwinian revolution, there can be little doubt that Darwin's work inaugurated a new era in the study of organic nature. Before discussing this revolution further, however, it will be well to inquire into its genesis in order to discover whether the development of natural history from Linnaeus to Darwin followed the pattern of normal science, anomaly, crisis, and paradigm invention described by Kuhn.

At the outset of this inquiry we are confronted with a phenomenon for which Kuhn's model makes no provision, namely, the appearance of a counter-paradigm coeval, or nearly so, with the establishment of the static paradigm of natural history.

In the same mid-eighteenth-century years when Linnaeus was rearing the edifice of systematic natural history on foundations laid by Ray and Tournefort, the Count de Buffon was publishing his splendid *Histoire Naturelle, Générale et Particulière*, based on a profoundly different concept of natural history from that which inspired Linnaeus and his forerunners. In Linnaeus' view, the function of the natural historian was to name, classify, and describe the productions of the earth and, above all, to search for a natural method of classification. In Buffon's opinion, classifications were arbitrary human devices that played a useful but subordinate role in the main business of natural history, which was to explain the observed uniformities in nature's productions as necessary results of the operations of the hidden system of laws, elements, and forces constituting primary, active, and causative nature. Where Linnaeus saw a world of plants and animals neatly ordered and perfectly adapted to their surroundings by the wise design of an omnipotent Creator, Buffon saw a confused array of living forms, some better adapted to their environment than others, all subject to modification through changes in climate, diet, and the general circumstances of life, all threatened in one