ONE

INTRODUCTION

Learning to Look with Books for the Literate Eye

In the early sixteenth century, images in printed books began to target a new intelligence agent: the literate eye. This eye became the focus of repeated encounters with images that aspired to a range of purposes, including cognitive prompts, memory devices, and instructions for performing specific tasks. The way these pictures began to confront the viewer sparks a reconsideration of the genres in which they were embedded, such as popular astrology or cosmology, as examples of popular science in which eyewitness authority was often constituted by texts but cemented by images. Images in books crystallized knowledge domains; one of the ways in which they did so was by demanding visual attention. This project inspects how sixteenth-century viewing practices were organized around pictures.

The eye was both magnetized by images and also appears in them, especially those in which thinking and seeing came together. The eye that the Ingolstadt mathematician Peter Apian planted at the base of the tandem terrestrial and celestial spheres (Figure 1.1) in his *Cosmographicus Liber* (1524) performs a physically impossible act: it must see "through" the earth to the celestial realm. The eye summoned by sixteenth-century prints was sometimes a literal eye and sometimes a thinking eye. Apian's eye is both: it sees past the earth and makes visual judgments about the heavens. Apian aimed to show viewers what they saw, but he also wanted to illustrate the theoretical principles that undergirded what the observer was seeing. This "literate" eye both observed and performed other cognitive acts. The stagings of such relationships in

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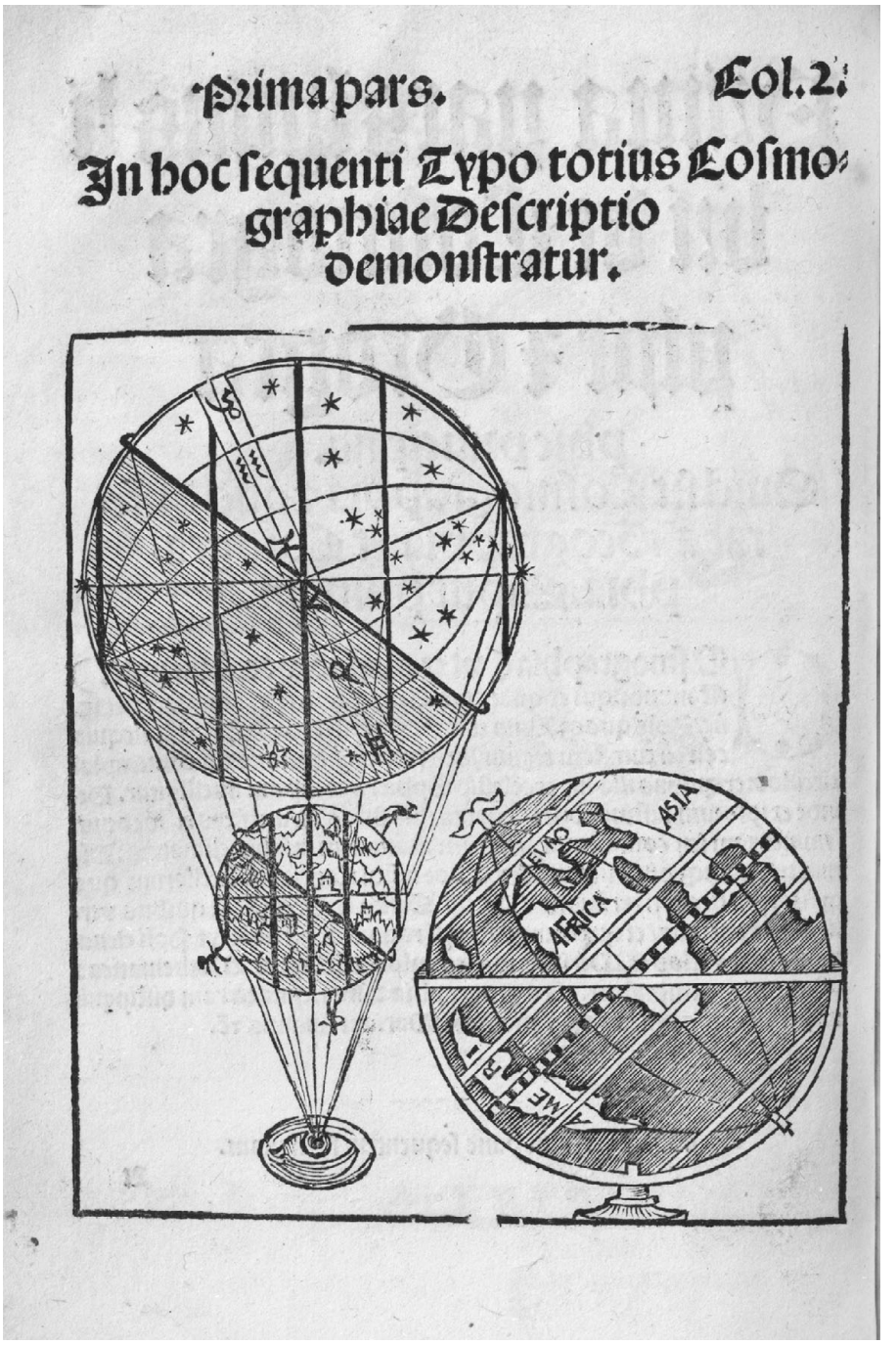

1.1. Peter Apian, *Cosmographicus Liber* (Landshut: Weyssenburger, 1524), fol. 2. *Source:* Zentralbibliothek Zürich, NR 870. Courtesy of ETH-Bibliothek Zürich.

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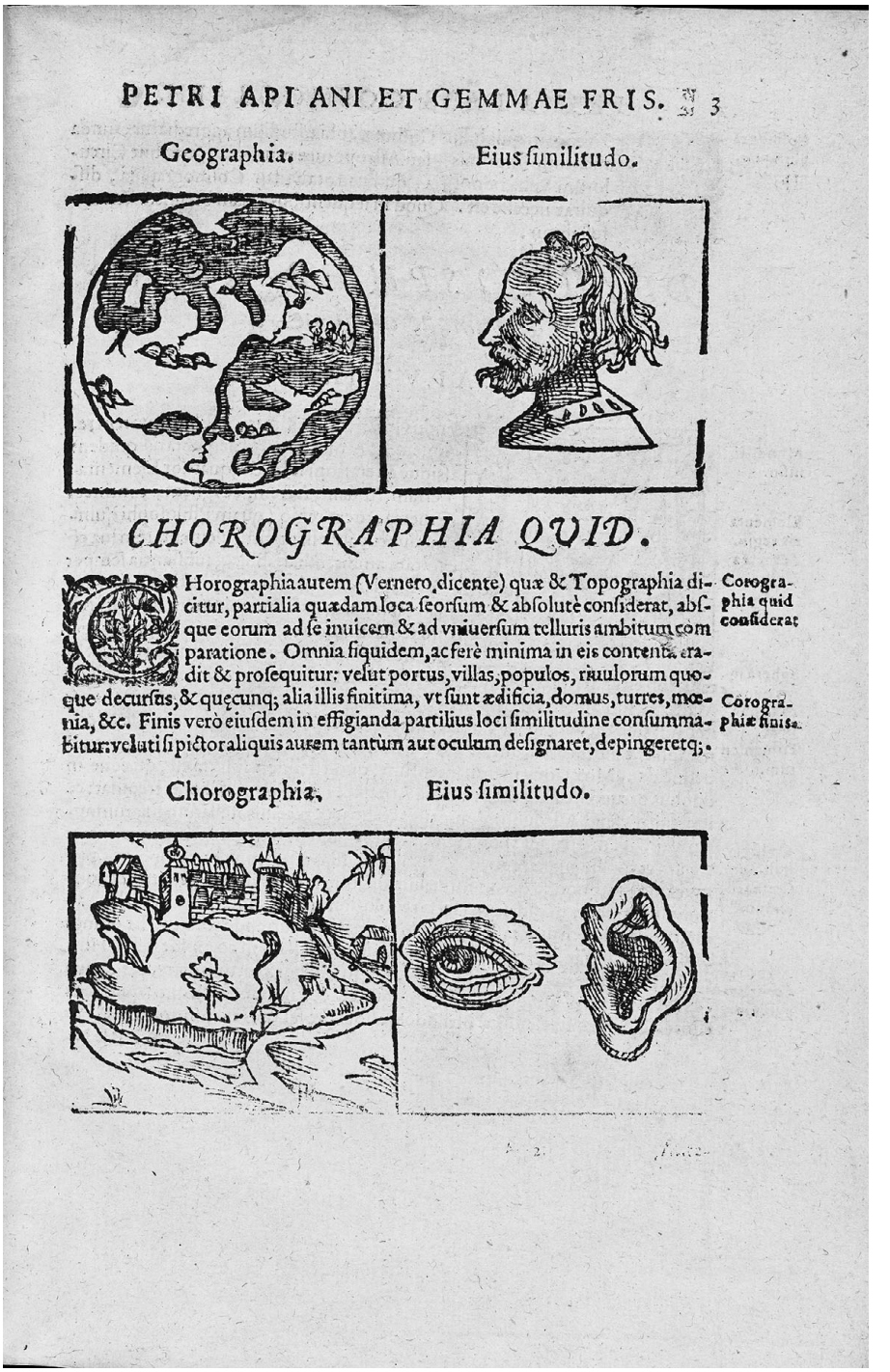
complex multilevel diagrams became integral to his developing scientific program, but the existing print infrastructure was inadequate to the task of producing these diagrams. Apian set out to build his own printing press to accommodate the pictorial complexities he envisioned for future volumes.

Firmly committed to the didactic properties of images, Peter Apian mobilized different types of pictures throughout a cosmographic text he published in 1524 to promote the merits of visualized thinking. Apian set out to instruct the reader that cognition must be routed through the visual field. Providing a cheat sheet for harder to grasp abstractions of cosmography, Apian chose a method of visual knowing with which he assumed his readers would be more familiar. With a diagram of an ear and an eye, Apian ingeniously linked the concept of cosmography to a genre already constituted as visually knowable: portraiture. This diagram helped viewers recall which mental images to conjure when contemplating complex concepts. The equation of a face with the representation of the terrestrial sphere that Apian announces with this image (Figure 1.2) shows cosmography to be a visual pursuit that can be likened to portraiture and explains them as kindred epistemic pursuits. Although each image reflected distinct modes of knowing the world, they were similar in that they could best be communicated by pictures. This book breaks down this metaphor into its component parts and asks how the subject matter of cosmography and faces, as well as other popular genres aimed at knowledge acquisition, began to shape the visual aptitude of vernacular viewers.

Illustrated books alerted the eye to a new consciousness in the early sixteenth century. Self-confident agents of learning, these heuristic tools aimed to help navigate the viewer's visual horizons. While expectations of viewers' visual sophistication are clear from Renaissance paintings, we tend not to think of books of the period as having a well-developed visual language.[1] But among the earliest printed books were ones in which illustrations were so integral that they were carved into the same block as the text. The first generation of books printed in northern Europe included just such instructional block books, which taught readers how to preach, how to live well, and how to die honorably, as well as warning about the perils of the apocalypse.[2] Advice for achieving salvation was delivered by pictorialized self-help books in which illustrations were the driving force. Even though these xylographic books (books with words and images cut into the same block) may seem unlikely ancestors of the technical books that are the subject of this study, they were similar in that their illustrations presume the reader as a user. In focusing on the visual epistemology of early printed books, this book argues that such manuals were usable tools that prompted empirical investigations. While manuscripts had delivered elements of the classical tradition through ancient texts, the how-to manuals of the sixteenth century marketed themselves as concise agents of visual data delivery.



PETRI API ANI ET GEMMAE FRIS. 3

Geographia. Eius similitudo.

CHOROGRAPHIA QVID.

Horographia autem (Vernero dicente) quæ & Topographia dicitur, partialia quædam loca seorsum & absolutè considerat, absque eorum ad se inuicem & ad vniuersum telluris ambitum comparatione. Omnia siquidem, ac ferè minima in eis contenta, eradit & prosequitur: velut portus, villas, populos, riuulorum quoque decursus, & quęcunq; alia illis finitima, vt sunt ædificia, domus, turres, mœnia, &c. Finis verò eiusdem in effigianda partilius loci similitudine consummabitur: velut si pictor aliquis aurem tantùm aut oculum designaret, depingeretq;.

Corographia quid considerat

Corographiæ finis.

Chorographia. Eius similitudo.

1.2. Peter Apian and Rainer Gemma Frisius, *Cosmographia, siue Descriptio vniuersi orbis* (Antwerp: Withagen, 1584). *Source:* Vault GA6.A55. Florida State University Special Collections and Archives.

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Theories of representation emerged from these new printed books and their images became the locus around which practical knowledge collected. The history of early printed books largely neglected images, instead narrating their technical achievement in terms of how many lines of movable type a page could offer (forty-two lines, in the case of the *Gutenberg Bible*).[3] While this bibliographic focus on text reminds us that many first-generation technical books were not illustrated, in a very short time, from 1510 to the 1540s, the pamphlets printed in German-speaking lands gave way to graphic layouts that were designed around illustrations. These books still accommodated text but their pedagogical intent was delivered with visual formatting in mind. If, in the past, text had chaperoned the images, images now became the codicological units *par excellence* and were the eyecatchers around which books were organized. In a mad rush to illustrate, publishers of complexion books, shepherds' calendars, and farmers' almanacs included arguably many more illustrations than their contents actually required. Calendars and almanacs were record keepers for wide usage and often covered a range of materials; they were mostly compilations of how-to knowledge, extending from *The Art of a Good Life and a Good Death* to collections of helpful shepherds' lore or instructions for farmers (*Bauern Practica*), from descriptions of purgatory to mnemonics to help the reader remember the Ten Commandments.[4] Calendar books printed with blank fields encouraged readers to pencil in activities as to-do lists.[5] Consultation of such visualized books, I argue, armed the viewer with new epistemic potential. Such books equipped vernacular viewers with skills to scan and scrutinize.

Early modern readers consulted printed schedules for lunar conjunctions before planting crops and cued the changing of bed linens to the stars' alignment; meanwhile, amateur observers were scrutinizing the firmament to figure out the time at night. Books taught merchants to gauge volumes of solids via instructive diagrams and formulas that could help them assess values in foreign markets. Another book tried to help readers identify potential scoundrels based on their profiles. Books featuring the palm of the hand engraved with lines (chiromancies) tried to help an employer assess the potential loyalty of an itinerant worker. Some of the information was culled from a number of older genres, such as Pliny's *Natural History*, Konrad von Megenberg's *Buch der Natur*, and the pseudo-Aristotelian *Secretum Secretorum*, but, in their new formats, this information was presented as visual data. Savvy printers such as Johannes Schott in Strasbourg, Sigmund Feyerabend in Frankfurt, and Walter Ryff and Levinus Hulsius in Nuremberg saw the value of repackaging information into pamphlets that were easier to consult. Publishers marketing these diverse genres as handbooks presented a united front that encouraged new audiences to engage interactively with their surroundings. The key to that engagement was the faculty of sight.

This book argues that the visual program of certain early printed books mandated a systematic visual engagement with the world. We might think of the manuals and pamphlets under review here as the root genealogy of books available today for purchase in hardware and drug stores: astronomy manuals, astrology charts, travel guides, and how-to manuals on a host of esoteric topics. They all share a desire to instruct and most of them place a premium on delivering and organizing that information visually. Some books advocated memorization, others delivered information about the care of horses and the types of bit a blacksmith could forge to control them, or they collected motifs for fancy headdresses and furniture designs. Other books offered sections of map gores, which, when cut along dotted lines, could be assembled into personal globes. Music amateurs could purchase instructional volumes that showed the correct finger placements for playing a recorder.

We cannot assume transparency or ease in the process of teaching the average early modern amateur scientific practitioner new skills: the lack of proper instructions on how to operate a rudimentary telescope sent by Galileo to his brother at the Wittelsbach court in 1611 left at least one hapless viewer very confused.[6] In a letter describing the event to Galileo, his brother ridiculed the observer's ineptitude as he peered through the wrong end of this hastily assembled telescope. While this clumsy observer was called out in the letter, those of us who hang our heads before complex online instructional tutorials might have more sympathy for the unfortunate chap. We tend to assume that knowing how to properly observe was an endowment of nature, not nurture. But according to the productions of the early modern corner presses, pinpointing where and how to look was indeed a learnable, and marketable, skill.

Of the many genres that were emerging in that market, two were especially insistent about their function as heuristics on the path to making visual judgments: physiognomy and cosmography. Indeed, these two genres were already related through their common origin in judicial astrology. Predictive astrology was the practical outcome of the training of physicians and mathematicians, whose skill sets merged theories of humoral balances with the complex mathematics required to draw horoscopes. The outcomes of astrological observations were made manifest in the many pamphlets marketed as usable knowledge called *Practica*, calendars, and horoscopes. The planets were thought to exert influence on a person's complexion, and if their trajectories were properly tracked, their positions could also render predictions and useful assessments about patients' health. The mathematical foundations of astrology turned planetary positions into complex problem sets that aided physicians and geomancers in determining humoral diagnoses. The printing environment for predictive astrology was served by trained mathematicians who simultaneously drafted horoscopes for courtly patrons and churned out pulp astrology for wider audiences. Eventually, an ecology of urban printers channeled academic

astrology into printed manuals for new publics of cosmographic practitioners whose eyes were schooled by cosmographies, geomancies, physiognomies, and complexion books.[7]

Cosmography and physiognomy find their common inspiration in predictive astrology. Unlike the modern tendency to separate the aims of astronomy from astrology, the array of publications about data drawn from the stars indicates that neither publishers nor readers found those two fields at cross purposes; on the contrary, they functioned symbiotically. In fact, Apian's day job printing prognostications under the title *Practica* was perhaps the most lucrative arm of his press. Apian's understanding of the stars fed both his scholarly preoccupations, and there is nothing to suggest that he privileged one over the other. Both genres aimed to unpack and systematize the knowledge he was seeking in the heavens.

The authors of such *Practica* observed the stars in order to link planetary and lunar movements to vernacular practices in the form of seasonal recommendations. This updated the doctrine of signs from Aristotelian material into more practical concerns: such information circulated for the purposes of weather watching and scheduling seasonal activities. Scanning the heavens closely at night, the day job of most celestial observers was to predict and schedule the occurrence of lunar eclipses for the public and to turn their observations into predictions and prognostications.[8] While the modern reader tends to consider the purview of astronomy as discrete from astrology, most early modern astronomers were unapologetic about the predictive origins of their trade. Johannes Kepler acknowledged that the astronomy of his era rested on the shoulders of astrologers scanning the sky for practical advice.[9] The symbiotic nature of the relationship of the two genres was made manifest in their shared iconography. For example, the precise schedule of lunar eclipses provided in Regiomontanus's *Kalendaria* (1532) closely resembles that which appeared in Apian's *Cosmographicus Liber*, a cosmographic manual of the sort that was transitioning from theoretical material to more practical concerns. Eclipses and comets were important events in calendars and *Practica*, linked to omens and prognostications.[10] Calendars and almanacs charted activities of both universal and particular relevance, ranging from the predicting of collective disasters (such as floods and plagues) to the scheduling of personal hygiene and health practices.[11] A typical passage in such a publication recommends restricting bathing and cupping to specific intervals in the lunar cycle, when a waning moon appeared in particular star signs.[12] As early as the 1480s, printed almanacs and calendars promoted regimens for scheduling bloodletting and baths. Image programs that included content such as a practitioner setting cups on a patient served as mnemonics for what activities to undertake during that part of the month.[13]

Sometimes it was the printer who cemented the connection of one sphere of study (astronomy) to another sphere of influence (medicinal care of the

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body). Jacob Cammerlander, the printer of the *Kalendarius* of Johannes Müller von Königsberg (called Regiomontanus after 1534), specifically geared astronomical information toward readers who used calendars for scheduling health regimens; the preface tightens still further the connection between astronomy and medicine. Many such manuals were printed in Strasbourg, where presses producing books on field surgery provided medical information for a market not driven by the needs of an academic institutional presence – a university would not appear in the city until approximately 1621.[14] Until that time, Strasbourg printers (as well as those in other towns such as Augsburg and Nuremberg) supplied knowledge largely to a vernacular public, and this public played a significant role in shaping publishers' lists. Robin Barnes's *Astrology and Reformation* outlines the prodigious trade in printing astrological literature in the urban centers of the Holy Roman Empire.[15] Vernacular publications are among the best extant sources we have of how craft-based professions were organized; in fact, the publications themselves did prodigious structural work for certain trades. Field surgeons, for instance, were grouped into guilds with barbers by virtue of the common tools that they used. Their instructional manuals were organized according to practical concerns and they helped match battle-induced wounds to the specific tools required for their treatment. *Practica* also articulated relationships between related modes of empirical learning; publishers were often the ones to forge these ties.[16]

Astronomy's connection to medicine is cemented in the title page of Regiomontanus's *Kalendarius*: "a pleasant comparison of astronomy with medicine/ [which asserts that] a successful Doctor must also be a skilled Astronomer."[17] This particular section of *Kalendarius* linked health regimens to the movement of the stars. The tracking of stars was related to other types of systematic visual investigations performed by physicians, such as evaluating urine samples.[18] Both types of analysis called for the observation of specific details and even comparative cross-referencing. Such manuals placed expectations of daily observations on the shoulders of amateur observers and vernacular readers. Physicians were expected to keep their eyes trained on the movements of celestial bodies through the constellations as well as on patients' humoral complexion.[19]

Early modern astronomy and astrology were locked in a symbiotic bind. The day job of an astrologer required the rigorous training of astronomy. Horoscopes commissioned by powerful patrons depended on correct predictions; these show the related pursuits of astrology and its handmaiden, astronomy.[20] Astronomy's tracking of movements in the heavens was the basis of the very practical concerns of judicial astrology. Perhaps the already close connection between astronomy and practical astrology in this period grew tighter as astronomers and mathematicians took the helm of some early modern print shops.[21] Both astronomy and astrology were underwritten by firsthand

practice, and printers parlayed related skill sets into a wide array of visually profuse genres that would guide future empirical activity.

In these new urban environments arose the twin genres of physiognomy and cosmography. Physiognomic texts can be thought of as guides to navigating a landscape of people, taking the generic data of faces and repackaging it into novel informational formats. Unlike the taxonomy of peoples that would manifest itself in costume books, the physiognomy book was for people watching, a manual that could help levy judgments about neighbors via the close inspection of their features. Physiognomy's collection of character heads presented tools for a practical science that developed around pictures. That many of these illustrated faces were shown in profile should not surprise us: Profiles best reflected the mountains and valleys of the face, the important data points of portraits. The heightened scrutiny that profiles received as a result of these manuals can be mapped onto the new forms of cosmography that likewise encouraged viewers to scan surfaces and volumes, such as the horizon or the heavens. Cosmography was a synthetic science that merged many individual observations. Apian's book tried to reconstruct that process by showing explicitly how to make those observations. In a study of the stimulus to cognition instigated by Apian, one group of book historians invoke these visualized genres in their description of the book itself. They describe the book's morphology as its "physiognomy," while their approach to it capaciousness as a whole work is presented as a measure of its "cosmography."[22] It is perhaps therefore auspicious that we consider here how the book constituted and facilitated physiognomic and cosmographic investigations.

TRAINING THE EYE

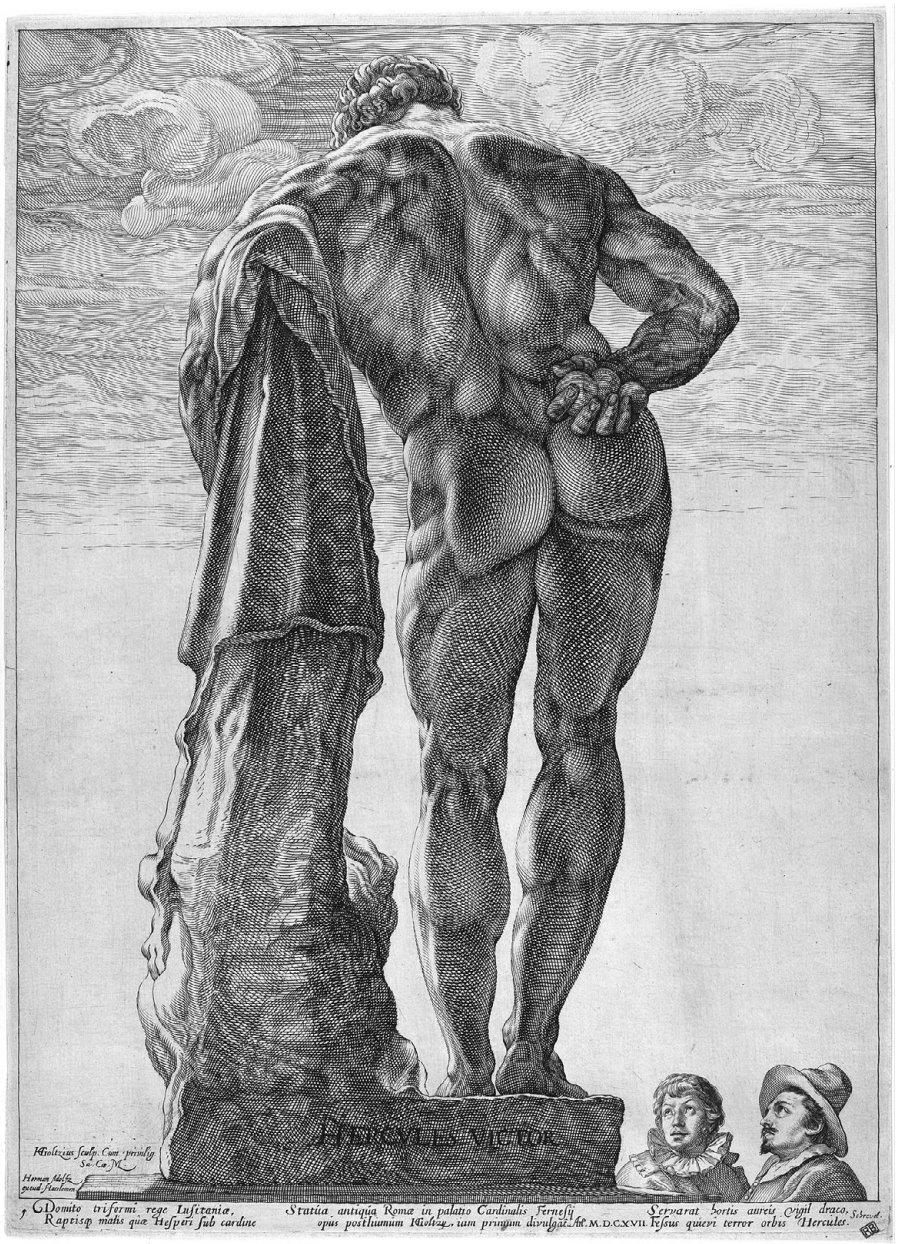
Prints made their readers look with rapt attention at things, some of which had always been fixtures on people's horizons, such as the stars, the moon, and rises and dips in the land's topography. But unique among illustrated books was the method they prescribed to take in that information via an appeal to the senses. Note, for example, Campanus of Novara's *Theorica Planetarum*'s goal of providing instructions for constructing rotating planetary models: "they may be able to see with their eyes by an instrument which is perceptible to the senses."[23] One thing that books suggested viewers do was to scrutinize in ways that other media did not. Prints of the sixteenth century invited new subjects for viewing as they solicited unfamiliar viewing practices. Some of these subjects were consonant with a newly activated viewer.

That the practice of sight was construed now as subject, rather than as object, can be seen clearly in the shift in visual interest in the eye. Gregor Reisch's *Margarita Philosophica* presented a diagram of the eye from a frontal view as well as a cross-section that showed it like an onion with the layers that

comprised it.[24] The image of a passive eye included in Reisch's text is embedded in a discussion of light and the optical power of the organ of the sensing soul. A theoretical discussion of optics as a multiplication of species precedes the depicted eye; these discussions also sometimes pull in luminous bodies, such as the sun and moon, to explain light and shadow, and darkness as the absence of light.[25] Reisch's eye is a passive receptor, a theoretical model in the domain of natural philosophy.

By contrast, the eye presented in the *Cosmographicus Liber* was a sensing, judging, and literate eye. Apian's illustration at folio 11 marshaled the reader's eye to participate in an active proof: in order to infer the shape of the earth, an observer was compelled to track the change of the shadow of the earth on the moon's surface during an eclipse. Even readers familiar with basic astronomy had never been ordered to scrutinize the moon so closely, let alone made to believe that their observations could verify such proof. Apian insists that seeing is the key to understanding. We could say that a similar scrutiny of a full moon activated the viewer of the back of the Farnese Hercules, engraved by Hendrik Goltzius in 1595 (Figure 1.3). Walter Melion explores Goltzius's engraving at the intersection of observation, cognition, and *handelingh*, or rendering as an executive skill.[26] In the latter, Goltzius's technical virtuosity made advanced claims for how printmaking could visualize observable objects, not just in the pattern of overlain hatched lines, but also in the way in which he conceptualized the process of observation. The print's viewer joins the pictured audience as a fellow onlooker. After exploring the intricate cross-hatched netting of Hercules's gluteal muscles, the beholder is also encouraged to muse on the prospect enjoyed by the pictured observers. Multiplying the angles of eye-witnessing, Goltzius pushes the viewer into reluctant voyeurism. The fine *moiré* pattern that shapes Hercules's rear established a syntax for engraving that diverted attention from the subject matter to the technique itself as another site of optical interest. This graphic feast pointed back to the act of observation itself; for Melion, the fine lines of Goltzius's prints "represent the cognitive act of knowing the world through the agency of attentive sight."[27] It was the intense web of lines, the *handelingh* of these aesthetic threads as an extension of Goltzius's burin hand, that commanded the viewer's aroused stare. By the end of the sixteenth century, such self-aware viewing was increasingly in demand.

This book unpacks the journey of the kind of close looking that Goltzius both expected and exposed. The history of our seeing as a materialized act that can be represented takes as an arguable start date the moment when artists posited the picture plane as an extension of the viewer's space. This was ushered in by Florentine architectural theorist Alberti's suggestion to artists that they use a *velo* or a gridded-off perspective screen as a trick of the trade, a crutch with which they might capture the view beyond the screen in the same way that a prospect might appear to an observer. In this conceit, the artist



1.3. Hendrick Goltzius, *Farnese Hercules*, engraving, 1592. *Source:* Metropolitan Museum of Art.

posited himself as the director of that view. Painting in the centuries following the Renaissance represents a concretization of the format of the picture plane as a window, a historical model of spatialized vision that retained a stranglehold in the Western tradition until experiments in abstraction took over in the artistic experimentation of the early twentieth century. Privileging the

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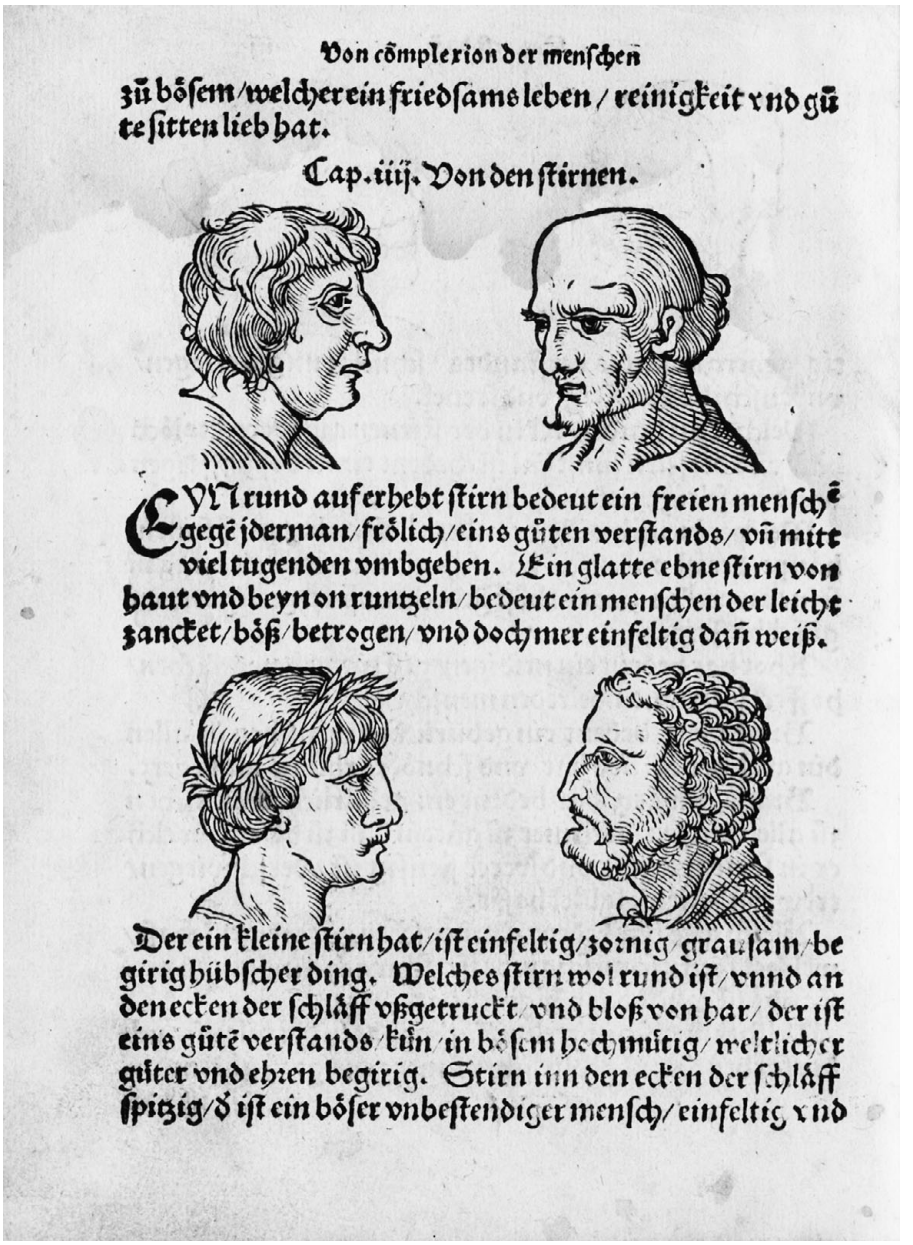
exigencies of vision and optical art made Renaissance pictorial conceits seem naturalized to future generations. In an important article that exposes the nationalist and Europocentric historiography of vision, Claire Farago has argued that an art history that captures the reality of intellectual and cognitive exchanges in early modernity would be one that acknowledges the constructed nature of such visual experiments and doesn't presume Renaissance naturalism as normative.[28] Vision itself, she argues, deserves its own history. Efforts to expose the seedy underside of naturalized vision that were already afloat in early modernity also preoccupied Stuart Clark's scholarship about vision's cultural determinism versus its normativity.[29]

This book tells observation's backstory by way of a history of attentive looking. Bracketed between advances in naturalism and perspective, the discourse on early modern vision has sidelined the prints that helped to shape it. The metaphor of Alberti's window was ill-suited to the prerogatives of printmaking, whose concerns were not vested in illusion but in market forces and in the art of persuasion. This book attempts to answer the question of how illustrated books and prints mediated visual processes and coached the viewer to see. Where did early modern viewers go for advice about how to see the world around them, if indeed they sought such advice? Cosmographies and physiognomies make it possible to tell the history of visual searches and speculate about the ways in which viewers made sense of what they saw, how they arrived at visual decisions, how they calibrated their eyes for analysis, and finally how they schooled their eyes to take note, remember, and recognize. Printed books tried to serve just such a market of readers in search of sharpened visual skills. Short, portable, and richly illustrated editions were issued by humming presses in the sixteenth century that were straining rag pulp, inking movable type and custom-made woodblocks. Publishers used these same methods to produce large tomes and slim volumes. Many were printed in vernacular languages that invited large publics of first-time book buyers to consume their content. In essence, these were how-to manuals. They taught people how to distinguish thieves from trusted companions, measure distances between stars, and gauge the height of the sun. Ultimately, it was books such as these that taught viewers how to use optical instruments, a skill whose development is outside the purview of this current study.[30]

Such books and their attendant illustrations helped stabilize subjects for visual investigation. Two examples – one from physiognomy, one from cosmography – show how this worked. In the first (Figure 1.4), two faces stare at each other across the page, offering poles of consideration for a reader trying to decide which face has the more trustworthy profile. Their formal set-up was very different from the types of heads that were familiar from painted portraits. In print, heads were turned to profile view and reproduced along



1.4. "Sets of foreheads," by an anonymous artist, in Bartolomeo Cocles, *Phisionomi und Chiromanci. Eyn newß Complexion Büchlein* (Strasbourg: Jacob Cammerlander, 1540), 3 volumes. *Source:* HAB N97.4 Helmst. 3. Courtesy of Herzog August Bibliothek Wolfenbüttel.

with directives to the observer to scrutinize them. A somewhat surprising feature of the accompanying instructions was that visual judgment was meant to be worked out on the page itself. A similar trend can be seen in a cosmographic text printed the same year, Peter Apian's *Cosmographicus Liber*.

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In a woodcut that enacted visual comparisons at folio 11, the earth assumes a variety of geometric possibilities, presenting the reader with a demonstration of how the shape of the earth can be inferred by observing the surface of the moon during a lunar eclipse. Most of the knowledge of the heavens on offer at the time came from astronomy textbooks available only to academics; these were both outdated and printed in Latin. While the first edition of Apian's book was issued in Latin to attract audiences perhaps already exposed to the medieval textbooks, a better marketing ploy was launched by printers in Antwerp who pirated the text and released it in a series of vernacular editions. Instead of targeting academics, these texts were designed for educated laymen. These printers found that texts printed in Dutch, Spanish, and French provided more accessible companions than scholarly Latin for the visual demonstrations appearing in the book.[31] Rather than simply recycling ancient content, printers formulated these volumes for a new purpose: coaching visual decision-making in the book's users.

Is it possible to historicize such practices of observation? In so far as we can, this book aims to unpack the phenomenology of visual searches. This study examines how printers coached observers to look and to make sense of what they saw, helping them earn credibility as reliable eyewitnesses. The act of eyewitnessing has been trending as a popular mode of constituting early modern subjectivity, or as an investigative mode of historical evidence.[32] This book amplifies these studies by considering the concrete way in which the eyewitness was defined in these printed manuals; indeed, these were the first books that told anyone to look anywhere in a manner that could be widely understood. Efforts to historicize the act of eyewitnessing have sent scholars to mine textual passages in which self-conscious looking was both hailed and demanded. Among such professional eyewitnesses were sailors, spies, and travelers. Navigation reports and Sacrobosco's astronomy pamphlet *De Sphaera* staged proofs of the earth's sphericality from the crow's nest of a ship – and often from the perspective of pictured eyes. We might also look for clues to purposeful viewing in the reports of Venetian spies who were sent out and tasked with providing reconnaissance on things that they observed. "Views" were suggested and prompted by those seeking data, in many cases requiring written reports in response.[33]

This book argues that recommendations for visual practice resided in illustrated texts whose images not only hailed the eyewitness with insistent pleas, but also guided readers in seeing sights. It tracks the rise of illustrated texts designed to coach the autodidactic viewer. Some texts were newly endowed with the potential to render the results of eyewitness testimony, such as Breydenbach's *Peregrinatio in Terram Sanctam* (published in Mainz in 1486), for whose graphic program an artist was specifically commissioned to capture the look of people and sights collected during the journey described. Later,

Sebastian Münster's *Cosmographia* (1551) aimed to collect the reports of eyewitnesses.[34] The *Relaciones Geográficas* of the 1570s, produced for King Philip II as a survey of his holdings in New Spain, also depended on local observers in the field to report back reliable descriptions of landmarks and the contours of the territory.[35] But prior to these mid-century large-scale and ambitious efforts, short and informative vernacular texts encouraged their readers to see with their own eyes.

Cheap printed books afforded a wider spectrum of the population the ability to interpret texts and images themselves. Although appreciably different in appearance from the publications that emerged from developing scientific societies, they provide the critical start date for the launch of vernacular observations in northern Europe. These books not only provided the impetus for the formation of professional assemblies; they also armed their readers with recommendations about systematic viewing practices. Images appearing in short and inexpensive vernacular how-to publications accompanied the reader through the procedures of physiognomy, chiromancy, field surgery, and astronomy and assisted in the execution of tasks that were shaping new skill sets. This volume also builds on recent studies of prints' agency to demonstrate a coordinated effort by printers to raise the intellectual horizon of knowledgeable laypeople through image-based learning.[36]

MAKING OBSERVATIONS

Images generated from Galileo's telescope have long marked an inaugural attempt in the history of observation. Perhaps ironically, we have sought the origins of scientific scrutiny in the views produced by instruments because we now see in them objectivity that we mistake for naturalism.[37] Yet, for which observers could Galileo's published images have been considered naturalistic – or, stranger yet, objective? We have already learned of one befuddled observer who couldn't determine the viewing end of the telescope. Galileo's contributions to observation are indeed important, but more for solidifying the idea that the results of scientific inquiry could be recorded in print. Views from instruments became normative in their own right. Galileo's publishers contributed to this by suggesting that the look of a mechanical process of recording mirrored Galileo's own drawn "observations."[38] This idea would also color the subsequent productions of the Royal Society, which sought to collect the direct results of observations made with instruments.[39] But even before scientific societies began to archive such observations, there was a market demand for how-to books that coached the public in how to perform systematic observations.

We must also briefly historicize what was meant by the term *observation* when it was used in a text. Practices defined by this rubric shifted in early

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modernity from a connotation of following rules and procedures to eventually refer to experimentation and, ultimately, to the coordinated efforts to share information that would later underwrite scientific inquiry.[40] The idea of precise and careful observations evolved in the early sixteenth century alongside its definition, which came to represent acts of sustained looking that, in some cases, would ultimately be mediated by instrumentation. The activation of the term *observatio* in early modernity to mean regular scrutiny represents a significant departure from its medieval usage, which implied following a set of practices or dogma. Scholars have located this syntactical change in the title of editions sent to press by the Nuremberg astronomer and cosmographer Johannes Schöner, whose designation of the term *observationes* refers to astronomic data collected from Regiomontanus, along with more recent weather observations.[41] But the idea of observation was also alive and well in Apian's *Practica* and related publications, such as those that tracked the path of a comet across the sky between the months of October and December in 1532.[42]

"Observations" could also refer to the descriptions, specimens, and images by naturalists such as Aldrovandi, Conrad Gessner, and Carolus Clusius. The collectivization of authored observations was a critical link to what eventually would become scholarly consensus.[43] Collections of pictures preserved in paper museums and printed "laboratories" were as much acts of visual common-placing as they were natural history per se. The methods of examination and classification staged by the artists and naturalists of the Accademia de Lincei would prefigure Cartesian eyewitnessing.[44] Living things seen under these intense practices of scrutiny were surrounded by the rhetoric of observation on the printed page. When Pierre Belon's research into zoological and natural historical material emerged with the title *Observationes* in its Paris printings (*c.* 1550), this guarantee prioritized the "things seen" over any particular traveler who might have generated those observations. The title pages of other such books with roughly similar content often featured the traveler's name or the travel itinerary itself. Publishing a book like Belon's as a record of observations, however, brought the author to the stand as an eyewitness and proposed the visual accompaniments of the book as a type of storage solution for the presentation of natural knowledge.

To this venerable lineup of observers, we can now add the amateur practitioners of cosmography, physiognomy, and other practical genres. The artisans of the book trade supplied their reading publics with a steady stream of images against which readers could check their own observations. In part, this was also a result of the claims advanced by the printmaker for the sovereignty of images. This project provides the prehistory of seeing, organizing, and observing through images, an approach whose privileging eventually earned Galileo his invitation to the faculty at Padua, before the market for empiricism became saturated with images of "observations" made by instruments.

METHODS

This book about how practical knowledge was visualized is perched at the intersection of an interdisciplinary rapprochement between art history, the history of science, book history, and the history of knowledge. Some new methodologies current in these fields have assisted me. A productive symbiosis of art history with the history of science has been underway in German approaches to *Bildwissenschaft*, essentially a science of images. The questions I pursue here about the use and methods of printed media to convey documentary observation and visual skills bring two scholarly avenues of inquiry into dialogue: the practice of scientific observation currently treated by historians of science, and the role of print media in circulating new knowledge as explored by historians of the book. The importance of images in codifying what became systematic studies of botany and anatomy already looms large in scientific observation's past; this book expands the investigation of the use of illustration to the realm of cosmographic, physiognomic, and related texts.

My evidence requires a decentering of standard art historical paradigms that value artistic originality. It likewise challenges mainstream approaches to illusionistic representation, especially art history's tenacious bias toward optical naturalism and mimesis. As we will see, the road to practical knowledge was strewn with non-naturalistic, optically and mentally challenging images that frequently coaxed users' participation and demanded their involvement. Because the viewer was directly implicated, we must also reshuffle the standard agents of art history: this story is about, in part, the printmakers who educated new publics through strategies of visualization.

The German branch of the study of visual culture, *Bildwissenschaft*, or the science of images, permits a look not only at the interstitial space between naturalism and didactics, but also at the dynamics between maker and receiver. The address to reader/viewers enunciated in the books' front matter evolved into a commonplace of marketing printed volumes. The strategy of hailing readers was in part advertising, but it was also a rhetorical spur to arouse the reader's epistemic potential. The polymath printer Walter Ryff summoned the attention of the *Hausvater*, a class of literate, but not necessarily learned, urban citizens.[45] In the early 1500s, readers in Strasbourg found themselves addressed as an aspirational how-to audience of *gestreifte Laien*, or "striped laymen," identified by the striped clothing they sported in the accompanying woodcuts.[46] Other Strasbourg printers entreated these laypeople to rehearse the diagnostics and procedures of specialists via the book's images. Single-sheet flap prints of female and male anatomical dolls printed by the Strasbourg physician Heinrich Vogtherr in 1539 also enticed the common man, or *gemeiner Mann*, to simulate surgery by lifting the layers of printed viewing fields as though they were virtually removing them with a surgeon's knife.[47]

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With the intention of targeting non-professional audiences, some impressions of these prints were fortified on canvas supports that could withstand the repeated lifting of flaps to reveal interior organs by lay viewers interested in anatomy; these prints might have been mounted in public places, such as in bathhouses, or at church festivals. These types of publication constituted a subject whom I like to call a vernacular viewer: a non-specialist schooled by vernacular texts.

Printers cultivated empirical engagement with the world and argued that the purchase of their books could make readers visually astute by providing ersatz empirical experience that rivaled the firsthand experience that came with travel. The Antwerp printer of Apian's *Cosmographia* (1553) had such confidence that books could deliver this that he entreated readers not to swap hard-earned income for the uncertainties of travel, but to buy his books instead. Fatigued and cash-strapped artists burdened with family obligations could find themselves consoled by the efforts of Heinrich Vogtherr's *Ein frembds und wunderbars Kunstbüchlin . . . hochnutzlich zu gebrauchen* (printed in Strasbourg in 1537), which provided a model book and copy manual for artists that cribbed designs from other artworks and was meant to be used in furniture making, armor design, painting, and presumably also printmaking.[48] Vogtherr advocated that the book's purchase could spare the journeyman the expenses and stress of traveling during his *Wanderjahr*.

Such ersatz acts of "eyewitnessing" were cultivated by a range of books that recommended readers' engagement with the world. Sometimes their images took the shape of things to observe, methods of measuring, or profiles to assess. Readers of these texts were invested with new eyewitness authority, which, in fact, had been an important rhetorical claim intimately tied to the history of printmaking. This guarantee of "being there" was frequently rehearsed by authors in travel literature. When travel literature became a mainstay of the early press, these eyewitness claims transferred to print. This may have spurred some printmakers to fortify their authors' claims through images surprisingly equipped to do just that – often imbuing special status through a variety of rhetorical tropes (such as *ad vivum*, *naer het leven*, or *contrafacere*) that suggested the presence of an observer with the guarantee that the image had been taken "from life," or at least from observation.[49] Images in the cosmographic and physiognomic literature reprised the strategies of these images and gave viewers the tools to make informed eyewitness assessments.

My study builds on scholarship that argues for the cultural determinism of vision, with an emphasis on how the eye was conditioned for scrutiny in order to develop a knowledge base. It builds on Claire Farago's charge to reposition Renaissance paradigms in *Reframing the Renaissance* by exposing the relativism of vision as a cultural practice; this thread is picked up by Dana Leibsohn and Jeanette Favrot Peterson's *Seeing across Cultures in the Early Modern World*.[50]

Jeffrey Chipps Smith's investigation into how visual and sensory communication in early modern Germany contributes to the discourse on the phenomenology of the senses in the art of early German modernity is likewise critical.[51] This type of investigation also characterizes some recent studies by historians of science and of craft practice, as well as historians of the book, and the history of technology. The relationship of epistemology to craft practice as explored by Pamela H. Smith previews artisanal practice that would later be codified in book form.[52] Instruments provide another way in which to measure the content around which observations, optics, and the physiology of sight were directed; the investigations by Sven Dupré and Samuel Gessner have broadened the scope of agents and practitioners.[53] The proceedings of a research group at the Max Planck Institute for the History of Science on the history of observation and scientific practice led by Lorraine Daston and Elizabeth Lunbeck provided fertile ground for new research in this area.[54] Studies of the book and the history of printing by Jonathan Sawday and Neil Rhodes, A. E. B. Coldiron, Elizabeth Spiller, Adrian Johns, and Tom Conley have all made great strides in showing how print shaped cultures of knowledge.[55] Peter Dear, Steven Shapin, and Matteo Valleriani have presented work on the transmission of knowledge as a technical revolution instigated by books.[56] These studies provide the spine of my investigation into epistemology and the working mechanism of the print.

To the paradigms of evidence in early modernity, I add and unpack the patterns and the paradoxes of printed images. How reproductive technology mediated the ontology of artifacts is the focus of study of *Forgery, Replica, Fiction*, in which Christopher Wood illuminates the role of print in constructing notions of historical time, as well as marking distinctions between the disciplines of archaeology and historical fiction.[57] We might also examine the hermeneutics internal to print by querying what functions as fact or fiction within the printed image and what constitutes evidence for those claims. For instance, while "*ad vivum*" was a rhetorical guarantee frequently elided with verisimilitude in other media, what special claims adhere to its use in the printed medium, one hopelessly inept at taking on illusionistic concerns? Was the look of truth vetted in the printed image itself, or in the paratexts on the print's surface? In the sixteenth century, prints began in earnest to organize subjects of investigation at the ontological level. Among other things, this study asks how such media called methods of inquiry into being.

SHAPING COGNITIVE PRACTICES

The community of visual literates that early modern prints sponsored has not been addressed by the substantial field that has developed around visual literacy.[58] The idea of collective interpreters of images in the field of art history

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has been largely restricted to nineteenth-century developments in photography and the decoding of technical images (radiography, LiDAR), yet the pervasiveness of the idea of visual literacy can be seen in the assumption of it as a competency that many art historians regularly proclaim their syllabi will develop. James Elkin's edited volume on *Visual Literacy* acknowledges the historicity of the form and function of images, mostly modern.[59] For the social art historian Michael Baxandall, visual literacy was a paradigm for considering the public's conversance with contemporary iconography and historical modes of visual address; his study produced the idea of a socially determined visual fluency that he called the "period eye."[60] But while the idea of image-literacy particular to historical periods seems still current in art history, scant attention has been given to the modalities of observing that printmaking engendered.

Studies of the history of the book suggest that the shifting layouts of text and paratexts and experiments with the typographic book birthed new cognitive experiences with the text.[61] It was indeed between the covers of books that images began a particularly close association with text. W. J. T. Mitchell's "Visual Literacy or Literary Visualcy?" showed how the image is inextricable from the textual matrix in which it is embedded, and indeed it is inseparable from words themselves.[62] Like Mitchell's premise, this book also argues that the pictorial component of early printed books was critical to the apparatus itself. Paratextual elements such as title pages, tables of content, glosses, and illustrations (both didactic and narrative) allowed readers to search for specific questions, and thus exposed them to new horizons of inquiry.[63]

The tightrope that these books trod between theoretical and practical knowledge was just one of the new cognitive balancing acts that the reader would learn to manage. The new organization of books reveals a tension between theory and practice – this plumped the trading zones between theoreticians and practitioners. Newly implicated as a practitioner, the reader/viewer braced for new empirical interfaces with the world.

The experiential horizon of the reader of printed pamphlets was broadened by information that was repackaged into guide books and manuals that attempted to structure experience. The stakes of this interface between the reader and the world brought about new cognitive approaches to understanding. Attempts to historicize such experiences gave rise to a methodology we can think of as historical phenomenology. Bruce Smith has tried to establish the period eye for the phenomenon of color.[64] Early modern experience could also be assessed by the ways in which images hailed their audiences. Suzanne Karr Schmidt shows how prints, in transforming the reader into a "user," assumed the work that physical tools previously did and distributed that knowledge to wider audiences. Autodidacts were developed through the agency of three-dimensional, or sculptural, prints that could be spun and lifted by users, and Schmidt counts the woodcuts of the fifteenth and sixteenth

century as early examples of the mutual synergy between image and viewer that we today label interactivity.[65] Early modern prints functioned as substitutions (for the Eucharist, for example), re-enactments (of surgical dissections), or as *memento mori* (as reprimands for engagement with worldly concerns).

This activation of the reader/viewer is an important heuristic that goes beyond the development of interiority to actual do-it-yourself sleuthing. Directing highly personal empirical experiences can be considered one of the primary goals of volvelles, or moving paper dials. Peter Apian's *Cosmographicus Liber* includes instructional tools whose didactic and dynamic interface to teach the principles of astronomy and measurement to users superseded their ability to render accurate readings.[66] Apian's example shows well the detente between studies of theoretical models and practical skills, a dichotomy that Matteo Valleriani sees as on the mend in recent studies of practical knowledge.[67] The materiality of the print – i.e., its tactility and its simultaneous visuality, and in some cases its prompt to handmade autodidactic DIY construction – is the topic of *Prints in Translation*, as authors Suzanne Karr Schmidt and Edward Wouk invite the reader to consider the range of cultural practices that developed around the print.[68] Of critical importance to these authors is how prints became agents of social epistemic transformations – redirecting experiences typically reserved for more elevated art forms designed for higher classes, and catapulting them instead toward a broader public. Prints' growing ubiquity occasioned reflexive commentary from within: Printmakers began to offer critiques on the medium itself. Producers invited reflections on their prints' self-referential quality, often mobilizing the idea of an "impression" as central to the print's agency.[69]

EPISTEMIC IMAGES

Increasingly, such tools were designed for helping viewers to size up their surroundings, to make knowledgeable inferences about the world, and to do this primarily through visual means. Printed images circulated widely and cultivated practical uses; the intersection of these aims with growing disciplinary investigations forms the content of *Prints in the Pursuit of Knowledge in Early Modern Europe*, an important scholarly intervention in the field.[70] The role of images in shaping new fields of knowledge generally is the subject of Alexander Marr's work on epistemic images, research that recognizes the novelty of these images' visual strategies.[71] Images were certainly being deployed for new purposes.

How prints mediated humanity's interface with the natural world, especially in the fields of anatomy and botany, has been explored in Sachiko Kusukawa's standard-bearer, *Picturing the Book of Nature*.[72] Sustained investigations of plants and the human body gave rise to new fields of optical interest and visual

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preoccupation. Changes in the organizational arrangement of printed botanicals from curative properties to a system ordered by visual morphology was a result of the degree to which prints shifted the science's emphasis to pictorial arrangements and inspired the future of visually driven, or phytographic, investigation.[73] Thus, images received new agency and sometimes assumed sovereignty over the texts into which they had once been embedded as supplemental information.

Recent scholarship has treated volumes of experimental science produced by the press as technical or knowledge-based publications. As a result, we can now review the complicity of their accompanying images. A consideration of images' epistemological work, per Renzo Baldasso, might provide a corrective to the artificial dichotomies in the study of Renaissance art and nature. His essay, "The Role of Visual Representation in the Scientific Revolution," outlined the roadblocks to an integrated study that could treat many aspects of images in science's service: aesthetics, naturalism, perspective, technology, didactics, and the ersatz "means available for the study of nature," as they were considered by members of the Lincean Academy.[74] The nomenclature of these images as epistemic images has opened up a productive mechanism for considering a range of disparate images united by their common objectives, but scholars have also offered caveats that the broad and anachronistic use of this term could bankrupt its usefulness.[75] A review of new heuristic and technical practices that expand the remit of epistemic images is the subject of a recent publication edited by Ruth Noyes, *Reassessing Epistemic Images in the Early Modern World*.[76]

Epistemic is a term that evolved to cover experimental and scientific images that contributed to a body of systematic inquiry. It also served to repair a divide between images with self-consciously technical functions and images of the artifacts of such inquiry. The anachronistic separation of technical concerns from aesthetic ones in Anglophone art history, per Renzo Baldasso, is an artificial gap that belies efforts of early modern publishers to endow books with the latest technical advances in the medium of printmaking, such as experiments in chiaroscuro and new printing forms for geometrical designs.[77] While some scholarship asserts a need to attend to the distinction between technical images and representations of technology in weighing the value of the term "epistemic," images themselves have invited this tension. *Bildwissenschaft*, a form of image-inquiry mobilized in German-language studies of visual culture, unites the purpose of technical images with their stylistic properties.

Under the umbrella of a "science of images," we can consider the images' agency in producing both knowledge and the structure of knowledge. How do images rise to the level of knowledge generators? The sheer organizing force of observers in search of collective knowledge, per Lorraine Daston, had

the power to stabilize subjects for investigation.[78] Images that accompanied the results of these pursuits can be seen as capturing scholarly consensus. Alternatively, some empirical pursuits were organized around images; Daniela Bleichmar has explored the footprint of this directive in the visual attachments of travel undertaken in the name of science.[79] Other images strategically advanced particular scientific positions; Volker Remmert has shown how the controversies of the Copernican revolution were mediated by the printed title pages of these treatises, shaping the sovereignty and argumentative thrust of a certain kind of image.[80]

Bildwissenschaft, as pioneered by Horst Bredekamp's research group, argues for the autonomy of images through the notion of style.[81] Under the rubric of technical images, this group interrogates potential stylistic commonalities that might unite diverse content under common epistemological origins. Analyses of images in *Das Technische Bild* straddle those that are diagrammatic and aesthetic, as well as those that are produced by instruments.[82] To bridge these anachronistic divides between useful, artistic, and technical images, Alexander Marr has proposed considering them as *knowing images*, thus welcoming a broader range of content and foregrounding instead how images signal the idea of knowledge and gesture at epistemology.[83] My book picks up the tracks of these investigations, examining images that incited epistemic inquiry. Those images sometimes coopted the sovereignty of their own visual searches and they themselves provoked organized inquiry into a host of experimental sciences.

CHAPTER PRÉCIS

The book is divided into two sections. The first two chapters reclaim images' role in standardizing methods of empirical investigation. Cosmography and physiognomy were both major initiatives in instructing laypeople to observe the world and make visual assessments about it. Images articulated these fields of study as visual ones – and breathed life, systematization, and longevity into modes of analysis that were critical for the future development of the disciplines of astronomy, natural history and the study of morphology. As such, images activated firsthand investigations of the world.

Chapter 2, "Don't Forget Your Apian: A DIY Guide to the Cosmos," discusses the achievements of Peter Apian, a sixteenth-century mathematician and printer of cosmographic texts, who successfully translated classical works into updated and pictorially enhanced editions that brought arcane scholarly astronomy and cosmography to a wider audience. Abstract principles of mathematized geography, per Apian, were better explained via mechanical pictures, diagrams that centered humans at the nexus of a world to be experienced firsthand and observed. Handy editions of the *Cosmographicus Liber* (1524) simplified musty academic astronomic knowledge and attracted a

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broader reading public with the explanatory clarity of its diagrams. Using visual and interactive volvelles with moving parts, Apian demonstrated principles of astronomy and mathematized geography in ways that could help the reader situate the local environment within the solar system. This chapter provides an art historical treatment of Apian's key mechanical images. It argues that Apian converted academic astronomy into prescriptions for observational practices designed to school the user in making visual judgments. Featuring visual tools and demonstrations that animated both the celestial and the terrestrial spheres, Apian's cosmography became a guide for the vernacular viewer. Early modern empirical encounters with the moon, sun, and stars were reconceptualized by cosmography's sponsorship of a lay observer with new cognitive potential. By presenting such phenomena relative to an earth-bound observer, Apian's *Cosmographicus Liber* brought the heavens to earth.

Chapter 3, "Facial Profiling: Physiognomy and the Art of Inspection," treats printed physiognomies as visualized books for people watching. These were shot through with generalized images of character heads that served to cue the viewer's experience in the field. With these images, publishers promoted interest in facial content among audiences; this resulted in new forms of visual stereotypes and a new form of how-to pedagogy. The introduction of such printed profiles in sixteenth-century editions of physiognomies, a genre with a long unillustrated tradition, revised its concerns. Printed heads challenged the text's diagnosis of moral character by shifting the emphasis to the realm of developing visual acuity. Paired profiles showing the difference between a variety of forehead types encouraged the reader to make visual comparisons. A similar comparative framework drove Mark Zuckerberg's pre-Facebook search engine *FaceMash*, a platform on which he asked users to make quick (and sexist) visual assessments of female undergraduates at Harvard that hinged on a simple essentialism: hot or not? This type of judgment was already enshrined in the early physiognomies, and our use of the word *profile* today to describe social media users' portfolios retains some of physiognomy's formal characteristics. Significantly, physiognomies were also among the earliest genres to utilize the term *observations* to characterize the searches they recommended and to provide illustrations to help organize their readers' viewing practices.

Many early modern printed portraits did not make rigorous claims to the positive identification of any particular subject; rather, they floated in the fluid in-between of type and identity. Instead of providing verisimilitude, generic character heads in physiognomies were intended to help streamline the practice of observation. This chapter argues for the contribution of physiognomic portraits to the development of skills such as visual acuity, and it shows how the aim of representing particularity as a guide for personal observations took precedence over mimetic claims. The reuse of many of these generic profiles is surprisingly vast in publications across the continent; we see the same content

appearing in cosmographies, for example, and we see their formal properties at work in sources as diverse as model books and costume books. Exploring common aspects shared by printed physiognomies in the epistemic tradition, this chapter looks at their organizational aptitude, the middle ground they formed between mimesis and idealization, and their role in shaping disciplinary activity related to empirical experience.

The following two chapters consider some of the outcomes of this enhanced visual acuity: the collecting and cognitive practices stimulated by these emergent how-to genres – namely, picture atlases and trick images. Picture atlases crystallized these genres as visually sovereign and contributed to their stability. The premise of fixity was interrogated by a special form of visual rhetoric that developed in tandem with the content of cosmography and physiognomy: trick images. With growing visual fluency among an audience that they themselves developed, printmakers also began to propose interpretative models alongside their pictures' content. This content took a back seat to the manner in which it was conveyed. As images increasingly assumed didactic roles in print media, other images volunteered to complicate their methods of delivering knowledge. Viewers with observational skills finely tuned by collected knowledge now found that visual acuity in the crosshairs of tricky images that destabilized their conclusions.

Chapter 4, "Visualized Data and Searchable Science: the *Liber Quodlibetarius* (*c.* 1524)," argues that the rising status of print media can be seen in the way in which prints were organized and collected in the period. Early modern cognitive practices can be tracked by the manner in which printed images deputized empirical searches. The novelty of these cognitive leaps can be seen in the way these newly sovereign images were collected together, and also in the manner in which they challenged their viewers. Presenting diverse material from chronicles, cosmographies, physiognomies, and model books, the *Liber Quodlibetarius*, an unusual manuscript compiled in the second decade of the sixteenth century and furnished with many designs copied from printed sources, leaves us with little doubt that prints were sought and collected for their capacity to intersect with observational practice. The compiler of this unpublished manuscript lifted images already enshrined in print culture and repackaged material from several epistemic sources, including cosmographies, physiognomies, chiromancies, artists manuals, and manuals of field surgery. Far from direct copying, however, the illustrator recomposed and reconfigured the prints' motifs on the manuscript's pages to feature their informational claims and enhance their didactic strategies. Extrapolations from texts such as Apian's cosmography and Cocles's physiognomy were supported by the vocabulary surrounding them, some of which was also derived from familiar print sources.

The *Liber Quodlibetarius* presents images of instrumentation and practical information on how to use quadrants, horologia, and astrolabes. These images

were derived from printed guides for investigating the terrestrial and celestial world via these instruments.[84] Throughout the manuscript, we see familiar images from how-to texts and artists' model books, abridged here by using their illustrations alone. What connects the images in this miscellany of diverse data is the manuscript's endorsement of their practical use for empirical activity. The way in which these prints were appropriated, cataloged, and intended for mixed use suggests a function for them grounded in knowledge acquisition. For us, it serves as an excellent case study of the parameters of sixteenth-century visual and searchable knowledge. In transposing only the images from these printed books, the compiler deputized that data to speak for those genres in the shape of searchable and consultable formats. In the manuscript, the images populate visual fields of a new type of storage solution that enabled collecting, collating, and cross-referencing.

Chapter 5, "Vexed Viewing: Anamorphosis and the Visual Argumentation of Labored Looking," positions visual tricks as the outgrowth of empirical practices taught by contemporary prints. Given the claims of observational authority that my argument suggests were accruing to printed images, it is not surprising that prints also became the locus of optical tricks. Tension between pictorial surfaces arose in anamorphic or "deformed" images, whose distortions commented on strategies of recording by deconstructing representation. By sacrificing fixed content to the process of skewing viewpoints, the pictorial tension of anamorphic images thematized their ambivalence about the practice of recording "sights."

By foregrounding the spatial conflict produced by perspective, anamorphic images thematized the process of viewing. Assuming both representational and phenomenological space, like many of the images treated in the previous chapters, anamorphic images inhabit a realm between directing the embodied practice of vision and representation. By exposing the construction of vision, anamorphosis presented a challenge to naturalism like the one that print posed to illusionism. Anamorphic prints pushed the viewer to question the range of optical exercises that they could handle precisely around the subject matter of portraiture and geography, seen here as an outgrowth of cosmography.

Images that took anamorphosis as a visual premise commented on the ambivalence of recording observations generally; but, in the medium of printmaking, this critique also took aim at print's authority to convey such observations. Anamorphic images rendered in print take the content of epistemic pursuits such as likeness and cosmography and place it on the ontological level of art. It is at this point that we find painting occupying itself with kindred concerns. It was the intersecting claims of knowledge and portraiture that brought the three portraits of Holbein's *The Ambassadors* into alignment, just like planetary conjunctions. Such reflections on the stability of the image surely overworked the observer, but they seem to have occasioned a new

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species of trick images in which portrait and topography were conjoined. Observation was never well compensated – not in the sense of empirical scrutiny, nor in the sense of surveying an image. Images became increasingly demanding. Visual acuity honed in the world turned into an arduous journey of visual attention to the images themselves.

NOTES

1 An important exception is the primer in social history by Michael Baxandall, which delved into the way in which accounting and mathematic texts taught Florentine merchants of the Quattrocento to recognize those same volumes and ratios in the visual vocabulary of paintings and frescos. See Michael Baxandall, *Painting and Experience in Fifteenth Century Italy: A Primer in the Social History of Pictorial Style*, 2nd edition (New York: Oxford University Press, 1988).

2 Peter Parshall and Rainer Schoch, *Origins of European Printmaking: Fifteenth-Century Woodcuts and Their Public* (New Haven, CT: Yale University Press, 2005).

3 David Price, *In the Beginning Was the Image: Art and the Reformation Bible* (New York: Oxford University Press, 2021). Price's book aims to repair the bibliographic focus on text by staging the Renaissance Bible as a visual field.

4 Phillipa Hardman and Nicola Bradbury, *Medieval and Early Modern Miscellanies and Anthologies*, Yearbook of English Studies 33 (Leeds: Maney Publishing for the Modern Humanities Research Association, 2003), 200.

5 For these almanacs designed for annotations, or *Schreibkalendar*, see the project at the Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU) led by Klaus-Dieter Herbst and Daniel Bellingradt on manuscript entries in these printed calendars: *Der frühneuzeitliche Schreibkalendar und seine handschriftlichen Einträge*, https://schreibkalender.wisski.data.fau.de/about. Many thanks to Richard Kremer for pointing out this initiative to me.

6 Eileen Reeves, *Painting the Heavens: Art and Science in the Age of Galileo* (Princeton, NJ: Princeton University Press, 1999), 3.

7 Steven Vanden Broecke, *The Limits of Influence: Pico, Louvain and the Crisis of Renaissance Astrology* (Leiden and Boston, MA: Brill, 2003). Vanden Broecke shows how Gemma Frisius was the first to officially direct his mathematical training into the service of a discipline constituted as cosmography versus astrology. Peter Apian is also part of this tradition.

8 Jonathan Green, *Printing and Prophecy: Prognostication and Media Change 1450–1550* (Ann Arbor: University of Michigan Press, 2012).

9 Anthony Grafton, *Commerce with the Classics: Ancient Books and Renaissance Readers* (Ann Arbor: University of Michigan Press, 1997), 215ff.

10 Anthony Grafton, "Some Uses of Eclipses in Early Modern Chronology," *Journal of the History of Ideas* 64, no. 2 (2003), 213–29.

11 Green, *Printing and Prophecy*.

12 "*Wann mann baden oder schrepffen will/ sol der Mon im abnemen sein und im Stier/ Zwilling/ Krebs/ Wag/ Scorpion und Fisch*," in Johannes Regiomontanus, *Kalendarius: News Und Volmon* (Strasbourg: Cammerlander, 1532), HAB HN97.4 Helmst. 2, 29r.

13 For an image of the application of cups, see *Kalendar: Iatromathematisches Hausbuch* (Augsburg: Blaubierer, 1481), http://daten.digitale-sammlungen.de/~db/0002/bsb00029544/images/index.html?seite=136&fip=193.174.98.30.

14 A Protestant secondary school, or gymnasium, founded by Johannes Sturm in 1538 would ultimately become the university in Strasbourg. Malcolm Walsby and Graeme Kemp, *The Book Triumphant: Print in Transition in the Sixteenth and Seventeenth Centuries* (Leiden and

Boston, MA: Brill, 2011). For the similar situation in Venice and Augsburg, see essays in the same volume by Neil Harris and Hans-Jörg Künast. For the Strasbourg press, see Miriam Usher Chrisman, *Lay Culture, Learned Culture: Books and Social Change in Strasbourg, 1480–1599* (New Haven, CT: Yale University Press, 1982). The university founded in Altdorf in 1578 would become the academic center of Nuremberg.

15 Robin Bruce Barnes, *Astrology and Reformation* (New York: Oxford University Press, 2016), 18–47.

16 Pamela H. Smith, "Making as Knowing: Craft as Natural Philosophy," in Pamela H Smith et al., *Ways of Making and Knowing: The Material Culture of Empirical Knowledge* (New York: Bard Graduate Center, 2017), 18. Schott, for example, brought together Otto Brunfels and Hans Weiditz for an important herbal; Panse also indicates that Gersdorff brokered the relationship between field surgeons and physicians, possibly an idea that also originated with Schott. See Melanie Panse, *Hans von Gersdorffs "Feldbuch der Wundarznei"* (Wiesbaden: Reichert, 2012), 33–5.

17 Or *Eyn Schön vergleichung der Astronomi mit der Artznei/ das ein berümbter Artzt auch muß eyn Astronomus sein*. See Regiomontanus, *Kalendarius*, HAB HN97.4 Helmst. 2.

18 Regiomontanus, *Kalendarius*, 36r. For example, in a passage that suggests judgment of quality: "*Alle harn seint dreierhandt. Eins ist weiß on drusen/ mit eim kleynen nebelin/ der ist böß. Das ander ist weiß on nebelin/ mit eim kleinen genist/ das ist vast ser böß. Das drit ist weiß/ dick/ und durchschinet/ und mann mag es doch nit durch sehen/ das ist gar todtlich*."

19 This is made plain in the couplets above the venesection man.

20 Franz Machilek, "Astronomie und Astrologie: Sternforschung und Sternglaube im Verständnis von Johannes Regiomontanus und Benedikt Ellwanger," *Astronomie und Astrologie in der Frühen Neuzeit: Akten des Interdisziplinären Symposions* 21, no. 22 (1990), 12.

21 Matteo Valleriani, ed., *The Structures of Practical Knowledge* (Cham: Springer, 2017), 345.

22 K. A. E. Enenkel and Wolfgang Neuber, eds., *Cognition and the Book: Typologies of Formal Organisation of Knowledge in the Printed Book of the Early Modern Period* (Leiden and Boston, MA: Brill, 2005).

23 See Richard L. Kremer, "Incunable Almanacs and *Practica* as Practical Knowledge Produced in Trading Zones," in Valleriani, ed., *The Structures of Practical Knowledge*, 333–69, especially 344.

24 Gregorius Reisch, *Margarita Philosophica* (Strasbourg: Johannes Schott, 1504), Liber X, Tract. II, *De Potentiis Animae Sensitivae*. See fol. 238 of the copy at the Herzog August Bibliothek (M:Li5881). See Andrew Cunningham and Sachiko Kusukawa, eds., *Natural Philosophy Epitomised: A Translation of Books 8–11 of Gregor Reisch's Philosophical Pearl (1503)* (Farnham, VT: Ashgate, 2010).

25 Cunningham and Kusukawa, *Natural Philosophy Epitomised*, 174–6.

26 Susanne Küchler and Walter S. Melion, *Images of Memory: On Remembering and Representation* (Washington, DC: Smithsonian Institution Press, 1991), 8–9, 18–19.

27 Küchler and Melion, *Images of Memory*, 17.

28 See "Even Vision Has a History," in Claire J. Farago, *Reframing the Renaissance: Visual Culture in Europe and Latin America, 1450–1650* (New Haven, CT: Yale University Press, 1995), 67–88.

29 Stuart Clark, *Vanities of the Eye: Vision in Early Modern European Culture* (Oxford: Oxford University Press, 2007).

30 See Heinz Herbert Mann, "Optische Instrumente," in Hans Holländer, ed., *Erkenntnis, Erfindung, Konstruktion: Studien zur Bildgeschichte von Naturwissenschaften und Technik von 16. bis zum 19. Jahrhundert* (Berlin: Gebr. Mann, 2000), 357–409.

31 "*Den welcken dit teghenwoordich boeck der Cosmographien Apiani/ uiten latÿne in duytsche nu eerst getranslateert zeer behulpich sal wesen*" (fol. 2r) in Peter Apian, *Cosmographie, Oft Beschrijvinghe Der Geheelder Werelt van Petrus Apianus. 3. Werk, Nu Ghecorrigeert van Gemma Frisio. Metten Zeecompasse Ende Anderen Boecxkens Byden Selven Gemma Daer Toegedaen*, ed. Rainer Gemma Frisius (Antwerp: de Bonte, 1553).

32 Peter Burke, *Eyewitnessing: The Uses of Images as Historical Evidence* (Ithaca, NY: Cornell Paperbacks, 2008).

33 Lorraine Daston and Elizabeth Lunbeck, *Histories of Scientific Observation* (Chicago: University of Chicago Press, 2011), 89. I thank Lorraine Daston for pointing this out to me. For instructions to Venetian ambassadors for recording what they saw, see Giovanni Comisso, ed., *Gli ambasciatori veneti, 1525–1792. Relazion di viaggio e di missione* (Milan: Longanesi, 1985). On views gathered by travelers, see also Joan-Pau Rubiés, "Instructions for Travellers: Teaching the Eye to See," in Rubiés, *Travellers and Cosmographers: Studies in the History of Early Modern Travel and Ethnology* (Aldershot: Ashgate, 2007), 139–90.

34 Jasper Van Putten, *Networked Nation: Mapping German Cities in Sebastian Münster's "Cosmographia"* (Leiden: Brill, 2018).

35 Barbara E. Mundy, *The Mapping of New Spain: Indigenous Cartography and the Maps of the Relaciones Geográficas* (Chicago: University of Chicago Press, 1996); Daston and Lunbeck, *Histories of Scientific Observation*, 87.

36 The history of knowledge-based aspirations in print was launched in an important exhibition and catalog *Prints and the Pursuit of Knowledge* that addressed the work that prints performed in a host of related genres. See Susan Dackerman, et al., *Prints and the Pursuit of Knowledge in Early Modern Europe* (Cambridge and New Haven, CT: Harvard Art Museums, 2011). Suzanne Karr Schmidt's *Interactive and Sculptural Printmaking in the Renaissance* (Leiden: Brill, 2018) unpacks the user's interface as a heuristic endemic to early printmaking.

37 Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007).

38 Ruth S. Noyes, "Mattheus Greuter's Sunspot Etchings for Galileo Galilei's Macchie Solari (1613)," *Art Bulletin* 98, no. 4 (2016), 473. Because he could not look through the scope at the sun, Galileo describes exposing the lens to a sheet of paper which would capture the impression of the spots. Noyes argues that the special quiddity of sunspots that Mattheus Greuter referenced in his etchings of Galileo's observations matched the indexical reflexivity that prints of the Vera Icon asserted with the relic of the Holy Face.

39 Such as the images made by van Leeuwenhoek's draftsmen, who recorded the views produced by his microscope, in Sietske Fransen, "Antoni van Leeuwenhoek, His Images and Draughtsmen," *Perspectives on Science* 27, no. 3 (2019), 485–544.

40 Daston and Lunbeck, *Histories of Scientific Observation*, 45–80, especially 50. For Gianna Pomata, observation would eventually come to represent "collective empiricism."

41 See Gianna Pomata, "Observation Rising: Birth of an Epistemic Genre, 1500–1650," in Daston and Lunbeck, *Histories of Scientific Observation*, 49. Regiomontanus's own efforts on behalf of observational practice can also be seen in his teaching of optics at Vienna, and his production of scientific instruments that supported the technical observations that underwrote his general predictions.

42 Peter Apian, *Practica auff das 1532 Jar . . . Auch wird nachvolgenden von dem naeschst erschinen Cometen/ wie und in was gestalt in gemelter Apianus observiert hat und welhe biß her dero vil sindt in irem schreiben irrig gefunden bewerlich angezaygt* (Landshut: Georg Apian, 1532).

43 Daston and Lunbeck, *Histories of Scientific Observation*, 87.

44 David Freedberg, *The Eye of the Lynx: Galileo, His Friends, and the Beginnings of Modern Natural History* (Chicago: University of Chicago Press, 2002). Freedberg asserts that these methods acted as an impetus to visualized natural history.

45 William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton, NJ: Princeton University Press, 1996), 100–1. Eamon identifies this person as an industrious householder, an urban citizen, a member of the village community, with an established position in the middle ranks of society. These would include citizens, non-noble landowners, and householders. The prerequisites of being *gemein* included having legal rights in a municipality or village corporation (*Gemeinde*); this status increasingly included women.

46 See Tillmann Taape, "Common Medicine for the Common Man: Picturing the 'Striped Layman' in Early Vernacular Print," *Renaissance Quarterly* 74 (2021), 1–58.

47 See *Außlegung und beschreybung der Anatomi* (Strasbourg: Vogtherr, 1539) in Schmidt, *Interactive and Sculptural Printmaking in the Renaissance*, 2, 122.

48 Heinrich Vogtherr, *Ein frembds und wunderbars Kunstbüchlin allen Molern, Bildschnitzern, Goldschmiden, Steinmetzen, Schreinern, Platnern, Waffen und Messerschmiden hochnutzlich zu gebrauchen* (Strasbourg: Vogtherr, 1537); see also "Heinrich Vogtherr: Heinrich Vogtherr: Ein frembds und wunderbars Kunstbüchlin allen Molern/ Bildschnitzern/ Goldschmiden/ Steinmetzen/ Schreinern/ Platnern/ Waffen und Messerschmiden hochnutzlich zu gebrauchen (Straßburg 1538/1572) herausgegeben und kommentiert von Maria Heilmann," ed. Maria Heilmann, *FONTES* 61 (2011).

49 For scholarship that unpacks these terms, see Thomas Balfe, Joanna Woodall, and Claus Zittel, *Ad Vivum?: Visual Materials and the Vocabulary of Life-Likeness in Europe before 1800* (Leiden: Brill, 2019); Peter Parshall, "Imago Contrafacta: Images and Facts in the Northern Renaissance," *Art History* 16, no. 4 (1993), 554–79.

50 Farago, *Reframing the Renaissance*; Dana Leibsohn and Jeanette Favrot Peterson, eds., *Seeing across Cultures in the Early Modern World* (Burlington, VT: Ashgate, 2012).

51 Jeffrey Chipps Smith, ed., *Visual Acuity and the Arts of Communication in Early Modern Germany* (Abingdon: Routledge, 2018).

52 See, for example, Pamela H. Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago: University of Chicago Press, 2004); Smith et al., *Ways of Making and Knowing*.

53 Sven Dupré investigates how the circulation through merchant networks of materials such as glass has shaped early modern cultural capital, while Gessner studies the intersection of tools and technical processes. See Sven Dupré, "Trading Luxury Glass, Picturing Collections and Consuming Objects of Knowledge in Early Seventeenth-Century Antwerp," *Intellectual History Review* 20, no. 1 (2010), 53–78; Sven Dupré and Christoph Lüthy, eds., *Silent Messengers: The Circulation of Material Objects of Knowledge in the Early Modern Low Countries* (Berlin: Lit Verlag, 2012); Samuel Gessner, "The Use of Printed Images for Instrument-Making at the Arsenius Workshop," in Nicholas Jardine and Isla Fay, eds., *Observing the World through Images: Diagrams and Figures in the Early-Modern Arts and Sciences* (Leiden and Boston, MA: Brill, 2014), 124–52.

54 Daston and Lunbeck, *Histories of Scientific Observation*, 1–9.

55 Neil Rhodes and Jonathan Sawday, *The Renaissance Computer: Knowledge Technology in the First Age of Print* (London and New York: Routledge, 2000); A. E. B. Coldiron, *Printers without Borders: Translation and Textuality in the Renaissance* (Cambridge: Cambridge University Press, 2015); Jonathan Sawday, *The Machine Mind: Technology and Culture in the European Renaissance* (London: Routledge, 2007); Elizabeth Spiller, *Science, Reading, and Renaissance Literature: The Art of Making Knowledge, 1580–1670* (Cambridge: Cambridge University Press, 2007); Adrian Johns, *The Nature of the Book: Print and Knowledge in the Making* (Chicago: University of Chicago Press, 2009); Adrian Johns, "The Uses of Print in the History of Science," *Papers of the Bibliographical Society of America* 107, no. 4 (2013), 393–420. Tom Conley has also written prolifically on Peter Apian; see, for example, Tom Conley, *An Errant Eye: Poetry and Topography in Early Modern France* (Minneapolis: University of Minnesota Press, 2011); Tom Conley, "A Topographer's Eye: From Gilles Corrozet to Pieter Apian," in Walter S. Melion and Lee Palmer Wandel, eds., *Early Modern Eyes* (Leiden: Brill, 2010), 55–79.

56 Peter Robert Dear, *Revolutionizing the Sciences: European Knowledge in Transition, 1500–1700* (Oxford and London: Macmillan International Higher Education and Red Globe Press, 2019); Steven Shapin, *Scientific Revolution* (Chicago: University of Chicago Press, 2019); Valleriani, ed., *The Structures of Practical Knowledge*.

57 Christopher S. Wood, *Forgery, Replica, Fiction: Temporalities of German Renaissance Art* (Chicago: University of Chicago Press, 2008), especially 95–107.

58 Indeed, these efforts concern much later periods. For an intriguing account of deploying photography to develop visual skills, see Josh Ellenbogen and Adam Jolles, "Visual Literacy

and 1960s Photography," *Critical Inquiry Critical Inquiry* 47, no. 3 (2021), 565–91. On visual learning more generally, see Barbara Maria Stafford, *Artful Science: Enlightenment, Entertainment, and the Eclipse of Visual Education* (Cambridge, MA: MIT Press, 1994); Barbara Maria Stafford, *Body Criticism: Imaging the Unseen in Enlightenment Art and Medicine* (Cambridge MA and London: MIT Press, 1997).

59 James Elkins, *Visual Literacy* (New York: Routledge, 2008).

60 Baxandall, *Painting and Experience in Fifteenth Century Italy*; Michael Baxandall, *The Limewood Sculptors of Renaissance Germany* (New Haven, CT: Yale University Press, 1980).

61 A. E. B. Coldiron, "Translation and Transformission; Or, Early Modernity in Motion," *Canadian Review of Comparative Literature/Revue Canadienne de Littérature Comparée* 46, no. 2 (2019), 205–16.

62 W. J. Thomas Mitchell, *Picture Theory: Essays on Verbal and Visual Representation* (Chicago: University of Chicago Press, 2014); Elkins, *Visual Literacy*.

63 Enenkel and Neuber, *Cognition and the Book*, 3.

64 Bruce R. Smith, *The Key of Green: Passion and Perception in Renaissance Culture* (Chicago: University of Chicago Press, 2009).

65 Schmidt, *Interactive and Sculptural Printmaking in the Renaissance*, 10.

66 Margaret Gaida, "Reading Cosmographia: Peter Apian's Book-Instrument Hybrid and the Rise of the Mathematical Amateur in the Sixteenth Century," *Early Science and Medicine* 21, no. 4 (2016), 297.

67 Valleriani, ed., *The Structures of Practical Knowledge*, 2.

68 Suzanne Kathleen Karr Schmidt and Edward H. Wouk, *Prints in Translation, 1450–1750: Image, Materiality, Space* (Abingdon: Routledge, 2017), 3.

69 Schmidt and Wouk, *Prints in Translation*, 10.

70 Dackerman, *Prints and the Pursuit of Knowledge*.

71 Alexander Marr and Christopher Heuer, "Introduction: The Uncertainty of Epistemic Images," *21: Inquiries into Art, History, and the Visual* 1, no. 2 (2020), 251–5; Alexander Marr, "Knowing Images: A Review Essay," *Renaissance Quarterly* 69, no. 3 (2016).

72 Sachiko Kusukawa, *Picturing the Book of Nature: Image, Text, and Argument in Sixteenth-Century Human Anatomy and Medical Botany* (Chicago: University of Chicago Press, 2011).

73 Brian W. Ogilvie, *The Science of Describing: Natural History in Renaissance Europe* (Chicago: University of Chicago Press, 2006). Peter Parshall stops short of claiming that images drove later taxonomic models but stresses the importance of how morphology emerged from the woodcut illustrations that accompanied mid-sixteenth-century printed herbals; Peter Parshall and David Landau, *The Renaissance Print 1470–1550* (New Haven, CT: Yale University Press, 1994), 245–59.

74 Renzo Baldasso, "The Role of Visual Representation in the Scientific Revolution: A Historiographic Inquiry," *Centaurus* 48 (2006), 83.

75 Marr, "Knowing Images," 1005.

76 Ruth S. Noyes, ed., *Reassessing Epistemic Images in the Early Modern World* (Amsterdam: Amsterdam University Press, 2022), especially 43–8.

77 Baldasso, "The Role of Visual Representation in the Scientific Revolution."

78 Daston and Lunbeck, *Histories of Scientific Observation*, 81–113, especially 87ff.

79 Daniela Bleichmar, *Visible Empire: Botanical Expeditions and Visual Culture in the Hispanic Enlightenment* (Chicago: University of Chicago Press, 2012).

80 Volker R. Remmert, *Picturing the Scientific Revolution* (Philadelphia: Saint Joseph's University Press, 2011).

81 Horst Bredekamp, Vera Dünkel, and Birgit Schneider, *The Technical Image: A History of Styles in Scientific Imagery* (Chicago: University of Chicago Press, 2015), 18ff.

82 Horst Bredekamp, Vera Dünkel, and Birgit Schneider, *Das Technische Bild: Kompendium zu einer Stilgeschichte wissenschaftlicher Bilder* (Berlin: Akademie Verlag, 2012).

83 Marr, "Knowing Images," 1000–13.

84 Apian himself published succinct manuals on these topics after 1524.