about a recalcitrant subject. Merton calls his paper on the reward system "The Matthew Effect in Science," the allusion being to the statement in the first Gospel, "For unto every one that hath shall be given, and he shall have abundance. . . ." Recognition is the common coin in which scientific rewards are paid, and as in other communities, treasure is unevenly distributed. It is the already prominent scientist whose name becomes associated with projects on which he works with junior colleagues, not the younger people who need the credit. Such collaboration is to their advantage in another way, however, since the notice that the findings attract will also depend on the fame of a name and not just on their importance, though on that too. For beginners the value of working with outstanding people is no mere matter of public relations. The guidance and example, Merton does not hesitate to say the character, of eminent scientists are instrumental in increasing the productivity and effectiveness of those fortunate enough to study with them, particularly in their identification and choice of problems. A significant proportion of Nobel laureates have been trained under older Nobel laureates, whose influence in science becomes then a function of their standing and not mainly of the research that won them the prize.

A more extensive paper, this one written with Harriet Zuckerman, inquires into the refereeing system in scientific publication, an aspect of the institutionalization of science that is coeval with the earliest societies and journals. Comparison with the humanities and social sciences exhibits a very low rate of rejection in science compared with humanistic disciplines; the harder the subject the lower the rate. (That is not his terminology. Always preferring to make a sociological statement, he says of the softer subjects: "This suggests that these fields of learning are not greatly institutionalized in the reasonably precise sense that editors and referees on the one side and would-be contributors on the other almost always share norms of what constitutes adequate scholarship" [p. 472]). It should, at any rate, prove startling to my historical colleagues to learn that leading journals in our field reject 90 percent of the manuscripts submitted to them compared with 24 percent rejected by physics journals. An intensive study of the archives of the *Physical Review* reveals that the judgment of referees is not significantly affected by the age, standing, or institutional affiliation of referees or contributors, and permits the conclusion that physics is well served by the system.

The final paper investigates another factor in science about which much myth and gossip have clustered but little research. Also written with Zuckerman, it is called "Age, Aging, and Age Structure in Science." Among the questions considered is that most famous or infamous one, on which views change as scientists grow older, whether indeed scientific invention is a secretion if not a secret reserved to youth. But I think it will be consistent with the main purpose of this article, which is to draw the attention of scientists to the interest Merton's work holds for them, not to give that answer away, nor even to say what he makes of the question. I shall observe only that this, his most recent paper in the sociology of science, is evidence that one sociologist, in what he will not mind my calling his maturity, need fear no weakening of his powers to see what is deep in things commonly mistaken for obvious, and to make the best and most humane of good sense out of the most unexpected of problems.

CHARLES C. GILLISPIE
Program in History and Philosophy of Science, Princeton University, Princeton, New Jersey

Celebrating a Quinquecentennial

Nicholas Copernicus: Complete Works. I, The Manuscript of "On the Revolutions," Facsimile. Polish Academy of Science, Warsaw-Cracow, 1972 (also to be published by Macmillan, London). xxv, 439 pp. + plates.

Symposium on Copernicus. Papers from a meeting, April 1973. American Philosophical Society, Philadelphia, 1974. xii, 140 pp., illus. Paper, $1. Proceedings of the American Philosophical Society, Vol. 117, No. 6 (pp. 413–552).

Nicolaus Copernicus. An Essay on His Life and Work. FRED HOYLE. Harper and Row, New York, 1973. xii, 94 pp., illus. $5.95.

Nicolaus Copernicus and His Epoch. JAN ADAMCZEWSKI. Scribner, New York, 1974. 164 pp., illus. $7.95.

The Scientific World of Copernicus. On the Occasion of the 500th Anniversary of His Birth, 1473–1973. BARBARA BIEŃKOWSKA, Ed. Translated from the Polish by Christina Cenkalska. Reidel, Boston, 1973. xii, 144 pp., illus. + plates. $19.50.

The Reception of Copernicus' Heliocentric Theory. Proceedings of a symposium, Toruń, Poland, 1973. JERZY DOBRZYCKI, Ed. Reidel, Boston, 1973. 368 pp., illus. + plates. $24.

Vistas in Astronomy. Vol. 17, Copernicus Yesterday and Today. Proceedings of a conference, Washington, D.C., 1972. ARTHUR BEER and K. AA. STRAND, Eds. Pergamon, New York. Scheduled for publication 1 September 1974. About $38.

Anniversary celebrations have become an increasingly popular sport for scientists as well as historians of science. The past decade marked the 400th year since the death of Vesalius (in 1564), the birth of Galileo (also in 1564), and the birth of Kepler (in 1571); the centenary of the birth of George Ellery Hale (in 1864); and the 300th year since the *annus mirabile* when Isaac Newton created so many wonderful things in Woolsthorpe, whence he had gone to escape the plague that had closed Cambridge University.

But of all these occasions, none was so widely observed as the Copernican quinquecentennial in 1973. The reasons are clear—never before have scientists actually celebrated a 500th birthday for one of their own, not to mention the fact that Nicholas Copernicus, a great international figure and symbolic founder of modern science, is also a favorite son of Poland, a brave nation not generously endowed with illustrious men.

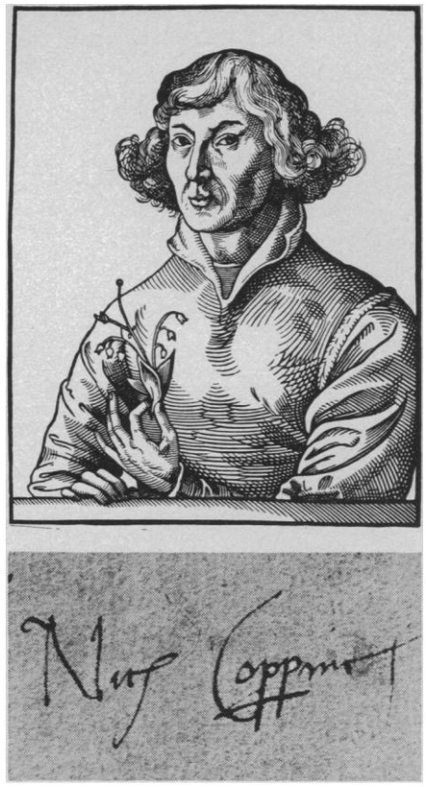
Not surprisingly, some of the finest pieces from the great outpouring of publications and symposia originated in Poland, where the astronomer was accorded a particularly high priority. Foremost among them is the Polish Academy of Science's *Nicholas Copernicus: Complete Works*, an ambitious three-volume project planned in separate English, Polish, and Latin editions. The first volume contains a handsome color facsimile of the original manuscript of Copernicus's *De revolutionibus* ("On the Revolutions"). Perhaps the most priceless artifact of the scientific Renaissance, the autograph manuscript has almost miraculously survived the

passing centuries, and is now preserved in the Jagiellonian Library of Copernicus's undergraduate university in Cracow. This is not the first time that the precious manuscript has been reproduced in its entirety; German scholars issued a quite adequate facsimile in 1944. The somewhat softer offset printing of the new Polish version and the careful rendition of the colors now enable the scholar to make subtle distinctions in the ink or to read through occasional blots. Besides, the introductory analysis carefully specifies the arrangement of sheets together with their watermarks, an indispensable aid to the researcher who is attempting to untangle the often inconsistent details of Copernicus's text.

Unfortunately publication of this triad of volumes fell behind so that the new English translation of *De revolutionibus* by Edward Rosen, scheduled for the second volume, has not yet appeared. Nor has the third volume, which will contain the relatively few letters written by Copernicus (including some newly discovered) as well as his *Commentariolus*. The *Commentariolus* or "Little Commentary" plays a key role in the Copernican opus largely because so little material is extant from the astronomer's earlier years. The *Commentariolus* was his first announcement of his new heliocentric system; it circulated in manuscript and was later known to Tycho Brahe, but it dropped completely out of sight for more than two centuries until a 16th-century copy was rediscovered in Vienna and finally printed in 1878. Shortly after, a second copy was found in Stockholm.

Copernican biographers of the 1880's assumed that the *Commentariolus* was a brief preliminary announcement, issued shortly before the publication of the main work itself in 1543. In 1900, however, the Polish historian L. A. Birkenmajer showed that the *Commentariolus* differs in many details from the final mechanisms adopted in *De revolutionibus* and that it was written much earlier, around 1510. A few years ago a third early copy of the *Commentariolus* was discovered in Aberdeen, Scotland, which will be used to establish an improved Latin text for the Polish Academy of Science edition. Presumably Edward Rosen's previous English translation (which has been adopted for volume 3) will be modified where necessary to take the new readings into account.

In the meantime, Noel Swerdlow has prepared a new English translation,



Above, Portrait of Copernicus from a woodblock by Tobias Stimmer, presumably based on Copernicus's self-portrait. The lily of the valley had just come to be appreciated for its medicinal properties, and Copernicus depicted it to show that he practiced medicine. *Below*, Copernicus's signature, from his copy of the Alfonsine Tables of 1492. The stroke through the tail of the *p* is the standard Latin abbreviation for *per*, and the final *-us* is abbreviated with the large loop and downstroke. [Photograph by Charles Eames, courtesy Uppsala University Library]

which has been published with the *Symposium on Copernicus* held in April 1973 at the American Philosophical Society. His diagrams are models of clarity, and his detailed and authoritative commentary will be required reading for every historian of early astronomy. One of the most intriguing new pieces of scholarship to emerge from the quinquecentennial is Swerdlow's analysis of a cryptic page of autograph notes that suggest how Copernicus may have worked out his heliocentric model via a geocentric proto-Tychonian system in which the other planets circled a moving sun. Because this fat issue of the American Philosophical Society Proceedings also contains the other two papers from the symposium (by Willy Hartner and by myself) as well as a translation of Maestlin's commentary on Copernicus from the appendix to Kepler's *Mysterium cosmographicum*, it must be considered the history of science publishing bargain of 1973.

Despite the flurry of Copernicana being produced as a result of the quinquecentennial, and despite the recent sustained interest in the Copernican revolution as a paradigm for scientific revolutions, the standard biography written 80 years ago by Leopold Prowe has not yet been superseded. Prowe's work is a gold mine for original documentation, but it is nationalistically biased and it lacks a correct appreciation of the nature or date of the *Commentariolus*.

In what will no doubt be one of the more widely distributed Copernican essays of 1973, the distinguished British cosmologist Fred Hoyle has written an account that leans heavily on Prowe. Where the German scholar did not provide the information, Hoyle has not hesitated to invent his own version of the biography. He would have us believe that the *Commentariolus* was written around 1533, "a dating that fits the known facts in a reasonable way." He tells us that "quite a major editing job" was done between the manuscript and the printed version of *De revolutionibus* and that this technical editing may have been done by "a certain Erasmus Reinhold," a conjecture long since discredited.

The main thrust of Hoyle's essay is not so much the reconstruction of Copernicus's intellectual biography, however, as a mathematical analysis using series expansions and complex variables to compare Ptolemy and Copernicus. He shows correctly (but not particularly clearly) that a series expansion to the first power of eccentricity of Kepler's first two laws leads precisely to the epicyclet solution adopted by Copernicus. (His power series is not carried far enough to show that Ptolemy's equant is actually slightly superior.) Hoyle states that "Terms of the order $a_E e_E$ were neglected in both theories"; this is incorrect because the actual values *ae* used for each planet were effectively the vector sums of the planets' and earth's eccentricities. His further remarks on the advantage of the Copernican theory of planetary latitudes is founded on a misconception of the Ptolemaic latitude theory. Thus Hoyle's *Nicolaus Copernicus* represents a blunderous foray into a field not his own.

Although making no pretense to being a serious, scholarly, "standard" biography, Jan Adamczewski's *Nicolaus Copernicus and His Epoch* pro-

Copernicus's library, now preserved at the Uppsala University Library in Sweden. His annotated copy of the *Calendarium romanum magnum* is in the center, and the 1515 *Almagest* is in the foreground. [Photograph by Owen Gingerich]

vides an unusually informative and beautifully illustrated account. Printed in Poland but issued in an English edition under the auspices of the Copernicus Society of America, the book contains numerous superb monochrome pictures, a modest sprinkling of color plates, and a well-written text. Working without footnotes, the author unobtrusively cites his authorities and on occasion backs up his claim with an original Latin quotation. The book steers clear of such sensitive issues as whether Copernicus spoke any Polish, and it properly rejects such debatable traditions as Copernicus's medical degree or ordination as a priest. The principal shortcoming of this otherwise splendid book (aside from the lack of an index) is the relatively small attention given to astronomy. There is little attempt to illustrate the state of astronomy in Copernicus's lifetime or to describe the astronomer's technical achievement.

Finding a satisfactory *astronomical* commentary among the prodigious quinquecentennial literature is not easy. Swerdlow's commentary on the *Commentariolus*, mentioned above, provides an excellent technical introduction, but is accessible primarily to the specialist. However, a short piece by Jerzy Dobrzycki entitled "Nicolaus Copernicus—his life and work" provides a reasonable sketch for an astronomical biography. His 25-page article is one of the best in a collection of nine essays, *The Scientific World of Copernicus*, edited by Barbara Bieńkowska. The opening article, "The country and the world of Copernicus" by Stanislaw Herbst, evocatively describes that world from the viewpoint of an art historian. Writing on Copernicus as an economist, Edward Lipiński lucidly depicts the changing economic conditions of Copernicus's world; he claims that the astronomer "broke radically with the medieval world of concepts" in his tract on currency reform.

Unfortunately, the rest of this collection has a rather uneven quality. Wlodzimierz Zonn's encomium "Nicolaus Copernicus—founder of the new astronomy" reveals a lack of historical sensitivity concerning its origins including the now-obsolete mythology about epicycles on epicycles in pre-Copernican planetary astronomy. Bieńkowska's own contribution on the heliocentric controversy in European culture is evidently only a short abstract of her much longer book in Polish on this subject; she outlines her picture with such broad strokes that, for example, we are left completely baffled by the mere mention of a Sniadecki in a list of "heliocentrists of various creeds." (Sniadecki is identified as a minor but interesting 18th-century figure in Bieńkowska's more satisfactory article in the next book cited in this review.)

The 1973 festival offerings to Copernicus included a broad variety of distinguished symposia, both in the United States and abroad. The best of these will generate one or more commemorative volumes, which for the most part are scheduled for publication later in 1974. The first to appear, bearing a 1972 copyright, was planned well in advance by the Nicolas Copernicus Committee of the International Union of the History and Philosophy of Science as a preliminary volume to the international symposium held in Toruń, Poland, last September. Printed and edited in Poland, the first volume on *The Reception of Copernicus' Heliocentric Theory* contains contributions from authors in nine countries, ten articles in English and one, by Hans Blumenberg, in German. In the first chapter, Robert Westman shows the extent to which the orbit of the Comet of 1577 drove Kepler's teacher Maestlin to the Copernican hypothesis. Although Maestlin's contemporary Tycho Brahe did not ultimately accept the Copernican cosmology, K. P. Moesgaard shows in the second chapter how much other influence Copernicus had on the Danish astronomer. These are the most significant contributions in the volume, and I would not be surprised if in the future this pair of scholarly articles is cited more frequently in the literature than all the rest combined.

Most of the remaining articles fall under the rubric of the acceptance of Copernican ideas in specific places. A series of specially commissioned chapters describe the spread of Copernican theory in Poland, Scandinavia, Japan, Great Britain, Spain, America, and Hungary. These papers help fill a notable gap in Copernican studies, but most readers will find they contain too much local detail. Nevertheless these stories illustrate what varied circumstances transported this important scientific idea. In Japan, Copernican cosmology entered both by the writing of Jesuit missionaries in China and from direct contact with Europeans or European sources. The reception in Japan did not really take place until early in the 19th century, and it did not evoke bitter ideological opposition except in Buddhist circles. In Spain there was an early acceptance of computational aspects of the new astronomy, but in the 17th century its reception was intimately related to the role of the Inquisition. In the comparatively open intellectual atmosphere of England, a fair number of 16th-century writers mentioned Copernicus favorably. In America the story is closely bound up with colonial almanac making.

In spite of the wide geographical

range of the chapters, articles on the reception of the Copernican theory in Germany, France, Italy, and China are conspicuous by their absence. Part of this lack has been amended in a small supplementary volume of late papers, which we can only hope Reidel will also publish in the West. This second volume contains a 60-page article on Copernicus in China by Nathan Sivin, an important piece of scholarship that traces the introduction of heliocentrism and subsequent confused backtracking by the Jesuit missionaries. My own piece "The role of Erasmus Reinhold" fills part of the gap on the Copernican reception in Germany, and Eugenio Garin's article on an early and previously undiscovered anti-Copernican manuscript in the National Library in Florence presents at least one aspect of its reception in Italy.

In December 1972 the American Association for the Advancement of Science stole the march on the Copernican year by scheduling its own celebration of the anniversary, and, aided by this head start, its symposium is now in press as volume 17 of *Vistas in Astronomy*. Like the previous volumes of the series, it is marked by handsome typography and abundant illustrations. Sessions on the scientific and humanistic significance of Copernicus and on the nature of scientific revolutions were held before a limited but international audience of scientists, historians, and theologians. These were followed by an evening lecture and a public AAAS session on the impact of Copernicus and his work. The 16 papers covered a broad variety of topics ranging from John North's study of the medieval background for Copernicus to a contribution of mine on Copernicus and the impact of printing.

A fascinating and somewhat unusual approach is taken by Benjamin Nelson, who argues that "the struggles for and against Copernicanism in the 'West' and 'East' alike were powerfully caught up with battles over the entire structure of credibility and of the grounds of proof and evidence in all spheres of thought." One of the finest papers in the volume is Stillman Drake's brilliant comparison of the Copernicanism in Bruno, Kepler, and Galileo. Edward Rosen has contributed a remarkable blast against Arthur Koestler, who is repeatedly called "our detractor" but never identified by name. Thomas Kuhn, though not actually present, powerfully influenced the papers on the nature of scientific revolutions. His thesis was criticized, but his vocabulary permeated the entire debate. A long verbatim record captures the spirit of the ensuing discussion.

Much scientific and historical scholarship was marshaled for this anniversary, which in effect marked the birthday of modern science. The results of at least four major symposia or lecture series have yet to appear. Although no major reinterpretation of Copernicus has emerged or is in prospect, his work and its complex relationship to the science both before and after him have been more clearly delineated. All of this material should help secure the foundations of a hoped-for new definitive biography of Copernicus.

To what extent Copernicus himself precipitated a revolution or participated in it is still debatable. To what extent he and his successors believed the heliocentric system was reality or a mathematical model is likewise debatable. These questions continue to challenge historians and philosophers, and the Copernican cornucopia of 1973 has provided more grist for their mills. Whether the fact that more scientists than ever before have been exposed to the historical foundations of their profession will in any way alter their approach to science remains to be discovered.

OWEN GINGERICH
Center for Astrophysics, Harvard College Observatory and Smithsonian Astrophysical Observatory, Cambridge, Massachusetts

Looking Outward

Mars and the Mind of Man. A panel discussion, Pasadena, Calif., Nov. 1971. RAY BRADBURY, ARTHUR C. CLARKE, BRUCE MURRAY, CARL SAGAN, and WALTER SULLIVAN. Harper and Row, New York, 1973. xiv, 144 pp., illus. $7.95.

The Cosmic Connection. An Extraterrestrial Perspective. CARL SAGAN. Doubleday, New York, 1973. xiv, 274 pp., illus. $7.95.

Life beyond Earth and the Mind of Man. Proceedings of a symposium, Boston, Nov. 1972. RICHARD BERENDZEN, Ed. National Aeronautics and Space Administration, Washington, D.C., 1973 (available from the Superintendent of Documents, Washington). viii, 106 pp., illus. Paper, $1.25. NASA SP-328.

Not to be taken as "mere discussions of the space program," these intriguing books are about the essential motivations of mankind, the meaning of God, and our own place in the history of the universe—that is, they are about what science is really about. These are attractive, modestly priced books that ought to be read by high school and college kids, college dropouts, your nephews and nieces, everybody who ever uttered a word against science and technology, and by Richard Nixon and Gerald Ford.

Mars and the Mind of Man is a record of a public symposium held at the California Institute of Technology a few days before Mariner 9 went into orbit around Mars, together with pictures from the mission and a post-mission recapitulation by each participant. To bring together science fiction writers Bradbury and Clarke, scientists Sagan and Murray, and *New York Times* science journalist Sullivan was a stroke of genius. These are not NASA public relations officers or a group of half-interested writers but the originators and doers of space exploration, talking here in a relaxed and witty manner directly to the reader. The scientists are not fumble-tongued, as in stereotype, but eloquent. Bradbury tells us in poems and prose that behind every scientist is a romantic. (This is probably widely true, except perhaps at Caltech, where romanticism must be either stamped out or overlain with cynicism.) The 21st century may regard Bradbury as the man who *really* understood why we left the Earth. Sagan reviews the history of Mars observations. Murray agonizes about the significance of the apparent decline in the space program —or is the shuttle a forerunner? Sullivan cites intriguing examples of the modern social impact of the idea of life on other worlds. Clarke concludes that if there is no life on Mars now, there will be by 2000. The theme here is the hopelessly human jumble of romanticism, sobriety, work, and dreaming that has gone into the study of the nearby planets, from the time of Jules Verne, Percival Lowell, *et al.* to the present.

Sagan's *Cosmic Connection* I was prepared to dislike. I think this had to do with the phrase "produced by Jerome Agel" on the cover. I had always thought that the producer of a book was its author. This ominous phrase led me to wonder if we are approaching an era when each scientist will have his own producer who stirs up support and acts as advance man. Whatever Agel did (Carl Sagan might need a producer but he certainly doesn't need a ghost writer), the book emerges as 39 genuine, vintage Sagan dinner con-