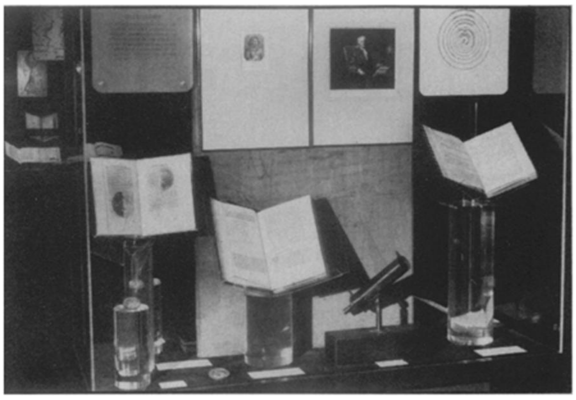
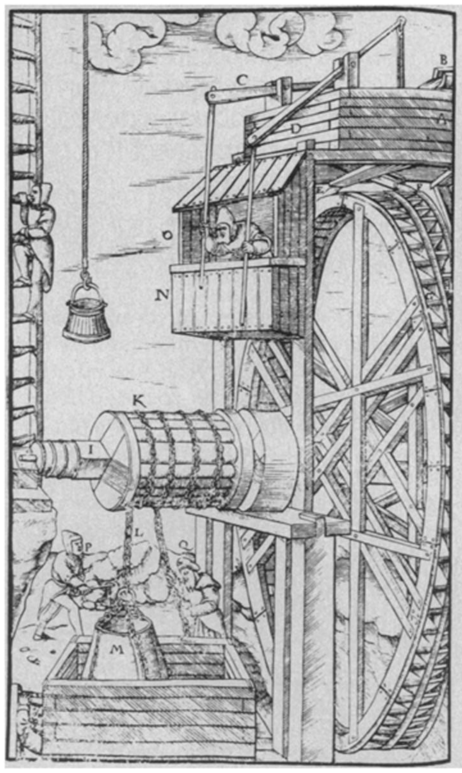


Astronomy: Works of Galileo Galilei, Nicolaus Copernicus and Isaac Newton transformed this science.

THE ROOTS



Engravings from 1556 work by Georgius Agricola on mining and metallurgy. Both show means of raising ore from shafts — at left, by water power; above, by manpower.

A museum exhibit helps us relive some of science's most notable achievements

BY SUSAN WEST

There are certain roots to which all of us must return. For the scientist, the fountainhead is the pioneering discourse that first brought his or her discipline from the closet of ignorance. For microbiologists, there are the works of Robert Hooke and Antonie Van Leeuwenhoek; for architects and engineers, Marcus Vitruvius's *De Architectura Libri Decem;* for mathematicians, the geometry of Euclid.

A collection of some of those signal works is on display at the Smithsonian Museum of History and Technology. Called the "Heralds of Science," the exhibit is the Holy Grail for the scientific pilgrim and a dream come true for the historian of science. Separated only by a thin piece of glass, the original words of William Harvey trace the flow of blood through the body. Undiluted by time and interpretation, the first edition of *The Origin of Species* describes the evolutionary sorting out of life: "This principle of preservation, I have called, for the sake of brevity, Natural Selection." As startling now as the day it was printed, nine concentric circles close toward a bullseye that is solemnly labeled "Sol" — a bullseye that fired the Copernican revolution.

Representing 35 similarly epochal scientific advances, the collection of first editions is only a small part of the nearly 11,000 volumes contributed to the museum by Connecticut industrialist and historian of science Bern Dibner. It represents the cream of the crop of 40,000 works collected by Dibner since 1936.

In 1955, Dibner compiled an annotated bibliography, which gave rise to the name of the exhibit of 200 documents published in large part before 1900 and marking "new truths or hypotheses in science." His bibliography, which includes the works displayed at the museum, is still considered *the* catalog of seminal scientific volumes. In the introduction to his book, Dibner describes the awe that these pivotal works evoke " ... it is felt that our democratic ways lead us to be most convinced by original sources and primary evidence.... To look upon the original Magna Carta or the Declaration of Independence makes one kin with its message and meaning. To go to original sources in science is to place the discovery or contribution in its proper time and framework — in its proper coordinates."

Seen in their proper coordinates and through the powerful telescope of hindsight, these works take on new meaning. Each appears — to the 1980 eye — as a stunning thunderclap of insight. Compared with the often obfuscating jargon of today's scientific literature, they show the poetry of the classics in which their authors were trained. One is struck by the youth of the authors, their powers of observation, their ingenuity and unpretentious modesty and, often, their courage.

Consider Nicolaus Copernicus. In *De Revolutionibus Orbium Coelestium* he says, "By no other arrangement have I been able to find so admirable a symmetry of the universe and so harmonious a connection of orbits as by placing the lamp of the world, the sun, in the midst of the beautiful temple of nature as on a kingly throne, with the whole family of circling stars revolving around him." With such imagery did Copernicus set the entire world on its ear. "In 1543," Dibner said in an interview, "only one man, Copernicus, existed who could say from his observations — not his dreams or his theories, but from his observations — what the relative motion of the sun and earth were. The rest of the world had a contrary view. You get the mental picture of a man who has evolved a point of view different from everyone else and who sets out to persuade the rest of the world."

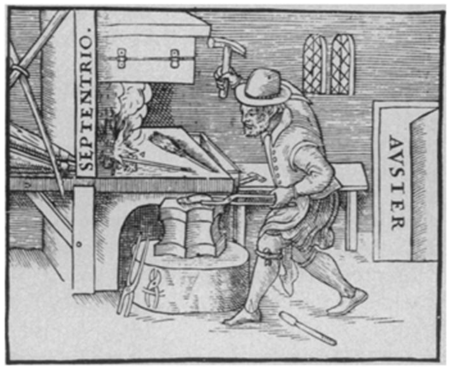
Like Copernicus, some pioneers knew they were making fresh footprints in the sands of science; others were not so aware. Gregor Mendel, says Dibner, knew just what he was doing for genetics. "He said, 'someday this will be recognized.'" And it was — 45 years after it was published in the journal of a local Czechoslovakian botanical club and six years after Mendel's death. William Harvey, on the other hand, had to be persuaded to publish his demonstration of the circulation of blood through veins and arteries driven by the beat of the heart. Printed as a small edition for the annual German book fair in 1628, the book "was not a best seller — it took a long time to be accepted," says museum librarian Ellen Wells.

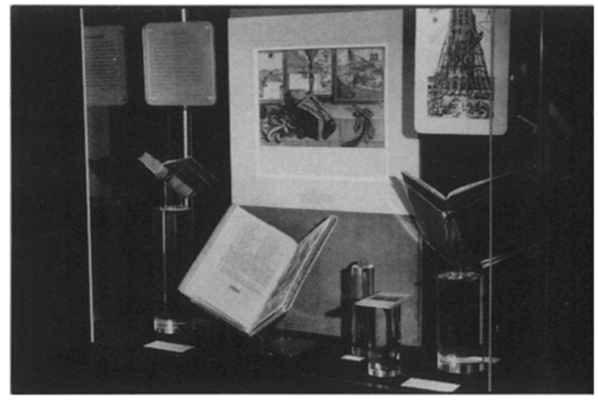
Many ground-breaking scientists, like Harvey, demonstrated the immeasurable value of experimental exactness and patient observation. English botanist Stephen Hales's careful experiments re-

OF SCIENCE

Illustrations: Smithsonian

15th century woodcut depicts three physicians diagnosing a plague-stricken patient—probably by examining his blood, urine and sputum.





Technology: Center engraving by Giovanni Piranesi, architect of Vienna, illustrates engineering devices. At right, Domenico Fontana's 16th century scheme for moving 361-ton obelisk from Circus Nero to the Piazza of St. Peter's in Rome. It worked.

William Gilbert, physician to Elizabeth I (left, above) tested magnetic hypotheses. Plate from his 1600 book shows blacksmith beating a glowing iron bar while holding it in the north (septentrio) and south (auster) direction, thereby making a magnet.

From Memoires pour Servir a L'Histoire Naturelle des Animaux *(left), a 1676 collection of exotic animals—from a French viewpoint.*

vealed respiration and the movements of fluids in plants. In *Vegetable Staticks,* published in 1727, he describes his painstaking work: "At noon I took a large branch of an Apple-tree, and cemented up the transverse cut, at the great end *x*, and tyed a wet bladder over it: I then cut off the main top branch at *b;* where it was $^{6}/_{8}$ inch diameter, and set it thus inverted into the bottle of water *b*.

"In three days and two nights it imbibed and perspired 4 pounds + 2 ounces + $\frac{1}{2}$ of water, and the leaves continued green; the leaves of a bough cut off the same tree at the same time with this, and not set in water, had withered 40 hours before. This, as well as the great quantities of water imbibed and perspired, shews, that the water was drawn from *f* most freely to *e,f,g,h* and thence down their respective branches, and so perspired off by the leaves."

Others are memorialized for their role as compilers, the recorders of the burgeoning information around them. Leonhard Fuchs — for whom American *fuchsias* were named — made his mark in 1542 with a spectacularly illustrated herbal. While revealing little new, the 896-page compendium gathered all that was known about nearly 400 German and 100 foreign plants and "introduced" Indian corn and the pumpkin from America.

Some of the works reveal the intangible intuition that marks a true genius. The mind of Carl Friedrich Gauss, Dibner says in his book, "leapt from solution to solution of problems ages old and the new ones of expanding science." By the age of 18, he had written a book that included the law of quadratic reciprocity, the notation of binary quadratic forms, the introduction of the theory of congruences, expansion of quadratic forms and a new theory of the division of the circle.

Michael Faraday, a blacksmith's son and a bookbinder's apprentice, had virtually no formal education, but in 10 feverish days during November 1831, he successfully proved that electricity could be generated from magnetism. In four handwritten pages, he outlined the principles of electromagnetic induction, principles that underlie electrical generation today.

While Faraday and Gauss remained lifelong wellsprings of knowledge, others appear as bright, but brief, flashes. Andreas Vesalius, who in 1543 at the age of 28 accurately derived the body's structure and function from actual dissection, became a local clinician and died at 34 in a shipwreck. His *De Humani Corporis Fabrica,* which he illustrated with artists from the school of Titian, was a "revolutionary moment in anatomy and in surgery in a format surpassed by no other scientific treatise," says Dibner.

Some, rather than creating new sciences, appear to have had a more basic mission — to set things aright. Nicolaus Steno, for example, straightened out the 17th century notion that fossils were half-made leftovers from the trial and error of creation.

Many were reinterpreters, reviewing old data in the light of new principles. Charles Lyell, caught in the growing acceptance during the 1800s of gradualism over catastrophism, published *Principles of Geology, Being an Attempt to Explain the Former Changes of the Earth's Surface, by Reference to Causes Now in Operation.* With that, geology became a dynamic science.

Though all were not so obviously influenced as Lyell, the collection clearly shows these scientists were creatures of their times — or Dibner's "coordinates." Isaac Newton, mathematician supreme, is viewed differently when one learns he was also an alchemist. The austerity of Robert Boyle's laws of pressure and volume is transformed when one sees the title page of his 1662 work:

New
Experiments
Physico-Mechanical,
touching
The Spring of the Air and its Effects,
(made, for the most part, in a New
Pneumatical Engine)

written by way of L e t t e r s
To the Right Honorable Charles Lord
Viscount of DUNGARVAN,
Eldest Son to the Earl of CORKE
by the Honorable Robert Boyle Esq.

But such, as Dibner says, is the beauty of the history of science. "To live in this age of science without an awareness of its fascinating origins is to miss much of the spirit of its attainments." □