In Defense of the Original

Could the wonderful new information technology which has placed the knowledge of the past at our fingertips also endanger its preservation for future generations?

By DUANE H. D. ROLLER

The ability *to write* gave the human race an intellectual tool second only to language itself. It also provided an improved mode of preserving knowledge. To be sure, knowledge had been preserved before writing existed. Oral tradition had passed on — as it still does — all sorts of information from elders to youth and sometimes in unbelievably large amounts: the content of the *Iliad* and the *Odyssey* of Homer was handed down orally from one generation to the next for centuries. But such oral preservation is a fragile affair; one generation's lapse of interest in a subject can become ignorance for all later generations.

Writing changed all of this, and today we have written documents from many thousands of years ago, on clay tablets from Mesopotamia and on sheets of papyrus from Egypt, making information available to us that otherwise would not have survived. The amount that could be written on a single clay tablet was limited by the size of the tablet, a problem that Mesopotamians tried to solve by using more tablets. Numbered tablets have been found, but few sequences have survived intact.

The Egyptians found a more successful solution by gluing sheets of papyrus edge to edge, producing a strip of any desired length which could record a document of any length. The strip then was rolled into a scroll for ease of storage and handling. Certainly, pieces could break off, but in general this was a highly successful technique, and it is often said that the Egyptians invented the book.

The form of the book as we know it, however, is a Greek invention of some 2,000 years ago. Sheets of papyrus were stacked up and then sewn together along the edge, with a protective binding over the stack. The Greeks also refined the use of animal skins as a writing surface, producing thin sheets known as parchment, which served as a particularly tough and durable alternative to papyrus sheets. Such books had a potential lifetime of many hundreds of years.

These books were handwritten, but multiple copies could be and were produced. If a particular generation became interested in a particular book, the copies produced to meet the demand gave the text of the book an excellent chance of survival. The only major threats to its existence were the ultimate decay of the organic materials in the book or such an extravagant lack of interest in the content that all copies would suffer eventual destruction through neglect or discard.

There were libraries in Classical Greek Antiquity, and the growth of a class of professional librarians further enhanced the survival chances of the books, with their priceless cargo of information. One of the curiously persistent characteristics of librarians has been the idea that the protection and preservation of books is a sacred duty, without regard to whether the content of the books is "good" or "bad" according to current standards. As a consequence, when books from Classical Antiquity began to rot away about a thousand years ago, monastic librarians recopied them, including many on subjects that were of little or no interest at the time. Without their efforts, our knowledge of Antiquity would be only a small fraction of what it is.

For example, our knowledge of the Greek atomic theory comes to us largely through a single book, the *De rerum natura* by the Roman writer Lucretius. This book also was concerned with the Epicurean philosophy, which was utterly abhorrent to early medieval Christianity; hence the book was not of interest. Yet some nameless monastic librarians preserved a copy of the book, generation after generation, century after century, recopying it as necessary to preserve the text, until, with the 15th century revival of an interest in secular literature, that one copy was discovered, other copies made, and the Greek atomic theory reentered into human knowledge, affecting the course of science ever since.

In the mid-1400s, a major change occurred in book production techniques. The new books looked exactly the same as the old ones except that the text was printed rather than handwritten, and the pages were paper. Within a few decades illustrations began to be printed in books, from drawings transferred to wood blocks. The printing press could turn out as many identical copies as desired, although the actual number printed tended to be small in the early years of printing.

From that beginning, the basic techniques of printing remained unchanged for the next 500 years, and the problems of preservation of knowledge remain the same today. Books, printed or manuscript, still are made of organic materials that can and do decay. That decay can be hastened by high humidity and the growth of mold on the pages. In the 19th century the replacement of linen paper with paper made with wood pulp, often with a high acid content, led to a new kind of deterioration, most familiarly seen as a browning of the pages. Chemical deterioration is more rapid the higher the temperature at which the book is stored, and fluctuations in temperature produce physical damage.

The advent of universal education has led to a greatly increased use of books, with consequently greater wear and tear. The greater the use, the greater the possibility of damage by careless users who may not know how to handle books or, in some cases, who do not care whether the books survive beyond their own use. Paradoxically, a book that is unavailable to users is of no value in the present; yet a book that is destroyed by present users is lost to the future.

In recent decades, the development of cheap and rapid photocopying, combined with a considerable drop in literacy, has made notetaking almost a lost art. Most users would prefer photocopying a book to reading it in a library. Unfortunately current techniques of quickly photocopying books is destructive of them and librarians must decide whether to protect the books or let a few users destroy them. This is not so serious a matter for books that are easily replaceable (although funds necessarily are diverted from the purchase of other books), but for a research library of irreplaceable books, it poses serious problems.

The History of Science Collections of the University of Oklahoma Libraries is such a library. This vast teaching and research resource, presently comprising some 64,000 volumes, contains many books of extreme rarity. The oldest book in the Collections, the *Opus de universo* of Hrabanus Marus, was printed in 1467 or earlier. Only three copies are known to exist. Johann Kepler's *Strena* of 1611, on the geometry of the snowflake, was composed by him as a Christmas greeting. Only 25 copies of the book were printed, and there is only one copy in the United States — the Oklahoma one. Sixty copies of Galileo's first book were printed, but only a handful have survived, one of them in the History of Science Collections.

The University of Oklahoma is determined to preserve this remarkable heritage. It is housed in specially designed quarters in the Doris Neustadt Wing of Bizzell Memorial Library, in the finest controlled environment for books in existence, minimizing biological and chemical damage. Quick photocopying is not permitted, although microfilming is cautiously used to serve the needs of the scholarly community.

The acquisition of books of such rarity is an expensive process that has been made possible in Oklahoma by gifts for the purpose from friends of the University. A question frequently asked, in a variety of forms, is whether an equally useful collection could be built at much less cost. Many famous books already have been reproduced photographically, and others could be microfilmed. A microprint library of approximately 15,000 volumes in the history of science is now available for purchase at a price of about $5 per volume.

Let us look at a few examples of books from the History of Science Collections that illustrate certain difficulties in photo reproduction. In 1931 an edition of Isaac Newton's *Opticks* was published by G. Bell and Sons. In 1952 that edition was reprinted, and on the back of the title page appears the statement "an unabridged and unaltered reproduction of the edition first published by G. Bell." The photographs at the bottom of this page are of the same page from the two editions. The "unaltered" photographic facsimile clearly has been altered, changing the text — and there are other alterations.

In 1892, a photographic facsimile of William Gilbert's *De magnete* of 1600 appeared. The same page from the two editions is shown on Page 7. Handwritten changes on the original have been eliminated in the "facsimile." But these identical changes appear in so many copies of the 1600 edition that it is believed the author made them at the printer. All have been carefully eliminated in the 1892 reprint. By helpfully cleaning up the "facsimile" to eliminate those changes, the producer of that reprint falsified the original intent of the author. In the preface to the *De magnete,* Gilbert wrote that he had marked his "experiments and discoveries" with marginal asterisks. One of these is missing in the "facsimile."

At the top of Page 8 are shown the title page of Newton's *Principia* of 1687 and the same page of a mid-20th century photo facsimile edition. There are distinct differences between the lower part of the two pages.

The discrepancies illustrated in these examples are known and can be explained. In the case of Newton's *Opticks* of 1952, someone believed that there were typographical errors in the Bell edition and corrected them. In the photoreproduction of the Gilbert, the publisher thought that the handwritten emendations were those of a previous owner of the particular copy being photographed and hence were not relevant to Gilbert's text. Someone, probably a printer's assistant, engaged in the usual and necessary routine cleaning of spots and stains off the plates, regarded the asterisk as "dirt" and removed it. How could he have known what Gilbert said about the asterisks in the preface? We know that the first edition of Newton's *Principia* appeared in two variant "states." The facsimile edition was photographed from a second-state copy.

These particular differences between the originals and so-called "facsimiles" discussed above are known. But every reproduction of a text, photographic or otherwise, contains the possibility of differences from the original. One never can be certain what is in the book unless one has access to *that* book. Microfilm, reprints, "facsimile" editions and other reproductions are not trustworthy.

This problem arises whenever an interpreter is interposed between the original text and the user. Those interpreters try to be helpful, correcting errors, cleaning away irrelevant materials, and otherwise improving on the material at hand, but that inevitably builds into the modified version the interpreter's opinions on what is an error, on what is irrelevant, and so on. The Great Books English version of Gilbert's *De magnete* simply omitted all of the marginal asterisks but included the preface of the book in which Gilbert explained the meaning of the now non-existent asterisks. A later reprint of this edition omitted the preface as well.

The editor of Niels Bohr's *Collected papers* was Bohr's first pupil, a well-educated physicist with a considerable comprehension of the nature and prob-

THE *OPTICKS* OF ISAAC NEWTON

that Force; and that Motion which is perpendicular to it will be altered according to the rule of the foregoing Proposition. If therefore for the perpendicular velocity of the emerging Ray CN you write $\frac{MC}{NG}$ CG as above, then the perpendicular velocity of any other emerging Ray CE which was $\frac{AD}{EF}$ CF, will be equal to the square Root of CDq + $\frac{MCq}{NGq}$ CGq. And by squaring these Equals, and adding to them the Equals ADq and MCq − CDq, and dividing the Sums by the Equals CFq + EFq and CGq + NGq, you will have $\frac{MCq}{NGq}$ equal to $\frac{MCq}{NGq}$. Whence AD, the Sine of Incidence, is to EF the Sine of Refraction, as MC to NG, that is, in a given *ratio*. And this Demonstration being general, without determining what Light

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At left, the 1931 Bell edition, Page 81. Note highlighted areas.

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At right, the 1952 facsimile of the Bell edition, Page 81.

lems of history. After a great deal of soul-searching he made a conscious, deliberate decision to correct (what he regarded as) errors in the original papers in republishing them in the *Collected papers*. This involved a good deal of anguish on the part of the editor, who ultimately decided that presenting the best possible version of Bohr's ideas (as he saw them) was more important than faithfully reproducing trivial errors. I have no quarrel with such decisions; they must be and are made in every case of reprinting materials. However, I would quarrel with those who suggest that reproductions of books can serve the scholar as well as can the originals.

Furthermore, there are other potentially important pieces of information in a book that simply will not show in photographs of the pages. Colors will not be reproduced in black and white photographs, and even if far more expensive color photography were to be used, the colors might not be faithfully reproduced. The watermark in the paper may be of historical importance. At times the pages of two incomplete copies of a particular book have been used to make up a complete copy. Again this interposes an interpreter who imposes on his handicraft his opinion of what a complete copy should be. Such made-up copies can be detected through careful examination of the details of the binding, the way the pages are assembled and, sometimes, even from the smell of the glue used. If tampering has occurred, the perfectly authentic individual pages may add up to a false book — for example, a portion may be lacking, or the pages may be in a different order, since many early books have unnumbered pages.

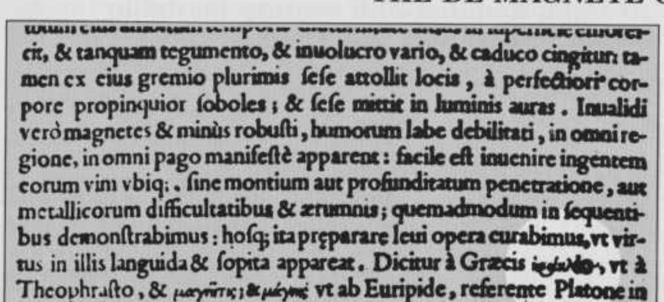
There remains one inevitable "interpreter" who always stands between the books and the scholar. This is the person who selects books to be acquired, who decides which books are not worth keeping, who determines the rules for use of the books.

The determination as to which books are to be acquired stems from two decisions: what is the scope of the collections, and what books (or other library materials) are important within that scope? For example, the scope of the History of Science Collections is the history of the sciences called today the earth, biological, physical and mathematical sciences and some aspects of technology. But what books are pertinent to that scope? Is a book appropriate that propounds a flat-earth theory or one that suggests all science is false? What about books on alchemy and astrology, labeled "pseudosciences" by many today?

These are not difficult problems if one desires to build a great teaching and research collection, for the views of the book selector as to what is important in science must not be allowed to inhibit the acquisition of books. A great collection must attempt to obtain every book on the subject. The same rule should apply to the discarding of books. The custodians must never decide that a particular book, on a subject within the scope of the collection, is not worth keeping, nor must they thoughtlessly limit that scope, particularly by their own ignorance; no one knows everything.

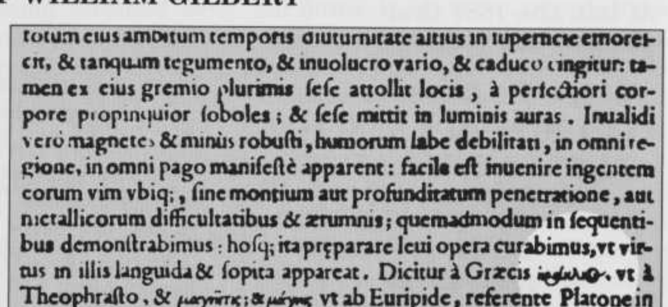
There is no doubt that a library in the history of science must contain books other than science books — aux-

THE *DE MAGNETE* OF WILLIAM GILBERT



totum eius ambitum temporis diuturnitate altius in ſuperficie emoreſcit, & tanquam tegumento, & inuolucro vario, & caduco cingitur: tamen ex eius gremio plurimis ſeſe attollit locis, à perfectiori corpore propinquior ſoboles; & ſeſe mittit in luminis auras. Inualidi verò magnetes & minùs robuſti, humorum labe debilitati, in omni regione, in omni pago manifeſtè apparent: facile eſt inuenire ingentem eorum vim vbiq;, ſine montium aut profunditatum penetratione, aut metallicorum difficultatibus & ærumnis; quemadmodum in ſequentibus demonſtrabimus: hoſq; ita præparare leui opera curabimus, vt virtus in illis languida & ſopita appareat. Dicitur à Græcis [illegible], vt à Theophraſto, & μαγνῆτις; & μάγνης vt ab Euripide, referente Platone in Ione: Ab Orpheo etiam [illegible], & [illegible] quaſi ferrarius: à Latinis magnes, Herculeus; Gallis aimant, corruptè ab adamante; Hiſpanis piedramant: Italis calamita; Anglis loadſtone & adamant ſtone, Germanis magneſſ, & ſiegelſtein: Ab Anglis, Gallis, & Hiſpanis vulgò ab adamante nomen habet; forſan quia olim decepti ſunt ſideritis nomine vtriſq; communi: magnes [illegible] dicitur à virtute alliciente ferrum: adamas [illegible] dicitur à ſplendore ferri politi. Ariſtoteles lapidis tantùm nomine deſignat [illegible] de anima 1. Magnetis nomine appellatur alius etiam lapis plurimum à ſiderite differens, qui argenti ſpeciem præ ſe fert; naturâ Amianto ſimilis, & quòd ex cruſtis (lapidum ſpecularium modo) conſtat, forma differt: Germanis Katzenſilbar & Talke.

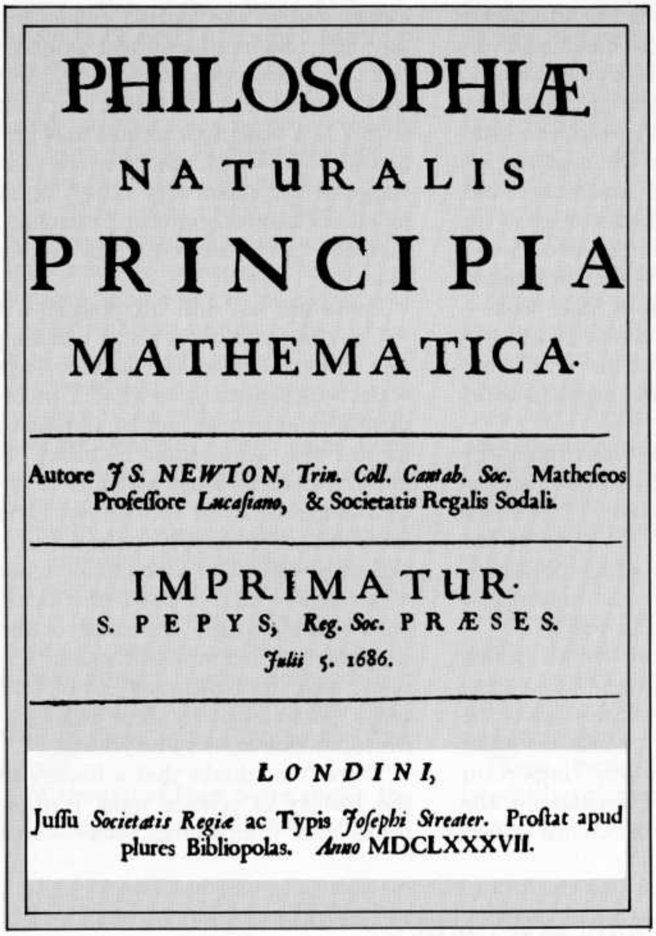
At left, the 1600 first edition, Page 11.



totum eius ambitum temporis diuturnitate altius in ſuperficie emoreſcit, & tanquam tegumento, & inuolucro vario, & caduco cingitur: tamen ex eius gremio plurimis ſeſe attollit locis, à perfectiori corpore propinquior ſoboles; & ſeſe mittit in luminis auras. Inualidi verò magnetes & minùs robuſti, humorum labe debilitati, in omni regione, in omni pago manifeſtè apparent: facile eſt inuenire ingentem eorum vim vbiq;, ſine montium aut profunditatum penetratione, aut metallicorum difficultatibus & ærumnis; quemadmodum in ſequentibus demonſtrabimus: hoſq; ita præparare leui opera curabimus, vt virtus in illis languida & ſopita appareat. Dicitur à Græcis [illegible], vt à Theophraſto, & μαγνῆτις; & μάγνης vt ab Euripide, referente Platone in Ione: Ab Orpheo etiam [illegible], & [illegible] quaſi ferrarius: à Latinis magnes, Herculeus; Gallis aimant, corruptè ab adamante; Hiſpanis piedramant: Italis calamita; Anglis loadſtone & adamant ſtone, Germanis magneſſ, & ſiegelſtein: Ab Anglis, Gallis, & Hiſpanis vulgò ab adamante nomen habet; forſan quia olim decepti ſunt ſideritis nomine vtriſq; communi: magnes [illegible] dicitur à virtute alliciente ferrum: adamas [illegible] dicitur à ſplendore ferri politi. Ariſtoteles lapidis tantùm nomine deſignat [illegible] de anima 1. Magnetis nomine appellatur alius etiam lapis plurimum à ſiderite differens, qui argenti ſpeciem præ ſe fert; naturâ Amianto ſimilis, & quòd ex cruſtis lapidum ſpecularium modo, conſtat forma differt: Germanis Katzenſilbar & Talke.

At right, the 1892 facsimile of the first edition, Page 11.

THE *PRINCIPIA* OF ISAAC NEWTON

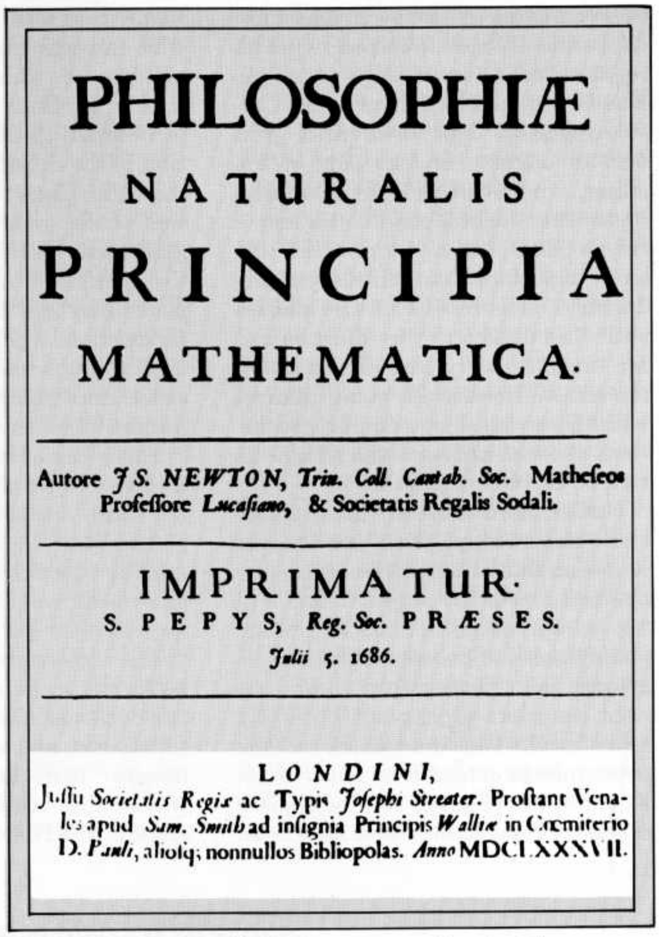

PHILOSOPHIÆ NATURALIS PRINCIPIA MATHEMATICA.

Autore *J. S. NEWTON, Trin. Coll. Cantab. Soc.* Matheseos Professore *Lucasiano*, & Societatis Regalis Sodali.

IMPRIMATUR. S. PEPYS, *Reg. Soc.* PRÆSES. *Julii* 5. 1686.

LONDINI,

Jussu *Societatis Regiæ* ac Typis *Josephi Streater*. Prostat apud plures Bibliopolas. *Anno* MDCLXXXVII.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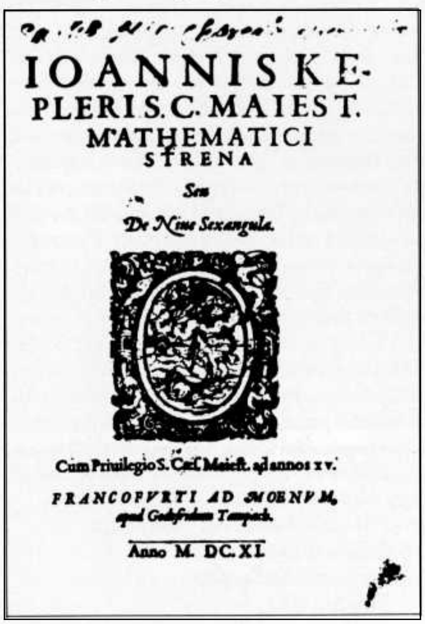
At left, the 1687 first edition, title page.

At right, undated 20th century facsimile of the first edition, title page.


IOANNIS KEPLERI S.C. MAIEST. MATHEMATICI STRENA Seu De Nive Sexangula.

Cum Priuilegio S. Cæs. Maiest. ad annos XV.

FRANCOFVRTI AD MOENVM, apud Godefridum Tampach.

Anno M. DC. XI.

Title page of Johann Kepler's book of 1611 on the geometry of the snowflake.

iliary materials such as histories of science, biographies of scientists, and dictionaries. But there are other items that might not seem to fit in. The History of Science Collections contains copies of Pierre Gassendi's *Life of Epikuros,* a Greek philosopher and nonscientist; a Renaissance collection of *Lives of the Artists* by Giorgio Vasari; the syrupy poem by Lodovico D'Ariosto entitled *The Mad Roland;* a work on Isaac Newton's theological writings. Each of these might appear to have nothing to do with the history of science, yet each was acquired because the technical knowledge of historians of science suggested that these books may yield important knowledge about the past of science. Decisions on whether to acquire — and keep — such books cannot be made by clerical assistants or indeed by anyone who is not well-informed on the history of science and willing to consciously, deliberately and continuously seek for more information on the materials needed by the research scholar.

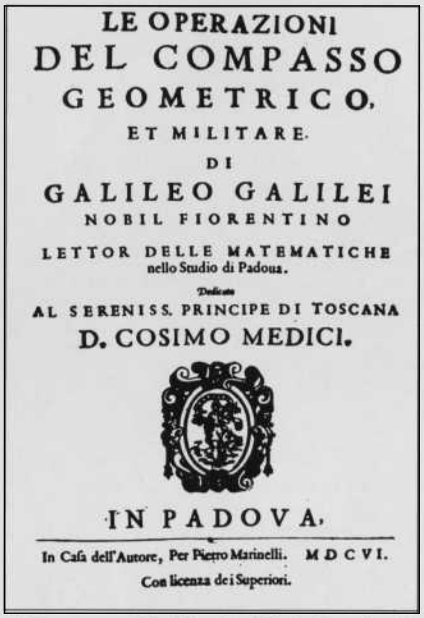
Inevitably any library is faced with the problem of limited funds, no matter how large the available funds are. Once again, in the selection of which books to purchase, with a given amount of money, the "interpreter" enters in. Is this particular book, at this particular time, worth this amount of money (which then cannot be spent for another book)? At this point, the book selectors can only do their best, based on what they know about these matters.

In recent years, the rapid growth of computer technology has provided the ability to store and manipulate vast amounts of information. The question inevitably arises as to whether information can be stored more conveniently and cheaply in computer memories than in books and perhaps also recovered and used more easily. The answer is, "Of course, in many cases." For many years, I have been developing a computerized short-title catalog of the History of Science Collections. Derived from the usual cataloging information provided by librarians for the books, this short-title catalog takes advantage of the peculiar characteristics and abilities of the computer to increase the bibliographic control over the Collections and assist scholars by providing new modes of access to the books. Such uses of computers can be very helpful indeed.

But what about the books themselves? In this "information age," couldn't all the information in all of the 64,000 books of the History of Science Collections be put into the computer, eliminating the necessity for preserving the books with all of the problems that entails? The bulk is large — many thousands of millions of words are involved, written in a great variety of languages, in a large number of different alphabets, such as Greek, Arabic and Hebrew, as well as our Roman alphabet. But even the Roman alphabet differs, has different letters in different languages. To take the text of these books word by word and transfer them to a computer memory bank would be impossible — but even if it were possible, marginal asterisks, colors of drawings and other such matters would be missed.

However, the problems of the vast numbers of words and the multitude of alphabets, marginal marks, and so on, presumably could be solved if the entire page were scanned and in effect photographed, with the information stored in the computer from which a photograph of the entire page could be printed.

Such a system, making use of the incredible speed of the computer to photograph pages and produce copies of the photographs, still would not overcome two insurmountable hurdles previously noted: the inadequacy of photography to provide all of the information in a book that may be of potential value to the scholars, and the interposition of an interpreter who in-


LE OPERAZIONI
DEL COMPASSO
GEOMETRICO,
ET MILITARE.
DI
GALILEO GALILEI
NOBIL FIORENTINO
LETTOR DELLE MATEMATICHE
nello Studio di Padoua.
Dedicate
AL SERENISS. PRINCIPE DI TOSCANA
D. COSIMO MEDICI.
IN PADOVA.
In Casa dell'Autore, Per Pietro Marinelli. MDCVI.
Con licenza dei Superiori.

Title page of Galileo Galilei's first book, published in 1606.

evitably makes decisions that alter the material.

The new technologies have produced new modes of publishing. "Books" increasingly are being published only in microform, photographed directly from the author's typescript. Original material also is being produced by word-processing techniques, stored in computers and transmittable directly to other computers. In such cases there is still an "interpreter" between the earlier forms and the final product, but that is no different from the printer who once took the author's manuscript or typescript and produced the printed book. The microform or the computer printout (which also may be produced directly in microform) becomes the original, to be preserved as thoroughly and cautiously as books.

The computer not only has an input but an eraser as well, which raises still new problems of preservation. For example the Short-title Catalog of the History of Science Collections is continuously (and, hopefully, perpetually) being altered, as new information is added. Printouts are produced regularly and preserved as a record of the growth of the Collections. In this way, there is a flow of originals, rather than a single one. Again the person who is concerned with preserving information must decide, in the ever-changing flow, what steps are to be preserved.

These new technologies present remarkable ways of handling information. They also present a danger that takes us back to the time before writing, when only the oral tradition preserved knowledge. Then a lack of transmission of the oral tradition could, in one generation, wipe out knowledge forever. Today the persuasive, enthusiastic technocrat can offer entrancing, tantalizing, tempting, low-cost ways of storing *reproductions* of information instead of the originals. The offer already has been accepted and implemented in some cases, for the financial pressure is enormous. Alas, some of the changes made have been unfortunate ones.

Decisions to change the modes of preserving knowledge should not be made lightly or ignorantly. Indeed the whole process of making such decisions should begin with a thorough acceptance of the Socratic advice that the first step to wisdom is the recognition of one's own ignorance. These are complex and difficult matters, and well-informed actions are important to our future. It would be a tragedy if the marvelous new technology of the "information age" were used to destroy valuable information and deprive the human race of this knowledge, forever.

ABOUT THE AUTHOR: The names "Duane H. D. Roller" and "History of Science" have become synonymous at the University of Oklahoma since he came from Harvard to join the faculty in 1954. He is holder of both the McCasland and David Ross Boyd professorships, recognized as one of the finest teachers in the history of the institution. Under his stewardship as the first and only curator, OU's History of Science Collections have evolved into the largest and best of their kind in the world.

All of the illustrations for this article are from volumes in the History of Science Collections of the University of Oklahoma.