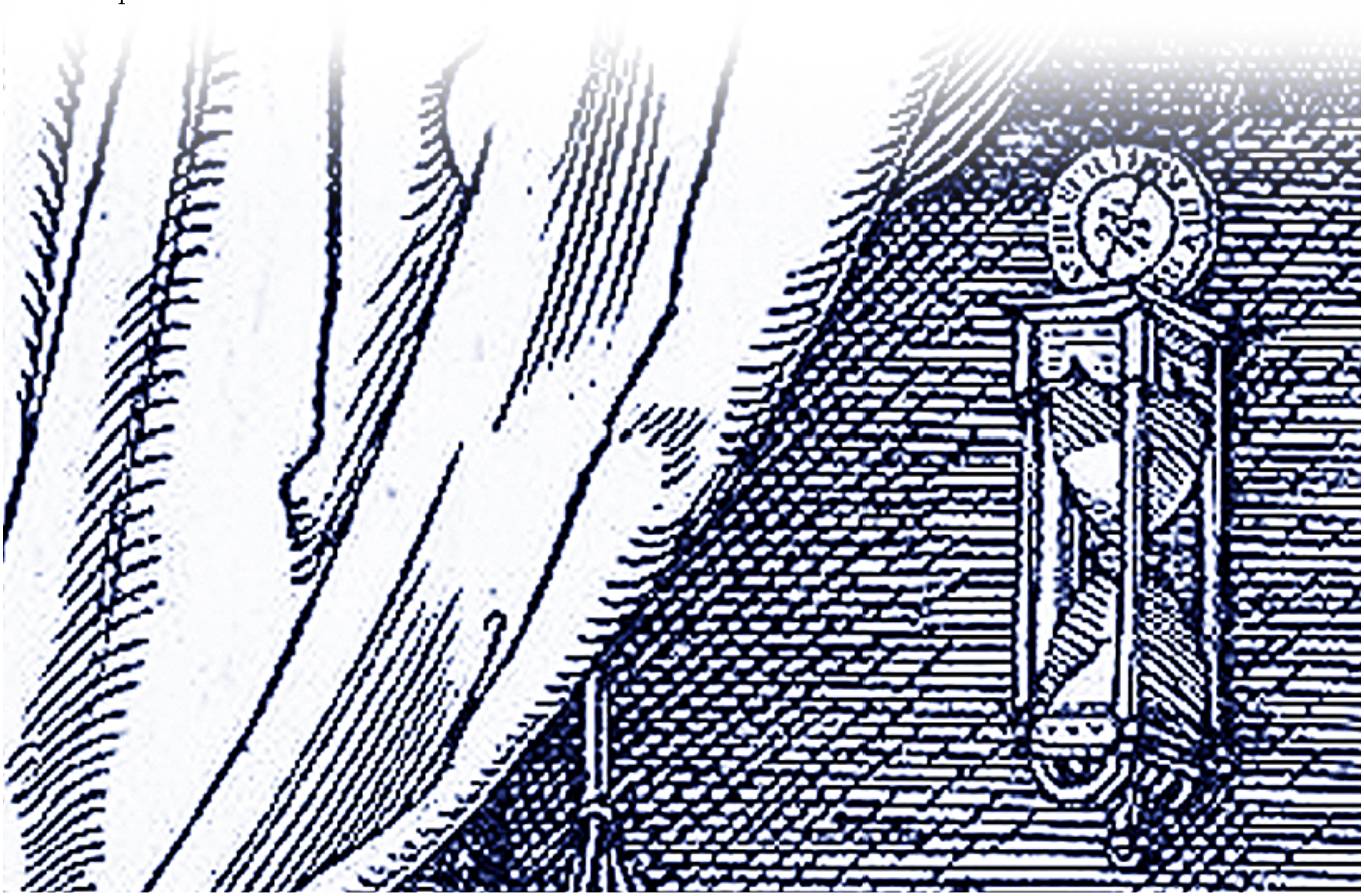
III Printing Time

Printing Time

What time is it? This question can now be answered nowadays with a glance at a cell phone. Yet time is also a concept with a history. In early modern Europe this conception was in flux and was visualized in heterogeneous ways. *Memento mori* prints reminded their viewers of time's constant passage and focused pious attention towards its ultimate horizon, death. In Hendrick Goltzius's virtuosic engraving, human life is argued to be as transient as bubbles floating across air. Even as this fatalistic notion of time persisted, however, scientists and artisans were advancing and fine-tuning technologies for time's accurate measurement. An example is the spring-driven clock, whose production boomed in sixteenth century southern Germany and which is depicted in Albrecht Dürer's woodcut of 1511. Sundials of remarkable precision allowed travelers to tell time by the rhythms of the sun (and, by means of ingenious conversion volvelles, even the moon). As our examples show, they could also be objects of remarkable artistry and beauty. Their circular format is invoked in a seventeenth century Distance Calculator, which measures the distance between Nuremberg and its outlying cities in terms of the normal duration of travel between them. The lifespan and development of living things were also aspects of nature to be taken into account and harnessed into new modes of scientific representation, such as the complex botanical illustrations of Leonhart Fuchs. The objects in this section thus show that there was no single understanding of what time was or how it could be represented.



9.
Georg Hartman
German, 1525-1564
Bowl of Ahaz [Refracting scaphe sundial], Nuremberg, 1548
Brass
Collection of Historical Scientific Instruments, Department of the History of Science (7397)

Georg Hartmann was an exceptional sixteenth-century German instrument maker and engraver. Penelope Gouk indicates that "between around 1527 and 1563 he published engravings of a whole range of instruments, including diptych and pillar dials."[1] There is an inscription from Ovid's *Fasti* on one such diptych sundial print that reads "Tempora labuntur tacitisque senescimus annis | Et fugiunt freno non remorante dies." [the times slip away and we grow old with the silently passing years; there is no bridle that can curb the flying days].[2] This object, Hartmann's Bowl of Ahaz-style sundial, tells a different story. At the behest of the prophet Isaiah, God is said to have turned back time, healed, and given extra life to the fatally ill Hezekiah, the fourteenth King of Judah. Isaiah's time-reversing miracle can here be performed by a clever trick of scientific artistry. Hartmann's bowl sundial simulates a biblical miracle.

Ahaz, Hezekiah's father, had been a notoriously wicked ruler: "he did not do what was right in the eyes of the Lord his God, as his father David had done, but he walked in the way of the kings of Israel. He even burned his son as an offering."[3] During his rule, Ahaz is said to have built a great stone bowl that could tell the time by the shadow of the sun. Hezekiah inherited the throne of Judah from Ahaz, but misfortune befell him later in life in the form of a fatal illness. Through the prophet Isaiah, God told Hezekiah that he would save him and add fifteen years to his life.[4]

And Hezekiah said to Isaiah, 'What shall be the sign that the Lord will heal me, and that I shall go up to the house of the Lord on the third day?' And Isaiah said, 'This is the sign to you from the Lord, that the Lord will do the thing that he has promised: *shall the shadow go forward ten steps, or go back ten steps*?' And Hezekiah answered, 'It is an easy thing for the shadow to lengthen ten steps, rather *let the shadow go back ten steps*'. And Isaiah the prophet cried to the Lord; and he brought the shadow back ten steps, by which the sun had declined in the dial of Ahaz.[5]

God turned back time at King Hezekiah's request as a sign that he was healed. Hartmann's bowl sundial performs this miracle using the angles of refraction of light in water.[6] The bowl is expertly crafted so that, when filled with water, sunlight is refracted moving the pin gnomon shadow backwards.[7]

This beautiful and clever instrument raises many interesting questions about the relationship between science and religion. Was Hartmann trying to explain Isaiah's miracle? Or was he trying to simulate it, making Hezekiah's miraculous experience present as in a play or a painting? Hartmann was a maker of precision scientific instruments who devoted his efforts to the measurement of time's constant passage, an occupation that required considerable understanding of astronomy. This may lead us to believe he was trying to provide a scientific explanation for the impossible miracle. However Hartmann was also a Lutheran pastor at St. Sebald's church, and may have been motivated by reverence for God's power rather than by the skeptical desire to explain.[8] In any case, as his quotation of Ovid makes clear, Hartman was well aware of the *memento mori* tradition so common in sixteenth-century European visual and literary culture, which presented time as a relentless and unstoppable force. Thus it is not surprising that he would engage with this story of time reversal and salvation from death.

Miracles were at the heart of the following century's debates about the relationship between God, science, and experiment. Peter Dear describes the difference between the seventeenth-century French Catholic belief that miracles were part of everyday reality and the English Protestant belief that they were not.[9] For Dear, these positions engendered different understandings of the ordinary course of nature and distinct scientific methods. Similarly, Steven Shapin places miracles at the core of the famous debate between Gottfried Wilhelm Leibniz and Isaac Newton's emissary, Samuel Clarke, in the early eighteenth century.[10] Newtonians believed in a God whose *will* was infinite and unbounded and who lorded over the universe, sometimes disrupting the course of nature. Leibnizians believed God's *knowledge* was his primary faculty, and interpreted any doctrine allowing for God's intervention as an attack on his perfect foresight. Although Hartmann preceded both of these debates, his decision to make a scientific *instrument* that performs and makes present a biblical miracle gestures towards questions that would become explicit and polarizing later in history.

Hartmann's bowl indicates that the relationship between science and religion is never obvious, and that science need not stand in opposition to miracles: this object could be born of reverence or of skepticism, although, given Hartmann's place in history, the former is more likely.[11] The bowl highlights the ways in which the intersection of craft technique and scientific knowledge allowed artisans to play with, alter, and think creatively about nature. Print technologies lie at the center of this power, with their capacity to make present nonexistent things (see catalogue nos. 6 and 8), to suspend the order of nature for the purposes of scientific classification (catalogue no. 11) and to make scientific models and ideas tangible and accessible in new ways (catalogue no. 10). Hartmann's expert engraving and craftsmanship combines artistry, ingenious scientific skill, and a truly incredible story to show the power of God and the power of the instrument maker.

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1 Penelope Gouk, *The Ivory Sundials of Nuremberg, 1500- 1700* (Cambridge: Cambridge University Press, 1988), 68.
2 The quotation and translation are from Gouk 1988, 68. The quotation is originally from Ovid, *Fasti*, Book 6, lines 771 – 2.
3 2 Kings 16: 2-3.
4 See 2 Kings 20: 1 – 6.
5 2 Kings 20: 8 – 11, my emphasis. Also described Isaiah 38: 7 – 8.
6 Hartmann was not the only instrument maker to construct a bowl of Ahaz. For a discussion and images of other models, see Alice Morse Earle, *Sundials and Roses of Yesterday; Garden Delights which are here displayed in very truth and are Moreover Regarded as Emblems*,

(Rutland, Vermont: Charles E. Tuttle Co. 1971), 390 – 410. In particular, Earle discusses another German instrument maker, Christopher Schissler's beautiful and ingenious Bowl of Ahaz, completed in 1578.

[7] There is a needle compass at the bottom of the bowl to facilitate proper alignment.

[8] Ivars Peterson reports on Christopher Schissler's Bowl of Ahaz in his article "Turning back time: an antique sundial simulates a biblical miracle" (*Science News*, February 10, 1990). Owen Gingerich is there quoted as indicating that Schissler's dial "was not in any sense an attempt to explain the miracle of Isaiah…It was a just a way of simulating it." The same is likely true of Hartmann.

[9] Peter Dear, "Miracles, Experiments, and the Ordinary Causes of Nature" in *Isis* 81, no. 4 (1990): 663–683.

[10] Steven Shapin, "Of Gods and Kings: Natural Philosophy and Politics in the Leibniz-Clarke disputes," *Isis* 72, no. 2 (1981): 187 – 215.

[11] For an extensive discussion of miracles and their relationship to science, see Malcolm Diamond, "Miracles" in *Religious Studies*, Vol. 9 No. 3 (1973): 307 – 324.

10.
Unknown artist
Paper Volvelle Sundial, 1575
Woodcut
In Petrus Apianus, *Cosmographia*, Antwerp, Belgium: Iuan VVithagio, 1575 (first edition Nuremberg, 1524)
Collection Owen Gingerich, Cambridge MA

The word "sundial" usually conjures up images of stone, brass, and ivory, not paper. Shown here, however, is a paper sundial from Petrus Apianus' *Cosmographia*, an introduction to Ptolemaic astronomy, geography, navigation, mathematics, and other then intimately related disciplines.[1] Apianus made wonderful and abundant use of printed images in the work, including maps of the new world, astronomical maps, and cosmological images, and employed the innovative print technology of volvelles: diagrams with rotating and moveable parts.[2]

The volvelle shown here is quite unique because it is not limited to a demonstrative function: it is a paper sundial that in principle could be *used* as a time-telling instrument (although it is perhaps unlikely that it was used for practical time-telling needs). In order to use the sundial, the book would be held up such that the point labeled "ZENITH" on the left-hand side of the page aimed straight up to the sky and the fixed bar labeled "HORIZON" would horizontally parallel the Earth's horizon. The triangular piece would then be rotated to reflect the vertical position of the sun in the sky. There is a weighted plumb line hanging from one corner of the triangle which, falling across the table of hours beneath, would allow users to discern the local time by reading the intersection of the string and the table for the appropriate month (indicated by zodiacal signs). The sundial could be adjusted for various locations by rotating the base circle (on which the table of hours is printed) to point at the appropriate latitude on the scale below.[3] The pages leading up to the volvelle list nine propositions concerning the motions of the sun and the craft of telling time. Entitled "The instrument to help understand the propositions, which has been discussed," the paper sundial is designed to *make those propositions visible* and so assist the reader in understanding them by manipulating the various parts.

Volvelles are constructed by superimposing layers of print components that can rotate around a pivot connector – in the sundial shown, a piece of string. The use of rotating and interactive diagrams as common pedagogical tools and instructional instruments is tied to the development of print technologies in the early modern period. According to Owen Gingerich, "[p]aper instruments with moving parts already existed in the medieval manuscript tradition, but like their more durable counterparts of brass, they were individually crafted devices. Hence, paper instruments first became widespread and important only after the advent of printing, which made mass production possible."[4] The paper instruments in this book are part of an exciting visual, tactile, and demonstrative pedagogical tradition. This particular volvelle allows the reader to develop an intuition for the motions of the sun and the art and craft of solar time-measurement while bypassing the complicated geometric reckonings and calculations involved in the science of sundials.[5]

The universe is not still. No matter how much detail one incorporates into a static map or diagrammatic model, the relative temporal motions of the heavenly bodies will be left to the viewers' imagination. Those with the required skills could also understand the heavens in terms of *mathematical* formalisms. However, until (geocentric) mathematical models of the cosmos were constructed in the work of Johannes Kepler in the early 1600s and of Newton in the late 1600s, these mathematical models were very complex and imprecise to apply. Many cosmographic texts, like Apianus's, were written for beginners or nonspecialist audiences and could therefore not rely on complicated mathematics. The relative motions of astronomical bodies are instead captured in the moving diagrams that perform the motions. Volvelles, and other interactive paper-and-print models simultaneously capitalize on the potency of visual representation and the efficacy of interactive, hands-on learning. Christine Johnson proposes that Apianus, by *involving* the reader in the process of cosmographical measurements and modeling, reinforced the validity of his claims and of cosmography as a discipline even in the face of its approximate, incomplete and in some ways uncertain state at the time.[6] Volvelles also capitalize on the power of the visual faculty and teach new ways of seeing and thinking visually and spatially: print can *show* rather than *tell* the reader the principles of astronomical models and measurements. Gingerich places volvelles in a wider pedagogical tradition that included "medical texts with layered anatomical illustrations, and also mathematical books such as the Henry-Billingsley-John Dee edition of Euclid's *Elements*…, which contained sixty 'pop-up' parts to illustrate solid geometry."[7] Print technology was at the heart of this tradition by making possible the mass production and dissemination of such paper tools. The paper tools, in turn, disseminated a set of tactile, visual and spatial intuiting, understanding, and argumentation skills. This paper volvelle was used to facilitate the development of skills needed to participate in the heterogeneous "sundial tradition" of telling time. Engraving and print technologies were at the heart of the development and dissemination of this tradition.

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[1] I have listed several disciplines that are now considered distinct. In the sixteenth century, however, they were held together under the term "cosmography." According to Klaus A. Vogel, over the course of the sixteenth century the "relationships among the various fields associated with cosmography changed." Klaus A. Vogel, "Cosmography", trans. Alisha Rankin, in *Cambridge Histories Online*, K. Park and L. Daston eds., (2008), 470. Vogel identifies Apianus' *Cosmographia* as one site of this change because it attempted to separate and define "geography," "cosmography" and "chorography."

[2] The *Cosmographia* was incredibly successful; many editions and translations were published, with the volvelles appearing in different numbers and variations. For a complete bibliography of the editions, noting variations in printing, see F. Van Ortroy, *Bibliographie de L'Oeuvre de Pierre Apian*, (Amsterdam: Meridian Publishing Co., 1963, originally 1902), 58. The book shown here is entry fifty-six in that compilation. Johannes Keunig, "The History of Geographical Map Projections until 1600," *Imago Mundi* 12 (1955): 1 – 24 also provides information on the various maps from Apianus' *Cosmographia*.

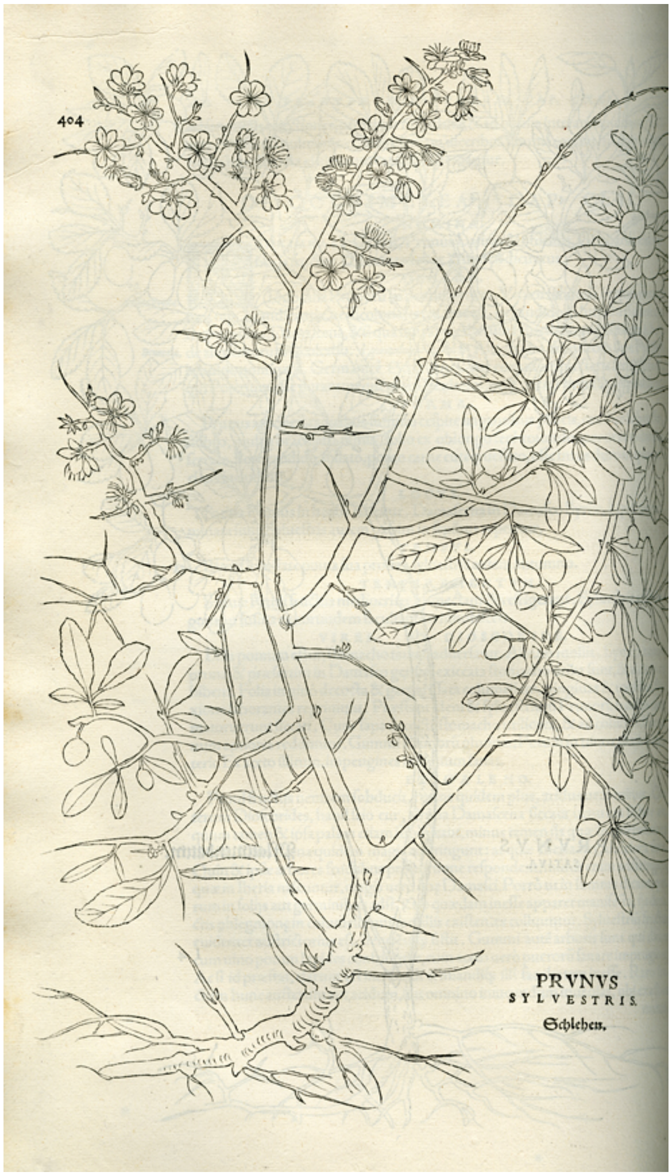
[3] For a discussion of how such a sundial can be constructed and used, see Oronce Finé, *Second Book of Solar Horology*, interpreted in English by Peter, I. Drinkwater, (Warsickshire, England: Peter I. Drinkwater, 1993), 19 – 20. An image of a similar paper sundial appears on page two.

[4] Owen Gingerich, "Astronomical Paper Instruments with Moving Parts", in *Making Instruments Count: Essays on Historical Scientific Instruments presented to Gerard L'Estrange Turner*, R. Anderson, J. Bennett, W. Ryan, eds., (Aldershot: Variorum, 1993, pp. 63 – 74), 63.

[5] See Christine Johnson, *The German Discovery of the World; Renaissance Encounters with the Strange and Marvelous*, (London: University of Virginia Press, 2008), 72.

[6] See Johnson 2008, 70 – 75, for a discussion the role of volvelles and other print technologies in establishing a semblance of certainty and the uncertainties of cosmography at the time.

[7] Gingerich 1993, 61 – 62.



11.
Veit Rudolph Speckle
German, d. 1550
Prunus sylvestris [Wild Plum]
Woodcut
In Leonhard Fuchs, *De historia stirpium commentarii insignes* [Notable Commentaries on the History of Plants], Basil: In officina Isingriniana, 1542.
Library of the Gray Herbarium
(Botany Gray Oversize Ka F95h 1542)
Facsimile in exhibition

Leonhard Fuchs' great herbal, *Notable Commentaries on the History of Plants*, offers an impressive, folio page-sized woodcut of each of the 497-odd plant specimens described therein. Fuchs was famously committed to the accurate depiction of plant specimens and emphasized that each plant was drawn directly *from life*. To this end, he writes in his dedicatory epistle, "we have not allowed the craftsmen so to indulge their whims as to cause drawing not to correspond accurately to the truth."[1] The image of the plum tree shown here, however, appears to violate Fuchs' claim to accurate representation from life and correspondence to the truth.

The plum tree is shown bearing fruit (in the right and left hand sections) and flowering (in the center) at the same time, which is impossible in nature. Flowers become fruit more or less uniformly during a plant's life cycle. Even during the transition period between flowering and bearing fruit, it is unnatural for the plant to be starkly partitioned in this way. It is therefore highly unlikely that the artist, Albrecht Meyer, drew this plant image direct from any single living specimen. Many such temporal hybrid images appear in the herbal. How, then, did Fuchs mean that the images "correspond accurately to the truth"?

Sachiko Kusakawa suggests that Fuchs was interested in more than the accurate depiction of specimens from direct observation. He was committed to capturing the *whole* of a plant, each one "rendered *absolutissima*," in the depictions.[2] Most of the images in the herbal conform to one particular interpretation of '*absoluta*': they present all of the *parts* of the plant. The root systems, the leaves, the seeds, the flowers, and the bulbs are shown, often clustered around a main central image of the adult plant, or in sequence across the page.[3] Images like the plum tree, however, function according to an interpretation of '*absoluta*' as *temporal* completeness. The two main phases of the mature plant's lifecycle are shown together, in an attempt to capture the "whole thing." Fuchs deployed print technology to *create* rather than to represent an object: no specific plant is the referent of this image, but rather all mature plants of this *species* are invoked by it.

Written text requires the reader's eye to move across the page; arguments, ideas, and descriptions unfold diachronically and linearly and cannot be grasped together. Illustrations and diagrams, on the other hand, are typically synchronic media. There is a kind of simultaneity to content made present by an image; it appears all at once and together on the page. Fuchs's temporally hybrid images are an ingenious attempt to represent living, changing, dynamic objects with the synchronic print medium. What does he gain by doing so? Kusakawa claims that Fuchs "was not examining this or that particular individual specimen, but arguing about medicinal virtues of *a species as a whole* that would be valid for all instances of the same" kind of plant.[4] The concept "species" unifies in one category many specific plant specimens, all of their different parts, in each of their life-cycle phases. The temporally hybrid images in Fuchs' great herbal do not represent plants, they visualize the concept "species" – the unit possessing the medicinal properties in which Fuchs was interested. This potent 'presencing' ability of images to make even abstract concepts like 'species' visually appreciable is one source of their immense power. Fuchs indicated as much in the dedicatory epistle to *De historia stirpium,* writing, "A picture expresses things more surely and fixes them more deeply in the mind than the bare words of the text."

Fuchs's appreciation of the importance of printed images extended to an appreciation of the artists who made them. In an unusual gesture of recognition, Fuchs's herbal includes a woodblock portrait of each artist who contributed to its production. The two illustrators are shown at a shared table with a potted, flowering plant between them. Albrecht Meyer is shown drawing that plant directly from life. Heinrich Füllmaurer is depicted transferring the drawing onto a wood block. The portrait makes visible the chain of representation that brings the real specimen to the reader through the hand of careful artistry. There is a self-portrait of the wood-engraver, Veit Rudolph Speckle, beneath the artists' portrait. Although Speckle is not shown engaged in his craft, the fact that his likeness is there created by it is representation enough.

This great herbal provides much fruit for thought regarding how images were used, how the complex and temporal objects of the natural world can be represented, how visual imagery can contribute to the stabilization of abstract concepts, and how scientists and artists forged respectful and interdependent relationships with one another. Crucially, Fuchs's images are not mere supplements to the written arguments. They contribute to his arguments by referring to plant *species* and not plant specimens as the '*absoluta*' of botany.

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[1] Quotation is taken from the University of Glasgow, Special Collections "Book of the Month" report of October 2002, at http://special.lib.gla.ac.uk/exhibns/month/oct2002.html.
[2] Sachiko Kusakawa, "The Uses of Pictures in the Formation of Learned Knowledge: The Cases of Leonhard Fuchs and Andreas Vesalius," in Sachiko Kusukawa and Ian Maclean, eds., *Transmitting Knowledge: Words, Images, and Instruments in Early Modern Europe*, (Oxford: Oxford University Press, 2006), 73-96; p. 77. See Fuchs, *De historia stirpium commentarii insignes,* p. 6.
[3] See, Fuchs, *De historia stirpium commentarii insignes*, pp. 69 and 441 for two examples.
[4] Kusakawa 2006, 81.


12.
Unknown maker(s)
Book-shaped diptych sundial, Italy, late 16th c.
Ivory
Collection of Historical Scientific Instruments, Department of the History of Science (7488)

This elegant ivory sundial is carved into the shape of a book, with pages and binding etched into the sides. Here, engraving techniques are not used to illustrate a book but to create one. The design choice of this and other book-shaped sundials may have been purely opportunistic aesthetics, capitalizing on the diptych form (diptych means 'folded in two') of most portable sundials. However, one guiding metaphor of early modern natural philosophy conceived of nature itself as a book that, when "read" alongside the bible, could lead to a deeper understanding of God, author of both. Therefore the concept of "reading" natural phenomena, like the passage of time measured by the motions of the sun, would not have been foreign to instrument makers and users in Italy at the time this sundial was made. Indeed, one of Italy's best known early modern scientists, Galileo Galilei, deployed "the book of nature" metaphor in his late sixteenth- and early seventeenth-century writings on natural philosophy. The rise of print technologies and the dissemination of illustrated natural philosophic texts, the emergence of "the book of nature" metaphor, and book-shaped sundials and astronomical compendiums like the one shown here, are likely not causally related. However, it may well be the case that different visual images, metaphors, and technologies reinforce, inspire, and illuminate one another at any given time in history.

Each inner face of this book-shaped diptych is equipped with a scaphe dial built in a concave dish (each for a different latitude). Most portable diptychs use a string gnomon for casting a shadow on a flat surface. Scaphes, on the other hand, are equipped with a pin gnomon that casts a shadow inside the bowl. The tip of the pin gnomon shadow indicates the time.[1] The hour lines inside the scaphe are curved to accommodate the curvature of the dish. These lines were often inscribed with the aid of a printed guide. For example, some sundial makers circulated prints of the engraved inside faces of diptychs, complete with hour lines and scales. Instrument makers could cut out the prints, mount and transfer their lines onto other surfaces.[2] Each inner face of this sundial is also equipped with a compass, a dish for storing a plumb bob weight, and a guide for a plumb line. The compasses and plumb lines help time-tellers to properly align, orient, and hold the sundial. Although the needle and the pin of both compasses are missing, the bowls remain, reminding us of another important part of sundial time-telling: knowing *when* you are requires that you know *where* you are. Sundials function because of the sun's height and changing direction in the sky.[3] Space and solar time calibration are therefore intimately connected since the path of the sun through the sky depends on one's location on the Earth's surface. Each scaphe dial of this instrument is calibrated for time-telling at a different latitude. Cartographic and navigational skills and tools, including maps and astrolabes, were therefore also necessary for determining how the hour lines needed to be drawn on a particular sundial. This instrument therefore represents a confluence of print technologies.

The hours on this dial have an interesting history. They are "Italian" or "Bohemian" hours. There are twenty-four hours in the Italian scale and they begin (with zero) at sunset. Each scaphe in this sundial is marked with the daylight Italian hours, from nine to twenty-three. They are a system of equal hours developed after the invention of mechanical time-telling technologies. Mechanical devices are often a hallmark of increased precision, speed, and efficiency. It is perhaps counter-intuitive then, that after the development of mechanical clocks in the fourteenth century, sundials became significantly *more* important for time-telling. According to Steven Lloyd, the mechanical clocks "were at first inaccurate and unreliable; the need to bring them into accord with the local solar time as defined by angular position of the sun in the sky led to the development of sundials calibrated to" the new mechanical, equal hours.[4] The sun's movement in the sky is far from mechanical. Its path, and therefore the number of daylight hours, changes each day of the year. Reflecting these cycles, hours were not of a constant duration in the Middle Ages. The night and the day were each allotted twelve of the twenty-four hours and, depending on the day, the hours would be appropriately longer or shorter.[5] Mechanical clocks, however, required a steady and constant measure with which to mark the passing of time. New scales of equal hours were developed to accommodate mechanical technologies, and new sundials were built to facilitate the coordination and (at first constantly necessary) adjusting of their mechanical counterparts. This sundial is marked with equal hours.

Although it is impossible to tell whether this specific instrument was used alongside a mechanical clock, the hours by which it tells the time are traces of that history. One can imagine that a new experience of time was engendered by the mechanization and equalizing of hours. Evidence that artist Albrecht Dürer was thinking about this changing experience of time is visible in his woodcut print of *St. Jerome* (see catalogue no. 14), in which a mechanical, spring-operated clock sits atop an hourglass. What incredibly different understandings of time are embedded in the mechanical ticking of a spring-operated clock, the downward rushing grains of sand in a closed glass container, and the quiet, perpetual motion of a shadow cast by the sun! The ongoing calibration between sundials and mechanical clocks, the creation of new scales of hours and new instruments with which to measure and inscribe them, are all part of the history of making time tangible, visible, and in this case, readable.

Stephanie Dick

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[1] The symbols along the sides of both tables of hours are the zodiacal signs. The passage of the sun throughout the year is variable. Time-tellers would find the intersection of the tip of the pin gnomon shadow and the hour line in the appropriate month as marked off by the zodiac signs.

[2] The German instrument maker Georg Hartmann was one engraver who circulated prints of his diptych sundials. For an example of such a print, and a description of their use in sundial making and standardization, see Penelope Gouk, *The Ivory Sundials of Nuremberg, 1500 – 1700* (Cambridge: Cambridge University Press, 1988), 68 ff.

[3] For a discussion of the different kinds of sundials and their relation to various properties of the sun's apparent motion in the sky, see Gouk 1988, 9.

[4] Steven A. Lloyd. *Ivory Diptych Sundials; 1570 – 1750*, Collection of Historical Scientific Instruments, Harvard University, (Cambridge: Harvard University Press, 1992), 14.

[5] For a discussion of unequal hours, see Lloyd, pp. 13 – 14. For a more comprehensive history of temporal units and the division of the day, see E. G. Richards, *Mapping Time; the Calendar and its History*, (Oxford: Oxford University Press, 1998), 42 – 51.

13.
Hans Troschel the Elder
German, 1549-1612
Rectangular Diptych Sundial, Nuremberg, 1611
Ivory
Collection of Historical Scientific Instruments, Department of the History of Science (7534)

Dates and times can be of such incredible importance that they define a religion. Simultaneously, dates and times can be the stuff of everyday, practical living. These two experiences of time are embodied in side-by-side calculating mechanisms on the bottom of this beautiful ivory sundial. The first, two Epact tables, is used for determining the date of Easter Sunday, arguably the most important event in the Christian Calendar. An Epact table is a series of numbers indicating the phase of the moon at the beginning of the calendar year for a series of years. The date of Easter Sunday can be calculated with this information. The other, a lunar volvelle, is used to facilitate the very practical need to tell time at night. Both devices are made of several concentric spheres and here the Epact table encircles the lunar volvelle, bringing together distinct experiences of time through a shared medium, a shared place, and a shared center. Engraving techniques similar to those used to make printed images are expertly deployed by the elder Hans Troschel (a member of a famous German instrument-making family) to render these two "times" more accessible, visible, and measurable.

The Christian religion is based on a belief that several actual historical events transpired in real places and times on the Earth: in particular, Jesus' birth, death, and resurrection. The major Christian holidays, Christmas and Easter, commemorate these events. Determining the dates of such prominent occurrences and when they should subsequently be celebrated has been an important thread in the history of Christianity.[1] In particular, E.G. Richards proposes that since the second century C.E. it was believed that "[i]f Christianity was to be independent of the Jewish religion it was necessary that it should develop its own method for working out the date of Easter" independently of Jewish Passover.[2] The famous Council of Nicaea, in 325 C.E. chose the "first Sunday following the first full moon on or after the vernal equinox" as the date for celebrating Jesus' believed resurrection.[3] Epact tables are designed to assist in calculating which Sunday that will be.

On the bottom of this sundial one finds a dual Epact table used for calculating the dates of Easter according to both the Gregorian and the Julian calendars. Determining the correct Sunday for celebrating Easter was clearly still a prominent concern in the seventeenth century. Each table is comprised of a sequence of numbers, each number indicating the phase of the moon (in its twenty-nine day cycle) at the beginning of each calendar year. The Epacts here are inscribed in the two outermost rings of the engraved circular scales, the Julian table in the outermost ring. Each begins with the year 1610 and is useful until 1628.[4] Knowing the phase of the moon at the beginning of the year makes it easy to determine the date of Easter. Epact tables put important religious knowledge in the hands of their users, freeing them from dependence on religious and government authorities. In this way, they can be seen as a technological instantiation of Protestant Reformation values.

The remaining five rings of engraved symbols (including the ring encircling the rotating brass dial) constitute a standard German lunar volvelle for telling time at night. The sun and the moon do not follow the same path across the sky or the same annual perturbations of height. Thus sundials are not obviously useful for telling the time using a shadow cast by moonlight. This clever calculating instrument permits users to convert lunar time to the desired solar time even after the sun has disappeared from the sky. First, time-tellers find the "lunar hour" by setting up the dial and reading the shadow cast by the light of the moon. The three central rings on the panel shown here are the core of the mechanism. The brass dial in the center must be rotated to point at the current phase of the moon. The innermost ring of numbers engraved on the rotating brass dial represents the "lunar hours" that users will have measured using the string gnomon. The first ivory ring around the brass dial will show the corresponding "solar hour." The solar hour that lines up with the measured lunar hour is the desired local time. The remaining two rings in the volvelle permit subtle corrections and adjustments to this conversion. In allowing time-telling to proceed after dark, the lunar volvelle represents another kind of freedom: freedom from the sun.

Beneath the Epact tables and lunar volvelle, there is a rectangular table listing twenty-three cities and their latitudes. Traveling time-tellers could adjust the placement of the shadow-casting string gnomon inside the sundial for use in different places. Sundials with this feature are called "universal sundials." Print technologies in early modern Europe enabled the dissemination and standardization of maps and distance calculators. Portable, universal sundials like this one should be understood as part of the constellation of print and engraving technologies that facilitated the mobilization not only of ideas and images in books, but also of people. The engraving skill of Hans Troschel, clearly evidenced by the detail and ornamentation on this sundial panel, also relates this instrument to less scientific uses of print. Simultaneously religious and scientific, artistic and practical, this sundial transgresses many boundaries often drawn in our own era. It ingeniously answers the question "what time is it?" in ways that offered new forms of independence. Users were freed from state and religious authority by being able to calculate the date of Easter Sunday, from the sun by the capacity to tell time at night, and from the latitudinal constraints of particular locations by being able to adjust the string gnomon. This object embodies the mobilization and the increasing independence that print technologies made possible for their users.

Stephanie Dick

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[1] For a helpful history of Christian dates and calendars and surrounding controversy, see Alden A. Mosshammer's *The Easter Computus and the Origins of the Christian Era* (Oxford: Oxford University Press, 2008).

[2] E.G. Richards, *Mapping Time; The Calendar and its History*, (Oxford: Oxford University Press, 1998), 346.

[3] Steven A. Lloyd, *Ivory Diptych Sundials, 1570 – 1750*, The Collection of Historical Scientific Instruments, Harvard University, (Cambridge: Harvard University Press, 1992), 27.

[4] The sequence of Epacts is given in Lloyd, p. 27, beginning with the year 1600.

14.
Albrecht Dürer
German, 1472-1528
Saint Jerome in his Study, 1511
Woodcut
Harvard Art Museum/Fogg Museum, Gray Collection of Engravings Fund (G4489)

Albrecht Dürer radically expanded the possibilities of print. Applying his stunning skills at draftsmanship to a range of reproductive media – woodcut, engraving, and etching – he created a new concept of the printed image as an object of high artistic and commercial value, a space in which artists could display their talents while participating in a variety of discourses.

This woodcut of 1511 is one of three prints Dürer made of Saint Jerome (c. 347-420), and the first of two depicting him in his study, a scene the artist would revisit in his famous engraving of 1514 [Fig. 1]. That the subject appealed to Dürer is not surprising: a Roman-born scholar and translator who also was a paragon of Christian piety and virtue, Saint Jerome was acquiring rising significance in the Renaissance as an exemplary proto-humanist. Images of him as an aged scholar absorbed in reading or writing – or, in the later sixteenth century, explicitly indicating or contemplating symbols of death (usually a skull) – flourished as *mementi mori*, reminding their viewers that knowledge is not a substitute for piety and that, like all earthly possessions, it will not save them on the Day of Judgment.

In this woodcut, however, Dürer links the theme not only to time but also explicitly to its *measurement.* While in the later engraving, light streams in from the windows and casts patterned shadows on the floor, here there is only a brightly-lit, parted curtain, which reveals the room but also emphasizes its hermetic quality. Crowded with objects (not to mention Jerome's massive pet lion), the space becomes a laboratory of time, subsuming reminders of death into a more complex essay that the viewer – ignored by the saint – is left to interpret.

Two timepieces are displayed on the wall, one atop the other. On the bottom is an hourglass, a late medieval invention, most likely derived from the realm of seafaring, which conveys time as the relentless passage of a single hour. Interestingly, the hourglass is still 'half full'; while clearly a symbol of death (the hour will soon be up), it is also suggested

Fig. 1. Albrecht Dürer, *St. Jerome in his Study,* 1514
Engraving, 9.8 x 7.5 in

by Dürer as a practical object captured at a random moment in Jerome's workday – much like the unlit candle on the wall, which indicates a 'snuffing out of life' but also simply its own present non-use.

Directly above the hourglass, Dürer depicts a cylindrical spring-driven wall clock. Such clocks were mass-produced in the sixteenth century thanks to the metalworking industries of southern Germany – with which Dürer, whose father was a goldsmith, had a personal connection. The invention of clocks driven by a spring as opposed to falling weights is often credited to the Nuremberg clockmaker and locksmith Peter Heinlein (1479/80-1542); this is a historical myth, as examples exist from the fifteenth century, the earliest known being the magnificent timepiece given to Philip the Good, Duke of Burgundy, in c. 1430 and now in the Germanisches Nationalmuseum in Nuremberg.[1] Yet it is clear that Heinlein, who is mentioned in the city's accounts as a maker of spring-driven clocks (*selbsgehend arologium*),[2] played an important role in the spring-driven clock's transformation from an object of extreme rarity and luxury (not to mention considerable size and weight) to a more affordable and portable household item or personal accessory, the ancestor of the modern pocket watch. In a description of Nuremberg published with his *Brevis Germaniae Descriptio* in 1511-12, Johannes Cochläus writes:

Every day they [the craftsmen of Nuremberg] invent finer things. For example, Peter Hele, still a young man, fashions works that even the most learned mathematicians admire: for from only a little bit of iron he makes clocks with many wheels, which, no matter how one might turn them, show and chime the hours for forty hours without any weight even when carried at the breast or in a handbag.[3]

Dürer's woodcut thus showcases a monumental innovation in the history of timekeeping.[4] Yet this and the hourglass are not the only *mementi tempi* in Jerome's study. Time is also given ritual form, in another object on the wall: the rosary, whose beads count the repetitions of prayers. Meanwhile, attached to the desk is a very different kind of 'clock': a crucifix, a reminder of the eschatological timeframe that lies beyond all human measurement and control. Placed before Jerome, the crucifix is directly juxtaposed to the hourglass and the cylindrical clock to which he turns his back.

To this, however, we must add one last indicator of time: the date, 1511, carved into the side of a wooden prayer bench, and Dürer's monogram, carved into the wooden floor – gesturing towards the medium and the bodily presence of the artist, who, like Jerome, would have spent hours bent over his labors in similar absorption.

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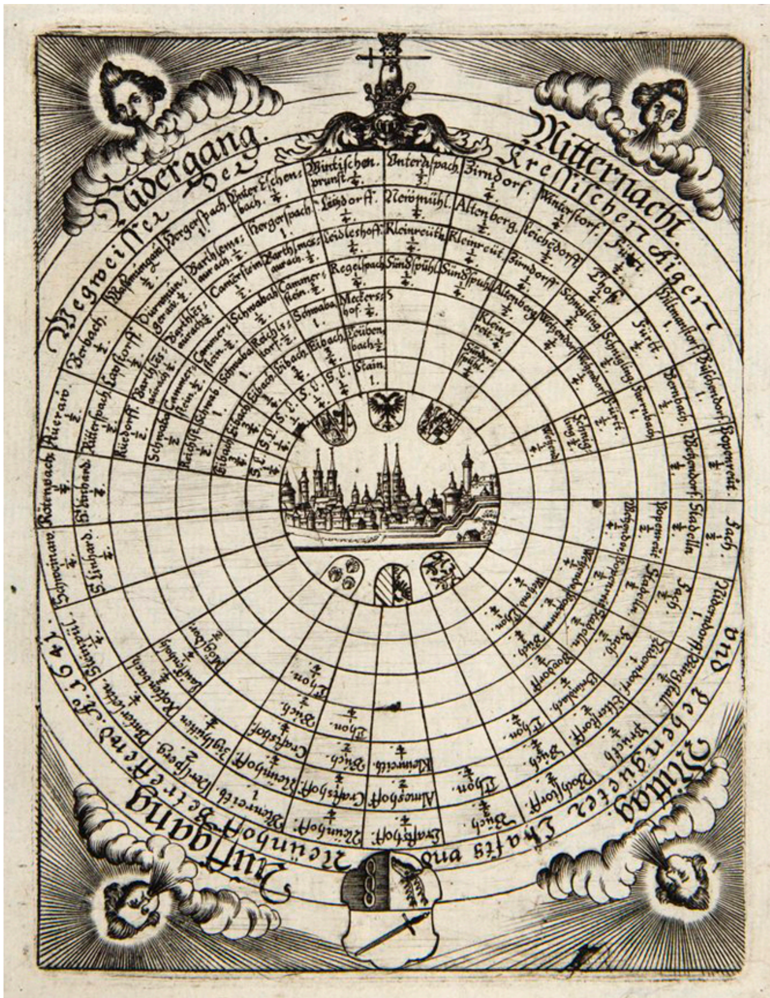
[1] See Gerhard Dohrn –van Rossum, *History of the Hour: Clocks and Modern Temporal Orders*, trans. Thomas Dunlap (Chicago and London: University of Chicago Press, 1996): 46-123. On the "Burgundy Clock" in the Nationalmuseum see See Klaus Marice, *Die deutsche Räderuhr: zur Kunst und Technik des mechanischen Zeitmessers im deutschen Sprachraum* (Munich: Beck, 1976), Vol. I, 85-87, and Vol. II, figs. 77 a-c.
[2] Dohrn –van Rossum, 122.
[3] Cited Dohrn –van Rossum, 122.
[4] Interestingly, many scholars believe that mechanical clocks originated in and in response to the timekeeping needs of medieval monasteries. See Dohrn –van Rossum, 47.



15.
Unknown artist
Distance Calculator, Nuremberg, 1641
Engraving
Harvard Art Museum/Fogg Museum,
Anonymous loan (52.2005)

This diagram shows its users how long it will take, in days or in simple fractions of a day, to travel between locations in and around Nuremberg according to various possible itineraries. Each town has a number below it indicating the approximate length of the journey from the previous town listed closer to the center. Thus, whereas the numbers below a town on a modern map indicate how many quadrants of the map lie between it and the previous town, here the largest unit is not the total space of the diagram but the time-span of a single day – translating space into time, and time into space. A view of Nuremberg is shown in the central oculus. Surrounded by the radiating grid, the city view with its vertical towers and horizontal ground-line is like the eye of the storm, stabilizing the image and indicating which way to hold it to begin viewing. Six coats of arms are also shown in the center, three above the city and three below it. Both circular and quadratic in format, the print thus posits and embraces multiple modes of viewing.

Depicted in the corners are the four winds, blowing rippling clouds onto the circumference of the diagram. They are surrounded with bright aureoles from which emanate sun-like rays, and are connected with four basic times of day listed in the outermost ring of the circle: *Nidergang, Mitternacht, Auffgang, Mittag* [sundown, midnight, sunrise, and noon]. Time, then, is conceived both as the linear progress of a traveler along successive points in space, and as the circular rotation of the sun over the course of a day. The latter conception is reflected in the diagram's general resemblance to a sundial.

Another inscription is divided into four quadrants in the second-outermost ring. Beginning in the upper left corner beneath *Nidergang,* it elucidates a more specific meaning of the print: *Wegweisser der Kressischen Aigen und Lehengüter Shafts und Neünhoff-Betreffend* [Directory of the Kress family's feudal property relating to Neunhof]. The diagram thus refers to one of the oldest patrician families in

Nuremberg, whose device, featuring a king with a sword in his mouth, appears at the top. Now known as Kress von Kressenstein, this family owned property throughout Nuremberg and its neighboring towns; their main residence, Schloss Neunhof – a small moated castle on the northern periphery of city that is still privately owned and can be visited today as a branch of the Germanisches Nationalmuseum – is most likely the starting point for the distances listed on the innermost rings. The diagram may have been made for Hans Wilhelm Kress (1580-1658), who served as mayor of Nuremberg and who in a document of 1625 made note of several works by Albrecht Dürer in the parlor of the Nuremberg city hall.[1]

While such a diagram might have been helpful for planning journeys – namely, for timing each departure so as to arrive at the destination before sundown – it does not require practical use to function as an emphatic visualization of the comprehensive and interconnected landholdings of the Kress family, an area on which, it would appear, the 'sun never set'. An analogy is sensed with the aspirations towards a universal time-scope harbored by the Hapsburgs, whose crest is shown at the top of the oculus. While the Hapsburgs ruled the world (or aspired to), this print makes clear that Nuremberg and its environs was the proper domain of the Kress family.

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[1] Susan Foister, "Dürer's Nuremberg Legacy: The Case of the National Gallery Portrait of Dürer's Father," 3. Article available online at http://www.britishmuseum.org/pdf/2%20Durer%20Nuremberg%20Legacy.pdf.

16.
Hendrick Goltzius
Dutch, 1558-1617
Child with a Skull Blowing Bubbles, 1594
Engraving
Harvard Art Museum/Fogg Museum, Gift of Belinda L. Randall from the collection of John Witt Randall (R2049)

Though he also worked as a painter, Hendrick Goltzius was and continues to be most celebrated for his prints and drawings. The art biographer Karel van Mander, writing at the end of the sixteenth century and construing artistic mimicry as a virtue, praised his protean ability to submerge his hand into the style of any other master. Yet many of his prints have a singular quality in their controlled system of cross-hatchings, often centered with tiny dots, giving an almost pixilated quality or the impression of a web cast over forms. He started out executing engravings after the designs of other artists, but gradually transitioned to making and engraving designs of his own. In addition to engravings and chiaroscuro woodcuts he is known for stunning 'pen work' drawings. He was primarily active in Haarlem but in 1590 he traveled to Italy, whereupon his art entered a more classicizing vein, with robust nudes inspired by ancient sculptures and those of Michelangelo.

In this engraving of 1594, Goltzius turns his mature skills to the difficult visualization of time, applying a rich variety of graphic marks. A child rendered as a classical putto is shown leaning against a skull, extending his right arm in the air to wave a pen-like instrument towards an array of bubbles in various stages of plenitude or rupture. A contemporary townscape appears hazily in the distance, where the long horizontal furrows of the sky disappear behind the wavy lines of a hill. The stalk of a flower with a single blossom shoots up along the left-hand border beneath a withering tree.

This scene refers to the Latin adage *homo bulla* or "man is a bubble," construing human lifetime as the course by which each person drifts towards an inevitable – and instantaneous – end. Included in Erasmus's *Adagia* of 1500, the saying was depicted as a subset of the *vanitas* genre well into the nineteenth century, enabling artists to show off their skills at capturing the effects of translucency and iridescence in the soap bubbles.[1] Sometimes the theme was pared down to a purely symbolic assemblage, such as Jacques de Gheyn the Elder's still life painting of 1603 [Fig. 1]. However, from the later seventeenth century it was often referenced obliquely in genre scenes of children blowing bubbles. Goltzius's engraving lies somewhere between, fusing elements of allegory into a plausible landscape setting.[2]

The theme of transience is expressed both visually and verbally. An inscription beginning in capital letters that appear as it engraved on a tomblike stone (suggesting a more morbid dimension of the term 'engraving') spells out a question – *Quis evadet* [Who escapes?] – that is answered in the margin below by four lines of Latin verse:

> The fresh and silvery flower, fragrant with the breath of spring / Withers at once; its beauty perishes. / So the life of man, already ebbing in the newly born / Vanishes like a bubble or like fleeting smoke. (F. Estius)

Divided into question and answer, the inscription thus straddles the realms of image and text. In the liminal lower zone of the image we see two monograms: on a section of earth beneath tufts of grass are the overlapped letters HG followed by *In*, short for "invenit" or "inventor" – labeling the image as Goltzius's design – while smaller letters on the top of 'gravestone' read *Hh. exc.*, a reference to the person who published (*excudit*) the engraving, possibly the Dutch printmaker and publisher Hendrik Hondius (1573-c. 1649). This publisher's monogram does not appear on a unique state of the print held in the Prentenkabinet in Rotterdam.[3]

That Goltzius signs on the ground is fitting, for this is shown as a site not only of burial but also of renewal and generation in the flower stalk that shoots up from it; the artist's process-time is thus related to operations of nature. The other side of nature's flux is shown the shell in the putto's hand, an example of nature's artistry that once housed a live creature but is now, like the skull, dead – though it harbors a substance (soap) that engenders new forms via the putto's breath.

Fig. 1. Jacques de Gheyn the Elder (Dutch, 1565-1629) *Vanitas Still Life*, 1603, Oil on wood panel, 32 ½ x 21 ¼ in The Metropolitan Museum of Art,Charles B. Curtis, Marquand, Victor Wilbour, Memorial, and the Alfred N. Punnett Endowment Funds, 1974 (1974.1)

Blossoming and dying are shown to be parts of the same dialectical process, captured also in the intangible smoke and bubbles shown simultaneously billowing and 'popping' or dissolving into lines along the upper border. All of the putto's signs of vitality – puffy cheeks, curling tendrils of hair, a foot lifting playfully off the ground – are thus transmuted to simultaneously signify death. Conversely, the most unambiguous symbol of death in the picture – the skull – shows eerie signs of continuing life, as two bright un-engraved crescents, centered with dark circles, give the distinct impression of a pair of eyes peering out from the sockets.

The focal point of the composition is the upper left corner, where the putto points towards the bubbles. The shape of the bubble-blowing instrument, the tensile position of the hand that holds it, and the gaze directed raptly towards this activity all generate a strong resemblance to the activities of drawing in pen or engraving with a burin. Goltzius's statement on time thus operates on a self-reflexive level, pointing back towards its own process-time and to the transience of all artistic efforts. Indeed, despite the title, the putto is not really shown blowing bubbles but rather *popping* them (or contemplating doing so) with the very tool that has created them. The dialectic of formation/deformation may also refer to the relationship between the additive process of designing and the subtractive one of engraving, in which images are formed by scraping material away from the copper plate. Goltzius's diaphanous and overlapping lines, which unify the image into yet also give the impression of forms unraveling or metamorphosing into each other – as the smoke and bubbles dissolve into the sky[4] – thus eloquently expresses the notion of transience.

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[1] See Michele Emmer, "Soap Bubbles in Art and Science: From the Past to the Future of Math Art," *Leonard*o 20, no. 4, 20th Anniversary Special Issue: Art of the Future: The Future of Art (1987): 327-334.
[2] On the tradition of depicting *putti* with skulls, see Horst W. Janson, "The Putto with the Death's Head," *The Art Bulletin* 19, No. 3 (Sept. 1937): 423-449.
[3] See Museum Boymans-Van Beuningen, Prentenkabinet, *Goltzius en zijn school: tentoonstelling Prentenkabinet* (Rotterdam, 1972), cat. no. 58, p. 24.
[4] On the self-referentiality of smoke in prints, see Michael Gaudio, "Making Sense of Smoke: Engraving and Ornament in de Bry's America" in *Engraving the Savage: The New World and Techniques of Civilization* (Minneapolis: University of Minnesota Press, 2008).

17.
Hans Lützelburger (German, d. 1526) after Hans Holbein the Younger (German, c. 1498-1543)
Last Judgment
Woodcut
In Hans Holbein the Younger, *Les simulachres & historiees faces de la mort, avtant elegamment pourtraictes, que artificiellement imaginées* ['Images of Death'], Lyon, 1538
Boston Medical Library in the Francis A. Countway Library of Medicine (1.Mx.63)

This is one of forty-one tiny woodcuts designed as a series by Hans Holbein the Younger around 1526 and published twelve years later as a book, *Les simulachres & historiees faces de la mort* [The images and storied faces of death], where each woodcut is accompanied by a Latin citation from the Bible and a French quatrain. Holbein's designs were cut into woodblocks by the Basel printmaker Hans Lützelburger, who also executed a related series by Holbein, the *Alphabet of Death*. By the time Lützelburger died in 1526, the woodblocks had been purchased from him by the Lyon printer Melchior Trechsel, who received them by the end of 1527.[1] However, Trechsel and his brother did not print the book until 1538 – a delay some modern scholars have attributed to publishers' concerns that the biting social satire of Holbein's images, targeting everyone from popes to kings, would offend some powerful authorities.[2]

Death is depicted as an animated skeleton whose victims are both male and female, and of all ages and estates. Sometimes he is more aggressive – beating a drum before a noble couple, prying the hood from the head of a monk – while in other images he is presented, ironically, as assisting his victims: driving forth the workhorses of an exhausted farmer, or gently leading an old man by the arm to his waiting grave. In each scene an hourglass is present as if freshly materialized along with death, a calling card signaling that a lifetime has run out.

Death commonly functions as an agent of social satire or leveling in late medieval images of the "Dance of Death," the title often given to Holbein's series. Yet as scholars have pointed out, Holbein's series radically transforms this genre, not only because it abandons the dance motif but also because its paginated format splits the theme into separate, successive scenes that are situated within the grander arc of Christian history.[3] This narrative begins with three scenes from Genesis – God creating Eve, followed by the Fall of Man and the

Expulsion from the Garden (during which Death makes his first appearance) – and concludes with Death's triumphal escutcheon or coat of arms. However, this last image is more of an allegorical postscript to the true finale of historical time: the Last Judgment.

In this scene, which is totally unprecedented in medieval Dances of Death, Holbein "zooms out" to view death from a cosmological perspective, as the end of earthly time – an event in which it is in fact Christ who triumphs over Death. Seated on a rainbow, Christ looms over a globe representing the universe. Fascinatingly, this globe resembles an armillary sphere, an ancient device made of metal rings denoting the rotating circles of the heavens. A similar device is pointed towards by one of Death's earlier victims: the astronomer, whose lesson on the workings of the cosmos is interrupted by Death handing him a large skull (Fig. 1). The universe of the Last Judgment looks like an armillary sphere that has been filled in with stars and matter and shaded to appear solid, like a celestial globe. The zodiacal signs are seen along the belt of the ecliptic. With Copernicus's *De Revolutionibus* still some fifteen years from publication at the time of the series' design, the Earth is still shown at the center

Fig. 1. Hans Lützelburger (German, d. 1526) after Hans Holbein the Younger, *Death and the Astronomer*, woodcut, 2.6 x 1.9 in, in *Les simulachres* ...['Images of Death'], Lyon, 1538, Boston Medical Library in the Francis A. Countway Library of Medicine (1.Mx.63)

of the universe; inside the overlapping rings of this supreme geometrical structure, it looks lumpy and cloddish (the outline of a single house is visible on it), gesturing towards the imperfection of mundane life and time.

Fig. 2. Hans Holbein the Younger,*Portrait of the Astronomer Nicolaus Kratzer*, 1528, Oil on wood panel, 32.7 x 26.4 in, Musée du Louvre, Paris

Interestingly, the Earth is also shown "close up" (or in lower case) as the ground stood upon by the resurrected bodies of the saved, who crowd around the hovering sphere of the universe and lift their hands towards Heaven. The allusion to an instrument thus has a specific function: by showing a *model* of the universe and not the real thing, Holbein rends an ontological fissure in the image that enables him to depict the End of Days from two perspectives – both as it is experienced on the ground by the resurrected souls, and as it is seen from Heaven, shown to exist here above and beyond the astronomical universe.

Holbein's citation of an astronomer's device prefigures what would be an enduring interest in the related fields of measuring time and mapping the cosmos. Upon his arrival in England, the artist became a close friend of Nicolaus Kratzer, the

German-born court astronomer to Henry VIII whose portrait Holbein painted in 1528 [Fig. 2]. The astronomer is shown constructing a polyhedral sundial that is nearly identical to one seen in what is probably Holbein's most famous portrait, the *Ambassadors*, which showcases not only a polyhedral sundial but also an array of other instruments including a cylindrical sundial, a celestial globe, two quadrants, and a torquetum.[4] In 1527 Kratzner and Holbein collaborated on the ceiling design of a temporary royal theatre at Greenwich showing the arrangement of the heavens;[5] and in 1528 Holbein illuminated an instruction book written by Kratzer on the use of an astronomical instrument given to Henry VIII as a New Year's gift. Shortly before Holbein's own death in 1543, he also produced a beautiful design for a "clocksalt" – a combination of a mechanical clock, an hourglass, a sundial, and a compass – that was given to Henry VII by the courtier Anthony Denny.[6] Holbein was thus an artist actively engaged with the representation of time.

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[1] On the production and publication of the series see Stephanie Buck, "The *Images of Death* and the Triumph of Life," in, *Hans Holbein the Younger: The Basel Years, 1515-1538*, ed. Christian Müller et al (Munich and New York: Prestel, 2006),117-121.

[2] An equally plausible explanation is that the workload of the Trechsels was too heavy; Buck, 117.

[3] I thank Charlotte Gray for bringing to my attention the temporal effects of pagination in Holbein's series.

[4] Susan Foister et al, *Making and Meaning: Holbein's Ambassadors* (London: National Gallery, 1997), 37.

[5] Foister et al (1997), 37.

[6] See Susan Foister et al, *Holbein in England* (London: Tate, 2006), cat. no. 80, p. 77. Otto Pächt argued that two inscriptions on Holbein's drawing are in Kratzer's hand; see "Holbein and Kratzer as Collaborators," *The Burlington Magazine for Connoisseurs*, Vol. 84, No. 495 (June 1944): 134-142.

The students and instructors in History of Science 215r would like
to thank those who assisted in the planning and execution of
Paper Worlds: Printing Knowledge in Early Modern Europe.
Without their expertise and generosity of time this exhibition would not have been possible:

Staff of the Botany Libraries
Staff of the Francis A. Countway Library of Medicine
Staff of the Harvard Art Museum
Staff of Houghton Library

Special thanks to the staff of the

Collection of Historical Scientific Instruments &
The Department of the History of Science
including:
Michael Kelley, Technology and Applications Coordinator
Judith Lajoie, Director of Administration
Martha Richardson, Collection Manager
Sara Schechner, David P. Wheatland Curator of the Collection
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We would also like to thank the administrators
of the President's Art-Making Fund for the financial
assistance to make this exhibition possible.