Changing Writing Technologies and Shifting Cultures in European Science: 1400s-1700s

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The introductions of new technologies of printing and engraving were one of the primary factors in the development of modern scientific thought and science culture in Europe (Ong 125). This essay looks at some of the cultural and design shifts in the early scientific field by examining two recently-discovered texts written in this era[1].

Fragment from "On Natural Philosophy and the Observation of the World" (Florence, dated October 1450, author unknown) and notes.

...You have requested that I enlighten you as to the purpose of my work as a Natural Philosopher and how this work helps us re-discover the wisdom of the ancients, such as Aristotle and the famous astronomer Ptolemy. I humbly hope to share my thoughts on this matter, although their worth compared to those of the Wise Ones is as a flickering candle next to the flames of the lost Lighthouse of Alexandria. For the ancients conceived of all things under the sun and it is only now that their works are being rediscovered.

Today, we Natural Philosophers use several arts to describe the world. Chief among them are Writing, Mathematics and Illustration. Our culture is that of the scholar, a different creature from the solitary monk who once sat in his cell laboriously copying the words of the ancients. Today the scholar relies upon the services of scribes to copy his words so that he may devote his time to the study of the World. Men of knowledge travel to centers of learning such as Florence to commune with other scholars and read their works.

We know that our World was created according to God's divine plan, and therefore our energies may be fruitfully bent to discovering its true form. It is with humility that the Natural Philosopher approaches his studies in order to divine the true patterns underlying the Creation. We see God's pattern in all our studies: the movements of the planets and sun around the Earth speak of the central importance of humanity to the Creation and predict events to come; the arcane symbols of alchemy allow the transmutation of lead into gold; the study of herbology lets us find the purpose of each of the kinds of plants upon the Earth.

We use Illustrations to help describe what we see in the natural world. The process of observing and illustrating an object allows us to commune with the Creation and understand it in a way that mere verbal description does not. Like writing, art is a technique that we may use to increase our understanding of the Universe. Fields of study such as botany, optics, astronomy, and geometry are dependent on images as well as text. Can we imagine a manuscript on herbology without illustrations of the plants showing us how they may be used? No- for such a work would be useless...

During late scribal culture, "discovery" meant "recovery"- it was assumed that the ancients had once held all knowledge, and that it had been lost over intervening time (Eisenstein 123). The Bible and writings of the ancient Greeks were referenced as ultimate sources of authority. The evidence of one's senses was subordinate to the wisdom of the ancients (see second illustration, right).

However, scribes were not merely copiers of the ancients' knowledge: by the fifteenth century, educated men were beginning to evaluate texts from antiquity, add to that stock of knowledge, and slowly question accepted truths (Eisenstein 464).

Manuscript culture in this period was scribal culture. The tools and skills to create texts had spread out from the monasteries in which they had been concentrated in the Middle Ages, and several cities such as Florence were centers of secular learning (Drucker & McVarish 62).

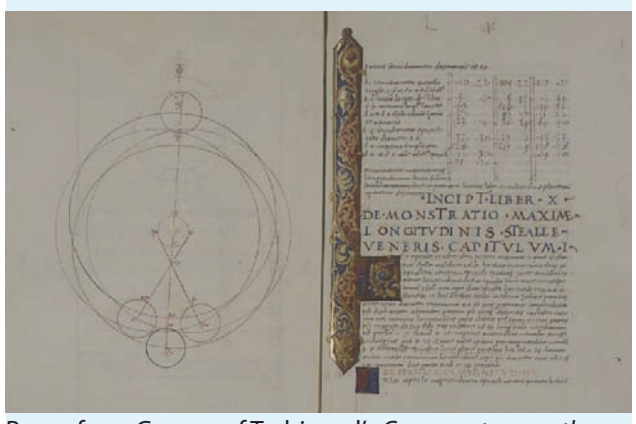
Most knowledge had been passed down for centuries, and the continual recopying of texts led to the gradual accumulation of errors. Since the process of copying books was time-consuming and expensive, books were rare and restricted. One had to travel to a book in order to read it (Eisenstein 622).

The dominant philosophy of the time with respect to the study of nature was descriptive naturalism, in which scholars looked for the divine plan that should be observable in natural phenomena. Nature and natural processes were seen as sacred and regular (Drucker & McVarish 59); philosophical and religious lessons could be discerned from a careful study of the world.

Manuscript illustrations were colorful and fanciful. They could be inexpensively produced with the same inks used for words. Accuracy was often less important than symbolic meaning (however, in some cases, diagrams were rigorously planned and executed, such as in astronomy or optics [Drucker & McVarish 82, Pyle]). They could be included organically with the text: spontaneous marginal drawings need not interrupt the overall layout of the text, or drawings could be inserted into the flow of writing, wrapping words around them.

Techniques and examples

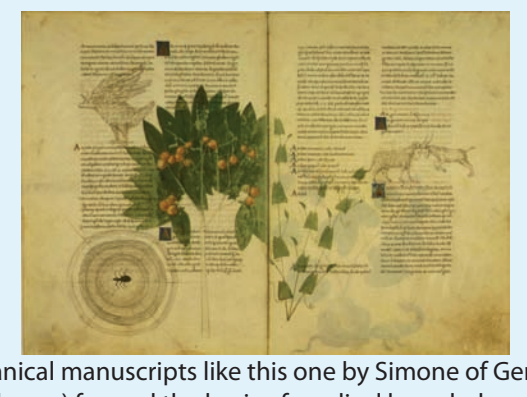
Technologies: handwriting, individual illustrations
Data presentation: tables, handwritten diagrams
Worldview: descriptive naturalism



Pages from George of Trebizond's *Commentary on the Almagest* (1482). On the left page is a model of the orbit of Mercury, showing its closest approach to the Earth at the center of the universe. This geocentric model of the universe was originated by Ptolemy in AD 150.

On the right page is information about Mercury and Venus. Note the table of numerical data in the upper right corner; such data was used for astrological predictions. There was no distinction between "astronomy" and "astrology" at this time. Decorative capitals and marginal illustrations with no relation to the subject matter were common in manuscripts.

Mandrake plant (*Mandragora officinarum*), from 15th century manuscript *Tacuinum Sanitatis* (author unknown). The lumpy mandrake root was compared to a human body, and this plant contains hallucinogenic compounds, lending it magical qualities. This illustration depicts the "safest" way to pick the plant, which was said to scream lethally loudly when uprooted. While the leaves and berries are accurately depicted, the root itself is highly stylized.



Botanical manuscripts like this one by Simone of Genoa (15th cen.) formed the basis of medical knowledge at this time. It contains translations of Greek and Arabic text; detailed descriptions of the natural world were arriving in Europe via Islamic civilization.

Excerpt from "A Description of the Work of the Empirical Observing and Collecting of Data" (London, 4 January 1700, by James Waterhouse, Scholar of Mining) and notes.

The study of the natural world allows us to accrue many benefits, and may, indeed one day help us to harness her power to our uses. Already in this century we see a flowering of knowledge about the natural world, which had led to great progress in Industry and the Sciences. To a great extent, this sharing of information is due to new developments in Printing pioneered by those like our good friend and colleague Mr. Dean. When one looks back upon the earlier Age of Man, one is struck by how fear and superstition clouded judgments and early attempts to find the pathway to True Philosophy, or Science.

In our work as Scientists, we have two goals. First, the observation of the natural world, carefully cataloguing its phenomena so as to lay bare its mysteries. No longer are we content to work as did the medieval scribe, copying errors without the curiosity to test the truth for himself. Second, we must share our insights with other men of knowledge. It is not enough to catalogue information; we share our studies with scholars across the civilized world by publishing books and the new Proceedings of Natural History Societies. This interchange of ideas allows all Men to advance in knowledge. While publication is expensive, it is a means to communicate with our peers and maintain a robust discourse. I will now share some examples of these matters.

Firstly, it is important to consider the manner of collection of one's data. It is not enough to know that an effect is being seen- one must take steps to ensure that that effect proceeds from the cause that one wishes to examine, and not from some other. I will add here that it takes special dedication of the intellect to decipher information from tables of data. My student Carl has the patience for this; however I must confess that I do not. We are fortunate in this Age in that there are many ways to approach such questions.

Secondly, we are fortunate to have our printer, Mr. Dean, working so closely with us. He is skilled with copperplate engraving, which, although expensive, allows us to accurately render our observations of our specimens. We work long and hard to select the correct illustrations with which to adorn our texts: such illustrations can illuminate both our understanding as we create them and the understanding of the reader as he reads.

Thirdly, note that interaction with other Scientists and Natural Philosophers can make one's own work more fruitful. For example, my correspondence with Mr. Jacquard of Paris has brought to light some interesting observations on formation of river deltas which bear upon my own interests, and from Mr. Schmidt of Frieberg I hear of a fascinating fern which was just discovered by miners made entirely of stone. And conversations at meetings of the Royal Society have also stimulated many ideas, the poor beer notwithstanding...[2]

In 1455, Johannes Gutenburg printed the first Bible in Europe using moveable type. This invention allowed information to be printed and disseminated much more quickly than by hand-writing. Moveable type allowed a printer to use and reuse the same letters (and numbers) for compositions as diverse as holy texts, treatises on herbology, and political tracts. Errors in both text and illustration could be widely distributed, although this wide network of distribution would mean that errors would eventually be noticed- the idea of the "improved edition" of a book arose (Eisenstein 108). The concept of a single true representation of an object began to take shape.

Printing books was much cheaper and faster than copying manuscripts, and copies could be disseminated and spread widely. Printing freed up hordes of students from copying tasks and allowed them to specialize in other tasks (Eisenstein 521). However, printing scientific texts was never inexpensive; early scientists typically sold subscriptions to a text before printing, both to defray costs and to guarantee a certain level of sales (Rudwick 46). Another way to minimize costs was to print shorter articles in scientific periodicals (Rudwick 47).

Early "scientists" would not actually have identified as such, so the term here is anachronistic; they would have been more likely to refer to themselves as "natural phiolsophers" or "savants". The distinction between the sciences and humanities was not firm in the eighteenth century, and the word "scientist" was not actually coined until the mid-1800s. (Rudwick 22-23).

By the end of the 18th Century, presentations of data had changed. Instead of tables of observations, data were presented in charts and graphs. People were becoming more comfortable with empiricism- gathering data and looking for patterns in the data itself, rather than merely using it to support ideas about the greater meaning of the world (Wainer 10, 16). This shift in many ways encapsulates a major change in thinking in the community of natural philosophers. No longer was a geometrically-perfect divine plan guiding interpretations of natural phenomena; now natural phenomena were becoming abstracted data to be analyzed and interpreted for their own sakes (Drucker & McVarish 106).

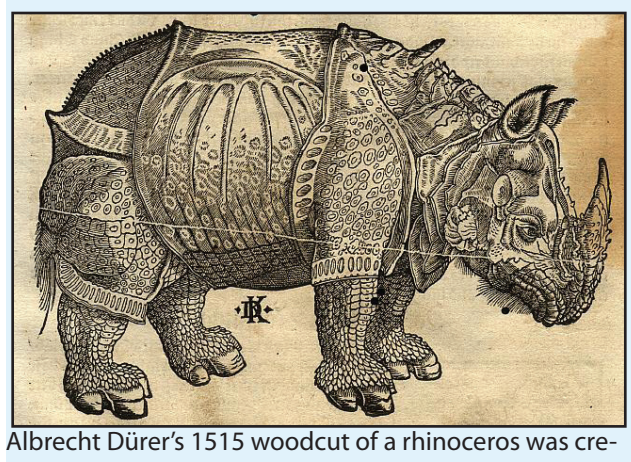
Illustrations for most printed texts were first carved on woodblocks. The separation of text from image eliminated the spontaneity to be found in manuscripts. The same principle of reproducibility applied as with print, though woodblocks would eventually deteriorate with use. Copperplate engraving was used for printing carefully-planned high-end scientific texts during the late 1700s, though its expense made illustrations rare; improvements in woodblock printing and lithography would later reduce costs (Rudwick 47, 357).

Throughout this period, handwritten composition was not disappearing; in fact, it was becoming more important for timely communication of scientific research. A "Republic of Letters" was springing up among natural philosophers and early scientists. This network of correspondence among leading thinkers of the time "transcended the boundaries of nation [and] language" (Rudwick 27). The sharing of inexpensively-produced letters allowed relatively swift exchange of ideas and opinions on observations and research.

Royal Societies and other academies were centers of research exchange and social interaction (Rudwick 23). They would eventually evolve into the peer-review system that forms the core of modern scientific culture.

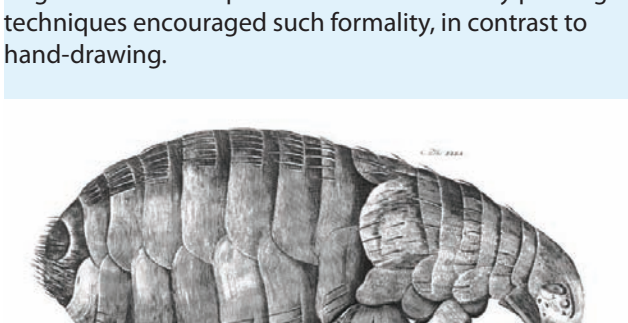
Techniques and examples

Technologies: print, woodblock & engraved illustrations
Data presentation: tables, printed diagrams, graphs & charts
Worldview: empiricism



Albrecht Dürer's 1515 woodcut of a rhinoceros was created without direct observation of the animal. Working from a written description and sketch, Dürer created this inaccurate figure, which was used for years in textbooks to illustrate the species.

Note the fixed, formal posture of the rhinoceros, in contrast to the fanciful depiction of the mandrake and dog in the manuscript illustration above. Early printing techniques encouraged such formality, in contrast to hand-drawing.



In 1665, Robert Hooke published this drawing of a flea in *Micrographia*, a microscopic study of living things. Using a microscope reveals details of the object of study invisible to the naked eye. Hooke believed that senses should be supplemented by such instruments just as memory is supplemented by writing and illustration (Pyle).

Accuracy in illustration is the intent of this figure, in contrast with the rhinoceros above. Different parts of the flea are labeled with letters; a printed legend would have described the parts of this figure so indicated.

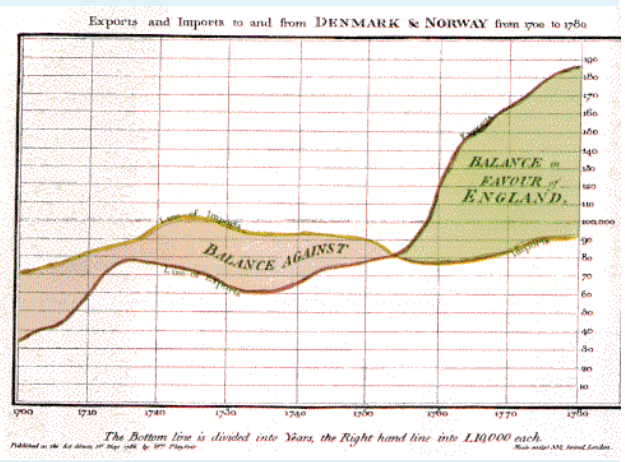


Chart of the English trade balance 1700-1780, by William Playfair (1786). Playfair pioneered graphical depictions of data such as bar charts and pie charts. Using such charts, rather than tables of numbers, makes it much easier for readers to draw inferences from data. Data presentation in non-tabular form was very rare before the late 18th Century.

Notes:
1. The two "texts" are fictional representations.
2. The Fell Type font used in the second "excerpt" is digitally reproduced by Igino Marini. www.iginomarini.com.

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