The Technical Image
A History of Styles in Scientific Imagery

Edited by Horst Bredekamp, Vera Dünkel, and Birgit Schneider
In science and technology, the images used to depict ideas, data, and reactions can be as striking and explosive as the concepts and processes they embody—both works of art and generative forces in their own right. Drawing on a close dialogue between the histories of art, science, and technology, The Technical Image explores these images not as mere illustrations or examples, but as productive agents and distinctive, multilayered elements of the process of generating knowledge. Using beautifully reproduced visuals, this book not only reveals how scientific images play a constructive role in shaping the findings and insights they illustrate, but also—however mechanical or detached from individual researchers’ choices their appearances may be—how they come to embody the styles of a period, a mindset, a research collective, or a device.

Opening with a set of key questions about artistic representation in science, technology, and medicine, The Technical Image then investigates historical case studies focusing on specific images, such as James Watson’s models of genes, drawings of Darwin’s finches, and images of early modern musical automata. These case studies in turn are used to illustrate broad themes ranging from “Digital Images” to “Objectivity and Evidence” and to define and elaborate upon fundamental terms in the field. Taken as a whole, this collection will provide analytical tools for the interpretation and application of scientific and technological imagery.

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COMPARING IMAGES

Generally, comparison can be described as a funda-
mental method that orients people in their environment so
that they can distinguish (differentiate) and categorize
(classify) what they see and experience. More specifically,
comparison can be described as a fundamental method
that orients people in their environment so that they can
distinguish (differentiate) and categorize (classify) what
they see and experience. More specifically, it is an in-
tellectual technique used in various scientific
disciplines and performed and evaluated in many dif-
ferent ways (Lutz et al. 2006; Elkins 2007). While texts,
verbal imagery, patterns of behavior, styles of thinking,
and cultures are compared in cultural and literary stud-
ies, art history deals explicitly with the comparison of
images. In art history, comparative visual analysis is one
of the central methodological paradigms of analysis
and argumentation. As such, it serves to order works of art
historically into schools and eras, to identify unknown
masters, and to identify authentic and inauthentic, genu-
ine and counterfeit works (Wölfflin 1932; Friedländer
1930; Gombrich 1960; figs. 1a and 1b). At the same
time, comparative visual analysis plays a fundamental
role as a basis for argumentation in presenting such find-
ings in publications and slide lectures.

One reason for the difficulties in theorizing compar-
ative visual analysis seems to lie in the double role
that comparison plays in this discipline as an instru-
ment of analysis and argumentation. Comparative
visual analysis was part of the implicit basic know-how
or “tacit knowledge” (Michael Polanyi) of art-historical
writing long before art history was established as
an academic discipline in the nineteenth century
(Friedlander 1942). Even today, it forms a self-evident
and largely unquestioned part of the discipline as a
means of acquiring knowledge, of analyzing and
describing images. This may explain why comparative
practices have only rarely been investigated as a prob-
lem in their own right.

Based on the German art historian Heinrich Dilly’s
seminal research, art history scholars have more recently
carried out studies that have investigated the meaning
and scope of comparison as a method in the develop-
ment of art history as an academic discipline; in particu-
lar, they traced the history of the material foundations
of comparison, which were laid by the emergence of new
reproductive media such as photography and their con-
nections with science (Dilly 1975; Wenk 1999; Nelson
2000; Ratzeburg 2002; Reichle 2002; Bader 2007). At
the same time, art history has repeatedly reproached
itself for not adequately substantiating the comparisons
it makes: with the help of apparently “evident” visual
comparisons, relationships between images are more
implies that comparison is a central methodological
paradigm of art history and that it has been used in
the discipline for a long time.
The formal similarity is just one such criterion among many. Comparability can also be based on a tertium comparationis that is not present at the visible level of the image but is, for example, established by a shared context. Further bases for comparison in this sense might be a shared time or place of origin, a shared theme or subject, or the same design purpose. In such cases, two images may be juxtaposed that show two completely different outcomes even though they were, for example, created to achieve the same end.

With regard to technical images, the spectrum of comparison criteria is expanded by the scientific contexts from which the images come, the functions they serve in these contexts, and the imaging technology used to generate them. A particular challenge is posed by companions of artistic and non-artistic images and the investigation of migratory imagery that diffuses through various disciplines. Here, too, comparison must always be made based on an awareness of the epistemic interests and deliberately selected criteria. For instance, when similar images are brought together with a particular interest in the transmission and adoption of forms, such comparison should be undertaken, on the one hand, with an awareness of the possible difference between individual associations, the viewer’s own visual memory, and that of the creator of the image. On the other hand, formal proximity must be continually related to other criteria such as function, context, and the conditions under which the images were produced. It is then just as possible for a comparison to fail to produce useful knowledge as it is for it to visibly provide associative, productive cause for thought and initiate new investigations (figs. 3a–3c). Whether a comparison is useful can only be determined in the course of further research and a detailed investigation of the objects brought together as well as in the discussion following a public presentation of comparisons. In this process, the relative significance of equivalences and differences should be subject to ongoing critical revision. The legitimacy of a presented comparison can only be measured by the verbal argumentation that accompanies it. This also means that the respective interests in it must be disclosed and made transparent. —VD

LITERATURE
ICONOLOGICAL ANALYSIS

The term iconological analysis designates the art-historical method that seeks to complement the method of iconography, which identifies and interprets subjects and motifs. Iconological analysis synthesizes the precise description of a work with studies of its contexts. This synthesis guides the interpretation of the work (Warnke 1980; Schmidt 1993; Warburg 1999). Although the method is central to the work of the German art historian Aby Warburg (1866–1929), his student Erwin Panofsky was the first to develop and publish a three-stage model of iconological analysis; he called the third stage of this model “iconological interpretation” (Panofsky 1970 and 1981; Holly 1984). Since then, iconological analysis has been taken to refer to the step-by-step interpretation of pictorial artifacts within their cultural and historical contexts (Elsner et al. 2012; Mitchell 1986).

According to Panofsky’s model, interpretation begins with a formal description (first stage), proceeds to an iconographic analysis of content (second stage), and then determines the meaning of the work of art (third stage). This last phase analyzes the period in which the work was created and the prevailing social, political, philosophical, and religious attitudes of the era or nation that influenced its creation. The work as a product of these attitudes thus appears as paradigmatic or symptomatic of an epoch or, in the context of the history of ideas, as a historical document of ideas, opinions, and views. Beyond such symptomatic qualities, the extent to which the work itself actively participated in forming these ideas, opinions, and views requires scrutiny as well.

Iconological analysis seeks to reconstruct traditions and reveal layers of meaning by critically investigating literary sources of various provenances, including documents from everyday culture and superstition as well as other artifacts related to the work of art. Such meaning may not be apparent to the observer at first glance, nor was it necessarily intended by the producer or commissioner of the work. Iconology as practiced by Panofsky, especially in the concluding phase of the interpretation, seeks to place a work in a wider context of meaning. The interpreter’s profound and broad knowledge of the cultural and historical context of the work serves as a corrective to his “personal psychology” or “worldview.” In 1912, Aby Warburg described iconological analysis in the conclusion to his lecture on the frescoes in the Palazzo Schifanoia, Ferrara, as a method “that can range freely, with no fear of border guards, and can treat the ancient, medieval and modern worlds as a coherent historical unity.” He proposed that art historians examine “the purest and the most utilitarian of arts as equivalent documents of expression” (Warburg 1999), overcome evaluative categories such as “high” and “low,” transcend disciplinary boundaries, and proceed by covering various periods, occasionally anachronistically, when searching for correlations among traditional forms of representation and motifs (Beyer 1992).

The underlying assumption that every form is a historical phenomenon and has a history of its own must therefore also apply to the interpretation of technical and scientific images and be the starting point of their iconological analysis. The latter takes into account first of all the image’s specific scientific context; in so doing, it relies on knowledge from other disciplines. To decode the ways in which scientific and technical images create meaning, iconological analysis examines their functions within productive and epistemic processes and attempts to identify the formal properties of images by examining the interplay of technological conditions, design inter-
The transfer of images to the public sphere, their popular receptions, and scientific convictions. In light of the ideas proposed by the Polish philosopher of science Ludwik Fleck, then, the aim is to reveal the extent to which social interactions, and interconnectedness of these areas. The challenge of an iconology of scientific imagery, then, is to establish a balance between this integration into a broader history of images and the attention to specific formal areas and still affects the visualization strategies of today's medical imaging processes. (figs. 1–8) Collections of drawings by sixteenth-century natural philosophers in which traditional representations of monsters and mythical creatures are presented on an equal footing next to images documenting individual observations are another example. This juxtaposition is virtually incomprehensible in the perspective of today's understanding of taxonomy. Yet the iconological method reveals, for example, the pictorial traditions inherent in the discourse on natural philosophy in Aldrovandi's picture collection and the concept of nature that is expressed in the composition of such a collection.

CONCLUSION

The full-body MRT scanning offers preventative health benefits, while others point to the possibility of erroneous results and the difficulties in interpreting the images. (figs. 1, 6, 7)

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chains of representations

According to a traditional understanding, scientific images attain a purpose outside themselves by referring to phenomena and data. Since the 1980s, however, scholars in the field of science studies have increasingly pointed out that the traditional notion of a correspondence between a scientific image and a discrete object is untenable because it is impossible to clearly correlate the representation with what is represented. Consequently, the question of the referent in science cannot be posed in the sense of a simple illustration of, and references to, reality. The philosopher of science Ian Hacking contributed a vital impetus to the discussion of these issues in the early 1980s with his book Representing and Intervening. He emphasized that representation is only possible through the experimenter’s intervention, so the representation can only emerge out of the intervening conception. The philosopher of science Ian Hacking sees the reference here not in a mimetic correspondence but in the properties of the chain. Each link in the chain must necessarily refer to a previous one, and the chain must be able to be traced back to its beginnings (Latour 1999). Only in this overall view did the gradual changes in the finches become apparent, helping Darwin to pave the way for his theory of evolutionary speciation. Fig. 1a: Julia Voss, Darwin’s Bilder: Ansichten der Evolutionstheorie 1837–1874 (Frankfurt a.M.: Fischer Taschenbuch Verlag, 2007), fig. 1a. Charles Darwin, ed., The Zoology of the Voyage of H.M.S. Beagle, Part II (London: Smith, Elder & Co., 1841), plate 37. Fig. 1b: Charles Darwin, Genommene Werke: Vorar eines Naturforschers um die Welt, 2nd ed. (Stuttgart: E. Schweizerbart’sche Verlagshandlung, 1899), 413. © Natural History Museum, London.

This approach may be productive in a historical Bild-
The Technical Procedure of Shaft-Weaving

Ziegler's notations cannot be appreciated without a basic familiarity with the loom for which they were set down, the shaft loom, which had come into general use in Europe in the thirteenth and fourteenth centuries; see figure 5 for a schematic illustration of a shaft loom. As the name indicates, the distinguishing feature of this weaving technology consisted of a system of shafts the weaver raised and lowered using pedals or treadles. To create a specific pattern using this process, the warp—the system of parallel threads held taut by the loom—is divided into groups and individually threaded through the eyeslets (heddle eyes) of a system of threads running vertically between the shafts. Moving like the arms of a marionette, the shafts can raise the groups of warp threads, opening a “shed” through which the weaver passes the shuttle with the weft. 10 The operation of the shafts resembles that of an organ: by stepping on one of the pedals, the corresponding shafts raise a set of warp threads before the weaver picks the shuttle—that is, inserts a single weft thread—and drop back once the pick is complete. Operating another treadle reopens the shed for the weave (the “ground” of the figure-ground distinction, as it were) in patterned fabrics. Yet Bild was in pattern-weaving also the general term for the schematic draft for a fabric made on paper; it is the historical term, that is to say, for pattern notation in weaving.5

The forms of patterns treated in Ziegler’s publication represent a complicated special weaving technique practiced primarily in southern Germany.5 These were geometrically patterned fabrics in which the weavers combined shapes such as squares, lines, and triangles to create abstract designs; the textiles were produced on so-called shaft looms. Aside from Ziegler’s notation, there existed other conventions on how to notate fabric patterns, but these did not circulate publicly until the age of the encyclopedia in the eighteenth century.11

Ziegler had various reasons to publish these materials, some of which related to his Protestant ideals about training and education. See Patricia Hills, “Transla-


5 For the historical use of the term Bild in weaving, see also Wolther von Flahm, Die Fachsprache der Textilindustrie im 17. und 18. Jahrhundert (Düsseldorf: VDI, 1971).

6 This weaving technique produced pattern

7 Schematic representations may be found in the French encyclopedic treatments of eighteenth-century weaving, where they appear under the label “transla-
tion”; see, e.g., Jean Paulin, L’Art du fabriquant d’toffes de soie, 7 vols. (Paris, 1773–1789). A third convention may be found in an Italian manuscript from Luca that is dated to the 1680s, or only a few years before Ziegler’s handbook of weaving. This notational format uses numerals. See Gino Araghi, Un manuale scenetico dei tessitori lucchese (Lucca: M. Facini Fazzi, 1986).

8 Ziegler had various reasons to publish these materials, some of which related to his Protestant ideals about training and education. See Patricia Hills, “Transla-


The specific quality of the historical forms of notation is best understood by comparing them to today’s prevailing convention, the draft. Figure 7 illustrates the basic weave pattern for twill as it appears in a modern textbook for manual weaving on a shaft loom. The arrows connect the schemata to the components of the loom they control. The structure of staggered squares shows the resulting weave as a pattern of black and white boxes. The modern *drawdown* here represents the order in which the threads interlace in the fabric: a black square tells the weaver that the warp thread passes over the weft thread; a white square, that the warp passes beneath the weft.

Three additional schematic representations accompany the drawdown. Along its upper edge runs the *threading*, which specifies the order in which the warp ends are threaded through the specific quality of the historical forms of notation is best understood by comparing them to today’s prevailing convention, the draft.
Drawing and the Contemplation of Nature—Natural History around 1600: The Case of Aldrovandi’s Images

Angela Fischel

Images have helped scholars gain knowledge of nature since the sixteenth century. The cabinets of the natural philosophers saw the compilation of large collections of drawings, documentary depictions of the natural world that recorded the forms of the animal and vegetal kingdoms. The collection built by the Bologna-based natural philosopher Ulisse Aldrovandi (1522–1605) is among the most formidable of its kind. It has survived almost in its entirety, allowing us to illuminate how natural philosophy around 1600 worked with images. Aldrovandi saw himself as a pioneer of the modern natural sciences and championed the visual study of nature as the most important source of knowledge about it. Closer inspection of his image collection, however, reveals that his drawings by no means derive directly from nature; many of the depictions of animals may be traced back to earlier printed sources. Other images stage their objects in suggestive compositions that exceed the purpose of objective documentation. This leads us to ask, then, what Aldrovandi meant by empirical study and, further, what specific functions images may have served in the context of early modern natural science.

One of the most spectacular drawings from Aldrovandi’s collection shows two vipers (fig. 1). The animals raise their heads in an aggressive posture; their bodies are intertwined to form a slightly asymmetrical ornament. The trompe-l’œil drawing presents the vipers in a pictorial space that is visually continuous with the beholder’s own environment, an effect underscored by the shadows and the use of perspective. The writhing snakes seem to come dangerously close to the beholder. The animals originally belonged to Francesco de’ Medici, who sent the living specimens to Bologna to have them studied. At the same time, Aldrovandi had also asked for a drawing of the vipers—a prescient request, as it soon turned out: one of the two animals died during transport to Bologna, the other shortly after its arrival. The death of the rare specimens left the collector with nothing but their likenesses. One of the functions of drawings in Aldrovandi’s research practice was evidently to provide a vivid documentation of the forms of nature that would survive their physical demise. It remains remarkable, however, that a picture as dramatic and suggestive as the draftsman Jacopo Ligozzi’s portrayal of the snakes would be used in this context. Ligozzi gave a very precise depiction of the animals, but what he shows is more than the phenotype of a rare species of viper: the use of trompe l’œil also conveys a vigorous impression of the danger they pose, vividly illustrating an aspect of their nature as well.


2 Ulisse Aldrovandi, who did most of his work at the University of Bologna, has always been considered a leading Italian natural philosopher of the sixteenth century. His most extensive project, a definitive natural history, remained incomplete. See Sandro Tignoli Pàttaro, Metodo e sistema delle scienze nel pensiero di Ulisse Aldrovandi (Bologna: Clueb, 1992); Paula Findlen, L’inventario del mondo, 22–157.
It is illuminating to note that method, to Aldrovandi, meant more than merely a research procedure. As Tugnoli Pàttaro suggests, Aldrovandi’s use of the term also comprised techniques of teaching and learning. Visual inspection and excursions were accordingly part of his tuition. See Tugnoli Pàttaro, Metodo e sistema delle scienze, 65–73.


Aldrovandi had received this drawing from Francesco I de’ Medici in Florence. A detailed account of its history can be found in Findlen, Possessing Nature, 241–48.

Aldrovandi experimented on the cadavers of the vipers, trying to find a recipe for theriac. The latter, a concoction already known to Galen that was regarded as the “antidote of antidotes,” had featured importantly in the pharmacoepia since the Middle Ages. Almost all early modern natural scientists sought to find a way to prepare this legendary compound. For extensive references, see Findlen, Possessing Nature, 241–43.

Drawings constituted one part of Aldrovandi’s natural history collection, which also included natural objects and preserved specimens; herbariums containing dried vegetal specimens and collections of drawings of plants; numerous wood engravings made after the drawings, and a library. The collection of animal drawings, which is now in the library of the University of Bologna, consists of six large leather-bound tomes. The order in which the folios appear today obeys no recognizable system, instead laying out a vast and confusing mosaic of all sorts of conceivable—probable as well as less probable—forms. There are depictions of reptiles (fig. 1), birds (fig. 2), mammals, fishes (fig. 3), insects (fig. 4), prodigious births and monsters, seashells and snail shells, and fossils (fig. 5) but also empty sheets and others containing unfinished drafts (fig. 6), indicating the collection’s incompleteness and openness to further expansion.

As shown in the following pages, Aldrovandi always devoted particular attention to his drawing collection. The importance he ascribed to it is also suggested by his writings, where he frequently refers to his drawing collection with particular pride. In addition, he expounded on the significance of images for the study of nature in numerous image-theoretical treatises.

In the “Discorso” and even more extensively in his last will, Aldrovandi also offers concrete information about the scope and status of his picture collection. Aldrovandi, however, tried to connect his new, empirical ideal of natural history to this classical Aristotelian term. This new view of Aristotle differs strongly from earlier (for example, late medieval) references to Aristotle’s philosophy. Prior to Aldrovandi and his precursor, Conrad Gesner, knowledge of nature was by no means based on perception of the outer appearance of an animal or plant. For an early modern interpretation of Aristotle in biology, see James G. Lennox, Aristotle’s Philosophy of Biology: Studies in the Origins of Life Science (Cambridge: Cambridge University Press, 2001). For Aldrovandi’s reference to Aristotle, see also Tugnoli Pàttaro, Metodo e sistema delle scienze, 180.

The empirical study of nature, this account indicates, did not simply mean perception of natural objects or their immediate study in situ. On the contrary, turning perceptions of nature into data that would be generalizable and communicable in scientific terms required technical mediation. In the museum, the following discussion aims to show, the drawing archive is a prerequisite for the scholar’s study of nature’s forms and appearances. Aldrovandi was one of the few early modern zoologists to examine the matter of the image as such at length; with Conrad Gesner, he was among the first to address the particular significance imagery had for the philosophy of nature. Aldrovandi’s writings advocate the employment of images and give a prominent role to visual perception and sensory experience in connection with his call for a transformation of natural history into a science founded on empirical data. Tactile and visual perception and experience, he argues, must form the basis for any profound study of nature; only the outward senses provide the access to the world that enables the human understanding to know it. In this context, Aldrovandi developed an interesting reading of Aristotle, who, he writes, characterized the experience of individual objects of physical nature as the first step toward knowledge of the substance of the world. His description of his own work clearly expresses the same ideal: in “my natural history [...] I have described not a single object I did not see with my own eyes, touch with my own hands, and dissect into its external and internal parts. [...] Over time, I have collected these objects in my small natural world, where anyone can come—and they do come all day long—to see and contemplate them, preserved in likenesses drawn from life, in our museum.”

Empirical Science and the Politics of the Image

FIG. 5: Fossils and a nautilus shell, from Aldrovandi’s collection of drawings, ca. 47 x 35 cm, second half of the sixteenth century. Aldrovandi’s collection of drawings, archive of the University Library of Bologna, Italy. Tavoli di Animali VI, c. 69, with permission of the University Library of Bologna.


13 In the “Discorsi” and even more extensively in his last will, Aldrovandi also offers concise information about the scope and status of his picture collection. Ulisse Aldrovandi, “Discorso naturale,” 180; Giovanni Fantuzzi, Memorie della vita di Ulisse Aldrovandi, Medico e Filosofo Bolognese (Bologna: Lello dalla Volpe, 1774), 67–85.