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Draughtsmen, Botanists and Nature:

DRAUGHTSMEN, BOTANISTS AND NATURE

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Draughtsmen, Botanists and Nature: The Construction of Eighteenth–Century Botanical Illustrations

by

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Preface

This book is based on a doctoral thesis submitted to the University of Bern in the summer of 2002. Research on the thesis was made possible through a grant provided by the Swiss National Science Foundation (SNF) from 2000 to 2002 for a project on the history and epistemology of scientific illustrations (Project No. 1152-059499). Gerd Graßhoff headed this programme at the University of Bern and made my reworking of the thesis into a book in English possible. He also provided the funding for the services of a professional copy editor (Margareta Simons, Bern).

The findings presented in this book are closely related to the general results of the SNF project, which are published elsewhere: the source material can be consulted in an earlier monograph and in an electronic edition on the internet;[1] the theoretical approach will be more thoroughly investigated in a textbook on the analysis of scientific illustrations. In addition, this study has made use of theoretical concepts developed by Gerd Graßhoff, which, in their latest form, have yet to be published; these concern primarily the model concept discussed in Chapter 3. The criteria put forward for optimizing scientific illustrations, which are dealt with in Chapter 7, were also originally proposed by Gerd Graßhoff; they were refined and elaborated in the SNF project. Some of the material on the copying links presented in this book was first published in an article in *Studies in History and Philosophy of Science; Part C*;[2] while some of the material in Chapter 5 on the hand-colouring of illustration was published prior to this book in the *Annals of Science*.[3]

I was able to access source material for this study from several archives and institutions.[4] Most of the images that I examined originated from copies held in the University Library Göttingen, while the remaining illustrations came

[1] See Nickelsen (2000), Nickelsen & Graßho (2001) and Graßho et al. (2001).
[2] Nickelsen (2006a).
[3] Nickelsen (2006b).
[4] Bibliographic details for all the illustrations can be found in a table at the end of this book (pp. 273 .).

from the collections of the Wiesbaden Museum and the University Libraries of Erlangen and Regensburg, whose archives I also used. In addition, I consulted material held in the Archives of the Berlin-Brandenburg Academy of Sciences. I am grateful for the kind support I received from the staff at these institutions and for their permission to quote from the material and reproduce a selection of the images in this book.

A considerable number of people gave practical support or helpful comments on various aspects of my research; I hope I have given them due credit in the appropriate footnotes. However, some contributions were more substantial. First and foremost, I would like to thank Gerd Graßhoff for his personal and scientific advice as well as his steadfast optimism. He devoted far more time to discussing botanical illustrations than would normally be expected of a supervisor and I am deeply indebted to him. Margareta Simons, mentioned above, greatly improved the book through her careful editing; Robert Casties advised me on computing problems; during moments of despair, Hans-Christoph Liess always managed to cheer me up; Julia Meier and Djuke Nickelsen proof-read earlier versions of the book; Katharina Nickelsen took care of my baby son while I inserted the final corrections; and, last not least, greatest thanks of all go to Johannes Sander.

Kärin Nickelsen
Bern, January 2006

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1

Introduction

"A picture is misleading",[1] Pliny the Elder warned the first-century readers of his *Natural History*; and even 1,500 years later Hieronymus Braunschweig advised the readers of his *Book of Distyllacyon* to pay more attention to the text than to the illustrations, "for the figures are nothing more than a feast for the eyes".[2] However, by the end of the seventeenth century the attitude towards scientific illustrations had substantially changed. Indeed, it had altered so much that John Ray maintained that his contemporaries would consider a botanical work without illustrations as ridiculous as a geographical work without maps.[3] In the eighteenth century, even botanical illustrations with no textual comment whatsoever were, on occasion, considered adequate for publication. The *Delineation of Exotick Plants*, published during the years 1796 to 1803 with drawings by Franz Bauer, consists solely of full-page illustrations of the South African *Erica* species. In his preface to the book, Joseph Banks wrote: "It would have been a useless task to have compiled, and superfluous expense to have printed, any kind of explanation concerning [the plates]; each figure is intended to answer itself every question a Botanist can wish to ask, respecting the structure of the plant it represents."[4] Thus, it seems to be worthwhile to take a closer look on how these images were produced, what they contain, how they were used and how people decided on the images' particular design.

[1] The original Latin reads: "Pictura est fallax." Plinius (1979), XXIV, 4, p. 141.
[2] Braunschweig originally published his work in Latin in 1500. The cited translation dates from 1527; see Braunschweig (1973). Cited Saunders (1995), p. 20.
[3] See Saunders (1995), p. 7.
[4] Cited Saunders (1995), p. 8.

1.1 The Draughtsman, the Botanist and the Plants

1.1.1 The Lonely Genius in the Meadow

Imagine a draughtsman in a meadow – brush and easel under one arm, strolling through the fields, looking here and there. Whenever a special-looking plant catches his eye, he takes out his brush and paints and begins to sketch a likeness of the plant into his sketchbook. Or perhaps a botanist and draughtsman are strolling along together, when the botanist[5] seizes the draughtsman by the shoulder and points to an inconspicuous but charming flower by the wayside, whereupon the draughtsman immediately stops to capture its likeness. These are two images of the first stage in the creation of a botanical plant drawing. The resulting picture would show the draughtsman's direct encounter with nature. It was perhaps the botanically trained companion, whose interests did not necessarily coincide with those of the draughtsman, who selected the plants to be sketched. However, the final illustration itself would one assume to be based on the original sketch drawn by the artist working from life. The draughtsman, the botanist and nature: a trinity providing the framework within which botanical illustrations were produced and in which their aesthetic and scientific effects were unfolded.

However, perhaps we were carried away a little imagining the artist walking through the fields and, without giving it much thought, transferred the working process of a flower painter painting predominantly decorative images to the techniques applied in the making of more scientific plant illustrations. The latter type of picture possibly required some other procedure – for example, something similar to the situation that Worthington G. Smith ascribed to himself in a 1917 caricature (fig. 1.1, p. 3). Many European botanical drawings of earlier periods dealt with plants that were not part of the indigenous vegetation but had been carefully grown in greenhouses (at least, that is what one would assume from looking at the choice of plates one generally finds in modern-day coffee-table books or calendars). To record exotic species the artist had to make his way to a greenhouse, where he often had to work in uncomfortable and difficult conditions, as can be seen in the caricature: in order to draw a particular plant in its actual location (and to distort nothing), the artist has approached it as closely as possible by placing an upturned flowerpot on top of a stepladder. His drawing equipment and a large folder are clasped between his legs, under his arms and behind his ears; paintbox and tumbler lie on the ground at the foot of the stepladder. Here the draughtsman balances, so totally absorbed in his work that he fails to notice the spider dangling directly above him and observing his efforts with interest.

[5] The designation "botanist" needs to be carefully used in the context of the eighteenth century. There was no such thing as a professional botanist, only physicians or other professionals interested in the subject of botany. In this study, they are all held to be "botanists", which is how they referred to themselves.

Fig. 1.1. The typical botanical draughtsman at work? Originally published in *The Gardener's Chronicle* (1917), entitled "The late Mr. Worthington G. Smith sketching under di culties".

But how do we know that this is an artist at work? It could just as easily be an artistically ambitious botanist, even a professor, who has recklessly abandoned the paraphernalia of civilian life – top hat, umbrella and bag – to devote himself to the observation and documentation of a rare and interesting species of plant. Whether he be an artist or a professor, though, the figure is represented as an unworldly and eccentric personality, who, with his unruly hair and beard, corresponds so well to the popular conception of an absent-minded (albeit perhaps brilliant) researcher, who is following his studies in the realm of botany in splendid isolation. One imagines that the drawing being sketched will disappear for ever into the folder, and, if the draughtsman gets back to it in a quiet moment, it will remind him of this encounter with the fascinating pot plant.

Even though this caricature may be a little exaggerated, the idea conveyed is not that far from the instinctive notion described above: a botanical drawing being the result of the confrontation of an artist with the object of interest in its natural location. However, many botanical illustrations were produced to be published in a book or a scholarly journal, and for that purpose copper engravings had to be produced – which means that besides the draughtsman who prepared a first sketch of the image there was the engraver and the printer who also contributed to the final product. The author also probably had a role in the production of the images; nor should it be forgotten that many plant illustrations were coloured after the print had been made, a production stage that was so time-consuming that, even with only a moderately large number of copies printed, usually more than one person was employed to do the job. One can easily see, then, that the result of this chain no longer has much in common with the solitary occupation of the botanical artistic genius. Producing botanical illustrations seems to have been a far more complicated procedure, so that a more detailed investigation of this process appears to be worthwhile.

1.1.2 Re”ections of Nature

Let me take a look at an example of eighteenth-century illustrations, namely, the representation of a coltsfoot from William Curtis's *Flora Londinensis*, published in 1777.[6] In this picture, the coltsfoot is growing from a long rhizome, which gives rise to two rosettes as well as to a runner with a number of flowering stems. The flowers are represented in all stages of their development: there are tightly closed buds next to half and fully opened flowers, including a clock with ripe fruit. At first glance, the illustration does not seem particularly unusual. It is unmistakably a coltsfoot, and the image appears as true to nature as one could wish. However, if one compares the illustration with a real coltsfoot, it becomes clear that, from a certain point of view, this

[6] Taken from Curtis (1777-98). Detailed source material of all the illustrations examined in this study can be found at the end of this book, pp. 273 .

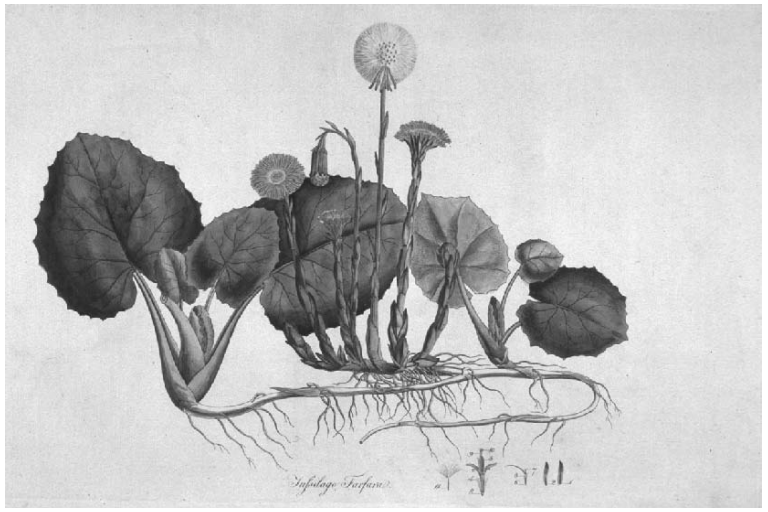

Fig. 1.2. Coltsfoot – *Tussilago farfara* L. Curtis (*Flora Londinensis*, Vol. 1, 1777).

representation should be considered incorrect: one would never be able to find such a coltsfoot, since the leaves of this plant do not appear at the same time as the flowers but only *after* the flowering period or at least towards the very end of this stage. Even if the flowering and leaf stages of the coltsfoot do occasionally overlap, one would never find all these stages of development simultaneously in the same plant, as represented here. Furthermore, the far too orderly arranged stems are anything but lifelike, and the same applies to the too regularly formed leaves of the all too pronounced rosettes.

Thus, on the whole, Curtis's eighteenth-century picture certainly does not show a lifelike image of a coltsfoot, and in this his work is no exception. Numerous examples prove that eighteenth-century botanical draughtsmen used techniques that, in effect, made their images unrealistic.[7] The "dawn of accurate and representational scientific illustration", which Brian J. Ford claims to examine in his survey of botanical illustrations beginning from around 1400, seemingly went unnoticed by Curtis and his draughtsmen.[8] Combining different stages of development, as in the Curtis illustration, is but one example of the respective techniques. The form and size of plant organs were also frequently misrepresented. One such example is the image reproduced in figure 1.3 (p. 6): another representation of the coltsfoot, but this time taken from a work of the German author Johann Zorn.[9] Surprisingly, this illustration has

[7] For detailed evidence of this thesis see Nickelsen (2000), particularly Chapters III and VII.
[8] See Ford (1992), p. 83.
[9] Zorn (1779-90).

Fig. 1.3. Coltsfoot – *Tussilago farfara* L. Zorn (*Icones Plantarum Medicinalium*, Vol. 1, 1779).

little in common with the Curtis picture, even though they were made for the same purpose and with the same claims regarding their content.[10] Depicting the same plant species, it seems, did not automatically lead to similar representations. Yet, this is exactly what would have been expected if the draughtsmen had done nothing else but document as exactly as possible what they were viewing. Naturally, even in this case, the results would vary slightly according to variations in the specimens used, but if the qualities of the subject matter, together with the drawing technique, determined the result, the images should not have differed as much as the versions of Curtis's and Zorn's coltsfoots.

The left flower head, oriented to the front, of Zorn's coltsfoot illustration is worth looking at in some detail. Like all species of the *Asteraceae* family, the coltsfoot is made up of composite inflorescences, that is, they give the impression of being one single flower but actually consist of many tiny individual florets. At the edge of the flower head, the florets are ligulate and form a radiate crown; the centre, however, is filled with tubular florets, the petals of which are almost completely fused. These tubular florets are comparatively small: if the whole flower head, say, has a diameter of two centimetres, every floret might measure two millimetres or less. In Curtis's version of the coltsfoot the individual florets can barely be distinguished but blur into one another (fig. 1.2, p. 5). Zorn, however, shows this detail in a completely different way (fig. 1.3, p. 6): he has depicted these tiny tubular florets in the centre of the flower head in such a pronounced fashion that even their five petals can be seen, grown together except for the outer corners. Had photorealism been the object of his work, this representation would be fundamentally incorrect! In order to show these central florets so clearly, Zorn has zoomed in on them, thereby distorting the scale of the drawing in this section. By doing so, but not giving the flower heads too much space altogether (since the other organs of the plant also had to be shown), Zorn could only insert a few of these enlarged tubular florets; there are only about eight to nine of them in the centre of his coltsfoot flower head, whereas in nature there could be up to a hundred.

An artist undertaking a realistic illustration should reproduce as exactly as possible the features of the particular plant specimen under examination. No qualities should be added or withheld, nor should the plant be simplified or schematized. No details should be given undue prominence and different stages of development should not be combined. In short a realistic illustration should be a lifelike representation of an existing specimen of the depicted species. For a correctly and accurately recorded plant image in this sense one can turn to the elaborate plant illustrations of Hans Weiditz, which feature in the famous sixteenth-century herbal by Otto Brunfels.[11] Three examples of the plates in this work can be seen in figure 1.4 (p. 9). Weiditz's pictures differ considerably

[10] In both pictures the Latin name of the species was recorded as *Tussilago farfara*. The "L." indicates that the respective name uses Carl Linnaeus's nomenclature.

[11] Brunfels (1531), in reprint Brunfels (1975). However, the illustrations in the Brunfels herbal were already exceptions when they were first published; one should not

from the scientific plant drawings examined so far. Folded, drooping and dried-up leaves are the rule rather than the exception here. Neither the shape of the flowers, nor the peculiarities of the fruits can be closely observed, since the flowers are shown not only in an unattractive but also in an uninformative stage of their development. Clearly, the beauty of the subject matter was not the draughtsman's main concern, but nor was the completeness of the information provided: as the specimens used had no intact flowers, the artist did not show any, even though this meant that important information on the species was being omitted. And if the leaves of the chosen specimen hung limply, this was also documented. The tables in Brunfels's herbal show one particular representative of the species in question; however, the botanical illustrations of the eighteenth century are presented quite differently.

That eighteenth-century plant illustrations were not produced as reflections of nature can also be confirmed by looking at the production techniques of the period. The analysis of a representative sample of eighteenth-century botanical illustrations has revealed that more than half are pictorially linked, that is to say, many later drawings contain elements that were copied from earlier illustrations.[12] That copying earlier images of the same species was a widespread technique in botanical illustrations of the sixteenth and seventeenth centuries is well documented; that the draughtsmen and authors of the eighteenth and early nineteenth centuries also worked in this way, however, was not known. This practice was used in a variety of botanical works of the time, ranging from the modest manual written by the self-taught Christian Schkuhr, who worked as a *Mechanikus* in Wittenberg, Germany, to the luxuriously splendid volumes illustrated by Pierre Joseph Redouté, a botanical draughtsman who worked at the court of the King of France. To take only one example, motives from Curtis's representation of the coltsfoot (fig. 1.2, p. 5) can be seen in a drawing of the coltsfoot by Johann Wilhelm Palmstruch, published at a slightly later date (fig. 1.5, p. 10).[13] If one compares the images in detail, it is clear that Palmstruch has used the same variety of developmental stages as Curtis and has duplicated almost exactly the rosettes of the earlier illustrator. Contrary to what is known from copying techniques of earlier ages, the eighteenth-century representations for which it can be demonstrated that this specific practice of copying was used did not turn out qualitatively any worse than their archetypes. One would expect copyists to commit slight errors, one after the other, finally ending up with a flawed drawing. This kind

jump to the conclusion that there was a general historical development from individualistic representation in the sixteenth century to idealizing images in the eighteenth.

[12] For detailed descriptions of this phenomenon, see Nickelsen (2000), Chapter V. The copying links can be checked by consulting the electronic publication of the images, Nickelsen & Graßho (2001). A handbook introduces the user to the COMPAGO program, which was specifically developed for this publication; see Graßho et al. (2001).

[13] Palmstruch & Venus (1802-38).

Fig. 1.4. Three herb drawings from the herbal of Otto Brunfels (woodcuts after watercolour paintings by Hans Weiditz). Left to right: *S. Jacobs blüm* (No. 317), *Teüffels Abbissz* (No. 90), *Ancissien* (No. 284). All taken from the reprint of the original edition, Brunfels (*Contrafayt Kreüterbuch*, 1975).

of mistakes did creep in because of inaccurate copying in some repeatedly copied botanical illustrations of the fifteenth and sixteenth centuries which finally led to a deterioration in quality and to the loss of information.[14] The plant images of the eighteenth century, however, were copied in an extremely intelligent way! The models were carefully selected and weighed up against each other. Complete illustrations were rarely copied: only individual elements were picked out and these were systematically modified through the use of a number of specific strategies.

[14] See, e.g., Arber (1986) or Baumann (1998).

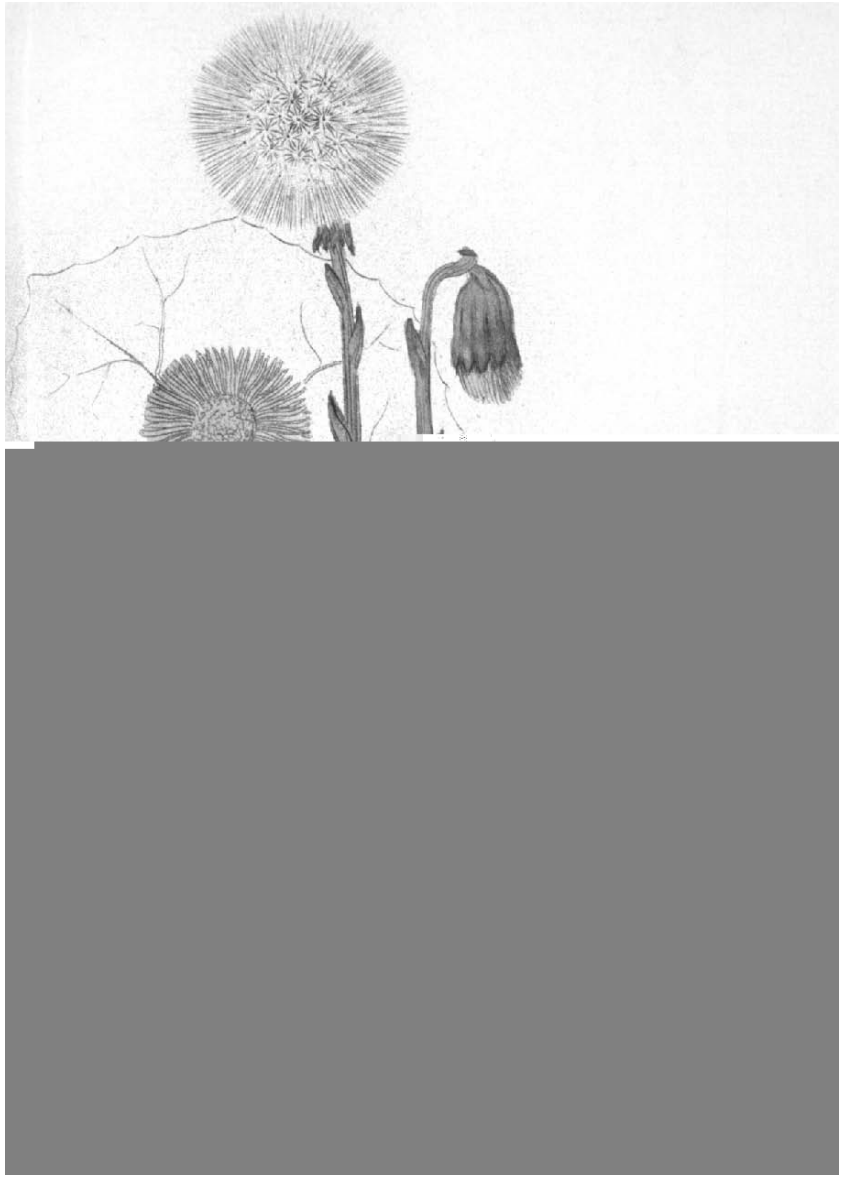

Fig. 1.5. Coltsfoot – *Tussilago farfara* L. Palmstruch (*Svensk Botanik*, Vol. 1, 1802).

1.1.3 Using the Images

Despite the high costs and the enormous effort it took to produce an illustrated work, herbals, which often included full-page-sized tables, were among the first books to be printed[15] – and the number of similar works published continued to rise until the eighteenth century. Many quotations of scientists of the time prove the significance they attached to plant illustrations: "It frets a Man [...] to see fine Objects, and not to be able to take Draughts of them; for without this help of Drawing, 'tis impossible any account thereof should be perfectly intelligible", the botanist Joseph Pitton de Tournefort wrote to colleagues during his voyage in the Levant.[16] And the Swabian botanist Johann Simon Kerner expressed himself even more pronouncedly at the end of the eighteenth century: "Correct illustrations by an expert are instructive, help settle any doubts and grant certainty."[17] But why the illustrations were able to do so and how is anything but clear.

1.2 The Matter in Question

So, in view of the previous sections the following conclusions in reference to eighteenth- and early nineteenth-century botanical illustrations[18] serve as a starting point for my study:[19]

1. The production of plant images was a complex process, which involved the collaboration of several people with their own specific competence.
2. Plant drawings of this period were not intended to be photographically exact copies of nature. Rather, the draughtsmen of the time consciously applied specific strategies (such as simplifying, schematizing and exaggerating details as well as unrealistically combining several stages of development in the life cycle of a plant) that sometimes rendered their illustrations quite unlike real-life specimens of the depicted species.
3. Copying individual elements from existing illustrations and integrating them in a modified form into a new drawing was common practice in the making of plant images.

[15] Some of the earliest herbals include, e.g., the *Puch der Natur* (1475), the text of which goes back to Konrad von Megenburg, a writer of the Middle Ages, the *Ortus sanitatis* (1491) and the works by Peter Schö er of the 1480s. For more detailed information, see Nissen (1966) as well as Blunt (1994).

[16] Taken from Blunt (1994), p. 124.

[17] Kerner (1786-96), Preface, p. 5. Original German: "Richtige, von einem Kenner verfertigte Abbildungen belehren, entscheiden Zweifel, und gewähren Gewissheit."

[18] See Chapter 8 an explanation of my use of the term "botanical illustration" and the specific genre I am dealing with here.

[19] The findings concerning the design of botanical illustrations peculiar to the eighteenth and early nineteenth centuries and the widespread practice of copying have already been set out in an earlier study in which a large number of examples were presented; see Nickelsen (2000).

4. In view of these findings, the function of botanical illustrations is far from clear.

What remains to be done, is to provide a satisfactory explanation of these findings: Why were the particular methods of design outlined above, and not alternative ones, chosen? And what was the rationale behind the copying technique and the modifications? Answering these questions appears as a promising approach to developing a model of how and why botanical illustrations were optimized within the period under study – which may hold also for other types of scientific images. Assuming that the images' design was the result of a series of conscious decisions between alternative actions from part of the botanist or draughtsman, one might be able to infer from a close analysis of the phenomenon the criteria which steered those decisions. This means that one has to adopt a rather unusual perspective on the images. It is largely undisputed that botanical illustrations formed an essential part of the stock of scientific images of the sixteenth to nineteenth centuries, and that they played an important role in the botany of these periods.[20] The comprehensive discussion of these images by Wilfrid Blunt[21] and Claus Nissen,[22] both originally written and published in the 1950s, are still the standard references. However, although they offer a detailed information base, both Nissen and Blunt concentrate on an art historical analysis of the pictures and their background – Blunt's title, *The Art of Botanical Illustration*, speaks for itself. The same approach was chosen by most subsequent studies of the subject matter – for example, the extensive and well-informed study of the natural history painting tradition of Nuremberg, published by Heidrun Ludwig in 1998.[23]; the contributions to an anthology on *The Natural Sciences and the Arts*, edited by Allan Ellenius; and the various works by Martin Kemp on natural history illustrations.[24] These works, no doubt, have produced valuable insight into the topic; however, it seems worthwhile to complete their point of view by an

[20] For an instructive introduction to the literature on visual representations in the sciences, see the preface to Hentschel & Wittmann (2000) or the detailed review of of Pang (1997). Some recent anthologies and proceedings give an of the many facets of research pursued today, such as Knight (1985), Mazzolini (1993), Chandrasekaran et al. (1995), Baigrie (1996), ?jones:1998 see also the reference lists in the above-cited literature.

[21] First edition: edition: Blunt (1950). Blunt's work has been revised in its fourth edition by W. T. Stearn; see Blunt (1994). Several works by other authors have since been published that closely follow Blunt's approach (even partly in the titles), although they are far less comprehensive and seldom go beyond Blunt's explanations. See, e.g., Bray (1989) or Rix (1981).

[22] First edition Nissen (1951); fifteen years later Nissen published a considerably revised and enlarged second edition; see Nissen (1966).

[23] Ludwig (1998).

[24] See, e.g., Kemp (1990).

analysis of the illustrations from the perspective of the history and philosophy of science.[25]

For doing so, one has to acknowledge that producing these illustrations was a scientifically – not only artistically – demanding activity. Questions arise as to how the actual process of making botanical illustrations can be described; who was responsible for which task – who, after all, guided the decisions relevant for the images' design? Furthermore, how can the content of the images be described in a methodologically consistent way? Establishing the images' subject matter seems prerequisite if one wants to find out not only the reasons but also the scope of possibilities for optimizing this content's representation. Content as well as representation are closely related both to the images' function in eighteenth-century botany – since they had to be designed in a way that served their users needs – and to their visual language, which determines the inventory of graphical means that stood at the botanists and the draughtsmen's disposal. Once these points have been clarified, one then can look again at the copying technique from a more informed perspective and try to give an adequate explanation of the procedure.

There remain many other interesting questions on botanical illustrations that cannot be dealt with in this study. An examination of how the content of pictures changes as botanical knowledge develops is one such example. Almost all the pictures chosen for this study were made within the context of Linnean botany, based on a similar level of knowledge and resting firmly on Linnaeus's so-called sexual system: therefore, the selection does not allow for any systematic comparison of the content of botanical images before the adoption of the Linnean system or after it had been superseded by the natural systems. This apparent restriction, however, renders the sample extremely suited to the purposes pursued here, since there are no changes in theoretical background that would have to be taken into account as a potential influencing factor regarding the design of plant images. Art historical questions on the aesthetic composition of the illustrations, on the drawing techniques or colour mixtures used are not discussed here either. The significance of new manufacturing techniques has also been passed over, although the development of new practices may well have influenced the principles and the content of represented objects. For example, the newly introduced technique of copper engraving had many advantages over the earlier woodcut method, and the spread of lithography in the nineteenth century may also have led to changes.[26] Examining the potential influence of these techniques on the design of plant images can be omitted here, since the sample of plant images chosen for this study was homogenous in this respect: apart from a few exceptions, this study deals

[25] Gill Saunders's history of botanical illustrations takes a serious look at the scientific context of images; see Saunders (1995). However, the volume is only brief, so that it provides a starting point for further studies rather than a comprehensive treatment of the subject.

[26] See the already classic works by Ivins (1953) and Eisenstein (1979).

exclusively with copper engravings. Neither is the influence of new devices or instruments discussed in this study – although one can assume that the inclusion of details in illustrations, for example, was closely connected to the development of new microscopes and magnifying glasses as well as to their increasing acceptance as scientific aids.[27] Furthermore, the original drawings on which the copper engravings were based are also not examined. As a rule, the original drawings contain details that were left out in the engravings, whether consciously or not. This phenomenon deserves closer investigation in order to find out which details were left out and why, or in what other ways the printed version differed from the original sketch. However, scarcely any of the original drawings of the images investigated here have been preserved, making a systematic comparison between original drawing and copperplate impossible.

1.3 The Course of the Argument

Since so far no one has ever described in detail which people were involved in producing eighteenth-century botanical illustrations and how they worked together, Chapter 2 presents a dense reconstruction of the way these images were made. For this purpose I take a look at the circle of botanical draughtsmen and engravers centred around the Nuremberg doctor and botanist Christoph Jacob Trew, one of the most influential editors of eighteenth-century illustrated botanical works, who counted among his employees Georg Dionysius Ehret, one of the most talented botanical draughtsmen of his time. The aim of this case study is to introduce to the reader how these images were designed, who was responsible for which task and what kind of knowledge (technical and other) was used. It transpires that in addition to the botanist himself, the manufacturing of botanical illustrations included one or more draughtsmen, engravers and colourists, who frequently worked together in a book publisher's workshop, as well as the printer, who completed the final product. The botanist played a decisive role, since it was he who selected his employees and, depending on their abilities, personally introduced them to the art of botanical illustrations and strictly controlled every stage of the working process. One is thus confronted with a highly organized process, based on a division of labour and strongly influenced by theoretical ideas in which a large number of sources of information were used – living plants of the species in question were just one of many.

However, after this reconstruction one is left with the question why people felt that this laborious procedure was justified – this painstaking selection of draughtsmen, this educating them first and still controlling their work afterwards, this enormous expense of time and money. What exactly do these

[27] However, Parnes (2000) has argued that the development of technically advanced microscopes was not as central to the emergence of new scientific interests (in, e.g., cells) as one might think.

images represent and why was it represented in this particular way? Does the content account for the elaborated procedure of manufacturing and for the choice of design? How were botanical illustrations able to communicate information on such abstract entities as plant species, and what form took this information? Chapter 3 deals with these questions from a systematical point of view and identifies the typical elements of the content of plant images, which includes taxonomically relevant features of plant species as well as other typical characteristics without taxonomical importance. Both depended very much on the scientific context in which and for which the illustrations were published and on the then predominant botanical theory; identifying the taxonomically relevant features depicted in eighteenth-century images thus requires a thorough look at the Linnean system. On this basis, the question arises how the images' content can be interpreted in a theoretically consistent and productive way – my suggestion is to assume that plant images are representations of scientific models. This interpretation will prove particularly well suited to explaining the specific qualities of the content of eighteenth-century botanical illustrations; and starting from here, one can procede to explain why the specific design was chosen to represent this kind of content.

However, before doing so, another aspect has to be clarified. The mode of representation chosen and the subsequent optimization depended, so one would assume, at least partly on the functions the images were expected to fulfil. These are subjected to an analysis in Chapter 4. The plant images addressed an extremely diverse audience and correspondingly appeared in a wide variety of works, from luxurious, folio-sized coffee-table books for rich enthusiasts to small textbooks for water officials, pharmacists and farmers. The illustrations published in these books, it transpires, were discussed in the private correspondence of individuals as well as during the meetings of scientific societies. Having access to "correct" images was considered so fundamentally important that specialist draughtsmen were engaged, for example, by the academies, whenever this was financially possible. Besides facilitating the classification of unknown plant specimens (the function most frequently assigned to these images in the literature) it is shown that botanical illustrations generally served as comprehensive descriptions in the Linnean sense of the word, which provided their readers with a wealth of information on the species in question. They were also used as evidence of one's own observations and as points of reference in scientific debates, particularly when participating scientists were separated by long distances. In this connection, the relationship between an image and a piece of text arouses some interest, since it is not at all clear why these functions should have been fulfilled by images and not by text, which were far less expensive to produce. The lesser cognitive effort required to understand the information communicated in images is identified as the one essential advantage that illustrations had over text, the significance of which only becomes understandable when one takes into account that the draughtsmen and botanists were primarily trying to meet the needs of their audience. They did not only do their utmost to convey scientifically correct

content; they also tried to communicate this content in a way that was as easy to understand as possible. These questions lead to a closer examination of the visual language of the time in Chapter 5.

Here, a visual language is understood as a system of pictorial elements, which are arranged according to a set of syntactic and semantic rules, so that they could convey the meaning of the image, when viewed as a whole and in sections. This language was far from natural and inevitable but subject to historical conventions and requirements. Selected examples demonstrate that the plant images belong to a long tradition of pictorial expression and reveal which written and unwritten conventions influenced the pictorial design. In this context, I also discuss individual attempts to render this language as clearly and unambiguously as possible, similar to the development of a written technical terminology. These attempts are interpreted to be the result of the aim of the botanists and draughtsmen to make their images as communicable as possible, that is, to communicate its content as unequivocally as possible. The hand-colouring of botanical illustrations as one component of an image's visual language is discussed in particular detail. To communicate precise information on the colours of plant species was extremely problematic in the eighteenth century. At least partly due to this difficulty, colour was taken to be a variable property of species in the Linnean system, and so was denied taxonomic relevance. Thus, botanists adhering to this taxonomic system did not need to include information on colour in their models. Nevertheless, illustrations continued to be hand-coloured. Yet, on closer examination, it becomes clear that the function of colour seems to have been to enhance the communicability of the image and to reduce the cognitive effort required to understand the image. Colour helped to make the content of the plant images easier to understand.

After having established these findings on the manufacturing procedure, content, function and visual language of botanical illustrations, Chapter 6 turns again to the many instances of copying links that were found in a representative selection of images analysed for this study. Within the sample of 137 illustrations, so many were involved in copying networks that it is clear that this procedure could not be taken to be an exception to the rule, a faux pas or due to laziness or lack of talent. Only certain elements were taken and integrated into the new image, and they were frequently simplified, elaborated, schematized, or modified in some other way. Incompetence on the part of the draughtsman, a lack of natural specimens of the species in question, and the wish to produce plant images as quickly and cheaply as possible do not provide a satisfactory explanation to this widespread phenomenon – there rather seems to be an epistemic reason for this carefully and so consciously applied copying procedure. Drawing images of species of plants is not an easy task. All the characteristic properties of a species had to be correctly recorded, including, if possible, the species' different stages of development. Additionally, the draughtsman had to take care to represent the content in a manner that prevented misunderstandings from occurring – the image had to

be communicable. Under these circumstances, starting a work from scratch and relying entirely on one's own capabilities, uninfluenced by traditions and conventions, seems pointless, if not hopeless. As in other scientific activities, it made much more sense to link oneself to and thus derive benefit from the achievements of one's predecessors – by reusing both the approved content as well as the approved means of representation. However, this was not done indiscriminately but with the utmost care. That even the most well-known pictures came in for criticism was shown through the examples of the many different types of modifications carried out to the copied elements in the later illustrations.

These modifications are examined in more detail in Chapter 7. They are not only interesting in themselves; they also hold enormous historiographical importance. As briefly mentioned before, all the modifications were the result of active and conscious decisions taken by the botanists or draughtsmen or both; moreover, the evidence suggests that these amendments were carried out for the purpose of producing an improved representation of the species, that is, one that, from the later botanist's point of view, was better than the earlier illustration. An analysis of these modifications thus offers the unique chance to infer which criteria had been used in terms of the content and design of the images. Three main criteria were identified: the permissibility, the correctness and the appropriateness of an image (with the latter divided into further subcriteria). The permissibility of an image refers to its fundamental ability to depict something that can be consistently understood. The correctness refers to the content of an image and, in the case of plant images, to the models, which have to be true as well as applicable. Finally, the appropriateness of a model refers to the design of the image as regards the means of content and representation. The strategies for optimizing the content of the images following these criteria are identified as being a typical heuristic process for forming models, which have be proven to have been followed up in several other cases in the history of science. The strategies for optimizing the representational means, however, bring a rather new aspect of scientific activity into focus, which until now has largely been ignored in the history and philosophy of science: not only could general criteria be identified to explain the dynamics of the content, so, too, could criteria to explain the construction and modification of the means of representation.

On the whole, it is suggested that the superordinate goal of the whole construction process was to produce an image that was "adequate". An image would be considered adequate if its qualities corresponded closely to the goals of the illustration. However, it was not only up to the individual botanist to define whether an image was adequate or not; the scientific community also had a strong say in this. To be accepted by this community – loosely understood to be a group of contemporaries actively interested in botanical matters – and to be able to fulfil its communicative function, the construction of a botanical image had not only to comply with what the individual botanist regarded as adequate but also had to observe the conventions of

the cooperative network of the science. From this point of view, the practice of copying approved elements and modifying them in a discreet manner not only becomes understandable, it even proves to be a well-founded strategy for accomplishing the intentions of the botanists of the time. The last chapters complete the analysis by providing a comprehensive list of all the background information and sources as well as a description of how the sample of images used in this study was chosen.

2

The Making of Botanical Illustrations

It was a series of lucky coincidences. If the young Johann Ambrosius Beurer had not studied medicine in Nuremberg, had not attended some of the courses on botany with the town physician Christoph Jacob Trew,[1] if the two had not become friends and if Beurer hadn't started his apprenticeship as an apothecary in Regensburg, where he befriended the gardener and flower painter Georg Dionysius Ehret in 1731[2] – things would probably have turned out very differently. Trew would have concentrated on his work as a town physician and on the illustrated anatomical textbook he was editing at the time (which he perhaps would then have completed); Beurer would have led a quiet existence as an apothecary instead of supporting Trew in the latter's laborious negotiations with draughtsmen, engravers and subscribers; while Ehret would, presumably, have remained an itinerant gardener, who, for lack of suitable backing, would never have become one of the world's most renowned botanical draughtsmen.[3]

[1] In 1730 Beurer attended "the botanical and osteological lessons that were regularly given in the spring and summer, [...] and his [Trew's] lectures in neurology and myology, given in the autumn and winter". The original German text reads: "die im Frühjahr und Sommer eingerichteten botanischen und osteologischen Unterrichtsstunden [...] sowie im Herbst und Winter seine [Trews] Vorlesungen in Neurologie und Myologie". See Beurer's autobiographical account, written on the occasion of his election to the German Academy of Naturalists (the Leopoldina), transcribed and published in Gossmann (1966), p. 187.

[2] Beurer wrote that he took daily lessons with Ehret in flower painting, from 7 to 8 o'clock in the morning. The two became friends and consequently went on some excursions together, studying the plants in Regensburg's gardens and surrounding areas. See Beurer's autobiographical account, transcribed in Gossmann (1966), pp. 188f.

[3] On Beurer, see Gossmann (1966), where, as well as his autobiographical account, some of Beurer's correspondence with Trew is reproduced. On Trew, see, e.g., Pirson (1953), Schug (1978), Schnalke (1995c) and Schnalke (1997); on Ehret, see Calmann (1977) and Schnalke (1996).

However, all the events described above did take place. Beurer met Ehret and was so enthusiastic about the gardener's plant drawings that he praised them to the skies in his letters to Trew, particularly Ehret's so-called *Herbarium Vivum*, a collection of about 600 drawings, showing mainly native plant species. It had taken Ehret two years to complete and, as Beurer wrote, "it had become so well-known that many *medici* in *diversis locis* had already seen it and been amazed by it, for it is unsurpassable".[4] And since Beurer knew that Trew was always eager to receive high-quality plant drawings, he sent some examples of Ehret's work to Nuremberg.[5] Trew ordered a few more pictures, finally promising to buy two to three pictures per week from Ehret, at the price of a guilder each.[6] At the same time, he advised Beurer to get across to the draughtsman his own particular demands concerning botanical drawings: "My dear cousin would be so kind as to remind the artist that I attach great importance to everything being drawn true to nature, since I need it not only for decoration but also for practical purposes."[7] The meeting between Beurer and Ehret would have far-reaching consequences: Ehret would become one of the world's best botanical draughtsmen and Trew one of the eighteenth century's most successful authors of illustrated botanical works. A closer examination of the collaboration between the two men may lead one to discover how botanical drawings were made in this period. In the following sections, therefore, Trew and Ehret are described in more detail.

2.1 The Author and his Draughtsmen

2.1.1 Trew and Ehret

Christoph Jacob Trew (1695-1769)

Today, Trew is primarily known as an enthusiastic collector of books, pictures, natural history objects and medical preparations, letters (written by himself,

[4] Original German: "Es sei so sehr renomirt worden, dass schon viele *medici* in *diversis locis* gesehen und es verwundert, dann es ist unverbesserlich." TRWC (Trew Collection). Beurer, J. A. to Trew, No. 23, 5 December 1731. Cited Ludwig (1998), p. 152. The numbering system established in the catalogue, Schmidt-Herrling (1940), to the Trew Collection of the University Library Erlangen (UB Erlangen) has been used for this and all the other letters referred to in this book. Besides containing a list of the complete collection, this excellent catalogue also has a detailed and informative introduction as well as background information on Trew's correspondents. In this study, the author of the letter, the letter's number in the collection and the date on which it was written are given, where possible.

[5] TRWC. Beurer, J. A., No. 22, 26 February 1731.

[6] TRWC. Trew, C. J., No. 34, 17 January 1732.

[7] "Der Herr Vetter sey so gütig und erinnern den Künstler, dass ich gar sehr darauf sehe, dass alles der Natur gemäss komme, dann ich es nicht alleine zur Zierrath, sondern auch zum Nutzen verlange." TRWC. Trew, C. J., No. 33, 22 December 1731. Cited Schnalke (1995b), p. 104.

correspondents and other scientists)[8] as well as the author of a number of eighteenth-century works of botanical literature.[9] Trew was a doctor by profession and worked in Nuremberg as a general practitioner, besides being an active member of the local *Collegium Medicum*, a kind of physicians' guild, and publishing his own medical professional journal as well as the journal of the German Academy of Naturalists (the Leopoldina). Scientific drawings played an important role in his life, especially plant drawings: notwithstanding all his other obligations, Trew gave a large part of his time, energy and attention to the making and publication of plant illustrations. So, it is entirely fitting that, in the portrait of himself included in his masterpiece, the splendid *Plantae Selectae*[10] (fig. 2.1, p. 22), Trew has, open in front of him, a book of plant illustrations.

Trew was born on 26 April 1695 in Lauf, a small town near Nuremberg. He finished his medical studies at the University of Altdorf in 1717, and then went on a three-year journey through Europe. He visited towns in Germany and Switzerland, stayed in Paris for a year, spent some time in the famous university town of Leiden in the Netherlands, and finally travelled north-east to Danzig and Königsberg – today called Gdansk and Kaliningrad – before returning to his hometown in 1720. This journey would prove to be of great importance to Trew, since he kept up a correspondence with many of the physicians, professors and botanists that he met on his travels for the rest of his life. These letters, coming as they did from all parts of Europe, kept Trew informed about what was going on in the scientific world.[11] The medical education he gained by visiting Europe's best anatomical theatres, collections, libraries and botanical gardens was also highly valuable. In 1721, Trew finally settled in Nuremberg as a general practitioner. He was elected to the local *Collegium Medicum* and was soon supervising in this position Nuremberg's *Theatrum Anatomicum* as well as the *Hortus Medicus*. These

[8] The part of Trew's collection to have survived is now held in the UB Erlangen. Trew stipulated in his will of 23 June 1768 that the complete collection should go to the University of Altdorf; after the university was dissolved in 1809, part of the collection was transferred to Erlangen. A facsimile of the will is reproduced in Schnalke (1995c), p. 18. In the will, Trew refers to the following: books, academic arguments, handwriting [presumably, manuscripts], copperplates, painted and dried flowers and herbs as well as dried and "alcohol-preserved natural products" ("in spiritu aufbehaltene naturalien").

[9] See among others, Trew (1750-73), Trew & Blackwell (1750-73), Trew et al. (1750-86) and Trew (1763-84).

[10] Trew (1750-73).

[11] Trew's extensive estate of letters is preserved in the UB Erlangen. A selection of letters from the collection has already been published, such as Trew's correspondence with Albrecht von Haller in Steinke (1999). For an analysis of part of Trew's medical correspondence, see Schnalke (1997).

Fig. 2.1. Christoph Jacob Trew (1695-1769). Copper-engraving by Johann Jacob Haid, reproduced in Trew's *Plantae Selectae*, Vol. 1, 1750.

posts were extremely useful for Trew, as he was able to make extensive use of the two institutions for his own research and public lectures.[12]

From the 1730s, Trew concentrated increasingly on a number of different scientific projects. Together with three Nuremberg colleagues, he founded a new professional journal, the *Commercium Litterarium, ad rei medicae et scientiae naturali incrementum* (Learned Correspondence to the Advancement of Medicine and the Natural Sciences), which became very popular and was widely distributed throughout Europe for the next fifteen years. He also started to publish richly illustrated botanical books, and gave encouragement and support for the publication of numerous other books.[13] In 1744, Trew

[12] According to Schnalke (1995c), p. 12, five announcements of lectures on surgical topics are preserved in Trew's estate dating from the period 1723-1730 (See C. J. Trew: *Amtliche Berichte [. . .], Beilage b-f, 17. März 1723-25, Juli 1730*). Furthermore, two manuscripts survive that provide evidence of his teaching on botany: a *Cursus Botanicus in Horto Explicatus 1721* and an *Introductio in Rem Herbariam Explicata Norimbergae anno 1730* (UB Erlangen, MS, 1915, No. 3).

[13] The number of works to which Trew gave his support is impressive; for details, see Ludwig (1998), pp. 157 .

Fig. 2.2. Georg Dionysius Ehret (1708-1770). Copper-engraving by Johann Jacob Haid, reproduced in Trew's *Plantae Selectae*, Vol. 1, 1750.

was appointed *Director Ephemeridum* of the Leopoldina, and forthwith became responsible for editing the society's journal, the *Acta Physico-Medica*. For twenty years, Trew managed to withstand this heavy workload, but it comes as no surprise to learn that not all his projects were completed; the most prominent failure of all was his ambitious plan for a book on anatomy,[14] but the *Plantae Selectae* were also never completed as planned (for details, see section 2.2 of this chapter, p. 39). Trew died on 18 July 1769, at the age of seventy-four.

Georg Dionysius Ehret (1708-1770)

A portrait of Ehret also features in the *Plantae Selectae*[15] (fig. 2.2, p. 23) – a rare honour for an eighteenth-century botanical draughtsman, even one as highly regarded as Ehret.

[14] A detailed description of the project and its sad end can be found in Schnalke (1995b).
[15] Trew (1750-73).

Ehret was born on 30 January 1708, the son of a Heidelberg gardener.[16] In the autobiographical outline that he wrote for the Leopoldina, Ehret stated that he first learned to draw from his father, who died when Ehret was still very young. During his apprenticeship as a gardener, Ehret managed to pursue his drawing talent and early on chose plants as his subject matter. On finishing his apprenticeship, Ehret went in search of work as an itinerant gardener: in Karlsruhe he worked in the gardens of the margrave Karl III Wilhelm of Baden Durlach, where he met the draughtsman Wilhelm Siewert. Ehret maintained that he had never had any contact with Siewert; however, in 1731 he had told Beurer that he had been trained by a Dutch painter, by whom he possibly meant Siewert.[17] Trew took up this account and referred to Siewert as Ehret's teacher in the preface to the *Plantae Selectae*.[18]

In 1728 Ehret happened to go to Regensburg, where both the apothecary Johann Wilhelm Weinmann and the rich banker Löschenkohl were looking at the time for botanical draughtsmen. Weinmann was working on his *Phytanthoza Iconographia*,[19] a large-format and extensive work in which he wanted to immortalize the plants of his luxuriant garden. Weinmann described his first meeting with Ehret in a letter to Beurer. Having had a quick look at Weinmann's famous collection of botanical illustrations, the twenty-year-old gardener allegedly claimed, "I should do it, and it would be a lot better", whereupon Weinmann, assessing some samples of Ehret's work, employed him on the spot.[20] Ehret was commissioned to produce 1,000 drawings at the (quite modest) rate of fifty talers per annum; and for the next one and a half years he worked for Weinmann, until the two men quarrelled over pay and performance and went their separate ways in 1731,[21] by which point Ehret had apparently completed 500 sheets. For the remaining drawings, Weinmann at first employed another protegé of Trew's, Nicolaus Friedrich Eisenberger, then a glazier, a printer's assistant, and finally, for fifteen months, a certain "Miss

[16] The following details have mainly been taken from Ehret's autobiographical outline, which is preserved in the archives of the Leopoldina, Halle, under the title *Herrn Georg Dionysius Ehret bisherige Lebens-Umstände nach seinem eigenen am 27. Oct. 1758 zugeschickten Entwurf mit einigen Anmerkungen ausgefertigt von Dr. Christoph Jac. Trew.* Ehret wrote this on the occasion of his election to the Academy (upon which he was given the Latin name Aemilius Macer II, after a nature-loving Roman poet). The Halle manuscript is a version of this outline, edited by Trew (as explained in the title). For a transcription, see Kastinger Riley (1996).

[17] TRWC. Beurer, J. A. to Trew, No. 27, 23 January 1732.

[18] Trew (1750-73), Preface, no pagination.

[19] Weinmann (1735-45).

[20] On Ehret in Regensburg, see Schnalke (1996), Kastinger Riley (1996) or Calmann (1977). The quotation is taken from J. W. Weinmann's letter to Beurer, dated 18 February 1739, TRWC. A facsimile of the letter is transcribed and reproduced in Schincke (1962), pp. 163 . Original German: "Das solte ich mahlen, es solte weit besser werden."

[21] For details, see Nissen (1966), pp. 164f., and Calmann (1977), p. 16.

Asam", of whom nothing further is known except that she did her work "in a skilful and delicate manner" – at least, according to Weinmann.[22]

After the rather unpleasant ending to this episode, Ehret went to work for Löschenkohl. His commission was to draw the plants of another Regensburg garden. Additionally, he was to colour by hand more than 800 plates of Löschenkohl's copy of the twelve-volume *Hortus Malabaricus*, a flora of Indian plants published in the late seventeenth century.[23] Ehret is reported to have worked for Löschenkohl for five years but, by the end of this period, had only completed the first three volumes of the work. Incidentally, it is far from clear which criteria Ehret used to hand-colour these plates. Did he work according to the scant information there was on colour in the text? Did he proceed according to Löschenkohl's directions or did he follow his own aesthetic judgment? Did Ehret use living specimens as a source of information? The hand-colouring of scientific plant drawings was a complicated business and confronted eighteenth-century authors and draughtsmen with considerable problems. I shall attend to this in greater detail later in this chapter and also in Chapter 5.

It was in 1731, when Ehret was still working for Löschenkohl, that he met the young apothecary Beurer. From that point on, Ehret began working for Trew on a regular basis and for the rest of his life sent his mentor drawings. Trew and Ehret met only once in person, in 1733, after Ehret, frustrated with the dull and endless work he had been doing for Löschenkohl, had resigned from his job and gone travelling again. After a visit to Nuremberg, during which he met Trew, and stays in Switzerland and France, Ehret reached the Netherlands, where he met the young Swedish botanist Carl Linnaeus, of whom – with the exception perhaps of the botanist himself – few suspected the eminence he would reach in his field. Linnaeus was then preparing a garden inventory for the banker George Cliffort, in which he put the practicality of his newly developed sexual system to the test for the first time. Ehret and Linnaeus started to work together (among other things, Ehret drew the illustrations for Linnaeus's *Hortus Cliffortianus*),[24] and they continued to exchange letters for the rest of their lives.

In 1736 Ehret reached England, where he settled until his death. He continued to work as a draughtsman of plants, gradually becoming one of the most sought-after illustrators of botanical literature; among other things he drew many plates for the Royal Society's renowned *Philosophical Transactions*. Ehret also published his own material,[25] and his reputation within the British and international scientific community increased. And so, the former

[22] In German, Weinmann wrote of a "Jungfer Asamin", who "gar künstlich und zart mahlte". See Weinmann's letter to Beurer from 18 February 1739; cited Schincke (1962), p. 164. Eisenberger mentions Weinmann employing a glazier and a printer in a letter to Trew, dated 9 January 1737.

[23] Rheede & Casearius (1678-1703).

[24] Linnaeus (1737e).

[25] See, e.g., Ehret (1748-62).

gardener was finally elected member to a number of learned societies and academies in whose journals he regularly published independent articles.[26] In his later years, Ehret's scientific activity declined, and he gave classes in drawing and botany to the aristocracy. He died in 1770.

2.1.2 First Assignments

As previously mentioned, Trew learned about Ehret's work through Beurer and, like Beurer, he was exceptionally pleased with the itinerant gardener's illustrations – so pleased, in fact, that Trew promised to buy them on a regular basis. However, at the same time Trew asked Beurer to inform his new employee of some specific requirements, since he wanted pictures that were not only attractive but also useful, as Trew explained in the letter quoted in the introduction to this chapter (p. 20). In his next letter to Beurer Trew explained his demands in more detail:

> As to the background, I will leave this to the judgment of the artist, although I am of the opinion that, when it comes to plants with pale green leaves or white flowers, a browner background would make the picture clearer. In any case, I would plead once more for nature to be expressed as clearly as possible and, whenever possible, for the fruit and seeds to be added. As to the plant species, I am admittedly more interested in foreign than in native ones, although I would also accept the latter, primarily when the former are not available. There should be no more than one single plant per sheet of paper, and, when it is small, it should be placed right in the centre of the page. However, if there are some species of small plants which only di er in the colour of the flowers, for example, the violet, *Bellis hortensis* etc., one of them can be placed on the top half of the sheet and the other on the bottom, and they would be paid, nonetheless, as two items. I do not want, however, two plants intertwined with one another, as in some of the already drawn images of *Papaveribus* and *Caryophyllis*.[27] Painted in this way, I would accept at least two items weekly and, as previously agreed, would always pay the same amount.[28]

[26] Articles by Ehret can be found in the journal of the Leopoldina, in the *Transactions* of the Royal Society as well as in the *Linnean Society Proceedings*. For details, see Calmann (1977).

[27] Poppies and carnations.

[28] TRWC. Trew, C. J., No. 35, 16 February 1732. Cited Ludwig (1998), p. 153. Original German: "Was den [Hinter-]Grund anlanget, stelle ich solches dem urtheil dess Herrn Künstlers anheim, doch hielte ich meines Theils davor, dass bey denen jenigen Gewächsen, welche bleichgrüne Blätter oder eine weisse Blume haben, ein brauner Grund das Gemählde deutlicher machen sollte. Bey allen aber will nochmals gebetten haben, die Natur auf das deutlichste zu exprimiren, und, wo es möglich, jedes mal die Frucht oder den Saamen beyzusezen. Was die Gewächse anlanget, so sehe ich freylich mehr auf die frembden als auf die einheimischen, doch will ich auch solche, sonderlich in Ermangelung der andern, annehmen. Auf jedes Blat soll nicht mehr als eine einzige Pflanze zustehen kommen, und, wann

Trew not only had very set ideas of what a picture should look like if it were to satisfy his demands, he was also very clear on the different roles of the draughtsman and the botanist. Purely aesthetic questions, such as the design of the background, Trew left largely to Ehret's discretion, merely proposing that a contrasting colour would make the illustration clearer. The way the plant was represented, however, was entirely up to the botanist: details of the fruit and seeds had to be integrated, since they revealed the essential characters of the species. Furthermore, each species was to be drawn on an individual sheet of paper; only when there were just variations in the colour of the flowers was it acceptable to place two small plants together.[29] Even in this case, though, the plants should be drawn separately, probably in order to present the morphology of the individual variants as clearly as possible. Plants decoratively intertwined with one another were unacceptable, although this was a popular method of composition in the eighteenth century and one which Ehret used at times. A little later Ehret delivered an illustration in which he had drawn the two sexes of a plant on one sheet, upon which Trew advised him

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es klein, unten herunter in die Mitte gesezet werden. Gäbe es aber von solchen kleinen Gewächsen einige species, die nur in der Farbe der Blume variierten, e.gr. bey dem Merzen Veil, *Bellide hortensi* &c:, so könnte eines oben und das andere unten auf ein Blat gesezet werden, und sollen gleichwohl vor 2 bezahlet werden. Zwey aber ineinander gewunden, wie in dem schon Gemahlten bey einigen *Papaveribus* und *Caryophyllis* vorkommt, wollte ich vor mich nicht gerne haben. Auf solche Weise nun gemahlet will ich, wie vormahls schon gedacht, wöchentlich wenigstens 2 Stücke annehmen und allezeit gleich bezahlen." This letter answers a question that Ehret had asked using Beurer as intermediary, that is,"whether the species should be *exotica* or *vulgarissima*" ("ob solche *exotica* oder *vulgarissima* seyn sollen") and "whether Your Excellency wanted some of them to be drawn against a dark background, since although this artist learned to draw and paint with a famous Dutchman, and therefore is able to do both against a white and a brown background, he regards it as better and more artistic to represent a flower against a white background. But if Your Excellency wishes to see some examples of his set against a brown background, then Mr. Hirschmann in Nuremberg, a painter on the Bohnersberg, has a flower painting of his." ("ob dann auf braunem Grund euer Exzellenz auch einige zu mahlen verlangen, dann ob zwar dieser Mahler das Zeichnen und Mahlen von einem berühmten Holländer erlernet und demnach beydes sowohl auf braunem als weissen Grund kan, so hält er es doch vor besser und künstlicher, eine Blume auf weissen Grund recht darzustellen als auf jenem. Doch wann euer Excellenz etwas von ihm auf braunem Grund zu sehen belieben, so hat in Nürnberg Herr Hirschmann, Mahler auf dem Bohnersberg, ein Blumen-Stück von ihm.") See TRWC. Beurer, J. A. to Trew, No. 27, 23 January 1732. Cited Ludwig (1998), p. 153. The "famous Dutchman" is perhaps Wilhelm Siewert, mentioned earlier in this chapter.

[29] The stipulation that the species be done on single sheets of paper o ered the advantage that one could then place them in any collection system, either according to a taxonomy or to other criteria.

to let him know in future "if two should come on one single sheet", presumably so that he could raise objections if necessary.[30]

Trew had the instructions quoted above transmitted to Ehret at the start of their collaboration, even without having been further informed of his new employee's proficiencies – obviously, Trew took it for granted that a newly employed draughtsman needed to be thoroughly introduced to the making of botanical illustrations, and he made it clear from the onset that he, the botanist, and no one else, was to determine how this should be done. The way it was finally done will be dealt with shortly by reconstructing Trew's working practices. For the moment, however, I shall turn my focus from the images of plants to the images of another subject. When Trew first got to hear about Ehret, he had yet to publish any botanical illustrations; Trew had, however, started working on a richly illustrated anatomical textbook. And it was during this first collaboration with draughtsmen and engravers that, in his role as author, Trew first exercised his requirements on scientific illustrations, which makes a brief look at this undertaking worthwhile, even if the findings cannot be transferred in every sense to Trew's later botanical works.

2.1.3 The Anatomical Work

Trew gave a number of lectures in Nuremberg, particularly in the 1720s: in the summer he used the official *Hortus Medicus* and his own garden to give introductory courses in botany, and in the winter he gave anatomy courses in the *Theatrum Anatomicum*. These events were open to a wide audience. Trew was not a professor of medicine but gave these courses in his capacity as a member of Nuremberg's *Collegium Medicum*, which, among other things, organized and controlled the education of local surgeons and midwives. Trew's courses were also open to interested graduates of the local Academy of Arts: the draughtsman Eisenberger and the engraver Georg Lichtensteger, for example, enrolled in Trew's course in osteology in the winter of 1726/27.[31] For Trew, meeting these two figures was a stroke of luck – he would get both of them to work on his ambitious, richly illustrated and comprehensive anatomical textbook. The whole venture and its sad end has been described in detail by the historian of medicine Thomas Schnalke[32]; therefore, I shall concentrate on the general manufacturing process of the plates.

Trew undertook this project with the professed aim of explaining the principles of human anatomy to a broad public. The first announcement and

[30] TRWC. Trew, C. J. to Beurer, No. 38, 21 June 1732. Original German: "wann 2 auf ein blat kommen sollen".

[31] TRWC. Trew, C. J.: *Amtliche Berichte [. . .], Beilage e*. Reproduced in facsimile in Schnalke (1995a), p. 55. On the circle of draughtsmen, engravers and others around Trew, see Mann (1964) and Ludwig (1998), pp. 157 . For further information on the two artists mentioned in the text, see Vol. 9/10, p. 432 (for Eisenberger) and Vol. 23/24, p. 192 (for Lichtensteger) in Thieme & Becker (1992).

[32] See Schnalke (1995b).

advertisement for the work appeared in a leaflet in which the addressees were not only those "who have a duty to keep people in good health", that is, those working in the medical profession, but also those "who want to present through artistic means all the beauty of the human body that nature has made visible".[33] Painters, draughtsmen and engravers, so one can interpret this passage, should learn more about the structure of the human body "than what is only revealed externally".[34] So, Trew intended his anatomical textbook to serve, among other things, as an introduction for artists to the scientific background of their work – perhaps he also foresaw using this work for his own lectures. In the leaflet, Trew's general goal "to serve the public" ("dem Publico zu dienen") clearly emerges; since he repeated this phrase in many letters and documents, one could consider this the basic principle running through all of Trew's work.[35] The more specific goals formulated here also reveal something about Trew's expectations of a good draughtsman: he believed, for example, that some technical knowledge of the subject matter was an essential precondition for making a good picture, and his textbook was to contribute to providing this knowledge.

As Trew explained in his leaflet, the best way to teach was to give a demonstration of the subject under consideration. However, not everyone was able to attend such demonstrations; furthermore, people were forgetful and usually required extra tuition in a set and written form: for this reason, there were books in which "a clear description and, at the same time, an illustration close to nature"[36] replaced lessons at the dissecting table. Unfortunately, Trew admonished, text and illustrations "up to this day have not always been represented with the same industriousness."[37] The illustrations, in particular, left a lot to be desired:

> Most show neither art nor nature. In some, the artist has admittedly put in some e ort but has observed little from nature; in others, the natural presentation has been defiled by artistic means; through which in all of them a false impression has been given.[38]

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[33] Trew (1733). In the original, the quotes read that Trew was not only aiming at those "welche die Sorge haben den Menschen bey seiner Gesundheit zu erhalten", but also for those, "welche durch die Kunst das an dem Menschlichen Cörper vorstellen wollen, was die Natur von ihrer Schönheit sichtbahr gemachet hat". A facsimile of the first page of this leaflet is reproduced in Schnalke (1995b), p. 239. All further quotations within this section that have no individual sources originate from this leaflet.

[34] Original German: "als was nur an denen äusserlichen Decken deutlich sich o enbahret".

[35] See on this principle Schnalke (1995a).

[36] Original German: "eine deutliche Beschreibung und zugleich eine der Natur ähnliche Abbildung".

[37] Original German: "biss anhero nicht mit gleichem Fleisse vorgestellet worden".

[38] Trew (1733). Original German: "Die meisten zeugen weder von der Kunst, noch von der Natur. Bey wenigen hat zwar der Künstler seinen Fleiss angewendet, aber

In the eighteenth century, producing high-quality botanical illustrations was extremely expensive, and the salaries for talented draughtsmen contributed greatly to this cost. According to Trew, many authors avoided this expenditure by employing poorly qualified staff – one of the obvious reasons for the often unsatisfactory results, as Trew saw it. But it was not only the talent of the draughtsman that had a bearing on the quality of an illustration, Trew explained, but also the skill of the author. He believed that in order to produce a high-quality illustrated scientific work the author had to know his subject as well as have some expertise in drawing:

> so that he [the author] knows how to instruct the artists [...] as to what to represent, for which he, in particular, has to be able to judge the likeness so that the appealing elements so popular with artists do not diminish the clarity.[39]

As for himself, Trew was confident that he was the right person to carry out such a project – he was skilled in both anatomy and drawing.[40]

Some of the remarks in the two quotes above strike one as strange. What does Trew mean when he claims that most illustrations "show neither art nor nature"? What does he mean by "likeness", and why does he think that some expertise in drawing is necessary for the author to be able to judge an illustration? One would think that a sharp eye, combined perhaps with some knowledge of the subject, would suffice for a person to determine whether a drawing resembled an object or not. Trew would obviously have disagreed. Furthermore, he asks that the artist avoid inserting any "appealing" elements, since they might diminish the drawing's "clarity". What is it that Trew wanted to show so clearly that would suffer so much by the addition of decorative refinements? Trew's criteria for what constitutes a good scientific illustration need to be interpreted. But this much should be clear by now: a scientific illustration could not meet Trew's quality requirements if it were produced by a single person. From his point of view, the draughtsman and the scientist had to collaborate closely for a project to be successful.

These, then, were Trew's high and noble aims on starting his anatomical textbook, supported by Eisenberger and Lichtensteger. This massive work was to consist of an extensive treatment of all the bones, muscles, tendons and nerves of the human body, all illustrated in large format. Eisenberger and Lichtensteger considered themselves fortunate, since their employment

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die Natur wenig beobachtet, oder es ist die natürliche Vorstellung durch die Kunst geschändet, bey allen aber dadurch ein falscher Eindruck verursachet worden."

[39] Trew (1733), cited Schnalke (1995a), p. 58. Original German: "damit er die Künstler anzuweisen wisse [...], was eigentlich vorzustellen seye, um welches willen er auch sonderlich die Aehnlichkeit wohl muss beurtheilen können, damit nicht die denen Künstlern beliebte Annehmlichkeit der Deutlichkeit etwas benehme."

[40] Examples of anatomical sketches by Trew are reproduced in Schnalke (1995c), p. 61 and p. 182. At least in this regard Trew's confident assessment of himself was not unfounded.

seemed secure for years to come. They immediately got down to work, so that the first plates could be printed at the same time as the text. However, they received no further word from Trew, and the project dragged on over many years without much noticeable progress. Eisenberger and Lichtensteger urged their employer to continue the venture, once so enthusiastically started, in which both of them had invested considerable time and effort.[41] Only seven years after the first announcement of the anatomical work did the first volume of the textbook, dealing with the bones of the skull, appear in print; no one at that time knew that this volume would be the only one to be published.

In his preface to the volume, Trew referred in detail to the making of the plates, describing the procedure as follows:

> First, I placed the items to be depicted in such a way that everything which had to be noted was visible; second, the painter made an outline of it; third, I examined the outline against the specimen; fourth, the painter completed the drawing; fifth, I held the completed drawing against the specimen again; sixth, the painter and I re-examined the copperplate against the drawing.[42]

Although Trew's description would have been written after the plates had been manufactured and might not accurately represent what had actually taken place, one can still get an impression of the different roles of the participants: and one finds that it was not the draughtsman but the author of the work who had the most important role! According to Trew, the author not only selected the objects to be depicted, he also arranged them in the way he thought best. Then, he presumably gave detailed instructions to the draughtsman as to how to represent every structure, finally minutely checking the execution of every stage of the working process. In addition, one should bear in mind that Trew had previously instructed the draughtsman and engraver in anatomy, precisely in order to prepare them for this kind of work. Incidentally, it is quite remarkable how every stage of the working process corresponds so exactly to what Trew had set out as the role of the author of illustrated works in his leaflet: from his point of view, the author was in charge. He was responsible not only for the text but also for the pictures; and therefore it was only right and proper to demand that the author should be knowledgeable in the field of anatomy or botany as well as know how to draw the scientific objects in question. Although the contributions of the

[41] See the correspondence of Eisenberger and Lichtensteger with Trew in the Trew Collection, TRWC.

[42] Trew (1740), Preface, paragraph 13. Original German: "Erstlich habe ich das, was abgebildet werden sollte, in dasjenige Lager gebracht, wodurch alles, was anzumerken war, in Vorschein käme; Zweytens hat der Mahler darnach den Umriss gemacht; Drittens habe ich den Umriss nach dem Muster untersuchet; Viertens hat der Mahler die Zeichnung völlig ausgearbeitet; Fünftens habe ich die ausgearbeitete Zeichnung wiederum gegen das Muster gehalten; Sechstens haben der Mahler und ich den Kupferstich wiederum nach der Zeichnung untersuchet."

draughtsmen and engravers were certainly important, there was little scope for them to make any decisions of their own.

The same method of working can be seen in the botanical drawings carried out for Trew, and in the works edited by other authors one finds similar principles: authors tried to have as much control as possible in the making of the illustrations. The supervision of employees and correcting the drawings and page proofs took up a large proportion of the time spent on the production of such a work. Frequently, authors would prefer an aesthetically inferior drawing to an incorrect one – and therefore often reached for brush and burin themselves. Many drawings of the *Selectarum Stirpium Americanarum*, to name only one example, were done by Nikolaus Joseph Jacquin himself, while Johann Jakob Dillenius as well as the less well-known Johann Daniel Leers even executed the engravings themselves.[43] In examining Trew's practice of publishing illustrated works, one should bear in mind that the circumstances in which he worked were extremely favourable: Trew had the financial and institutional means not only to train his draughtsmen but also to employ them in the long term, which meant that they could get used to his requirements and that Trew, in turn, knew what he could expect of them. Few eighteenth-century botanists were in such a position and could exploit the advantages of a collaborative method of working to the same extent. Not least on account of their long-standing and intensively supervised training, the draughtsmen and engravers working for Trew were highly sought after in Europe, as will be shown later on.

2.1.4 The Instruction of the Draughtsmen

Both Eisenberger and Lichtensteger were studying at the Nuremberg Academy of Arts, that is, both of them were qualified academic draughtsmen. However, not all the artists involved in botanical or more generally scientific drawing underwent a formal education. Ehret, for example, never saw a drawing academy from the inside, and the same applies to the Bauer brothers, Franz and Ferdinand, who also became famous for their botanical drawings.[44] Ehret and the Bauer brothers had first been taught to draw by friends or family members, and had then been lucky enough to find a botanist to introduce them to the special features of scientific illustrations: Trew and Linnaeus took on the botanical instruction of Ehret, while Jacquin and later Joseph Banks and John Sibthorp instructed Franz and Ferdinand Bauer. Other draughtsmen were trained in workshops; and, as previously mentioned, even botanists with no broad artistic knowledge occasionally illustrated their own works.

[43] See Leers's preface to his *Flora Herbornensis* in Leers (1775) and Dillenius's preface to the *Hortus Elthamensis* in Dillenius (1732).

[44] On the two Bauer brothers, see the extensive studies Lack (2000) and Lack & Mabberley (1999); on Ferdinand Bauer, in particular, see also Norst (1989). Further references can be found therein.

Studying at an academy of arts, it seems, was not a necessary precondition for becoming a successful botanical draughtsman; it provided, nonetheless, a possible entrance ticket, especially in Nuremberg.

However, there was a lot more to making high-quality botanical illustrations than simply knowing how to draw – otherwise the circle of artists engaged would not have been so restricted: in the eighteenth-century world of plant illustrations, the same small number of draughtsmen working in different locations crops up again and again. The particular conventions of scientific drawing were part of the additional knowledge that draughtsmen were expected to acquire; plants intertwined with each other, for example, were unacceptable. But an aspiring draughtsman of botanical illustrations had to learn more than that, as, for example, Ehret discovered when he met Trew in 1733. In Ehret's autobiographical outline, transcribed by Trew, this meeting was described as follows:

> Here [in Nuremberg] he [Ehret] stuck around for a few days and made a few paintings of plants, which were then flowering in my private garden, on which occasion I told him which parts of a flower and fruit should be presented particularly clearly so that the characters of its genus could be clearly recognized, upon which he became even more eager to continue painting plants.[45]

So, the botanist not only had to teach his draughtsmen how to design a scientifically usable drawing, he also had to givem them an introduction to botanical theory. Even Ehret, who, as a gardener, would have been more familiar with plants and their organs than most academic artists, had to improve his knowledge in this respect. Among other things, Trew explained to Ehret the details of flower morphology, which was to gain enormous taxonomic relevance once Linnaeus's sexual system became established. In a way, though, it is rather surprising that Trew instructed Ehret in botanical theory, for he could have relied on the draughtsman's well-known talent for drawing exactly from nature. However, Linnaeus was also not completely satisfied with Ehret's work when he met him in 1735 on George Cliffort's estate in the Netherlands. Johann Beckmann, a contemporary of Linnaeus, described the collaboration between draughtsman and botanist in the (published) notes of his *Swedish Journey*:

> [Linneaus] talked Cli ort into engaging Ehret to paint the flowers required for the *Hortus Cliffortianus*. He did so, but initially did not want the

[45] *Herrn Georg Dionysius Ehret bisherige Lebens-Umstände* [...], no pagination. The transcript of this text was taken from Kastinger Riley (1996); this paragraph appears on p. 520. Original German: "Hier [in Nürnberg] hielt Er [Ehret] sich einige Tage auf und verfertigte etliche Gemählde von Pflanzen, die damals in meinem Hauss-Garten blühten, bey welcher Gelegenheit ich Ihm einige Anweisung gab, welche Theile einer Blüthe und Frucht besonders deutlich müssten vorgestellet werden, um seine Geschlechter-Zeichen daraus ersehen zu können, worauf Er desto begieriger wurde, in Mahlung der Gewächse fortzufahren."

> stamina, pistils and other small details to be included, since he thought they would spoil the look of the drawings; in the meantime, however, he let himself be persuaded, and then he liked the work so much that he even wanted the tiniest and most unnecessary details to be noted down.[46]

Ehret's botanical knowledge was perfected still further, it seems, by Linnaeus, particularly with regard to the organs of flowers. Trew and Linnaeus allegedly quarrelled over whom had the greater influence on Ehret; for the purposes of this study, it should suffice that both men believed that a botanical draughtsman needed some technical knowledge in order to make good illustrations. And both sacrificed much time and effort putting this conviction into practice and imparting some of their botanical knowledge to the ambitious gardener.

In this Ehret was no exception. When, for example, Trew set out to publish a new edition of the *Herbarium Blackwellianum* and engaged Eisenberger for the project, he gave him a similar introduction to botany.[47] Beyond this direct introduction, copying earlier illustrations played a central part in Trew's training strategy. It has been attested for almost all the draughtsmen working around Trew that they drew copies of other illustrations. Andreas Ignazius Mayr, for example, one of the first draughtsmen to work for Trew, was asked to copy Ehret's florilegium, which the artist had shown to interested parties in Regensburg.[48] Many copies of other illustrations by Ehret are also preserved in Trew's estate, some executed by Eisenberger.[49]

By borrowing the originals of botanist friends and having them copied by his employees, Trew was able to enlarge his own collection. But this was not the only purpose of copying: in the eighteenth century, copying older, high-quality illustrations was standard teaching practice in art academies and workshops, and was something that at least some of the draughtsmen working for Trew were familiar with. As drawing manuals regularly maintained, copying helped educate an artist's "visual judgment", "manual skills" and "good

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[46] Fries (1911), p. 118. I am grateful to Professor Dr. G. Wagenitz (Göttingen) for pointing out this book to me. Original German: "[Linné] beredete Cli ort, dass er Ehret bedung, die zu dem *Horto Cliffortiano* nöthigen Blumen zu mahlen. Er that solches, wolte aber durchaus nicht anfänglich die stamina, pistilla und andern kleinen Theile mit mahlen, weil er meynte, solche verunzierten die Zeichnungen; inzwischen liess er sich doch endlich bereden, und da gefiehl ihm diese Arbeit selbst so sehr, dass er hernach auch die geringsten und unnöthigsten Kleinigkeiten bemerken wolte."

[47] Trew & Blackwell (1750-73); Vol. 1, Preface.

[48] Schnalke (1995a), p. 108; Ludwig (1998), p. 205. Beurer referred to this florilegium in his first enthusiastic remarks on Ehret's skills. See the quotation at the beginning of the chapter on p. 20. After having it copied, Trew sold the original florilegium to his colleague Johann Wilhelm Widmann. See Schnalke (1995b), p. 306.

[49] Eisenberger also copied some images of the contemporary Nuremberg painter, Barbara Regina Dietzsch. An example is reproduced in Ludwig (1998), p. 160.

taste"; in short, it taught the apprentices the common conventions of the genre.[50] The widespread use of copying in botanical illustrations was possibly influenced by this teaching practice.[51]

2.1.5 Nuremberg as *Pflanz Schule*

Trew's influence on eighteenth-century botanical illustrations was so great that it is difficult to appraise it fully. In addition to the works he edited, he also initiated and often supervised numerous other projects, mostly carried out by draughtsmen that he had trained. Partly because of these activities, Nuremberg became to be known as a centre of botanical illustrations – and of natural history illustrations in general – the protagonists of which worked all over Europe. This was, of course, not only due to Trew's activities but also to the extremely favourable conditions in Nuremberg at that time for producing illustrated scientific works. At the beginning of the eighteenth century, the Nuremberg Academy of Arts had been turned into a public educational institution, which guaranteed a regular supply of newly and well-qualified artists looking for work. [52] But even in prosperous Nuremberg, the demand for portraits, still-lifes and other pieces of fine art was not limitless; the moving in of foreign artists looking for commissions from the wealthy middle class intensified the competition still further. Therefore, many draughtsmen and engravers looked for fields of activity outside the fine arts, and for some natural history illustrations offered a welcome market niche. Furthermore, thanks to Nuremberg's long tradition of book-making, a large number of experienced publishers, well-trained engravers, printers, colourists and bookbinders were at hand.[53]

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[50] On the education of eighteenth-century draughtsmen, see, e.g., Pevsner (1986), Dickel (1987) or Rümelin (1996).

[51] See Nickelsen (2000), Chapter V, as well as Chapter 6 of this book.

[52] The restructuring of the Nuremberg Academy of Arts was launched on 14/15 December 1704 when the Academy's council o cially released its new statutes. From this point onwards, the Academy o ered an academic course in fine arts – a training that hitherto had been strictly regularized by the guild-like organization of this craft in Nuremberg and could only be attained through an apprenticeship in an approved workshop. Only in 1713 was this old order of the guild completely abolished, and painting became considered a liberal art. See Ludwig (1998), pp. 105 . and Schwemmer (1973), pp. 234 . See Tacke (2001) for facsimile editions (and their instructive explanation) of the rules that regulated the craft of painting in Nuremberg from the sixteenth to eighteenth centuries, set out in Nuremberg's so-called *Malerzunftbücher* (painters' guild books). Dackerman (2003a), pp. 19 ., describes the trade of the *Briefmaler* and *Illuministen* in sixteenth- and seventeenth-century Nuremberg, tracing the activities of the Mack family as a case study.

[53] See Nissen (1966), pp. 167 . For more comprehensive accounts of eighteenth-century book illustrations and related crafts in Nuremberg, see Grosswald (1912), Lanckoronska & Oehler (1932) and Schwemmer (1973).

Like the draughtsmen, some of the people qualified in these other professions also chose to specialize in scientific works, so that many natural history books were commissioned by specific publishers and engravers in Nuremberg, for example, by Johann Michael Seligmann and his heirs, Georg Wolfgang Knorr, Adam Ludwig Wirsing or Augustin Christian Fleischmann. Few publishers, however, could afford to restrict themselves exclusively to works on natural history, since these books were usually not very profitable, to put it mildly; at times, the multi-volumed and poor-selling scientific books almost ruined publishers.[54] Scientific draughtsmen also often worked in other fields. It is known, for example, that, when his project with Trew stagnated, Eisenberger journeyed to North Germany, where he was "so lucky as to do portraits of mostly people of the higher classes", which presumably gave him some money to live on.[55]

It was in this artistically productive environment that Trew demonstrated his abilities as a physician, botanist, art teacher, author and mentor of scientific illustrated works. For his botanical work alone, a whole circle of draughtsmen was employed by Trew, some more talented than others.[56] Best documented, however, is Trew's close collaboration with Ehret and Eisenberger. At the same time Magnus Melchior Payerlein and Georg Wilhelm Baurenfeind were also working for Trew. While very little is known about Payerlein, Baurenfeind gained renown primarily for having participated as a draughtsman in the expedition to Arabia under the leadership of Carsten Niebuhr, during which all the expedition members, with the exception of Niebuhr, died.[57] Payerlein and Baurenfeind were succeeded by Johann Christoph Keller, one of the most talented draughtsmen working in Trew's circle and whom Trew recommended to Casimir Christoph Schmidel for his *Icones Plantarum*.[58] Keller's drawing of a grapevine has been included in the picture selection of this study as have his microscopic plates, which were commissioned by Wilhelm Friedrich Freiherr von Gleichen (known as Russworm).[59] Keller was also employed by Carl Christoph Oelhafen to do the

[54] On this point, see the detailed account in Johns (1998) on the production and sale of scientific works in London from the sixteenth to eighteenth centuries.

[55] See Eisenberger's autobiography, written for G. A. Will's *Nürnbergisches Gelehrten-Lexicon*; the manuscript is preserved in Nuremberg's town library, see shelf mark Will III, 43, 2. Cited Ludwig (1998), p. 158.

[56] Trew gave a short list of the draughtsmen working for him in the preface to his *Plantae Selectae*; see Trew (1750-73). A detailed summary of the circle around Trew with short biographies of many of those involved can be found in Ludwig (1998), pp. 157 . For further details, see the comprehensive biographical dictionary on artists, Thieme & Becker (1992).

[57] See Niebuhr's descriptions of his travels in Niebuhr (1772) and Niebuhr (1774-78). On the expedition, see the classic account in Hansen (1964) and, more recently published, Wiesehöfer & Conermann (2002).

[58] Schmidel & Keller (1762-97).

[59] Gleichen (1777).

illustrations for the German translation of a work on forestry originally written in French by Henri Louis Duhamel du Monceau.[60] Martin Rössler was another draughtsman who worked for some time for Trew, before being wooed away to the royal botanical gardens in Copenhagen in 1755:[61] he was one of the first botanical draughtsmen that Georg Christian Oeder engaged for the prestigious Danish project, the lavish *Flora Danica*.[62]

Oeder did not visit Nuremberg by chance when looking for suitable draughtsmen and engravers for his project; rather, he thought it more probable that he would find suitably qualified employees in Nuremberg than anywhere else. He announced his visit on 2 December 1754 and asked Trew whether he could:

> with advice from the director [of the Nuremberg Academy of Arts] Mr. Preissler look around for a good man – well-mannered and obedient – who would be able to draw plants from nature competently, using ink and colours and based on good drawing principles.[63]

He "had always been of the opinion [. . .] that it would be easiest [to find] a competent person in Nuremberg, [it] being such a good *Pflanz Schule* [literally, plant school]".[64] Shortly before, Oeder had tried to engage Ehret as director of the botanical gardens that had recently been established in Copenhagen under the patronage of the Danish king – possibly with the ulterior motive of getting Ehret to work for him as a draughtsman as well. Having sought advice from the British naturalist John Ellis, however, Ehret had declined this offer[65] – just as he had turned down Linnaeus in 1747, when the latter had asked him to work for him as a draughtsman in Uppsala, Sweden.[66] In Nuremberg, Oeder's high hopes were not disappointed. He not only engaged Martin Rössler to work for him as a plant draughtsman, he also recruited the latter's father, Michael Rössler, as an engraver for the *Flora Danica*. And these

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[60] Duhamel du Monceau & Oelhafen (1762). It is not known whether Keller also executed the engravings in this work that were copied from a book published earlier by Joseph Pitton de Tournefort.

[61] See Schnalke (1995a), p. 112.

[62] Oeder (1766-1883).

[63] Original German: "[. . .] sich mit zurathe ziehung des Herrn Director Preisslers nach einem guten Menschen umzusehen, der bey guten Sitten und einer folgsamen Gemüths Art, Pflanzen nach der Natur, mit Tusch und Farben, nach guten Zeichnungs gründen, mit einiger Fertigkeit mahlen kann."

[64] TRWC. Oeder, G. C. to Trew, No. 1, 2 December 1754. Cited Ludwig (1998), p. 164. Original German: "[Er sei] allezeit der Meynung gewesen [. . .], in Nürnberg, als einer guten Pflanz Schule, am leichtesten einen tüchtigen Menschen zu finden". In another letter dated 4 July 1755, Oeder thanks Trew for the kind reception he was given in Nuremberg. See TRWC, Oeder, G. C. to Trew, No. 6.

[65] See Calmann (1977), p. 81. See also in the Linnean Society's *Proceedings*, Nov. 1883-June 1886, *Short Memoir of G. D. Ehret*, p. 49. Letter from Ellis to Ehret, 27 July 1754.

[66] See Nissen (1966), p. 110.

were not the only two Nuremberg artists that were to collaborate with him in this venture: in July 1769 Oeder engaged the Nuremberg-trained Johann Christoph Bayer as a draughtsman, whose son, Johann Theodor Bayer, was to continue the work after his father's death. And the fourth employee from Nuremberg to travel to Copenhagen was Franz Michael Regenfuss, who also had made a name for himself as an engraver of natural history illustrations in Trew's circle.[67] Thus, even the *Flora Danica*, produced in far-away Copenhagen, was heavily – if indirectly – influenced by Trew. Albrecht von Haller also consulted Trew when he could not find adequately qualified employees to make scientific plates for him in Berne, Switzerland.[68] Trew recommended the engraver Lichtensteger, who had worked on Trew's anatomical project, and to whom Haller consequently gave several commissions. By this time, Haller, who was then based in Göttingen, had already worked successfully with employees trained by Trew: Michael Rössler had drawn at least two panels for his well-known *Icones Anatomicae*.

Throughout Europe one finds similar networks of recommendation: the same draughtsmen and engravers tended to be commissioned to carry out the natural history works of that period. Ehret worked first for Weinmann, then for Trew (in between for Linnaeus) and finally in London for the Royal Society as well as independently.[69] Keller also worked for Trew, then later for Freiherr von Gleichen, for the publishing house Knorr, for Schmidel and for Oelhafen. Friedrich Guimpel was trained and supported by the pharmacist Friedrich Gottlob Hayne, received further training from Karl Ludwig Willdenow, before finally exercising an almost total monopoly on the making of natural history plates in and around Berlin towards the end of the eighteenth century: Guimpel not only drew and engraved almost all the illustrations for the journals of the Academy of Sciences and for the Gesellschaft Naturforschender Freunde (Society of Friends of Nature Research); he also did drawings for Hayne and other authors as well as publishing some of his own works.[70] The draughtsman and engraver James Sowerby, who, with his family enterprise, supplied the whole of England with scientific illustrations, was also influential, as was Jakob Sturm and his sons, who manufactured plates for botanists all over southern Germany.

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[67] For details, see Ludwig (1998), pp. 164f.

[68] Haller first enquired after anatomical illustrators; later he was also involved with producing botanical plates. See, e.g., Haller to Trew, 28 March 1737 (No. 10, pp. 60f.) and 18 August 1737 (No. 11, pp. 61f.). Trew to Haller, 26 November 1738 (No. 13, p. 63f), Haller to Trew, 28 February 1763 (No. 40, p. 123.) The numbers and page references refer to the printed versions of the correspondence between Haller and Trew; see Steinke (1999).

[69] Among others, see Ehret's biographical outline in Calmann (1977).

[70] From the author's own research.

2.2 The Plantae Selectae

After this general view on Trew and the craft of scientific illustrations in the eighteenth century, I shall now look at one of his projects in detail: the production process of the *Plantae Selectae*, Trew's most ambitious work. His intention was to publish 100 of Ehret's finest plant drawings (Ehret had, by then, become very well-known as a draughtsman of plants.). The first issue of this work, composed of ten illustrations, appeared in 1750; the last was published in 1773, after Trew's death.

Trew was not simply satisfied with engaging the best draughtsman on his project; he also wanted the best publisher and engraver. For the *Plantae Selectae*, he managed to engage the renowned Johann Jacob Haid to work with him (fig. 2.3, p. 40). Haid was regarded as one of the best copper-engravers of the time; additionally, he was widely experienced in producing botanical works, since he had done a large part of the engraving and printing of Weinmann's *Phytanthoza Iconographia*. There was, however, one snag in engaging Haid for the project – at least, from Trew's perspective: at the time, Trew was living in Nuremberg, Haid ran his workshop from Augsburg and Ehret was based in London. This state of affairs made the collaboration between author, draughtsman and engraver rather difficult. However, this arrangement turned out to be a stroke of luck for historians, since much of the correspondence, which out of necessity took place between the protagonists, has survived (preserved, as mentioned in earlier footnotes, in the University Library Erlangen). Trew kept all the letters sent to him, plus many draft versions of his own letters, and they reveal a great deal about the project and its difficulties.[71]

2.2.1 The Project

Trew intended the *Plantae Selectae* to be his masterpiece: only Ehret's most beautiful drawings would be included, of which the majority would be illustrations of foreign plants, with the aim of impressing readers both with their novelty and beauty.[72] Notwithstanding the need for splendour and beauty, a high scientific standard was also paramount: even in this work, where aesthetics played a far more important role than, for example, in the *Herbarium*

[71] See TRWC; the rest of the chapter concentrates on an analysis of the correspondence between Trew and Haid: Trew, C. J., Nos. 256-295, and Haid, J. J., Nos. 153-311).

[72] See on this point, e.g., Trew (1750-73), preface, or Trew's account in TRWC, Trew, C. J. to Haid, No. 263, 29 October 1749, stating, with reference to the *Plantae Selectae*, that "to this purpose only those pictures shall be selected from the large collection that not only distinguish themselves by their rarity but also by their exceptional beauty". Original German: "[. . .] hiezu aus dem grossen Vorath derselben nur solche [Bilder] sollen ausgewehlet werden, die nicht nur allein wegen ihrer rarität sondern auch wegen ihrer besonderen Schönheit sich distinguiren".

Fig. 2.3. Johann Jacob Haid (1704-1767). Copper-engraving by Haid, printed in the *Plantae Selectae*, Vol. 1, 1750.

Blackwellianum,[73] which appeared contemporaneously, Trew wished to avoid purely decorative flower images.

Originally, it was agreed that twenty plates per half-year would be produced – at least this is what Trew was still stating in 1750 in a letter to Haid;[74] but only a year later, in the preface to the first issue of the work, published in 1750, he was already speaking of delivering only ten plates per half-year. But even this revised estimate would not be fulfilled: after the first issue, the next two issues took a year each to produce. Then, production increasingly broke off and, by 1765, only the seventh issue had been published. This was the last issue which Trew oversaw before his death in 1769. Furthermore, not only the number but also the precise criteria for the selection of illustrations were considerably revised: by 1755, five years after the appearance of the first issue, Trew had abandoned the idea of publishing solely Ehret's drawings. They would, in future, only use the drawings from Trew's collection that needed the least work: on the one hand, because Trew could no longer provide the text to

[73] Trew & Blackwell (1750-73).
[74] See TRWC; Trew, C. J. to Haid, No. 267, 16 March 1750.

Ehret's elaborate pictures quickly enough; on the other hand, because Haid and his employees were increasingly complaining of the cost per illustration, which, they said, would bring them to financial ruin.[75]

Thus, the *Plantae Selectae* proceeded in a way similar to Trew's anatomical textbook: from a sweepingly ambitious, even somewhat megalomaniac beginning, progress became increasingly hesitant until the original aims and criteria were gradually dropped (owing to lack of time and practical difficulties). Nevertheless, seven impressive issues of the work did appear under Trew's competent editorship, and it is the production of their illustrations that I shall examine next.

2.2.2 The Drawings

In the eighteenth century, copper-engraving was the technique used for reproducing drawings of plants (and other subject matter) in book form. These engravings were not designed free hand; the images to be reproduced were usually taken from watercolour drawings executed on paper or parchment.[76] In this first, unprinted form, botanical illustrations were offered for sale to enthusiasts and botanists, such as Trew, who collected them and, depending on their level of interest, either only admired or used them for scientific purposes. If, however, one wanted to publish these pictures, they had to be transformed into copperplates for multiple printing.[77] For the moment, I shall examine the watercolour drawings and reconstruct the way they were made.

Sources of Information

First of all, plant draughtsmen needed sufficient information of the species on which they could base their drawings. William Curtis, for example, wrote the following in the preface of his *Flora Londinensis*, published in 1777:

> [The author] means to take the greatest pains in the examination of those plants which he figures; to have them drawn from living specimens most expressive of the general habit of appearance of the plant as it grows wild; to place each plant, as much as is consistent, in the most pleasing point

[75] See TRWC, Trew, C. J. to Haid, No. 279, 8 December 1755. A year later, Trew asked Haid to return him the text of two images by Ehret, which were considered too complex, and suggested instead a picture by Eisenberger, which would reduce the workload: the drawing of an aloë (which was actually a yucca plant, as Trew pointed out) that had flourished in Trew's own garden. See TRWC, Trew, C. J. to Haid, No. 281, 30 December 1756.

[76] The technique of watercolour painting was the rule; in addition various gouache techniques were also used.

[77] The term "copper-engraving" is used generically in this book and I do not di erentiate between the di erent types of engravings or etchings. For more detailed explanations of the di erent techniques, see, e.g., Lippmann (1963), Koschatzky (1993) or the specific literature they cite.

> of view; and to be very particular in the delineation and description of the several parts of the flower and fruit, more especially where they characterize the plant.[78]

This description more or less fits the method described by Trew for producing his anatomical work. The botanically well-informed author plays an important role: he chooses the subject matter and is responsible for the arrangement of the motives – and, it should be noted, all *before* the draughtsman has had any influence on the picture's design.

In this quotation, Curtis laid particular emphasis on using living plant specimens for the illustrations of his work. Living plants were an important source of information, and presumably all draughtsmen and authors of illustrated botanical works used them in their work, including Ehret. This does not mean, however, that he selected a single specimen – or that Trew gave him one – and then kept strictly to this model. Typically Ehret used many examples of a species for his illustrations. The botanist William Watson reported on Ehret's working method while the latter was drawing an *Oenanthe aquatica, succo viroso crocante* to illustrate an article by Watson to be published in the Royal Society's *Philosophical Transactions*:

> I am informed by Mr. Ehret, that, in drawing the *Oenanthe*, which he has executed with his usual Elegance and Accuracy, he was obliged to have a Quantity of it placed before him on a table; when, the Room being small, the E uvia thereof caused in him an universal Uneasiness, with a Vertigo; so that he was constrained to have it removed, and never after placed before him but a small piece at a time.[79]

Thus, for his drawing of the *Oenanthe aquatica* (water fennel) Ehret had placed so many plants before him that the ethereal oils which this species secrete had made him nauseous. However, even this did not persuade him to stick to using only *one* specimen: Ehret merely decided not to examine all the plants at once, but one after another. Numerous other authors have acknowledged that they used a large quantity of specimens for their plant illustrations, in order to avoid depicting individual peculiarities. In the preface to his *Vegetable System*, John Hill declared:

> The Reader will be pleased to know, that the Work now laid before him, has been printed and engraved more than a year; and has been kept so long unpublished, that truth and nature might appear in it, not only correctly represented from particular objects, but confirmed, ascertained, and universal. [...] The Plants themselves have furnished their own characters, not the accounts of those who had elsewhere seen them. They have been raised for this purpose in a garden where no manure has ever been admitted; and where there are no single Plants, but intire beds of each. They have been

[78] Curtis (1777-98), Preface.

[79] Watson (1746), in *Philosophical Transactions*, 44 (480), pp. 239f. For the illustration, see Plate IV of the same volume of the *Philosophical Transactions*.

> therefore raised in a state of simple nature; and, if any thing has appeared particular in one or two, it can have caused no error, since there were others of the kind wherwith to compare those variations.[80]

Hill was, it seems, concerned to provide his draughtsmen with a large quantity of fresh material – he even grew plants himself for exactly this purpose, without the use of fertilizers or other artificial means. In this way, Hill stressed, atypical characteristics of a specimen could be recognized and thus excluded: "truth" and "nature" should appear "confirmed, ascertained, and universal".

However, living specimens were not always available in any great quantity. In particular, the yields of scientific field trips and expeditions form exceptions to the practice just described: on a field trip, many new species had to be recorded comparatively quickly, usually with no time to compare different specimens – not to speak of the impossibility of consulting the technical literature. The splendid plates of the *Flora Graeca*,[81] illustrated by Ferdinand Bauer, are the result of such an excursion – and they also show that these pictures did not quite arise as one might have imagined.[82] Bauer executed only rough drawings in the countryside, which he then annotated with a number code to denote the colouring. Hence, he did not draw these illustrations in a romantic Greek setting, as one would like to imagine, but in cold, grey England.[83] To complete the images, Bauer used his memory, his sketchbook, perhaps a specimen growing in the local botanical gardens, but most importantly he based his final drawing on various dried specimens that had been collected during the expedition. The botanist in charge of the expedition, John Sibthorp, wrote to Joseph Banks after the journey:

> I would have sent you at present some of the dried specimens, had I not been apprehensive that you already possess a considerable part of them [...] & my Painter at the same time pleading the necessity of several specimens to compleat his Figures, having taken only rough sketches in the course of our Route.[84]

This procedure can be reconstructed by comparing the dried plants collected by Bauer with the final drawing.[85] The drawing resembles the dried plants in its details and design, which is surprising, since one would assume that a dried plant would only bear a slight resemblance to the living plant; but Bauer did not use just one dried specimen for his drawing, he unified the features of several specimens to construct his own version of the plant.

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[80] Hill (1759-75), Preface, no pagination.

[81] Sibthorp & Smith (1806-40).

[82] On the history of this work, see Lack & Mabberley (1999).

[83] For the code system of the Bauer brothers, see Lack (1997) and Chapter 5, section 5.2 of this book.

[84] Cited Lack & Mabberley (1999), p. 50.

[85] Two examples of photographed dried plants and the drawings made from them can be found in Lack & Mabberley (1999): figs. 26 and 27 (pp. 78/79: *Campanula rupestris*) and figs. 15 and 16 (pp. 56/57: *Ranunculus asiaticus*).

It was common practice for draughtsmen to work from dried plants. Ehret is also said to have occasionally used dried plants, and at least one of his illustrations for the *Plantae Selectae* was executed in this way.[86] He also did the drawings for Banks with the material that Banks had brought back from his expedition to Newfoundland and Labrador.[87] Even for the representation of native species, dried material was an important source of reference if fresh samples were unavailable. The same procedure that had been applied to the plates of the *Flora Graeca* were used for the drawings of Oeder's *Flora Danica* and was described by Beckmann in his *Swedish Journey*. The plants were, Beckmann wrote:

> painted in loco natali, however not always the whole plant, but occasionally only the flowers, buds and a leaf, from which the painter afterwards painted the whole plant with the help of a dried specimen. This would be the reason why Linné complained that not all the plants were shown in a natural position and in their natural habit and appearance.[88]

Thus, although this practice may have been widespread, the results were not always successful. In order to reconstruct a living plant more truthfully from a dried specimen, special techniques were developed, as John Hill described in the preface to his *Exotic Botany* (1759):

> Most of the plants came over dried, as specimens; and they were brought to the state wherein they are represented in these designs, by maceration in warm water. The method was this. The plant was laid in a china dish, and water was poured upon it, nearly as much as the cavity would hold; another dish, somewhat smaller was turn'd down upon this, and the edges were cemented with common paste spread over a gentle fire. Thus after a little time the lower dish heats; and the water gradually in it: a few minutes then complete the business. The plant, however rumpled up in drying expands and takes the natural form it had when fresh. Even the minutest parts

[86] See Ludwig (1998), p. 182, footnote 38. Ludwig quotes a note of Ehret's on his drawing of the *Sida abutilon*, which reads: "This was a dry specimen of Mr. Miller". Original German: "Dieses wahr ein truckenes Specium von Herrn Miller". UB Erlangen: MS. 2380, 93. Engraved, this plate was Tab. XC of the *Plantae Selectae*, issue No. 8, 1771.

[87] Blunt (1955), p. 68: "When he returned from Newfoundland and Labrador in 1766 Joseph Banks became the last explorer to entrust Ehret with his botanical discoveries. Ehret made 23 carefully coloured drawings on vellum, all from dried specimens, but this is noticeable only in the flower of the *Dryas integrifolia* which is shown yellow instead of white." This detail has unfortunately been omitted in the latest edition of this book, Blunt (1994).

[88] Fries (1911), pp. 146f. Original German: The plants were "in loco natali gemahlet, jedoch nicht allemal die ganze Pflanze, sondern nur zuweilen besonders die Blume, Knospen und ein Blatt, woraus der Mahler hernach mit Hülfe eines getrockneten Exemplars die ganze Pflanze mahlet. Diess wird die Ursache seyn, warum Linné klagete, dass nicht alle Pflanzen die natürlichste Lage und den habitum oder faciem naturalem erhalten hätten."

> appear distinctly. The specimen is destroyed by this operation, but it shews itself, for the time, in full perfection: I could have wished to save some of these but they were sacrificed to the work; and I hope their remembrance will live in the designs.[89]

Dried and living specimens were not the only source material for plant illustrations. When, in 1740, a specimen of the *Camellia mellia* flowered in Britain for the first time, the owner of the plant engaged Ehret to record this event in a drawing.[90] In Ehret's sketchbook, next to the outline for this drawing, is a note that reads: "The fruit is copied from a Chinese drawing which I received from Sir Hans Sloane in 1741."[91] Earlier illustrations of species were important sources of information for draughtsmen, and not only in a case such as this, where the Chinese drawing was perhaps the only available reference for the fruit of this rare plant.

The Making of the Image

Thus, plant illustrators used a variety of different types of sources as reference material, which, as a rule, was not selected by the draughtsman but by the author of the illustrated work. The latter also supervised and checked the remaining production stages of the illustration. For example, in the preface to his *Flora Batava*, Jan Kops, a professor of botany in Utrecht, assured his readers that he had made clear to his draughtsmen which parts of the plant needed to be drawn, so that the taxonomically relevant features, in particular, would be correctly shown:

> It should su ce to refer to the images themselves, in order to convince everybody that the plants were drawn by him from life; whereas, in the first place, I explained them to him and dissected them, so that the di erent parts, whether in their natural size or enlarged, could be better depicted by him.[92]

Both the author and the draughtsman were, it seems, required to have a deep understanding of the subject matter. Not only did they have to examine the objects and prepare them adequately, sometimes they even observed the

[89] Cited Saunders (1995), p. 76.

[90] This is a rare example of a drawing for which only one single plant specimen was used. One would expect, however, that the sketches made were then double-checked, if at all possible, using other sources.

[91] Cited Calmann (1977), p. 68. The quote can also be found as an annotation to the printed version of the drawing, note No. 106, in Watson (1746).

[92] Kops (1800-49), Preface, Vol. 2; no pagination. Original Dutch: "Het zal genoeg zyn, my op de Afbeeldingen zelve te beroepen, om een iegelyk te overtuigen, dat de Planten door Hem naar het leven getekend zyn; wordende dezelve alvorens eerst door my verklaard en ontleed, op dat die onderscheide deelen door Hem te beter, 't zy volgens hare natuurlyke groote, 't zy vergroot zouden kunnen afgebeeld worden."

plants over a period of time in order to get to know the different stages of growth as well as the invariable characteristics of a species. This, for example, is what Hill reported in his work (see the quote on p. 43), while the preface of Curtis's *Flora Londinensis* contains a similar description:

> And in order that he [the author] may obtain a more perfect knowledge of each plant; that he may see it in every stage of its growth, from the germination to the maturity of its seed; that he may compare and contrast the several species together; that he may make experiments to elucidate the nature of such as are obscure, or bring into more general use those which bid fair to be of advantage to the public; he is now cultivating each of them in a garden near the city, into which, by the kind assistance of his friends, he has already introduced, in the course of one year, about five hundred di erent species, including sixty of that most valuable tribe of plants the grasses.[93]

Drawing the details of a species was no easy task. Ehret examined all the plants he drew under the microscope; his contemporaries later attributed his increasingly poor eyesight to this exhausting – and demanding – practice.[94] Eventually, Ehret's skill in this field became so well known that he was chosen to draw the details of the first work in English to apply the new Linnean system: Patrick Browne's *Civil and Natural History of Jamaica* (1756).[95] Although Ehret was honoured to be asked, he replied that he could only execute some of the drawings owing to the great effort that this kind of work demanded:

> Consider that examining and dissecting the particular Characters in Plants takes up as much time, as painting allmost a whole plant without Character, so I am afrayd that the price will run too high, and to neglect my present bussnes for another work of little advantage will never do, which I am afraid at the end will turn out so.[96]

Ehret wrote this towards the end of his long and remarkable career when he was in a position to turn down offers of work. His illustrations were undoubtedly of extremely high quality, but even the most accomplished, beautiful and splendid among them – those that Trew wished to publish in his *Plantae Selectae* – needed to be modified for this grand project.

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[93] Curtis (1777-98), Preface.

[94] On 4 October 1768, Mrs. Delany was staying with the Duchess of Portland, who, at that time, had invited Ehret to work for her, and wrote in a letter: "Mr. Ehret is very busy for the Duchess of Portland, he has already painted above *150 English plants*, and now they are collected together their beauty is beyond what we have a notion of, particularly the water-plants! but poor Ehret begins to complain of his eyes, he has hurt them with inspecting leaves and flowers in the microscope in order to dissect them." Cited Blunt (1994), p. 162.

[95] John Ellis obtained this commission for Ehret. According to Calmann (1977), p. 67, the letter is preserved in the archives of the Linnean Society, Ellis Collection MSS, Vol. 1, dated 21 July 1754.

[96] Cited Calmann (1977), p. 67.

Drawing Standards

Over the course of the next few years, Trew repeatedly pointed out to Ehret that:

> In many of your paintings that I already have in my hands the characters of the flowers or fruit, or sometimes both, are missing, the depiction of which I would like to have, in order to make the description complete.[97]

As Trew announced at the beginning of their collaboration, he considered Ehret's paintings not as decorative items but as objects that should be of some practical use. Therefore, the usual standards of scientific plant drawings had to be met, and the detailed views of flowers and fruit as well as the correct representation of all the other organs of a plant formed part of these standards.

Occasionally, Trew asked for additional views of a male or female flower in the case of unisexual species; more frequently he wanted representations of the seeds or the fruit at different stages of their growth, drawn showing the internal as well as external structures. Leaves and flowers were also not always adequately shown in some of Ehret's works, according to Trew, and on one occasion he asked for an additional view of a flowering shoot ("blühender Gipfel").[98] In other cases, Trew already had detailed views but was not entirely satisfied with them. For the *Laurus indicus* (Indian laurel), for example, Ehret had sent him the illustration of a branch, and a colleague of Trew's, Lorenz Heister, had sent him details of the flower and fruit. However, in Trew's opinion, the latter came out imperfectly ("unvollkommen"), so that Trew then asked Ehret to send him new drawings of these details.

In all these examples Trew did not seem to mind that the same specimen was not used for the general view and the newly requested details. Had Trew's aim been to represent individual plant specimens, this procedure would have been totally unacceptable. Neither did it trouble Trew if the general view and details had not been executed by the same person. He did not hesitate, for example, to ask Ehret for details of the flower and fruit of a *Bignonia*, for which he only owned a general view drawn by somebody else.[99] Trew obviously attached less importance to preserving the drawing style of a picture than to the completeness of the subject matter, to which the details of the fruit also belonged. In a postscript to one of his letters, Trew explained how Ehret should send these details to him:

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[97] TRWC. Trew, C. J. to Ehret, No. 203, 28 December 1766. Original German: "Dass mir bey vielen Gemählden, die ich schon von Ihnen in Handen habe, die *charac*tere der Blüthe oder der Frucht, auch wohl von beyden fehlet, deren Gemählde ich ebenfalls zu haben wünsche, um die Beschreibung davon vollständig machen zu können."

[98] TRWC. Numerous examples of Trew's detailed requests for the completion of pictures can be found in Trew's letter to Ehret, TRWC, No. 203. The above and following examples have been taken from this letter.

[99] TRWC. Trew, C. J. to Ehret, No. 203, 28 December 1766.

> The *characters* of the flowers and fruits should only be painted on loose sheets or scattered over one sheet, so that I can cut them out and paste each one onto its main view.[100]

Whereas Trew had emphasized in his first letters that every species had to be done on its own sheet of paper, the details could be drawn on the same sheet (which would save paper!). Trew would then cut them out and stick them onto the sheet with the main drawing of the plant. It is known that Ehret had worked in this way before, that is, that he sometimes drew the general view of a flowering plant on one sheet and later added to this sheet details of the plant that had been drawn on a separate piece of paper and at a later date. See figure 2.4 (p. 49) for an example of this practice. The main view and the details of the flower and seeds were cut out from other pieces of paper, stuck onto a new sheet, and the whole drawing was then hand-coloured with watercolour paints. Ehret may have been compelled to work in this way simply because he was using living plants and, therefore, had to draw the details of the fruit at a later date than the flowering plant. Furthermore, working on only one small sheet of paper was possibly more practical when viewing details from under a microscope.

2.2.3 The Engraving

These drawings, however, were just the first stage in the process of producing illustrations for publication: making the copperplates required just as much attention and at least as much time. There has never been a comprehensive examination of the production of scientific copperplates on the basis of a systematic analysis of archive material, which makes it worthwhile to treat this aspect in considerable detail.[101] Since almost all the illustrations of the examined selection were made in the technique of copper-engraving, the technical

[100] TRWC. Trew, C. J. to Ehret, No. 203, 28 December 1766. Original German: "Die *characteres* der Blüthe und der Früchte können nur auf Blättern oder zerstreuet auf ein Blat gemahlet werden, so kan ich solche zerschneiden und jeden zu seiner Haupt-*Figur* kleben."

[101] Lack & Mabberley (1999) roughly outline the production process of the copperplates for the *Flora Graeca*, without, however, going into very much detail. Adrian Johns announced in his book on London's book printing culture a study of the origins of the illustrations to the *Historia Piscium* by Francis Willughby, which was commissioned by the Royal Society. Similar to the approach I use here, Johns aims to reconstruct the production of the plates based on the correspondence between Willughby and the Royal Society; see Johns (1998), p. 434, footnote 116. This study unfortunately has not yet appeared. For an art historical-oriented examination of the methods of copperplate engraving and their theoretical discussion in the eighteenth century, see Rümelin (1996), which also contains a description of the Stuttgart school of copperplate engraving. It does not, though, cover the production of scientific illustrations and their special requirements.

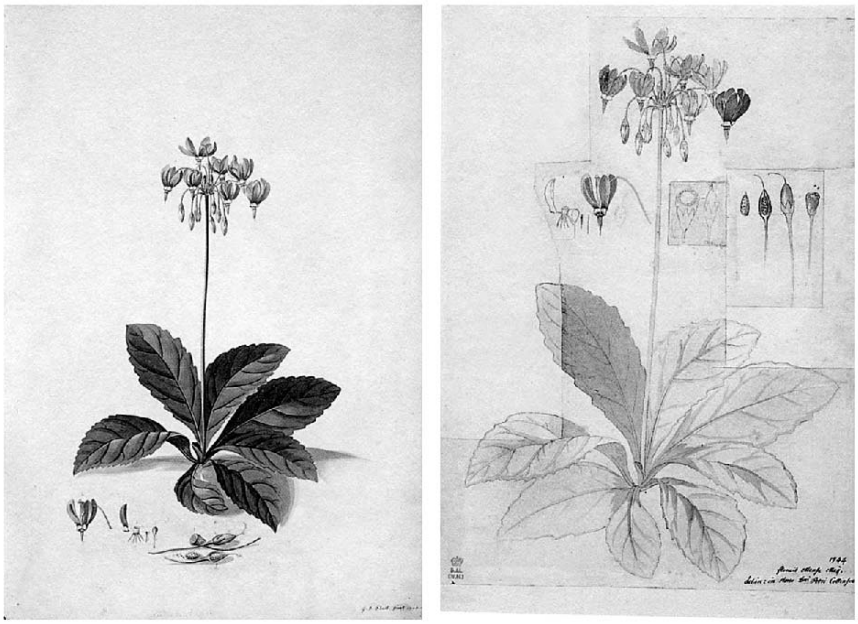

Fig. 2.4. Two drawings of the shooting star (*Götterblume*) by G. D. Ehret, dated 1744. Reproduced from Ludwig (*Nürnberger naturgeschichtliche Malerei*, 1998), p. 216. Original drawings: Natural History Museum, London. The drawing on the left was probably based on the one on the right. The sketch on the right is an example of Ehret's collage-like style of drawing: the general view of the plant and the details of the flowers were drawn on one sheet of paper, then cut out and stuck onto another piece of paper on which parts of some of the leaves executed on the first sheet were completed. The views of the fruit and seeds were done on a third piece of paper, which was then also stuck onto the underlying second sheet to form one illustration.

explanations of this section apply not only to the *Plantae Selectae* but also to the majority of other plant illustrations looked at in this study.[102]

From his collection of drawings, Trew chose those images for the *Plantae Selectae* that he considered most worthy and suitable for publication, and sent them to Augsburg for processing. To transport these packages, Trew used the services of a certain "Miss Cüstin, who delivers every fortnight to Augsburg

[102] The exceptions are the prints by Mayr and David Heinrich Hoppe, made using a method known as nature printing, and George Sinclair's lithograph of the sweet vernal grass.

for free", as Trew informed Haid.[103] (The ordinary postal services of the time were possibly too slow, too expensive or too dangerous.) The lady in question seemed to have been able to travel the distance of approximately 170 kilometres between the two towns of Nuremberg and Augsburg remarkably quickly: Trew mentioned in one of his letters that, if required, transportation there and back could be done within 48 hours.[104] In Augsburg, under Haid's close supervision, Ehret's drawings were then transferred onto copperplates, a process that required considerable observational and drawing skills, and determined the quality of the print. It comes as no surprise, therefore, that the publisher Haid sometimes engraved Ehret's detailed drawings himself.[105] How Haid and his employees presumably proceeded can be taken from the technical litera-

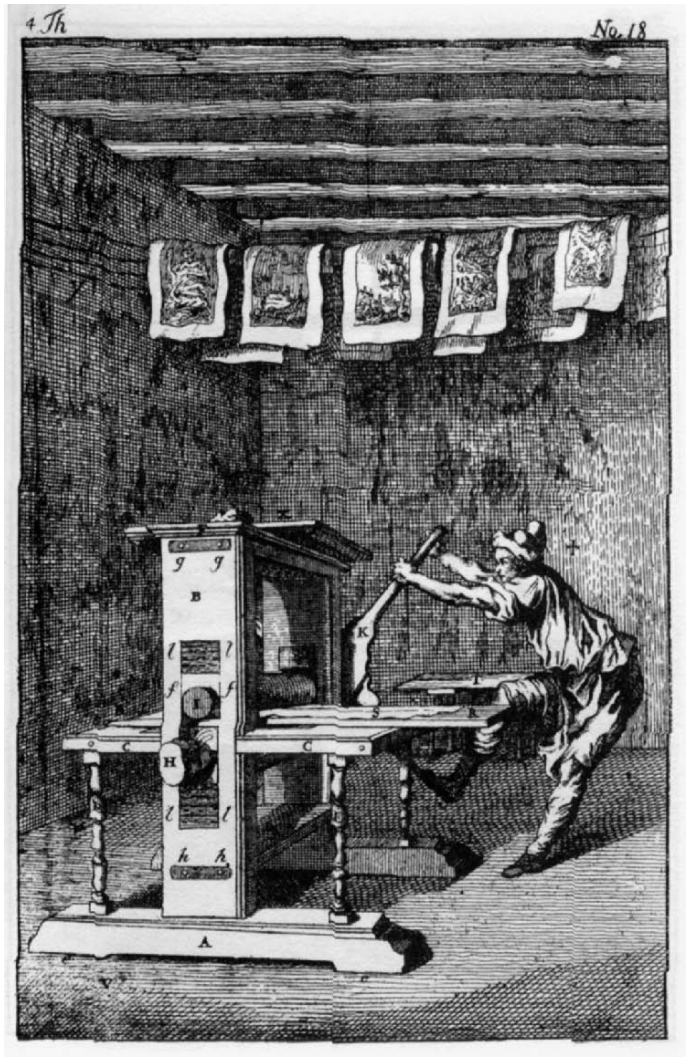

Fig. 2.5. A printing workshop for copper-engravings from the second half of the eighteenth century: the printer is driving a prepared plate through the copper press; above him, prints have been hung up to dry. From Bosse (1765), No. 18.

to another project elsewhere. Haid described this problem in one of his next letters to Trew:

> Five or six weeks ago, I finished the copperplates and proofs of the second issue, large format, with the exception of Plate XII, in order to send them to Your Excellency for assessing and correcting. And I also [...?] flattered my engraver so that he would complete Plate XII in order to be able to send it with the others. However, this wasn't possible, since whenever these people are not always and continuously provided with work, they go to somebody else, and then one can wait until it pleases them to deliver the final items. I would readily have used the services of someone else, except that this artist is especially neat, good and skilful with our plants.[120]

So, owing to the long periods of time between instructions, the work took even longer to be completed, since Haid's most experienced engraver was, in between his work for Haid, working for someone else. Haid was not only worried about the delay; he feared losing his engraver altogether because of Trew's erratic working schedule, which would have been disastrous for the *Plantae Selectae*.

As soon as the effortful first proofs were finished they were sent back to Nuremberg for Trew to correct them or give the go-ahead for printing to begin. Trew, however, was rarely happy with the proofs, neither with the text nor with the plates, and frequently demanded that changes be made. On receiving the proofs of Plate XIII (see fig. 2.6, p. 64) in January 1750, for example, he remarked:

> One thing caught my eye, that in Plate XIII of the Lilio-Narcissus the two truncated stems are not in proportion to each other, which is probably a mistake of the original. It is true that this stem is very pliant at the bottom and gradually [...?] thickens. However, the two truncated ends should still [...?] be in proportion to each other, and therefore, the stem bearing the flower could be made a little more pliant at the base, and the second [stem] of the leaves a little thicker at the tip, and by this means they would be in proportion to each other.[121]

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[120] TRWC. Haid, J. J. to Trew, No. 167, 20 December 1749. Omissions marked with [...?] indicate an illegible word. Original German: "Ich bin schon 5. oder 6. Wochen mit den Kupfern oder Probedrucken zur II. Dec[urie] gr[oss] Format bis auf Tab. XII parat, um solches zur censur und correctur an Eur. Excellenz zu senden, habe auch [...?] meinem Kupferstecher die schönsten Worte gegeben, dass er mir doch Tab. 12 [Tab. XII] auch vollend anfertigen mögen, um es mit den anderen versenden zu können, es ist aber noch nicht zu erhalten gewesen, dann wenn diese Leute nicht stets und fortwährend mit Arbeit versorgt werden, wenden sie sich an jemand anderen, und dann kann man warten, bis es ihnen gefällt, die letzten Stücke abzuliefern. Ich wäre damit wohl an einen andern gegangen, allein dieser Künstler ist zu unseren Pflantzen gar ordentlich, gut und geschickt."

[121] TRWC. Trew, C. J. to Haid, No. 265, 3 January 1750. Original German: "Diß einige ist mir in die Augen gefallen, daß bey tab. XIII Lilio Narcissus die beyden abgeschnittenen Stengel keine proportion mit einander haben, welches aber

In a similar vein, Trew commented on every one of the proofs that Haid sent back to him, with varying levels of criticism. Frequently, Trew enclosed his corrections on a separate piece of paper, to which he would refer in the letter, with the aim of making it easier for Haid to go through his remarks; unfortunately, many of these notes have not been preserved in Trew's estate.[122] Correcting the plates entailed a considerable amount of work for Haid and his employees. Flatly carved, solitary lines could occasionally be corrected by simply levelling the plate. In the case of deeper furrows, however, a different procedure was required: close to the engraved line, cuts were inserted with a slender steel knife, in the direction of the line in question, and then the shavings were driven into the former furrow with a special steel burin. Finally, the plate was hammered on the back to smooth it down once more. One can assume, therefore, that Haid and his employees did not receive Trew's demands for changes and corrections with much pleasure.

Less laborious than carrying out the actual corrections but nevertheless involving a certain degree of effort were the additions to the original designs that Trew regularly requested, in particular recently drawn details that he received from Ehret from time to time. In a typical passage, Trew asked Haid, in October 1749, whether he could:

> In Plate VIII, small format, please insert the enclosed details (if prints have not already been made of it) and also engrave the attached text; I only had the opportunity to have them drawn this summer. Please do not get impatient with these repeated changes: if they can be done without causing much inconvenience, all the better; if not, then so be it.[123]

One of the plates that almost drove Haid to despair owing to the numerous and at times contradictory requests for amendments was that of the ginseng

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wohl ein Fehler am original selbst seyn wird. es ist zwar dieser Stengel zu unterst sehr geschmeidig und wird zugleich [...?] zu dicker. es sollten aber doch [...?] die abgeschnittenen Enden eine proportion zu einander haben, und könnte demnach der Stengel an der Blume zu unterst etwas geschmeidiger u: der zweite den Blättern zu oberst etwas dicker u: also eine proportion gemacht werden."

[122] See, e.g., one of Trew's first letters to Haid in which he mentioned some notes on the proofs that he had enclosed on a separate piece of paper. To help Haid understand these notes, Trew enclosed the originals with the proofs. TRWC. Trew, C. J. to Haid, No. 259, 2 May 1749.

[123] TRWC. Trew, C. J. to Haid, No. 263, 29 October 1749. Original German: "<(wenn von dieser nicht schon einige Abdrucke gemacht sind)>, bey tab. VIII. Kleinformat, bitte hiebey kommende Kleinfiguren beisezen u: die beygefügte explication dazustechen zu lassen, ich habe solche diesen Sommer erst abzeichnen zu lassen Gelegenheit gehabt. <Über diese abermalige> Veränderung bitte nicht ungeduldig zu werden: Können sie ohne Ungelegenheit geschehen, ist es gut; kan es nicht geschehen, ist es auch recht." The phrases in angle brackets < > mark the insertions Trew made in the margins of his attached piece of paper. Round brackets, such as in the first sentence, were in the original manuscript.

with a red fruit. Haid had first engraved the outline onto the plate and made proofs in 1748;[124] however, Trew had found so many errors that the proofs went repeatedly back and forth between Augsburg and Nuremberg. Trew was also not very happy with the colouring of the print. And then, in July 1749, when Haid finally believed that the ginseng was ready, Trew asked him to change the plate once more; he had recently had the chance to get hold of a fruit of the ginseng and had it drawn. No image of the mature fruit of this species had ever been published before, so, if at all possible, he wanted two additional small drawings carved into the plate and, to be more precise, as closely as possible to the immature fruit.[125] This was more than Haid's engraver could bear and he refused to carry out any further corrections to the plate without additional payment, as Haid informed his demanding client:

> To Plate VI, large format, ginseng [...]: the copperplate has already been engraved and the engraver is not willing to add the Catesby fruit, which I recently got from Your Excellency, unless I pay him extra, which I wouldn't mind if the stem with the red fruit wasn't that di erent from Ehret's as always beautiful style. I therefore expect new orders from Your Excellency as to what I should or should not do in this case.[126]

In addition to executing the characteristics and details of a plant correctly, Trew also felt it important to show the plants life-size. This could be done with plants originally drawn life-size and with others that had been slightly enlarged or reduced without too much trouble. However, there were plants whose size exceeded the book's format: for these Trew suggested occasionally inserting a whole printing sheet that could be unfolded by the reader.[127]

As has been shown in some of the examples quoted, Trew's notes were, on the one hand, concerned with the accuracy and correctness of the content of the pictures and, on the other hand, with the ease with which they would be

[124] TRWC. Haid, J. J. to Trew, No. 155, 27 January 1748.

[125] TRWC. Trew, C. J. to Haid, No. 260, [date illegible] July 1749.

[126] TRWC. Haid, J. J. to Trew, No. 158, 11 January 1749. Original German: "zu Tab. VI. gross Format, Ginseng [...]. Die Kupfertafel ist schon geätzt, u. der Kupferstecher will mir die letzt von Eurer Excellenz erhaltene Frucht – nach Catesbi [–] nicht mehr beystechen, ich zahle es denn aparte, so ich noch nicht ansehen wollte, wann nur solcher Zweig mit der roth Frucht mit der Ehretischen schönen geläuffig Manier nicht so sehr di eriren thäte. Will also das Eure Excellenz nochmahls gegen Befehl erwarten was dich diesfall thun od. lassen solle."

[127] See, on this point, TRWC, Trew, C. J. to Haid, No. 163, 29 October 1749. Here, Trew reminded his publisher that he should also show in his plates "which size the species have in nature" ("welche Grösse die Arten dieses Gewächses natürlicherweise haben"), even if the size exceeded the format of the book. To this end the species in question should be printed on larger sheets and be inserted, folded, into the book: "In future, every issue is to have one entire sheet of paper, and this is necessarily to be considered while setting the price for the whole." ("Künftighin wird also bey jeder Ausgabe ein ganzer Bogen eingerückt werden u. desswegen nöthig seyn bey dem zu bestimmenden Preiss darauf zu reflectiren.")

understood by the book's readership. The aesthetics of the pictures and their sequence within the issue were of subsidiary importance, and something that Trew willingly left to Haid and his employees. However, any additions made to the plants fell between aesthetics and content. According to the taste of the time, Ehret adorned some of his pictures with bees, butterflies, ribbons and the like. However, Trew had written often enough that he did not want his illustrations to resemble decorative flower pictures – and so the question arose for Haid whether a stake inserted by Ehret supporting a flowering *cereus* in one of his drawings, should be included in the engraving or not. Trew responded as follows:

> As to the gentleman's query about the stake next to the *cereus* I believe that it is necessary with this plant, since the *cereus* species, with its branches hanging downwards, looks unsatisfactory, and moreover the way this plant grows wouldn't be as clear without it: however, whether you want to give this stake another form or colour, whether you want to represent it with or without pedestal, is up to you. The other additions that Mr. Ehret has inserted into his copperplates certainly do not belong there and therefore should be left out. In our other work, should other plants have stakes or containers, they would better be left out, unless the posture of the plant requires them, as was the case here, but only to spare any trouble, not because of the poor opinion of Weinmann's work: since when something is added for decoration, without the buyers having to pay more for it, I don't see why one should feel the need to criticize and, anyway, who wants to please everybody.[128]

Trew is arguing in this answer from the scientific point of view: the stake needed to be included in the copperplate because in this way the overhanging form of the plant would be better expressed. However, Trew did not mind what colour the stake was and whether it was drawn with or without a base – such questions were purely aesthetic and did not fall into Trew's field of expertise. Details such as these would not interfere with the botanical value of the image

[128] TRWC. Trew, C. J. to Haid, No. 263, 29 October 1749. Original German: "Was übrigens [...?] Herr wegen des Strebens bey dem *Cereo* angefraget haben, ist meiner meynung, dass es bey diesem Gewächse nothwendig seye, weil das *Cereus* Specium zwischen den unterwärts hängenden Ästen sich übel praesentiret, auch überdieses die Art, wie die Pflanze wächst, nicht so deutlich seyn <würde>: Ob Sie aber dem Streben eine andere Gestallt oder Farbe geben ungleich mit oder ohne postement fürstellen wollen, stehet in Dero Belieben. Die anderen Beysachen, die Herr Ehret in seine Kupfertafeln beygebracht, gehöhren sicher nicht, und müssten also auch weg bleiben. Im übrigen Werk solten bey anderen Gewächsen Streben oder Gefässe vorkommen, oder doch wann nicht die positur des Gewächses, wie hier, solche erfordert, wegbleiben, aber nur zu erspahrung der mühe, und nicht wegen des bey dem Weinmannschen Werk gefällten schlechten Urtheil: Dann wann etwas zum Zierath beygefüget wird, ohne dass deswegen die Käufer mehreres bezahlen dörfen, sehe ich nicht, dass man deswegen zu critisiren einige Ursach habe, und wer will allen Köpfen es recht machen."

and therefore could be left to the discretion of the artist. In other cases, similar additions should be left out, Trew believed, not for botanical but for pragmatic reasons, since this would spare Haid and his employees unnecessary work. Decorative accessories were acceptable, so Trew believed, as long as they did not increase the final cost of the issue. Here, Trew alludes to the intended purpose of the work and to its target group, which included learned botanists as well as enthusiasts, who would probably not object to the presence of a butterfly next to an impeccably drawn cactus. This tolerance, however, had its limits, as revealed by Trew's allusion to Weinmann's *Phytanthoza Iconographia*, which had been criticized for containing too many superfluous and distorting details.

To include this stake of Ehret's into the picture, meanwhile, required further changes, as can be gathered from Trew's next letter to Haid:

> If, because of the stake next to the *cereus*, some of the more delicate parts of the branches would be concealed, these could then be added to the two remaining branches.[129]

This concession seems rather strange, coming as it does after Trew's otherwise pedantic corrections: Haid could insert those parts of the plant which, for practical reasons, could not be shown where Ehret had placed them, elsewhere. He even encourages Haid to do this! Clearly, Trew's idea of a correct copperplate, following the original as closely as possible, included the possibility of changing the position of important details. All the characteristic features of a plant had to be shown, but their position or even their absolute number were irrelevant; for example, four branches could be reduced to two if everything of relevance could be shown on simply two branches.

After the plates had been corrected according to Trew's instructions, they were printed again, from which second proofs were then sent from Augsburg to Nuremberg. A parish priest from Augsburg volunteered to check these second proofs[130] but Trew declined his offer: he did not want to pass on the responsibility for the proofing of his masterpiece to someone that he did not know. Haid, though, would probably have preferred to have the priest do the proofs, if only to avoid any further changes or additions by Trew, but he followed his client's wishes.

Only after this long and laborious procedure had been completed could the plates be driven through the copper press to produce the printed engravings that would later be published. However, the plates of the *Plantae Selectae* were not yet ready to be sold at this stage. Like most other plant images of the picture selection being examined in this study, the prints were then

[129] TRWC. Trew, C. J. to Haid, No. 264, 20 November 1749. Original German: "Wenn wegen des Strebens bey dem *cereo* einigen Ästen wegen der zärtlichen Theile etwas abgehet, so werden doch solche bey den zwey bleibenden können angebracht werden."

[130] TRWC. Trew, C. J. to Haid, No. 263, 29 October 1749.

coloured by hand – illuminated as it was then known – and this was also done in Augsburg under Haid's supervision.

2.2.4 The Hand-Colouring of the Plates

The hand-colouring – or illumination – of the prints was by no means less time-consuming or arduous than the actual making of the prints, particularly if the plates were very detailed and had to meet high aesthetic as well as scientific demands. In December 1749 Haid assured his client that he had tried, albeit in vain, to finish the first issue of ten plates by the end of the year:

> The painters make things very di cult and expensive. They are admittedly hard-working and willing, but the accuracy and beauty holds them back, so that they do not achieve very much. I do hope that it will, out of necessity, become better, easier and more pleasant for them and me once the painters are used to this work and they are more familiar with the style of drawing. In the meantime, it costs me dearly, not only in terms of money but also in time and e ort, that neither Your Noble Excellency nor anyone else would suspect and believe.[131]

As this complaint of Haid's confirms, the time it took to colour a print by hand added considerably to the cost of manufacturing scientific illustrated works. It is not clear how many people Haid employed to paint the plates and how educated they were. For a work of similar size, for instance Curtis's *Flora Londinensis*, allegedly up to thirty colourists, men and women, were engaged, all of them closely supervised by Curtis, as he assured his readers (which one may or may not believe).[132] Haid probably had not as many workers employed as Curtis, although he would perhaps have enjoyed the extra hands. Colourists still had to be paid, and talented painters of scientific plant images were as hard to find as good copperplate engravers, particularly if the work was demanding. Nevertheless, in the same letter of December 1749, Haid proudly reported the following:

> I have already got one of the best painters and colourists, and I am still looking for a few others, in order to get things going, since I need to have a supply of willing and hard-working people, so that I can threaten one or more with the sack if he isn't proper, attentive and hard-working.[133]

[131] TRWC. Haid, J. J. to Trew, No. 167, 20 December 1749. Original German: "... die Mahler machen es mir sehr sauer, und kostbar. sie sind zwar fleissig und willig, die richtigkeit und Schönheit aber hält sie eben auf, dass Sie nicht viel leisten können. ich ho e aber nothwendig, dass wann die Mahler hierinnen geübt, und ihnen geläufiger seyn wirdt zu zeichnen, es vor Sie u. mich besser, leichter und schöner gehen werde, dieweil köstet mich es so viel lehrgeld, Zeit u. so grossen aufwand, dass es Eur. EdelExcellenz, u. niemand vermuten u. glauben wird."

[132] Saunders (1995), p. 128.

[133] TRWC. Haid, J. J. to Trew, No. 167, 20 December 1749. Original German: "Ich habe bereits einen der besten Mahler u. Illuministen, u. suche noch mehrere,

Haid knew that much of the quality of the final work depended on the colouring of the plates and so he tried to employ as highly qualified people as possible – he already had found one and hoped to find more: on the one hand, this would ensure that the work would speed up; on the other hand, it was crucial not to be too dependent on the good will of one single person. However, the search for painters turned out to be quite difficult, as Haid explained, since he could not "use just any painter and illuminist but only people of intellect, compliancy and patience".[134]

Haid was more particular than many other publishers and authors in his choice of employees. The ability and motivation of the people taken on to colour botanical prints differed considerably, and the results varied correspondingly.[135] Generally, the colouring of the plates was the responsibility of the publisher (as in the case of the *Plantae Selectae*), who also had to cover the expenses for this work as well as for the making of the copperplates; whether he would be able to make up for this expenditure in the end depended substantially on how well the prints sold. And so, few publishers could afford to employ well-trained specialists to hand-colour their engravings, in addition to engaging qualified copperplate engravers. Unskilled workers were, therefore, often hired, and these were frequently women, even occasionally children. Oeder's *Flora Danica*, for example, was mostly painted by women, who, as Johann Beckmann reported, "were paid 4 Stüver per plate".[136] According to Heidrun Ludwig, Oeder employed two women colourists on a full-time basis: a Mrs. J. A. Seizberg neé Ridinger[137] and the wife of a Nuremberg sculptor called Starck, who had worked as painter for A. J. Rösel von Rosenhof. Together, these two women are said to have educated orphan girls, who then later worked as colourists on the *Flora Danica*.[138]

How did one judge whether a printed plate had been adequately painted? First, this was a question of the right technique. The colours should be strong and clearly recognizable, while they were not allowed to cover the lines of the engraving. Watercolours were, therefore, primarily used and were applied either freehand or with stencils. Furthermore, the colours of the prints should

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um gefördert zu werden, dann ich muss willige und fleissige leuthe hiezu vorräthig haben, damit ein od. anderer den abschied betrohen kann, wann er nicht ordentlich, achtsam und fleissig seyn wollte."

[134] TRWC. Haid, J. J. to Trew, No. 173, 30 May 1750. Original German: "[Ich kann] nicht jeden Mahler und Illuministen gebrauchen, sondern es müssen Leuthe seyn, die Verstand, Willigkeit, und Gedult haben".

[135] For a study of the professional colouring of engravings by so-called *Briefmaler* in the sixteenth century, complemented by an analysis of their technical manuals, see Dackerman (2003a), pp. 15 .

[136] Fries (1911), p. 147. Original German: "denen für jede Tafel 4 Stüver bezahlet wird".

[137] Possibly some relative of the Nuremberg engraver J. E. Ridinger, who collaborated with Weinmann on his *Phytanthoza*.

[138] Ludwig (1998), p. 188.

in all copies of the work correspond as exactly as possible to the original work. Eighteenth-century colourists, however, did not have precise scales for measuring pigments and worked without standardized colour formulae, using only rough preparations based on natural products, which always vary in nuance and intensity. Therefore, this last condition, justified though it might have been, could not be met in practice. Even the colours of two copies of a work were almost never identical,[139] and even more variations became apparent when the printed plate was compared with the original drawing.

The colourists of the plates of the *Plantae Selectae* always worked from Ehret's original illustrations, even when Trew himself only owned copies of them. This was, for example, the case with the *Lilio-Narcissus* (fig. 2.6, p. 64): the copperplate was made after a copy that Eisenberger had drawn; however, for the colouring of this engraving Trew sent Ehret's original drawing to Augsburg, which belonged not to him but to a Nuremberg colleague. This procedure had the advantage that the precious originals remained in the engravers' workshop for as short a time as possible. As mentioned before, only a few pictures came out of the whole engraving process undamaged, which explains why Trew insisted that Haid ask his colourists to treat the image of the *Lilio-Narcissus* more carefully than usual, since he only had it on loan. Trew was used to being disappointed in this respect, and for his own pictures he always expected the worst; however, as Trew stressed in his letters to Haid, he would have to account for the damage done to drawings that belonged to other people, so that at least these pictures should be treated with the utmost care.[140] Unfortunately, even this fervent request went unheeded. On 12 December 1750, Trew complained bitterly to Haid that he did not dare to return the *Lilio-Narcissus* to its owner in the sorry state in which it had come back from Augsburg. Instead, Trew commissioned a new painting from Ehret and, in order to prevent this from happening again, pleaded that more care be taken with the originals.[141] Five years later, though, Trew was still making the same complaint, when two other originals were damaged:

> [I] have seen with much sorrow that both originals are once again abominably spoiled and therefore I can't refrain from expressing my just complaint to the illuminist. My dear Sir may consider for himself what kind of needless damage is caused to such a valuable collection by this inattentiveness. I can prove that it is possible to spare the originals by giving the example of Mr. Seligmann,[142] who returned the paintings that I gave him for his flower book as clean and pure as I had given them to him. If your illuminists are not capable of sparing the original, I ask in future that you

[139] See, e.g., Trew's critical remark on Weinmann's *Phytanthoza Iconographia*, quoted on p. 162.

[140] See TRWC, Trew, C. J. to Haid, No. 259, 29 October 1749.

[141] See TRWC, Trew, C. J. to Haid, No. 269, 12 December 1750.

[142] Johann Michael Seligmann was one of the most renowned publishers of illustrated natural history works, who in 1754 had edited the *Opera Botanica* by Konrad Gesner, with Trew's encouragement.

Fig. 2.6. *Lilio-Narcissus*, from an original watercolour drawing by G. D. Ehret. Trew (*Plantae Selectae*, Vol. 2, 1751).

> have somebody else, who is skilful at this, to make a copy and to use this copy, once it has been approved, instead of the original and give it to the illuminists to work from.[143]

Even as late as 1763 Trew still beseeched his publisher to have the original drawings treated more carefully, but these last pleas were probably heeded no more than the earlier ones.[144] With this knowledge, it comes as no surprise to learn that only a few of the original drawings have been preserved: if they were not damaged when the composition was being transferred onto the copperplate or by other accidents in the workshop, then it was surely the colourists who ruined them.

Once a test plate had been coloured, it was sent to Nuremberg for Trew to correct or give the go-ahead for the remaining prints to be coloured in the same way. Ehret's original drawings were usually sent with the test plate to enable Trew to compare the original with the printed plate. Haid's regular appeals that the work of his highly stressed colourists be appreciated went unheeded. Trew considered the colouring of the prints to be almost as important as the accurate execution of the engravings, and criticized every single test plate in detail. Occasionally, his remarks were devastating. In January 1751, Trew sent a number of illuminated proofs back to Haid with sarcastic comments, as in the following:

> Plate XV: Without even looking at the enclosed original, I knew it would need changes made to it. Held against it [the original], however, nobody would consider this a work of Ehret owing to the faulty illumination: and so, nothing remains to be censured but simply everything. The illuminist must have done this at night, or in his sleep or while drunk, or must su er from a considerable defect of the eyes. Otherwise he could not have mutilated it more, so that Ehret's delicate hand has been totally spoiled. [...]
>
> On the whole I have to say of these sheets that the praise that the engraver finally earned for himself on account of his exceptional industriousness has been totally obscured by the careless illumination. Plates XI and XVIII retain their value. Plates XIII, XIV, XV and XIX are the worst

[143] See TRWC, Trew, C. J. to Haid, No. 279, 8 December 1755. Original German: "[Ich] habe mit vieler Betrübnis ersehen, dass beyde originalia abermals abscheulich besudelt sind und habe desswegen mich nicht entbinden können, unter einer Probe meine billige Klage dem illuministen verstehen zu geben. Herr HochEdel bedencken selbst, was durch diese Unachtsamkeit für ein Schade einer so schäzbaren Sammlung mit ohne Noth zugefüget wird. Dass es möglich ist, die orig[inale] zu schonen, kann ich mit Hn. Seligmann beweisen, der mir die Mahlereyen, die ich ihm zu seinem Blumen Buch communcire, eben so sauber und rein zuruck gibt wie ich solche ihm einhändige. Wann Ihre Illuministen nicht fähig sind, das original zu schonen, so bitte gar sehr, ins künftige von jemand, der dazu geschickter ist, die Probe Platte verfertigen zu lassen und solche <wenn sie approbiret sind statt des originals> hernach denen illuministen zur Nachahmung zu übergeben."

[144] See TRWC, Trew, C. J. to Haid, No. 288, 6 June 1763.

> and even the rest need many corrections done to them if they are not to damage Mr. Ehret's reputation.[145]

The endless corrections, additions and Trew's pedantic criticism made Haid's work even more arduous than it already was. In parts, these remarks were justifiable, for example changing a name, requested in the quoted passage for Plate XVI, or the wish to arrange the flowers in Plate XV a little more conspicuously. Fussing over tints between yellow and green or red and orange, though, was going too far. Finally, Haid in his distress asked Trew to send him one of the coloured prints that Ehret had done himself from one of his original drawings, plus the original itself. And from this Haid concluded, with satisfaction, that even Ehret had represented some of the original details differently in the engraving. He commented on this to Trew:

> I very much appreciate that I have in my hands the *cereus*, the original version as well as a print made by Mr. Ehret, and so can see, which is now clear, what I discovered with much research, testing and trying, and which I finally also obediently communicate to Your Excellency. Namely: that it is one thing to colour from nature; it is something else entirely, however, to print and illuminate from another painting. As beautiful as Mr. Ehret's print is, it di ers greatly from the original, in the actual colours as well as in its treatment, a fact which Your Excellency refused to accept for my own work, but had been taught the opinion, I don't know by whom and from where, that an illuminated print should and could be totally similar to the original in colours and in treatment, even with respect to the mixed and broken colours, since Nature requires this and nothing else. So, I will repeat once more that I am determined to bring out the *cereus* as well as I can in print and colouring as Mr. Ehret, but more Your Excellency will not demand, unless it were possible.[146]

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[145] TRWC, Trew, C. J. to Haid, No. 266, 26 January 1750. Original German: "Tab. XV: ist mir schon ohne das beygelegte original gleich anfangs verdrustig [?] vorgekommen, gegen dieses aber gehalten wird sie der fehlerha ten illumination wegen von niemandem vor Ehretisch gehalten: dahero auch <davor> nichts als nur alles zu censiren ist. Der Illuminist muß die Probe bey Nachtzeit oder im Schlaf, oder Trunk gemacht haben, oder sonsten einen mercklichen Fehler am Gesicht leiden, anderst er dergleichen nicht verstümmelter hätte vorstellen können, indeme hierbey der delicate Ehretische Geschmack gäntzl[ich] verdorben worden. [...] Überhaupt aber muß von diesen Blättern sagen, daß das Lob welches sich lezthin der Kup erstecher durch seinen besondern Fleiß erworben hat durch nachlässiges Illuminiren gäntzlich hinwiederum verdunckelt worden. Tab. XI und XVIII behalten hier den Preiß. Tab. XIII, XIV, XV u. XIX sind die schlechtesten und die übrigen alle brauchen noch sehr große Verbeßerungen, wann sie H. Ehret nicht zum Nachtheil gereichen sollen." I am grateful to Professor Dr. T. Schnalke (Berlin) for his advice in transcribing these passages.

[146] TRWC Haid, J. J. to Trew, No. 164, 15 October 1749. Original German: "Es ist mir ungemein lieb, dass ich die *Cereus* in original und im abdruck von Herrn Ehret in Handen habe, und sehen kann, welches nun deutlich zeiget, was ich mit vielem Forschen, probiren, und versuchen ersehen, und endlich auch Eur.

Thus, even Ehret did not follow his original drawings exactly when engraving his copperplates and then colouring the resulting prints. This is not too surprising: first, the techniques of watercolour painting and print engraving are very different in terms of their possibilities and limitations; second, a watercolour painting is usually a one-off item, which consequently can be polished and elaborated in far more detail, whereas copper engravings were serially produced and each individual copy had to be hand-coloured. Compromises regarding the quality of every single print therefore had to be made. This might include accentuating single thorns or other parts of a plant with white. Even Ehret had refrained from incorporating this detail when colouring the engravings, as Haid wrote in a later passage of the same letter, so how could Trew ask him, Haid, to do so, since it "is a business for which a colourist would have to spend almost a whole day only on the hairs or white thorns, and that with every single print".[147] Additionally, Haid mentions the advantage of working with fresh material or other sources of information, as opposed to having only a picture, which made the work far more difficult, since one was unable to double-check whether the compromises were apt or not.

In short, Trew should take these differences between watercolour paintings and copperplates into account and not be fussier than the actual artist about the colouring of the prints. One cannot say, however, that Haid's pleas were heard – Trew continued to fuss, the project dragged on even more slowly than before and became an unpleasant burden to everyone involved. Nevertheless, despite all the delays, some issues did manage to be completed.

2.2.5 Completion and Sale

For these issues, the hand-coloured plates, plus the accompanying text written by Trew, were printed, the desired number of copies made and arranged by Haid into so-called *fascicles* of ten illustrations each and then offered for sale. It was common for eighteenth-century illustrated works to be arranged in these small fascicles or issues. A fixed number of fascicles together made

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Excellenz gehorsamst zu erkennen geben habe. nemlich: dass es ein andres seye nach der natur Mahlen, ein anders aber nach einem gemählde drucken und Illuminiren. Denn so schön H. Ehrets abdruck ist, so viel di erirt er doch gegen sein original, in der eigentlichen Colleur so wohl, als in der übrigen tractation, womit Eure Excellenz mir es doch nicht haben gelten lassen wollen, auch sich, weis nicht von wem also und woher, die meynung bey bringen lassen, als ob ein illuminirter abdruck dem original in Colleur und tractation völlig ähnlich seyn müsse und könne, auch in vermischten und gebrochenen Farben, es erfordere solches die natur, and. [anderes] erfordere es nicht. ich sage also nun nochmahls, das ich die *Cereus* so gut in abdruck und illumination bringen wolle, wie Herr Ehret, ein weiteres wird Eure Excellenz nicht fordern, es seye denn, dass es mir möglich werde."

[147] TRWC, Haid, J. J. to Trew, No. 164, 15 October 1749. Original German: "eine a aire ist, dar zu ein Mahler bey nahe einen Tag nur mit den Härеn oder weissen Stacheln zubringen müste, und das bey jedem abdr[uck]."

one volume, which frequently had its own preface and table of contents. The title page, a bibliography and various indices for the complete work typically appeared with the publication of the final issue. Binding the plates, the text, the title pages and indices into a book was the responsibility of the customer.

It could take years before the first volume of an illustrated work such as the *Plantae Selectae* was published in its entirety, while the completion of an entire multi-volumed work often took several decades. The production costs of these projects were so high that publishers could not wait for a whole volume or an entire work to be completed before receiving their first takings, but had to cover running costs by selling the first issues as quickly as possible. The sale of copies in bookshops or at book fairs was not the main source of revenue. Generally, author and publisher collected a certain start-up capital by attracting subscribers, usually long before the appearance of the first fascicle: in the hope that the project would be completed quickly and reliably, the subscribers paid a deposit on the fascicles in advance, thereby supporting the running of the venture. In favourable cases, the production process was financed by the subscribers and the sales of the first issues. However, this was not always the case and quite a few projects never went beyond a first volume due to lack of money. The *Plantae Selectae* sorely tested the patience of its subscribers, and Haid had to put them off again and again.

And so the project that Trew and Haid had started so enthusiastically of publishing 100 of Ehret's most beautiful and splendid plant images of a hitherto unseen quality only saw seven issues during the lives of its chief protagonists (the seventh issue was published in 1766). However, since Haid's publishing house held the rights for completing the work and additionally had access to an adequate quantity of other plant images from Trew's estate, the work was continued after Trew and Haid had died by Johann Elias Haid, Haid's son, in collaboration with the Altdorf professor, Benedikt Christian Vogel. In 1773, the tenth issue appeared, and in the years 1790/92 two supplementary volumes were published, all of them, though, of a far lower quality than the first seven issues.

2.3 The Art of Botanical Illustrations

In its range, high standards and design, the *Plantae Selectae* may not be representative of eighteenth-century illustrated botanical works; however, the workflows and difficulties described in this chapter can, nevertheless, be generalized. The production of a technical illustrated work was a costly and extremely demanding business. Not only did each of the different stages of the working process, from the artist's first outline to the print-ready illustration, proceed in a far more complicated way than one would imagine; they were also connected and depended on the work of many protagonists, all of whom contributed to the success or failure of the enterprise – just as Linnaeus wrote in his *Philosophia Botanica*: "A draughtsman, an engraver & a botanist are

equally necessary to produce a praiseworthy image; if one of these is at fault, the image turns out to be flawed".[148]

The empirical basis on which plant images arose was shown to be broad and varied; the images were constructed very much like a collage from a variety of sources. Although plant specimens were regularly used, they were just one source of information – even on excursions or expeditions, only rough outlines were done in situ, and these were then completed in the studio or workshop based on the sketches and notes made as well as on dried specimens. Already available pictures of the plant were also used as information source, which is the most difficult to understand, particularly in cases where fresh or dried plants of the species would have been at hand. Why refer to an earlier illustration when making a new one; indeed, if images of the species in question were already available, why bother at all to create a new one?

In doing so, the draughtsman usually followed the demands of an author with knowledge in the field of botany, who closely supervised the progress of the work. Frequently, he not only introduced the draughtsman to the special requirements of the genre but also selected the sources, determined the composition, explained the subject matter's peculiarities and painstakingly double-checked the draughtsman's work at every stage. This collaboration between a botanist who gave instructions and a draughtsman who executed them was the norm when it came to producing an illustrated botanical work that was to meet certain scientific standards. Exceptions to this rule, when both functions were executed by one person, can be found: when, for example, a graphically talented botanist illustrated his books himself, as in the case of Dillenius and his *Hortus Elthamensis*;[149] or when a draughtsman or engraver with botanical experience published a work independently without the support of a botanist, as, for example, John Miller and his *Illustratio Systematis Sexualis Linnaei*.[150] In most cases, however, botanical prints were not produced by an individual but by a carefully organized group of professionals, under the leadership of an author knowledgeable in botany.

Of course, collaborations of this kind did not always run smoothly. Every participant brought not only his or her special skills into the project but also the additional risk of error: no botanist could ever be sure that he had double-checked everything. Linnaeus took a quite radical stand on this issue, since only the botanically correct execution of every single stage guaranteed the scientific quality of the final result: "For this reason, the botanists, who were both knowledgeable in their discipline and in the art of drawing and engraving, left behind the most excellent images".[151] Thus, besides the actual execution

[148] After Linnaeus (2003), p. 283. Original Latin: "*Pictor*, *Sculptor* & *Botanicus* aeque necessarii sunt ad figuram laudabilem; si alter horum peccet, evadit figura vitiosa." Linnaeus (1751), Paragraph 332, p. 263.

[149] Dillenius (1732).

[150] Miller (1777).

[151] Linnaeus (1751), para. 332, p. 263. Original Latin: "Hinc Botanici, qui una exercuere artem & picturiam & sculpturiam, praestantissimas figuras reliquerunt."

of the drawing, Linneaus decisively put the main emphasis on the scientific contribution of a plant drawing and on minimizing the risk of error. Under favourable circumstances, however, the collaboration between a draughtsman and a botanist could develop into a stable working relationship with outstanding results, which none of the protagonists could have obtained on their own. The partnerships between Trew and his draughtsmen Ehret and Eisenberger described in this chapter in some detail are but two examples; similar working relationships developed between the botanist Joseph Pitton de Tournefort and the draughtsman Claude Aubriet, between Sibthorp and Ferdinand Bauer, between Banks and Franz Bauer, and between Charles L'Héritier and Pierre Joseph Redouté. Trew was perhaps an exception in that he committed himself with particular effort to the technical instruction of his draughtsmen and encouraged them to attend his lectures. However, the other cases also show that it was usual for the botanist to explain to his draughtsman the special requirements of scientific illustrations and to instruct him in basic botanical theory.

The analysis of the engraving and colouring process revealed even more clearly how the botanist did the utmost to control the high standard of the product. Only because Haid was well known for the excellent quality of his botanical engravings did Trew have the plates for the *Plantae Selectae* made by him in Augsburg. All of Trew's other works were produced in Nuremberg, which made it easier for him to check every drawing, proof and the quality of the hand-colouring personally and on the spot. But even from a distance Trew did his best to control the work up to the tiniest details, as demonstrated in the examples given. Virtually every single detail of the images was consciously designed (or at least consciously approved of), which needs to be taken into account when interpretating the pictures.

But what was the point of all this? According to the quotation used at the beginning of this chapter, Trew wanted his draughtsman to express nature "as clearly as possible" (see quotation, p. 26). But what exactly did he mean by that? He could not have had in mind the accurate representation of a particular plant specimen as it grows in the wild, since Trew accepted certain changes by the engraver and did not mind having details for one and the same plate drawn by different people using different plant specimens. Other authors are known to have praised their plant images for *not* resembling any one particular specimen of the species. This point deserves some explanation, since one then wonders what the alternative aim consisted of: in the next chapter, I shall take a closer look at the content of the images, in order to clarify what the botanists and draughtsmen wanted to represent.

3

The Content of Botanical Illustrations

3.1 Elements of the Content

Identifying the elements that are typical of the content of botanical illustrations is best done by studying an example in detail, say, the botanical illustration reproduced in figure 3.1 (p. 72): an image of the sweet vernal grass, *Anthoxanthum odoratum*, published in 1798 in the first comprehensive flora of the German countries by the Nuremberg author and engraver Jakob Sturm who was a founding member of the Nuremberg Naturhistorische Gesellschaft in 1801.[1] Engravings of some of the plants shown in this flora had already been published, however, as Sturm wrote in the preface: "Some of them are badly drawn and coloured; some have been broken up and dispersed; some are only to be found in large and splendid publications which often even the lover of botany does not get a chance of seeing once in a lifetime."[2] In order to make it cheaply available to a broad audience Sturm deliberately chose the tiny duodez format (13-15 cm or 5-6 inch in height) for his seminal work, which contains no less than 2472 engravings altogether. What is the factual information provided by these images and how is it conveyed?

3.1.1 Taxonomically Relevant Properties

Christoph Jacob Trew (as well as Carl Linnaeus) took considerable pains to ensure that Ehret learned how to draw the details of the fruit and flower of a plant "so that the characters of its genus could be clearly recognized", as Trew put it (see quotation, p. 33).[3] In the preface to his *Flora Londinensis*, William Curtis also stressed that he had been "very particular in the delineation and

[1] Sturm (1798-1855).

[2] Sturm (1798-1855), preface. Cited Blunt (1994), p. 259.

[3] The original German text reads: "um seine Geschlechter-Zeichen daraus ersehen zu können", in *Herrn Georg Dionysius Ehret bisherige Lebens-Umstände*. For a transcript of the document, see Kastinger Riley (1996).

Fig. 3.1. Sweet vernal grass – *Anthoxanthum odoratum* L. Sturm (*Deutschlands Flora*, Vol. 1, 1798).

description of several parts of the flower and fruit, more especially where they characterize the plant".[4] Conveying this type of information in their illustrations – that is, the properties of a plant which determine its species and genus – was obviously of particular importance to eighteenth-century botanists. This assumption can be checked by examining Sturm's illustration of the sweet vernal grass. According to the above claim, this image should convey information on the properties that characterize plants of the species *Anthoxanthum odoratum* and on the properties that distinguish them from plants of other species: in other words, the image had to convey the plant's taxonomically relevant properties. Representing these properties in an image is not straightforward. Plant species are not concrete objects, the properties of which can be gathered by just looking at them. Rather, they are abstract concepts designating whole classes of objects whose definitions depend on the taxonomic system used at the time.

By the middle of the eighteenth century, the so-called sexual system of Linnaeus had been adopted by the majority of botanists working in Europe – including almost all the botanists whose images were selected for this study.[5] It is obvious that Linnaeus's taxonomy was also used for the illustration of Sturm's sweet vernal grass: the letter "L." placed after the binomial Latin name indicates that the species depicted was given its name by Linnaeus, while the number "II.2" at the top of the picture was the conventional abbreviation for a certain Linnean class and order. Therefore, to evaluate the taxonomical content of Sturm's illustration, one has to familiarize oneself with the principles of the Linnean system.[6]

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[4] Curtis (1777-98), Preface.

[5] A few authors used other taxonomies: Joseph Pitton de Tournefort developed his own system before Linnaeus, Johann Hieronymus Kniphof used Christian Gottlieb Ludwig's system, and some authors, publishing towards the end of the eighteenth century, had already begun to apply Antoine-Laurent de Jussieu's natural system, as, e.g., Regnault & de Nangis Regnault (1774), Redouté (1802-16), Duhamel du Monceau (1804-19) and Jaume Saint-Hilaire (1808-22). All of them, however, still referred in their texts to the corresponding Linnean nomenclature and classification. With some works, namely Weinmann (1717), Weinmann (1735-45) and Blackwell (1737-39), it is unclear whether they took taxonomical considerations into account at all. For a description of the image selection under study, see Chapter 8, p. 265.

[6] Stafleu (1971) contains the most comprehensive description of the Linnean system and its underlying principles; Larson (1971) analyses the Aristotelian roots of Linnaeus's system. However, Müller-Wille (1999) reinterprets the system's theoretical value, arguing against the commonly held view of Linnaeus being the last representative of Aristotelian scholasticism. All these titles have extensive bibliographies on the topic. Blunt (1971) contains one of the most comprehensive biographies available on Linnaeus. For a more recent biographical account of Linnaeus which predominantly examines his "cameralistic" stance, see Körner (1999).

Linnaeus•s Sexual System

General Principles

Linnaeus introduced the principles of his sexual system for the first time in 1735 in a short outline entitled *Systema Naturae.*[7] "The flower is the plant's joy", was Linnaeus's motto therein, to which he added: "So the plant propagates!"[8] These two short sentences embody Linnaeus's stance on taxonomy. The reproductive organs of a plant formed the basis of his system, which was, therefore, called the "sexual system" – a designation that Linnaeus himself used. Linnaeus employed the term "fructification"[9] to refer to the following seven parts of a plant: the calyx, flower (or corona), stamens, pistil, fruit and seed, all contained within the receptacle.[10] Linnaeus was convinced of the central importance of these organs – he even called them the "essence" of the plant.[11]

In his system, Linnaeus classified all the plants known to him into five hierarchical categories, from most general to most similar. Species and varieties were the two lowest categories, and even amateurs could, Linnaeus believed, practice this form of "practical classification", that is recognize and define plants in these categories. "Theoretical classification", that is, defining the higher, more abstract categories – genera, orders and classes – was, however, the work of experts, since it required a deep knowledge of botany. According to Linnaeus, Andrea Cesalpino, Robert Morison and Joseph Pitton de Tournefort were the leading experts in theoretical classification.[12]

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[7] Linnaeus (1735). The *Systema Naturae* also includes Linnaeus's proposals for classifying the animal kingdom as well as minerals, neither of which are examined in this study.

[8] Original Latin: "Flos est plantarum gaudium ... Sic planta propagat!" See the motto on the page of the plant realm in Linnaeus (1735).

[9] In this study, the expression "fructification" is used as a translation of the Latin Linnean concept "fructificatio".

[10] In addition to what is today understood by this term, Linnaeus's "receptacle" included, for example, the inflorescence of a plant.

[11] See Linnaeus (1751), p. 56, paragraph 88: "The essence of a FLOWER (87) consists in the *anthers* (86) & the *stigma* (85). [The essence] of a FRUIT (87) in the *seed* (86). [The essence] of a FRUCTIFICATION (87) in the *flower & fruit.* [The essence] of PLANTS (78) in the *fructification* (87)." Original Latin: "Essentia FLORIS (87) in *Anthera* (86) & *Stigmata* (85) constitit. [Essentia] FRUCTUS (87) in *Semine* (86). [Essentia] FRUCTIFICATIONIS (87) in *Flore & Fructu.* [Essentia] VEGETABILIUM (78) in *Fructificatione* (87)."

[12] Linnaeus (1751), p. 92, paragraph 152. The sixteenth-century botanist Cesalpino established the first comprehensive botanical taxonomy; like Linnaeus's system, it focused primarily on the properties of the flower and its organs. Morison introduced in the seventeenth century a modified version of Cesalpino's system, which also took into account the properties of the ovules and the fruit. Tournefort was probably the most famous taxonomist working around 1700. He established the

Classes and Orders

The "key" to determining the twenty-four classes into which Linnaeus grouped plants and their respective orders was also published in the *Systema Naturae*.[13] Step by step, this key explains which properties of the flower and its sexual organs (male stamens and female pistils) have to be checked to classify a given plant into one group or another. To find out which class a plant belonged to, the following points had to be determined:

1. whether a plant's sexual organs were exposed or hidden;
2. whether the flower was unisexual or a hermaphrodite;
3. whether the stamens grew together or stood independently;
4. whether the stamens were all of the same size or differed in length;
5. how many stamens per flower could be observed.

The name of a plant's class was usually derived from the last criterium – the number of stamens per flower. So, the sweet vernal grass, for example, with its two stamens, belonged to the class *Diandria* (*di* = two; *andros* = man). Other classes were *Monandria* with one stamen per flower, *Triandria* with three stamens, *Icosandria* with twenty stamens and *Polyandria* with "many" stamens. Within the classes, there were several orders, and a plant's order was usually determined by the number of female organs per flower. Thus, in each class one had to distinguish between *Monogynia* with only one pistil (*mono* = one; *gyne* = women), *Digynia* with two pistils, *Trigynia* with three, and so forth. The sweet vernal grass has two pistils per flower: within the class *Diandria* it, therefore, belonged to the order *Digynia*. The peony, to take another example, also has two pistils per flower but a great many stamens, not just two like the sweet vernal grass. It, therefore, also belonged to the order *Digynia* but in the class *Polyandria*. Not all classes and orders, however, fitted into this scheme. The hazel, for example, has not hermaphrodite but unisexual flowers of both sexes. This genus, therefore, failed to get past the second of the defining properties in the above check-list. Its male and female reproductive organs are found in different types of flowers growing on the same plant. Therefore, the hazel was placed in a class called *Monoecia* (*mono* = one; *oikos* = house). In this case, the number of its stamens determined not the class but the order: the hazel belonged to the class *Monoecia*, order *Polyandria*.

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first comprehensive definition of genera based on the properties of the flower and the fruit. Interestingly, Linnaeus failed to mention in this context the then renowned John Ray, a contemporary of Tournefort, who in his system explicitly wished to see all the organs of a plant taken into account, which contradicted Linnaeus's principles.

[13] See *Clavis Systematis Sexualis* in Linnaeus (1735).

The criteria described above for classifying plants into classes and orders were chosen more or less arbitrarily, as Linnaeus was well aware.[14] This was justified, Linnaeus believed, since so far no adequate natural system had been found.[15] A different matter, however, were his definitions of the genera, as will be seen in the next section.

Genera

Linnaeus repeatedly emphasized in his writing that, unlike classes and orders, genera were natural categories that one should not arbitrarily separate or class together in taxonomic systems. He explained how to classify genera in his *Genera Plantarum*, first published in 1737.[16] The book's full title clearly shows Linnaeus's line of research: *The Genera of the Plants, with their natural characters according to the number, shape, position and proportion of all the parts of fructification.*[17] After an introduction on the principles of defining plant genera – or, as Linnaeus put it in a later work, the principles of characterizing them[18] – Linnaeus gives an overview of the classifying properties of all the plant genera known to him. The book was revised many times, by Linnaeus and others, and is regarded as one of the principal texts of the history of systematic botany. However, Linnaeus gave a more detailed account of his theoretical principles in his *Philosophia Botanica*, which, in addition to the *Genera Plantarum*, has been used for the following description.

"We admit as many genera as there are different natural species of which the fructification has the same structure", is how Linnaeus explained his understanding of the taxonomic category of the genus in the *Philosophia Botanica*.[19] Thus, a Linnean genus included all those species with similar fructifications, and the common features of these organs provided the classificatory properties of the whole genus. According to the full title of the *Genera Plantarum*, Linnaeus claimed that the diagnosis of a genus should be constructed by taking into account the properties of all the organs of fructification not only those of the fruit *or* the flower, as his predecessors had done at times. Not all the properties of these organs, however, were considered of taxonomic importance

[14] I do not go into a discussion here as to why Linnaeus chose the flower and its organs as the basis for his classification system.

[15] "In general it is maintained that an artificial method can only be a substitute for a natural one, and has to be dropped if the latter is found". Original Latin: "perpetuum est, quod methodus artificialis sit tantum naturalis succedanea, nec possit non cedere naturali, si detegeretur." Linnaeus (1738), Preface. On Linnaeus's project to find a natural system, see the already cited Müller-Wille (1999).

[16] Linnaeus (1737d).

[17] Original Latin: *Genera Plantarum, eorumque characteres naturales secundum numerum, figuram, situm & proportionem omnium fructificationis partium.*

[18] Linnaeus (1751), paragraph 186: "The CHARACTER is the definition of a genus." Original Latin: "CHARACTER est Definitio Generis."

[19] Linnaeus (1751), paragraph 159. Original Latin: "Genera (155) tot dicimus, quot similes constructae fructificationes proferunt diversae Species (157) naturales."

but only the number[20] of the respective organ, its external shape, its position and its proportion relative to the other organs of the plant.[21] In a number of paragraphs in the *Philosophia Botanica*, Linnaeus explains in greater detail how to assess the different characters for classifying a plant. If, for example, the flowers of two species resembled each other but the fruit did not, these two species were still to be counted as members of the same genus, since Linnaeus considered the shape of the flowers to be more reliable than the shape of the fruit.[22]

In the main body of the *Genera Plantarum*, Linnaeus demonstrated how to carry out the diagnosis of a genus. His diagnosis of the sweet vernal grass can serve as an example:[23]

> CALYX: *Glume*: with a single flower, bivalvular. *Valves*: ovoid, acuminate, concave; the interior larger than the exterior.
> CORONA: *Glume*: with a single flower, bivalvular; as long as the calyx's larger valve; each of them producing a small awn from the lower part of the back. *Nectary*: two-leaved, very tender, cylindrical, with almost ovoid leaflets embracing each other.
> STAMENS: two *filaments*, capillary, very long. *Anthers*: oblong, both sides bifurcated.
> PISTIL: *Ovary*: oblong. *Styles*: two, capillary. *Stigmas*: simple.
> FRUIT: the *glumes* of the corona fuse with the seed.
> SEED: single, both sides acuminate, smoothly polished surface.

Here, as with every other genus that he knew of, Linnaeus listed all the parts of the fructification in a set order and characterized them with

[20] "Number" does not necessarily mean the absolute quantity of the respective organ; Linnaeus also used indefinite numerals such as "many" and "few". Exact numbers were, however, given for the stamens, pistils, petals, etc.

[21] See Linnaeus (1751), paragraph 167: "Every characteristic feature (189) must be determined by the number, shape, proportion and position of all the di erent parts (98-104) of the fructification (86)." Original Latin: "NOTA CHARACTERISTICA (189) omnis erui debet a Numero, Figura, Proportione & Situ omnium partium Fructificationis (86) di erentium (98-104)." Cain (1994) argues that Linnaeus actually borrowed these principles from the fields of mathematics and geometry in order to make his system more accurate.

[22] See Linnaeus (1751), paragraph 176: "If the flowers (87) agree, whereas the fruit disagree, the genera are, all else being equal, to be united." Original Latin: "176. Si Flores (87) conveniunt, Fructus (87) autem di erunt, ceteris paribus, conjungenda sunt Genera." Note the ceteris paribus condition included in this rule.

[23] Cited Linnaeus (1960), p. 17, No. 40. "CAL. *Gluma* uniflora, bivalvis. *Valvulis* ovatis, acuminatis, concavis; interiore majore. COR. *Gluma* uniflora, bivalvis, longitudine valvulae majoris calycinae; valvula utraque aristam parvam e dorso inferiore emittente. *Nectary* diphyllum, tenuissimum, cylindricum, foliolis subovatis, amplexantibus. STAM. *Filamenta* duo, capillaria, longissima. *Antherae* oblongae, utrinque bifurcatae. PIST. *Germen* oblongum. *Styli* duo, filiformes. *Stigmata* simplicia.PER. *Gluma* corollae adnascitur semini. SEM. unicum, utrinque acuminatum, teretiusculum."

attributes, particularly regarding the four dimensions listed above. The technical language needed to describe these characteristics was first expounded in Linnaeus's *Fundamenta Botanica* (1736);[24] later, in the *Philosophia Botanica* (1751), Linnaeus clarified the terminology and added vocabulary to his list of terms. By this means, Linnaeus was able to put forward succinct characteristics for every type of genus, summarizing the relevant properties according to his taxonomic system. The resulting sets of properties were called *characteres naturales*, natural characters of the genera.[25] These generic characters comprised all those properties that certain species had in common, so to define a genus one needed to know all the species affiliated to it. Since the botanical illustrations under examination are primarily concerned with this one category, I shall examine the principles of the characterization of species in some detail.

Species

For Linnaeus, species of organisms were, like genera, natural units that should not be separated or placed together at whim. Unlike genera, however, species were not only distinguished by the properties of their fructifications but also by the morphology of their roots, stems and leaves. Even then, Linnaeus stressed that only those properties that were most constant in all conditions should be used. Properties that varied among individual specimens of the same species growing in different locations (for example, the size, life-span and luxuriance of a plant) should not be used for classifying purposes. Likewise, a plant's colour, scent and taste were considered unsuitable, since a description of these properties depended not only on environmental conditions but also on the ability and judgment of the observer. Other properties to be excluded were those that did not pertain to the species itself but described it relative to other objects – as in, for example, the description of a leaf as "ivy-shaped" or its characterization by referring to the name of its discoverer, its pharmaceutical use or other practical values.[26]

Constant properties included differences in the morphology of the root, the stem, the leaves, the auxiliary organs such as thorns and buds, the inflorescence and, of course, the fructification. The latter could be used for the diagnosis of the character of a species if it distinguished different species within a genus. The properties in question should be as clearly recognizable as possible, which, for example, applied more to differences in the morphology of the leaf than to the root.[27] Furthermore, the same four dimensions that were applied to the natural character of a genus should be applied to the natural character of the species:

[24] Linnaeus (1736).

[25] Linnaeus (1751), pp. 129f., paragraph 189: "The natural character [of the genus] comprises all potential generic properties." Original Latin: "NATURALIS character (186) notas omnes (92-113) genericas possibiles (167) allegat."

[26] See Linnaeus (1751), pp. 206 ., paragraphs 260-274.

[27] See Linnaeus (1751), pp. 217 ., paragraphs 275-281.

> There are four dimensions from which to take [specific] di erences: *number, shape, position, proportion*, that is, the same as for the genus. These [four dimensions] are constant everywhere, in the plant, in the herbarium, in an illustration.[28]

The reason Linnaeus gives for using the above four dimensions is quite remarkable: the qualities he mentioned stand out because they remain unaltered not only in plants in different locations but also in all the different methods of representation that botanists use: living plants, dried plants and – illustrations. Thus, Linnaeus makes it clear that, for him, illustrations were one of botany's essential aids and that the possibilities and limitations of illustrations were to be taken into account when specifying taxonomically relevant properties. Only those properties that could be represented pictorially could be used, while properties that were variable or would be lost in pictures were of no use in ascertaining the definition of a species.

As already mentioned in the section on genera, Linnaeus admitted that the qualities of these four categories might vary; however, they were still the best possible option, since they were the most invariable of the qualities. Furthermore, it was unlikely that there would be variations in all four dimensions occurring at the same time and in all the relevant parts of an individual specimen.[29] That is, although a single flower might differ from the given species definition in the number of its petals, this would not automatically mean that the classification of the plant was incorrect, since it would be highly likely that all other flowers would show the usual number of petals and, in addition,

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[28] Linnaeus (1751), p. 224, paragraph 282. Original Latin: "*Modi*, quibus di erentia desumitur, sunt quatuor: *Numerus, Figura, Situs, Proportio*, adeoque iidem, qui in genere. Hi ubique constantes, in planta, in Herbario, in Icone." Linnaeus had already expressed this theory in his *Critica Botanica* (1737), in which he also confined the classifying properties of the species and genus to the number, shape, position and proportion of the di erent organs: "These four [properties] determine the outer appearance of a plant by which one distinguishes it from others. These properties and not others we represent in an image. These we preserve in a herbarium: the remaining could all be accidental. These do not leave the Reader uncertain and doubtful; these are words of weight and value." Linnaeus (1737b), p. 201, paragraph 282. Original Latin: "Ex hisce quatuor dependet externa structura plantae, qua una nobis ab aliis diversa repraesentatur. Has notas, non alias, repraesentamus in iconibus. Has conservamus in herbariis vivis: reliquae omnes accidentales esse possunt. Hae non dimuttunt Lectorem incertum & dubium; Hae verba sunt ponderis & valoris."

[29] "Although shape, number, proportion and position do vary in plants, it is rare, and not all of them change at the same time and not in all parts of the plant at once. After all, they are less variable than all the other properties and changes in them do not lead to a di erence in the plant's structure." Linnaeus (1737b), p. 202, paragraph 283. Original Latin: "Variat quidem figura, numerus, proportio & situs in plantis, licet rarius, non tamen omnes simul, nec in omnibus plantae partibus simul; variant licet minus, quam reliquae omnes, licet minus quam ut inde structura di erens evadat."

would share the other properties that determined the species. Sporadic variations in these properties, Linnaeus maintained, would not lead to a major change in the structure of a plant and, therefore, it would still be possible to determine its species.

Species' Names, Characters, Descriptions

As he did with the genera, Linnaeus also published his own descriptions and characterizations for all the species known to him. These make up the famous *Species Plantarum* or, as the complete title reads: *The Species of Plants, containing all properly known plants, related to their genera, with their distinctive characters, trivial names, selected synonyms, natural locations, arranged according to the sexual system.*[30] This work was first published in 1753, and marks the starting point of modern botanical nomenclature: all the species names that were in use before this date and were not adopted by Linnaeus are no longer recognized. Today, only the binomial names are usually referred to when speaking of "Linnean" nomenclature. Originally, though, Linnaeus put forward these binomial names, which he called "trivial names", as handy abbreviations for everyday use. For the actual designation of a species, he gave a long descriptive name, the so-called *nomen specificum*, which contains the generic name plus a short phrase giving the plant's distinctive characters compared with other species of the same genus. Some of these names were quite long and, therefore, clumsy to use. They had the advantage, however, that, compared with the trivial names, a species designated with a *nomen specificum* did not require any additional description, since everything was already included in the name.

The *Species Plantarum* lists, for example, three species within the genus *Anthoxanthum*: (i) the sweet vernal grass to which Linnaeus gave the trivial name *Anthoxanthum odoratum*, (ii) another with the trivial name *Anthoxanthum indicum* and (iii) a third called *Anthoxanthum paniculatum*. Although these binomial names are catchy and easy to remember, they are not logically connected: the first grass is described as "odorous", the second as "Indian", the third as "panicle-flowered". Nothing is said about the properties that distinguish one species from the other. On the contrary, a vernal grass could have all these three properties: it could be fragrant *and* originate from India *and* bear panicle-shaped inflorescences. No such confusion, however, arises with the *nomina specifica* given to these species. They are as follows:

1. Vernal grass with an ovoid-oblong spike and florets on short peduncles that are longer than the awn.[31]

[30] *Species Plantarum, exhibentes plantas rite cognitas, ad genera relatas, cum differentiis specificis, nominibus trivialibus, synonymis selectis, locis natalibus, secundum systema sexuale digestas,* Linnaeus (1753).

[31] Anthoxanthum *spica ovato-oblonga, flosculis subpedunculatis arista longioribus.*

2. Vernal grass with lineally shaped spikes and sessile florets that are shorter than the awn.[32]
3. Vernal grass with paniculate inflorescences.[33]

The structure and function of these long names become clear when one compares the first two entries. The *nomina specifica* for these two species of grasses indicate precisely (and only!) those properties that distinguish the two species from one another: the shape of the inflorescence, the position of the individual florets at the spike and the length of their awns. The third species is only distinguished by its inflorescence, which differs so much from the two others that Linnaeus presumably considered any further specification unnecessary.

These specific characters, of course, presuppose that the plant's genus has been correctly determined. Once this has been established, the three species can easily be differentiated with the help of the long names, since they describe exactly those properties of flower and inflorescences that distinguish all three. Interestingly enough, these long names indicate not one distinctive feature but three – although logically speaking it would have sufficed to note only, for example, "florets that are longer than the awn" and do without "florets on short peduncles". One should bear in mind, however, that, as Linnaeus himself admitted, even the supposedly constant properties of a species could sometimes vary. A specimen of plant can always be atypical in one respect or other, which is why it would have been unwise to base a definition on only one distinctive property. Few plants, however, would have all three distinctive properties and not belong to the species in question. So Linnaeus came up with a "safe" definition, which takes into account the occasional idiosyncracy.

Even so, these specific characters still include only a small number of taxonomically relevant properties, and are not to be confused with the description of a species, as published by Linnaeus in, for example, the *Flora Lapponica*[34] and the *Hortus Cliffortianus*.[35] Linnaeus himself made a fundamental distinction between these two forms of description, not only with regard to the length of their name but also with regard to their function in the system:

> The specific differences include only as many properties as are required for distinguishing all the species known at the time belonging to the same genus: if they include more [properties], a mistake has been made. Descriptions of species, however, exhibit all the differences that exist and, therefore, a description will always endure, even if myriads of new species should be discovered, whereas the *nomen specificum*, which only distinguishes known species from each other, will turn out to be insufficient on the discovery of

[32] Anthoxanthum *spica lineari, flosculis sessilibus arista brevioribus.*
[33] Anthoxanthum *floribus paniculatis.* All quoted from Linnaeus (1753), p. 28.
[34] Linnaeus (1737c).
[35] Linnaeus (1737e).

> new ones. One might even say that the description of a species, if in itself it is perfected, is the basis for all the di erent specific names.[36]

Thus, while the specific or characterizing name of a species should only include those properties that distinguish two known species of a genus from each other, the description was to include all the properties of a species in general – it was not only restricted to the constant properties. For this reason, descriptions, if they were competently done by a knowledgeable expert, were timeless and no newly discovered species could question their validity. This was not the case with the specific character or diagnosis of a species, Linnaeus explained, since it included only the distinguishing properties that were necessary for all the species known at the time – one might have to extend or change them totally on the discovery of a new species.

Varieties

Finally, varieties were the lowest category in Linnaeus's hierarchical system. He defined them as "plants of the same species that vary due to some occasional condition".[37] Linnaeus considered plants as natural varieties in which the male and female of a species were morphologically different, as is true of the dog's mercury (*Mercurialis perennis* L.), for example. All other varieties were "monstrosities", such as plants with double blossoms owing to the petalody of the stamens, plants with winding stems or deviations in wild types in colour, scent and taste. According to Linnaeus, botanists should not unduly concern themselves with varieties; nevertheless, he considered it important for botanists to be able to recognize the different varieties of a species – indeed, this was almost as important as being able to recognize the different species of a genus. A taxonomic system would become unnecessarily complicated if new species were introduced only because one did not recognize that the respective specimen was a variety of an already existing species.[38]

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[36] Linnaeus (1737a), *Botanical Lectures* [1]. Original Latin: "Di erentiae enim specificae tot modo notas sistunt, quot necessario requirantur ad distinguendas species detectas a congeneribus: si vero plures admittant, culpam incurrunt; descriptiones vero specierum exhibent omnes di erentias quae existunt, adeoque persistit inconcussa descriptio semper, licet myriades novarum detegeruntur specierum, dum Nomen Specificum, quod exclusit modo notas species a novis detectis insu ciens evadit; ne dicam quod descriptio speciei, si in se ipsa perfecta sit, fundamentum contineat omnis di erentiae nominis specifici." The Latin taken from Müller-Wille (1999), p. 78.

[37] Linnaeus (1751), paragraph 306: "Varietates sunt plantae ejusdem speciei, mutatae a caussa quacunque occasionali."

[38] Linnaeus (1751), paragraph 317: "Placing di erent varieties in their species is no less important than placing species in their genera." Original Latin: "Varietates diversas sub sua specie colligere, non minoris est, quam species sub suo genere collocare."

The Sexual System and Illustrations

In Sturm's illustration of the sweet vernal grass (fig. 3.1, p. 72), it is apparent at first sight that the reproductive organs belonging to Linnaeus's fructification apparatus have been done in particular detail. There are magnified views of the individual flowers and their components, two details of the seed and a separate representation of the ear. In addition, Sturm has shown a general view that demonstrates the complete habit of the sweet vernal grass with its leaves, stems and roots. Thus, the properties needed for determining the plant's class and order, as described on page 75, are easily recognizable: (i) the sexual organs are exposed, not hidden; (ii) the flowers are hermaphrodite; (iii) the stamens are separate, that is, they are not fused; (iv) and the latter are all of the same size. Furthermore, there are: (v) two stamens per flower; and (vi) two pistils. The sweet vernal grass, therefore, belongs to the class *Diandria*, order *Digynia*.

Looking at this picture it is also possible to determine the plant's genus within the Linnean system. According to Linnaeus, this required a detailed observation of the number, shape, proportion and position of the seven fructification organs. This can easily be done by looking at the strongly magnified details. All the organs are shown so clearly that assigning their genus definitions should not cause any difficulty – even a new genus could be determined. The calyx of the sweet vernal grass, for example, has grown in the form of two pointed glumes (detail d), the corona is made up of two additional glumes with one awn each (detail F). The supposed nectary – which is, in fact, a structure consisting of an outer and an inner bract – is shown in two separate details (H, I). The two stamens clearly exhibit their long and thin filaments, with their anthers structured in two packages each (details E, g). Equally clearly shown is the pistil, made up of a longish ovary and two thin styles with simple stigmas (detail g). The seed, fused with its pericarp, is shown in two detailed views (details k, K). The inflorescence, or receptacle, has also been presented twice, both in the general view of the plant (detail a) and in an extra detail (detail b). If one compares the organs represented in the picture with the generic definition of the sweet vernal grass by Linnaeus (see the quote on pp. 77f.), one can confirm that the characters have indeed been correctly represented.

Finally, to characterize a Linnean species required a number of specific properties, which, within the genus *Anthoxanthum*, distinguished several species from each other. The long name of the sweet vernal grass, which names all these properties, has already been mentioned: according to Linnaeus's *Species Plantarum*, it was called the *Vernal grass with an ovoid-oblong spike and florets on short peduncles that are longer than the awn.*[39] And indeed, all three components of this definition are clearly depicted in Sturm's illustration: the spike is shown twice and its "ovoid-oblong" shape is particularly obvious from the general view (detail a) – it is almost a caricature of an

[39] Linnaeus (1753).

egg-shaped spike. The detailed view of the inflorescence (detail b) shows the short stalks of the individual florets, while the proportion of the flower organs is best seen in details E and g: the floret is indeed shown considerably longer than the two awns.

The aim of representing the different elements of the Linnean definitions is explicitly referred to in some botanical works, as, for example, in the *Flora Batava*, the first volumes of which were written by the Utrecht botanist Jan Kops:

> One should not expect [in this book] a complete description of all the parts of each plant. This would have made the work unnecessarily voluminous, since one can find enough in this respect in the works of other botanical writers. Therefore, special importance was attached to those parts of a plant represented in the illustrations that distinguish it from all the other plants related to it. I thought it particularly useful to describe the characters of a plant's genus and species both in the illustration and in the text; and in this I shall always follow throughout the book the 15th edition of *Caroli a Linnaeus systema vegetabilium, quae est recognitiones A. Murray institutae, tertia, procurata a C. H. Persoon, Gottingae A°. 1797.*[40]

3.1.2 Additional Speci“c Properties

Sturm's illustration, however, presents more than just the shape, number, proportion and position of the fructification organs and other parts of the plant, as required within the Linnean system to determine the plant's class, order, genus and species. Not only does it show that the florets are longer than their awn but also the knee in the awn, the hairs on the glumes, the furry surface of the stigmas and the mature bifurcated x-shape of the anthers. The general view shows the complete habit of the sweet vernal grass, although this was not required for a classification of the plant according to Linnaeus's definitions. Also taxonomically irrelevant are the depictions of the roots, stalk, leaves, nodes and sheaths – as well as the sweet vernal grass's unusual mode of maturation: it is one of the few grasses that flower protogynously, that is, the stigmas mature before the anthers. This is indirectly depicted in Sturm's picture by the fact that the florets are shown either with mature stigmas

[40] Kops (1800-49), Voorbericht (Preface), Vol. 1. Original Dutch: "Men zal niet verwagten eene vollendige beschryving van alle de deelen van elke plant. Dit zou het Werk buiten noodzaake omslagtig maaken, dewyl men hiertoe by Botanische Schryvers genoeg kan te regt komen. Hierom heest men by de Afbeeldingen zich voornaamlyk bepaald, om alleen die deelen der Plant byzonder aantewyzen, of afzonderlyk optegeeven, welke haar van alle aanverwante Planten onderscheiden. Het scheen my toe vooral nuttig te weezen, de kenmarken van het Geslagt en Soort der Plant, zo door afbeelding als beschryving, te doen kennen; en hier in zal ik door het geheele Werk bestendig volgen, die vystiende uitgaaf van *Caroli a Linnaeus systema vegetabilium, quae est recognitiones A. Murray institutae, tertia, procurata a C. H. Persoon, Gottingae A°. 1797.*"

only, or with both stigmas and anthers; none of the florets bear only mature anthers. Furthermore, the illustration demonstrates that the anthers are far longer than the styles when mature, that the stigmas are in the form of a twisted moustache, and so on. All these properties have no bearing on the plant's position in Linnaeus's sexual system but are, nevertheless, of interest to botanists and plant enthusiasts alike, since they are as typical of the sweet vernal grass as the fact that it carries two anthers per floret.

The same can be seen in the illustration of the coltsfoot by Curtis, reproduced in Chapter 1 (fig. 1.2, p. 5). The taxonomically relevant flower heads and individual florets have been given special attention and enable the plant's class, order and genus to be determined. Furthermore, Linnaeus's definition of the coltsfoot species reads *Coltsfoot with a stalk covered with scale leaves supporting only one flower, and with almost heart-shaped, angular, indented leaves*,[41] which meant that the stalks and leaves of the coltsfoot had to be added – duly done by Curtis. However, the detailed views of the flower heads in all stages of their development are of no taxonomical relevance. Curtis has also folded the flower heads into a nodding position after flowering, and raised them up again on the ripening of the fruit, exposing the clock vertically.[42] The coltsfoot's creeping rhizome is also taxonomically insignificant but surely an interesting characteristic, as is the arrangement of the leaves in the form of a rosette, where the leaves at first are rolled up in the centre before they uncurl. Curtis has also shown the gradual elongating of the stalk over the course of the year by depicting the stalk in several stages of its development. Interestingly, the stalk is not at its longest when the flower has matured, as might have been expected but on the ripening of the fruit! After having flowered, the stalk receives another growth spurt in order to expose fully the clock to the wind. This has no taxonomical value but it is nevertheless a characteristic that reveals much about the coltsfoot's life cycle and ecological adaptation (as it would be termed today).

So it seems that a large part of the factual information conveyed in plant illustrations concerns plant properties that are not taxonomically relevant. Indeed, some illustrations even give the impression that the taxonomically relevant information was of subordinate interest as, for example, the illustrations by Elizabeth Blackwell. Her image of the vine, reproduced in figure 3.2

[41] *Tussilago scapo imbricato unifloro, foliis subcordatis angulatis denticulatis.* See Linnaeus (1753).

[42] Eighteenth-century botanists suggested a number of di erent hypotheses to explain this phenomenon. According to the German Curt Sprengel, e.g., in the nodding position the seeds at the bottom of the flower are directly exposed to the sun during the sensitive stage of their development, when they need nursing. When the fruit has ripened, this concentrated flow of energy has to be stopped, which is why the mature clock straightens up again. See Sprengel (1793), p. 375. Curtis maintained that the flower head gets increasingly heavier and for that reason begins to droop; once the seeds have matured, the weight decreases by evaporation and the head rises again. See Curtis (1777-98), no pagination.

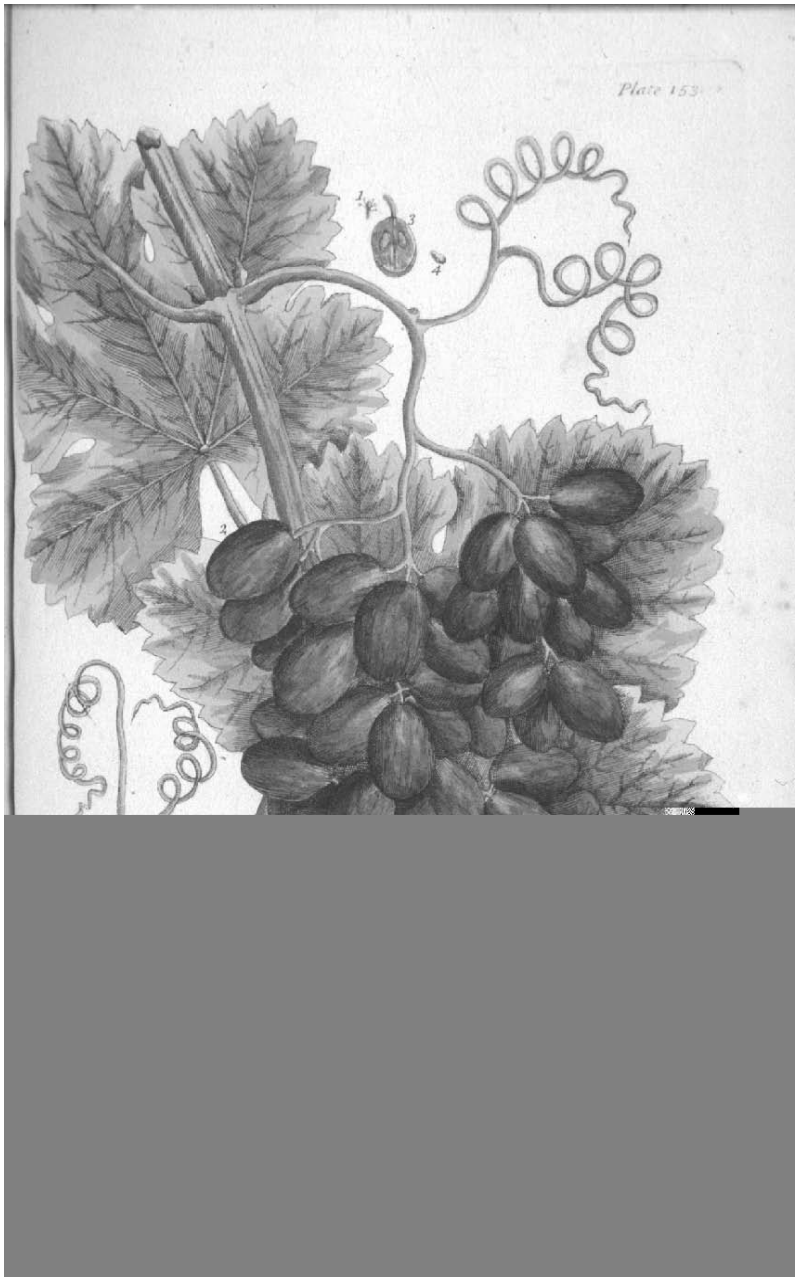

Fig. 3.2. Grapevine – *Vitis vinifera* L. Blackwell (*A Curious Herbal*, Vol. 1, 1737).

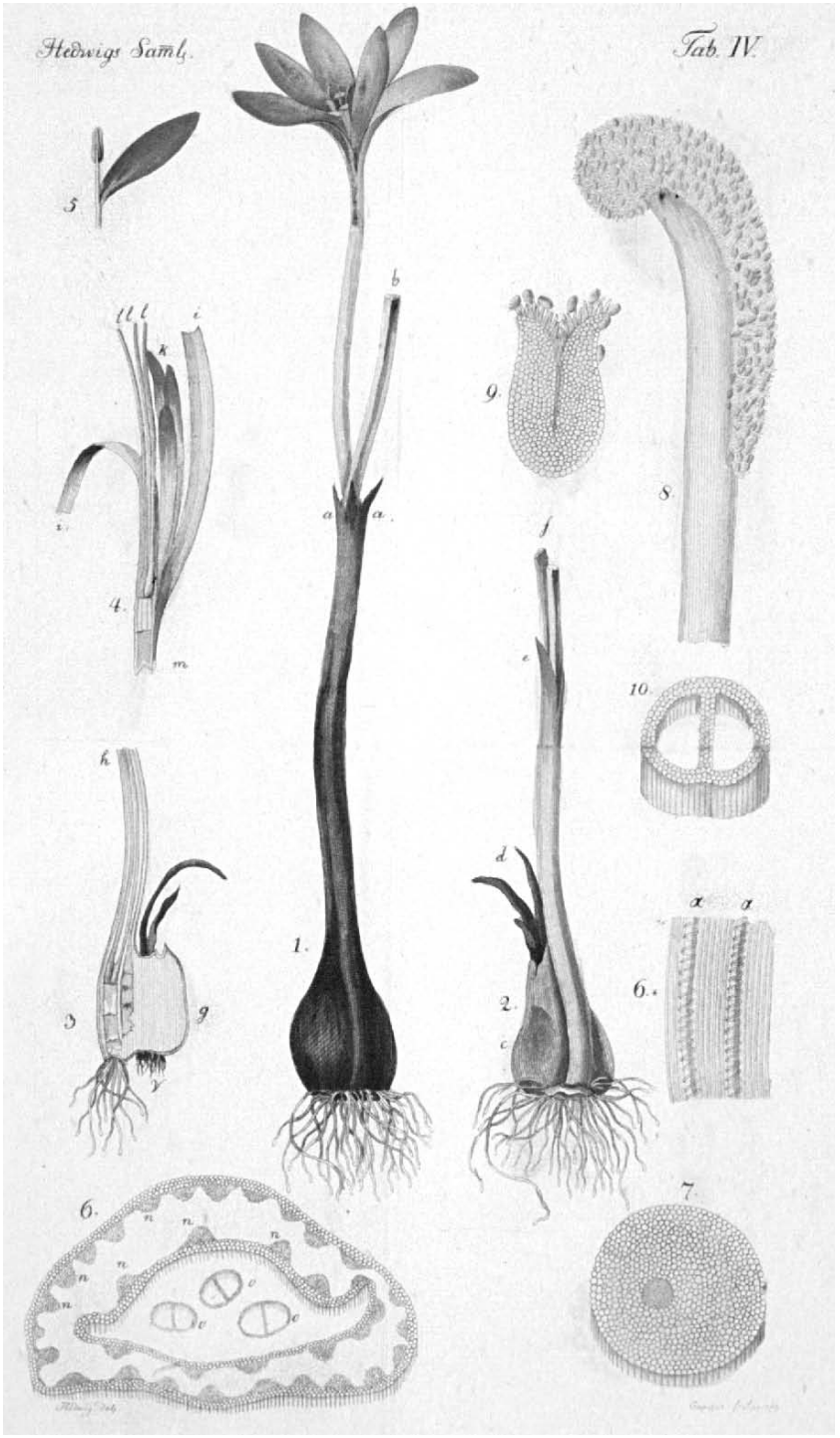

Fig. 3.3. Meadow sa ron – *Colchicum autumnale* L. Hedwig (*Sammlung seiner zerstreuten Abhandlungen*, 1793).

Essentially, a picture consists of colour distributions on a surface, in the way that an expression of language consists of sounds of different pitch, duration, and so forth. These colour distributions and sounds are not, however, used as an end in themselves, at least not in the context of scientific practice, but as a means of representing information. One can understand more easily how this was achieved if one accepts that pictures, like expressions of language, can mean propositions, for example, propositions on the properties of a species of plant. One can then explain how and why pictures convey information, in the way sentences and words do. Botanical images communicate their information on plant species not directly, that is, not by imitating a plant's physical properties but indirectly, by stating propositions on the subject matter's properties. The pictorial means of an illustration should, therefore, be as precisely distinguished from its content as the sounds of a sentence can be distinguished from the meaning of a sentence. It is not the colour on the surface of a picture that tells something about the objects depicted; it is the propositional content that gives the necessary information. And only in this respect does an illustrator strive to achieve a likeness, since the propositions to be taken from the picture have to resemble the propositions one would formulate when viewing the object itself.

Botanical illustrations are meant to convey a particular type of information, namely propositions that answer the question, "Which properties pertain to all representatives of the species?" That would mean propositions such as "All individuals of species x have the properties E1, E2, and so forth". In a way, it is surprising that a picture that shows only a single plant can convey information of this kind. However, as we have already seen, the plants depicted in eighteenth-century illustrations, strictly speaking, should not be called a specimen at all but rather a constructed "type".[46] The result is not a realistic representation of an existing specimen, that is, showing a paradigm of the species, a method that had the advantage of offering a genuine description of one real object of the concept in question. It does, however, have two enormous advantages: (i) the amount of general valid information can be markedly increased; and (ii) this information can be conveyed in a very pronounced way, so that few observers will miss it. However, calling the subject matter of the images a "type", does not solve the problem of an adequate theoretical interpretation. How can the content of eighteenth-century botanical illustrations be determined more productively?

[46] The term"type" has several meanings in a botanical context. The *morphological type*, a construct that includes the average properties of a species, should not be confused with the *nomenclatural type* or *holotype*, which refers to the particular, physical specimen of a species (or variety) on which its first definition is based. See, e.g., the corresponding entries in the botanical dictionary Wagenitz (1996). The "type" that might be depicted in the images refers to neither of these technical meanings but only to the colloquial and at the same time ambiguous use of the expression.

3.3 Possible Interpretations

Realistic in Detail, Artefact in Construction

To answer this question, I shall return to the first example introduced in Chapter 1, the coltsfoot illustration by Curtis (fig. 1.2, p. 5). As mentioned earlier, this picture shows an unrealistic variant of the coltsfoot, in particular by combining several stages of the plant's development in the drawing of a single specimen. However, each of these stages appears very true to nature, both in content and pictorial design, which could possibly give us the key to a new and better understanding of what the vague term "type" means: namely, a comprehensive montage, which in this form and combination cannot be observed in nature but nevertheless consists of a number of realistic components that describe the appearance of real coltsfoots.

However, on closer consideration this hypothesis becomes far less persuasive, since even the isolated flower heads, stalks and rosettes are not really drawn in a life-like manner: they are too symmetrical and too perfect in appearance to be a true reflection of nature. One has only to look at the scale leaves on the stalk: their tips are too brightly coloured, they are too smooth and polished, too similar to one another to be natural. In effect, the plant in Curtis's illustration appears far more perfect, prettier and symmetrical than a real specimen or a specimen recorded photographically. And maybe this finding allows one to consider a more promising approach: the illustrations are not montages of realistic documentation but may depict, on the whole, hypothetical perfected plants representing the "ideal" of the species.

Perfect Idealizations

This approach would be close to the theses on the content of eighteenth-century scientific illustrations expounded by Lorraine Daston and Peter Galison.[47] According to these two authors, the aim of eighteenth-century draughtsmen was to present "typical" phenomena in a Goethean sense, that is, phenomena that can be reduced to an underlying archetype from which all individual occurrences and variations can be derived – at least conceptually, as the authors maintain.[48] Daston and Galison distinguish between two types of eighteenth-century scientific illustrations that were used to represent typical phenomena in this sense: the "ideal" and the "characteristic" variants. The two types differ in the content they convey, as the authors explain: "Briefly put, the 'ideal' image purports to render not merely the typical but the perfect, while the 'characteristic' image locates the typical in an individual."[49] Within

[47] See, among others, Daston & Galison (1992).

[48] Daston & Galison (1992), p. 87: "In eighteenth-century atlases, 'typical' phenomena were those that hearkened back to some underlying *Typus* or '*archetype*', and from which individual phenomena could be derived, at least conceptually."

[49] Daston & Galison (1992), p. 88. See also p. 94.

the picture selection under examination, none of the illustrations could be considered to be an example of the characteristic type; whether the illustrations by Otto Brunfels, mentioned in the Introduction, fall into this category is debatable, and shall not be discussed here.[50] But could not the other illustrations be of this "ideal" type, that is, show something like an "archetype" of the species from which all individual specimens could somehow be "derived"?

However, it is unclear as to what the "archetype" of a botanical species actually is. Daston and Galison are not very precise on this point. They surely assume that the archetype embodies the typical properties of a species in a perfected form; but whether it has a physical existence or not is questionable: it could not be observed directly, yet, according to Daston and Galison, eighteenth-century botanists were firmly convinced of its "reality", as they put it. No individual actually showed the properties of the archetype; a knowledgeable researcher could nevertheless intuit them from his own experience.[51] As an example of an archetype and its visualization, the authors refer to Goethe's *Urpflanze* and his sketch of it;[52] this picture, however, differs considerably in content and aim from the usual botanical illustrations of the time, and is therefore not representative. Goethe's concept of an archetype was developed to explain the common properties within the plant realm in general; it was not meant to refer to any specific plant species and its various individual organisms. Without a discussion as to how this concept might be transferred to species and their properties, it does not seem very helpful to assume that these illustrations depict "archetypes" in the Goethean sense. One could, however, ignore this theory and keep to what Daston and Galison additionally said on the content of the "ideal" variant of eighteenth-century scientific illustrations: a construct that represents the common properties of individuals of a botanical species more ideally and more perfectly than one would ever see in nature – a construct, moreover, of whose real existence eighteenth-century

[50] Daston and Galison describe a third type of illustration prevalent in other periods, which they call the "naturalistic" variant, and which represents individual specimens as they are. However, they do not clarify how these images di er from images of the "characteristic" type, so that it is hard to decide into which category to place Brunfels's illustration.

[51] Daston & Galison (1992), p. 87: "The typical is rarely if ever embodied in a single individual; nonetheless, the researcher can intuit it [...] from cumulative experience. [...] This is not to say that the archetype wholly transcends experience, for Goethe claims that it is derived from and tested by observation." See also the explanation of illustrations of the characteristic type (ibid., p. 96): "Like the latter [the naturalistic image], the characteristic atlases presented figures of actual individuals, not of types or ideals that had not and/or could not be observed in a single instance. But like the former [the ideal image], these individuals still embodied types of whose reality the atlas maker was firmly convinced. The typical must now be instantiated in the individual but the typical nonetheless exists, to be discerned by judgment and long acquaintance with the phenomena."

[52] Daston & Galison (1992), p. 88.

botanists were convinced.[53] However, there is no empirical evidence for the latter assertion, neither in the sources examined for this study, nor in the sources presented by Daston and Galison.

But even if one ignores this lack of evidence, the interpretation of plant images as depicting ideals of species is still inadequate. Looking at illustrations such as Curtis's coltsfoot, one might get the impression that botanical illustrations portray individual plant specimens more perfectly and beautifully than they would appear in nature – although combining the different stages in a plant's development requires far more of a botanist and draughtsman than merely drawing a perfected and prettified version of an observed specimen. However, it seems very questionable to speak of the illustration by Sturm or others, produced in the same context and to the same purposes as the Curtis image, as representing similarly perfected and prettified specimens. It would seem far more obvious to understand the picture by Sturm as being the opposite of a comprehensive, perfected archetype: he shows not an ideal specimen but a simplified and schematized version of the sweet vernal grass, which may resemble the empirical avarage of the species.

Schematized Specimen or Empirical Average

This interpretation differs from the first (rejected) hypothesis in that one would give up the idea of a true-to-nature representation right from the start. Showing the average of a species implies that certain details will be dropped. However, with this approach, unrealistically combining different stages of development, as Curtis does, poses a problem, while the peculiar incompleteness of Sturm's picture still shows far more than the average properties of a real species.

The strange selection of properties to be found in the Sturm and Curtis images is typical of the illustrations being examined: they either tend to show more properties of a species than would be observed in any given specimen at one time or, paradoxically, fewer properties: many features that are common to all specimens of the sweet vernal grass were inexplicably omitted in Sturm's picture. The properties shown in the illustrations are, on the whole, highly selective, although the criteria according to which they were chosen are far from clear. Something else entirely would be expected from a picture documenting the empirical average of all the individual specimens of a species.

However, as was clear from some of the examples discussed, it was the taxonomically meaningful properties of the species that were emphasized in the pictures: the illustrations contain statements on all those properties that define the species in question. This may be the crucial point when it comes to finding an interpretation: is the content to be understood as a visualization of the concept of, for example, a sweet vernal grass?

[53] See Daston & Galison (1992) p. 87 and p. 96.

Visualized Concepts

Traditionally, a concept is defined by the essential features of all the objects that fall within it. Having these properties, then, is a necessary condition for an object to belong to the respective class of objects. Linnaeus's long names are concept definitions in this sense, as he acknowledged himself.[54] If the aim of botanical illustrations was to visualize concept definitions of this kind, they should then contain information on all those properties that define the respective concept. And, to some extent, this is the case, as was shown in the examples examined above. They regularly contain information on exactly those properties that made up Linnaeus's characters. A visualized concept, however, should contain no more information than that – not, as the botanical illustrations do, additional information on a wealth of taxonomically irrelevant aspects. Moreover, the illustrations contain not only information on properties that are taxonomically irrelevant but still typical, they also contain statements on properties that are only valid for a few representatives of the species – or, even worse, for none at all! Take, for example, the red stamens in Sturm's picture: it is highly unlikely that one would ever find a specimen with such stamens. So, on the whole, the visualization of concepts does not seem a particularly well-suited interpretation of what the pictures contain, either.

Models

Before discussing a more promising interpretation, I shall briefly summarize what is known about the illustrations and their content so far. Plant images of the eighteenth and early nineteenth centuries present schematized and occasionally idealized plants, the properties of which are purposefully not depicted true to nature, although these images were still intended to convey information on living specimens of the represented species. Not all the properties of real plants were included in the images' content, however, not even all the properties that all species representatives share with each other; on the other hand, not all of the included properties apply to all specimens of the respective species. Yet, there is no doubt that the images' content was based firmly on empirical observations, although it was not documented in a naturalistic manner, as, for example, in the Brunfels's herbal, but simplified or exaggerated. Finally, if one takes into account that these images were to represent species according to a certain taxonomic system – and this was the draughtsmen's and botanists' explicit aim – even the most accurate empirical observations would be insufficient: in order to represent all the properties that were characteristic of plants falling into the respective definition of the species in sufficient detail, one needed to have a thorough knowledge of the prevailing theoretical culture.

In this sense, the content of the plant images being examined appears to be made up of an elusive combination of theoretical concepts and empirical

[54] See section 3.1.1, pp. 71 .

data, whose connection with real objects is hard to describe. These combinations of empirical and theoretical content referring to whole classes of objects, which convey numerous simplifications and are in a complex way related to individual organisms of the class of objects referred to, could be taken, from a certain point of view, to be models.

3.4 Models of Plant Species

3.4.1 Approach

Does it make any sense to describe the subject matter of botanical illustrations as "models" – after all, there is no evidence in any of the eighteenth- or nineteenth-century sources that the draughtsmen and botanists of the time understood the content of their work in this way. The more general, underlying question is a contentious issue in the historical sciences: is one justified in explaining the practices of historical protagonists using concepts to which they never referred or does this inevitably lead to anachronistic projections?

The only way of explaining historical processes – in this case, the practices of scientists of previous centuries – is to study the testimonies they left behind (publications, manuscripts, letters, images and other textual or non-textual sources). However, these testimonies are often incomplete, frequently exasperatingly incomplete, not only because many documents inevitably go missing over the years but also because not every single detail was always put down in writing. Details that systematically are missing include the goals scientists had in mind, the criteria they used to decide between alternative courses of action, and their methodical knowledge, that is, the knowledge based on their educational background, which they used to reach their objectives. On the other hand, the inclusion of these details is essential if one is to arrive at a satisfactory explanation of what scientists did and why. Frequently, as in this particular case, the protagonists themselves can no longer be consulted and, even if this were possible, the information they would provide would not be reliable – even if they were honestly striving to give an accurate account of their goals and working methods.[55] Like other people, scientists are mostly not in a position to indicate in detail why they pursued certain goals and which rules, conventions or principles they followed, which, however, does not mean that they did not follow any rules or conventions.

Thus, there are two options for the historian: either one totally abandons any idea of explaining the practices in question or one tries to reconstruct the unknown elements in a way that elucidates as much of the historical evidence as possible, or that, at the very least, accords with all the known sources. No concepts and theoretical assumptions should be presupposed that were

[55] See, e.g., Graßho (1994) and Graßho et al. (2000), pp. 323 ., for a discussion on the problem of "historical fallacies" in the retrospective accounts of people's own actions.

unfamiliar to the protagonists at the time: that would indeed be anachronistic. However, the fact that none of the eighteenth-century draughtsmen and botanists ever used the term "model" when referring to the content of their images means nothing more than that the word does not occur in their textbooks, letters and manuscripts. It does not exclude the possibility that eighteenth-century botanists presented in their images the kind of content that today would be described as a "model". The language these historical protagonists used themselves can even lead one astray, for it is well known that in everyday speech the same object is usually given a host of different designations whereas different objects are given the same name. Therefore, it seems advisable to develop an explanation beginning with the practices themselves rather than with the scientists' explicit comments on them. Often, introducing new terms and concepts can be of considerable help in tracing the objectives and criteria of the historical figures in question, such as, for example, using a certain model concept in the case of plant images to explain their content, as I shall do in this chapter. Among other things, this has the great advantage that the approved model concept in question will lead to further characteristics, the presence or absence of which one would then be able to check against the content of the plant images, which will put one in a position to find out even more about the images and start with further explanations on a much higher plane.

3.4.2 Scienti"c Models

In this study, scientific models are understood as being sets of propositions that describe and frequently also explain the properties of classes of real objects.[56] These statements rely on the principles and definitions of scientific theories; they are, however, also based on empirical data, which are included in the model in a slightly or considerably altered form. This altering of empirical data is achieved by applying construction assumptions. Scientific models allow for hypotheses to be formulated, usually with recourse to the principles and definitions of the underlying theories that describe the properties of their instances.[57]

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[56] The description of a model as a "set" of propositions was consciously chosen, although it is not intended to be a definition of equivalence. Models are not necessarily structured systems of propositions that are related to each other in a determined way; sometimes they are not even consistent. The structure of a model arises from its application to certain objects, that is, through the interplay with the theory (or theories) the model is related to and the respective empirical data in each case. For details, see Graßho (1995) and Graßho (1998).

[57] The model concept referred to in this book was developed by Gerd Graßho in Graßho (1995) and elaborated further in Graßho (1998) as well as in subsequent, as yet unpublished, lectures. In the literature of the philosophy and history of science, the notion of a scientific model is used in innumerable variations that all di er in a number of central respects. The approach chosen for this study is

Models, defined in this way, must be sharply distinguished from their means of representation. The same model can be represented in very different ways: drawn in a diagram, described in a text, or made into a three-dimensional construction. The means of representation has no bearing on which objects instantiate the model and which do not. The latter depends only on whether the model statements accurately describe some of the properties of a given object. This distinction is prerequisite if one wants to formulate a generally applicable model concept, which, in addition to pictorially (or other forms of) represented models, also includes, among others, weather forecast models, simulation models and models on the behaviour of people in conflict situations, the representations of which are intangible and unclear. Furthermore, images, in particular, are not tied to one particular interpretation. The content of an architect's plans, for example, would usually be interpreted as containing instructions for use; under certain circumstances, however, an architect's plan could be understood to represent a model, as, for example, the pictorially represented model of an architect's plan. In the following, I shall explain the different components of scientific models mentioned so far – theoretical background, instances, construction assumptions, and hypotheses – in more detail with reference to the hypothesis of botanical illustrations depicting models of species of plants.

3.4.3 Theoretical Background

As was mentioned earlier, the Linnean system, which was so important for the illustrations under study here, provides a canon of properties and criteria that determines a plant's class, order, genus and species. Furthermore, it is based on a framework of theoretical principles and definitions, which are presupposed in classification. To summarize, the incorporation of a plant into the Linnean sexual system is mainly based on the following assumptions:

- The essence of the plant lies in its fructification, which includes the calyx, flower, stamens, pistil, fruit, seed and receptacle.
- Six properties of the flower and its parts determine a plant's class and order: (i) the reproductive organs, open or concealed; (ii) the flowers, hermaphrodite or

distinct in its definition, has already been fruitfully applied in other cases and clearly explains the relation between the model and theoretical and empirical data – three aspects that most alternative approaches do not o er to the same degree. A detailed discussion of the use of model concepts in the history and philosophy of science cannot be carried out here. However, some recently published anthologies give an idea of the current debate in this area, such as, e.g., Herfel et al. (1995), Magnani et al. (1998), Morgan & Morrison (1999) and Magnani & Nersessian (2002). See also the special volume of the journal *Philosophia Naturalis* on this topic (Vol. 35, 1998). For an application of model concepts in case studies of the history and philosophy of science, see, e.g., the contributions by Ronald N. Giere, in Giere (1992), Giere (1996) and Giere (1999). Further references are available in the previously cited titles.

unisexual; (iii) the stamens, fused or independent; (iv) the stamens, of equal or varying length; (v) the stamens number x; (vi) the pistils number y.

- The constant properties are the number, shape, proportion and position of an organ.
- The constant properties of the fructification determine the genus of a plant.
- The constant properties of the leaves, stems, buds, fructification (if it distinguishes members of the same genus) and other parts of the plant determine the species of a plant.
- Variable properties have no taxonomic relevance. These include, for example, the colour, scent and taste of a plant, its absolute size, luxuriance and pharmaceutical value.
- Plants with the same fructification (all else being equal)[58] may not be classified into di erent classes, orders or genera. They can, however, belong to di erent species.
- Plants with di erent fructification organs (all else being equal) must be classified into di erent classes, orders, genera, and species.

Some knowledge of these definitions and principles was essential if an illustration was to contain all the details required to characterize a species according to the Linnean system; and the reader also needed to be equipped with this information if he or she was to derive these details from the picture's content. Some authors explicitly stated that they based their work on Carl Linnaeus's theoretical principles: the Utrecht botanist Jan Kops kept strictly to the guidelines of the Linnean *Systema Vegetabilium* when preparing the text and illustrations for the *Flora Batava* (see quotation, p. 84) and the Swabian botanist Johann Simon Kerner also wrote in the preface to his *Bäume und Gesträuche Wirtembergs* that he had made drawings "that I always compared with nature and with descriptions by Linnaeus and other good botanical writers, which I constantly had beside me".[59] Even deriving statements on properties without any taxonomical relevance does presuppose a substantial degree of prior knowledge of plants and their species. To an observer lacking any previous knowledge of the organs and structure of a plant, the picture by Sturm would be incomprehensible.[60]

Thus, the content of the illustrations is closely related to certain theories or at least (to put it more vaguely) to a theoretical background knowledge that includes a number of conventionally determined principles and definitions and a general knowledge of botany.[61] This theoretical background knowledge

[58] Linnaeus added to this and the following assumption a ceteris-paribus condition. For both, see Linnaeus (1751), p. 116, paragraphs 165 and 166.

[59] The original German text reads: "welche ich ganz nach der Natur und nach den beständig darneben liegenden Beschreibungen des Linnés, und anderer guten botanischen Schriftsteller verglich." Kerner (1783-92), Preface, folio 2f.

[60] The picture would be just as incomprehensible to an observer with a knowledge of plants but with no understanding of the pictorial language Sturm used. See, on this point, Chapter 5 of this book.

[61] In this book, I shall not enter into a discussion of what constitutes scientific theory; this debate is immaterial to the progress of my argument.

is not part of the picture's content. Rather, it served as a guideline for representing the content and provided observers with an indispensable basis for correctly understanding it. The less background knowledge a reader (or observer) has, the fewer statements on the properties of individual specimens of the species in question he or she will be able to derive. And even the most learned botanist will generally derive considerably fewer statements on the scientifically relevant properties of a species from a picture made by someone with only a rudimentary technical knowledge, since such a work might lack information on essential properties or some details might be unclearly or inaccurately represented.[62] This relation between a picture's content and its underlying theories is typical for the relation between models and theories. To extract statements on the properties of objects that come under that model can also be described as deriving hypotheses. And to arrive at this derivation, it is essential that the theoretical background of the model is included. The derivation of the taxonomic position of a species, for example, presupposes some theoretical principles that have been laid down elsewhere; and deriving statements on further properties presupposes a knowledge of what was understood at the time by a glume, a nectary or even a root.

But theories are only one part of the story. According to the quotation cited above, Kerner consulted not only works by Linnaeus but also living plants (see quotation, p. 97). On the one hand, this is confirmation of the fact that different sources of information were used in the complicated process of preparing a botanical illustration, as described in Chapter 2; on the other hand, it acts as a reminder that the content of the pictures referred not only to abstract entities but to real plants. In the following section, I shall, therefore, examine the relation between the pictures' content and individual specimens of the depicted species.

3.4.4 Instances

It was established earlier in this chapter that the relation between the illustrations and the plant specimens is not as obvious as one might have expected. The illustrations certainly do not show all the properties that are typical of a species of plant; on the other hand, no specimen would ever exhibit all the properties shown in the picture. This relation between the information given by the picture and the properties of actual specimens is characteristic for the relation between models and the objects to which they refer. (These objects shall henceforth be called instances; an object, which is the instance of a model, instantiates this model.) A model is not a copy of its instances and neither are the instances copies of the model they instantiate. Thus, a coltsfoot plant may instantiate the content represented in the Curtis illustration,

[62] This is not to say that some good draughtsmen could not document the essential properties of a plant species they had observed without any knowledge of its scientific importance.

even though it would never exhibit all the qualities the picture ascribes to individual specimens of this species. (In fact, it is very unlikely that it would show all these properties at the same time and in exactly the same manner.) Yet, the content of the William Curtis illustration is valid also for those coltsfoot specimens that do not resemble the plant in the picture. The colours and shapes on the paper reveal nothing about the properties of individual specimens of the depicted species; only the content does.

However, how can an object be considered an instance of a model when its properties contradict a number of model statements? How can a given specimen of the sweet vernal grass be included among those objects to which the Sturm illustration refers when the content of the picture describes only a fraction of its properties? These problems resolve themselves as soon as one drops the idea that an object should instantiate a model in every conceivable respect. Rather, objects instantiate a model only relative to certain hypotheses. One could assume, for example, that real sweet vernal grasses instantiate the content of Sturm's illustration only as regards hypotheses on the ovoid, longish shape of their inflorescences and some other properties – not with respect to more detailed statements on the structure of the inflorescences.[63] If the hypothesis is merely to state that the instances of a model have leaves, stems and flowers in any form or shape, then not only all Central European plants but all flowering plants in general will come under the content of the Sturm illustration. For many of the additionally derivable hypotheses, the model represented by Sturm would not be applicable with respect to this set of instances, since the difference between the model's properties and the properties of most instances would exceed by far what can be tolerated. No one would claim that all flowering plants on earth have spikes; and one would just as little claim that all members of the *Poaceae* family have florets that are shorter than their awns. But one could formulate (and empirically confirm) the hypothesis that all members of the *Poaceae* family have awns of some shape and that they develop caryopses.

3.4.5 Construction Assumptions

There is no doubt that the content of Sturm's illustration of the sweet vernal grass (and of botanical illustrations in general) was based, in large part, on empirical findings. Nevertheless, the shape of the inflorescences of the sweet vernal grass were assumed and represented in a strongly schematized way, simplifying the properties of real inflorescences to a few hazy features. Although one could derive general hypotheses on their shape, one would find that most plants contradict these hypotheses, from which one would conclude that they are false. This is a characteristic of the illustrations under examination. As I have demonstrated, the pictures idealize, simplify, schematize,

[63] The object remains, however, an instance of the model, e.g., of the model of the species sweet vernal grass. It does not mutate to an instance of the hypotheses, which only concern singular properties and refer to concrete, given objects.

exaggerate and combine in an unrealistic way the impressions one would gain from observing living specimens of the sweet vernal grass, the meadow saffron or the grapevine.

Empirical findings are an essential part of every model – findings, for example, on the shape of the inflorescences, stamens, or glumes of a species of plant or perhaps findings on the distinctive sequence of certain rock layers in a mountain. This empirical content distinguishes models sharply from theories. Furthermore, it is because of this empirical content that models cannot be derived from theories alone but in some respects contain more information. As a rule, however, empirical findings are not integrated into a model in an unaltered state but in a reduced or sometimes exaggerated form. These simplifications and distortions of empirical findings, which are applied for the purposes of constructing a model, are the result of what in this study are called "construction assumptions". In order to design a certain model, one assumes that the objects to be modelled have certain properties, even when one knows that this is not actually the case. This enables one to describe the few properties included in the model far more clearly and concisely than would be possible in a more complicated version that tries to include as many properties of the modelled object as possible.

As a rule, construction assumptions are not formulated explicitly (although it would be desirable for reasons of transparency); they arise implicitly. This includes the assumption that all qualities of the object that were not taken into account for the model are insignificant or of only minor influence on the derived hypotheses. If one assumes that botanical illustrations represent models of plant species, then their simplifying, exaggerating or even distorting features may be interpreted as being the result of the construction assumptions. In this case, the chosen means of representation for the picture is not the distorting factor; rather, it is the content itself (that is, the model and its properties) that has been distorted by the construction assumptions. Take, for example, the unrealistically large representation of the tubular coltsfoot florets by Johann Zorn (fig. 1.3, p. 6): from this illustration one might formulate the hypothesis that the flower head's centre is filled with a small number of spacious tubular florets. However, this is not the case, as the observation of any real coltsfoot quickly proves. Neither are the coltsfoot's buds pink in colour, and its leaves and roots by no means always resemble those of the picture. The draughtsman of this illustration would certainly have been aware of these characteristics; nevertheless, for his purposes he assumed real specimens to have these properties. The morphology of the tubular florets was obviously one of his major interests in depicting this species, in particular perhaps the fact that they have exactly five fused petals; this is the information he wanted observers of the picture to derive from its content (which could also be derived from the actual instances), and in this sense his image certainly is correct.

Which leads us to consider how one can decide which construction assumptions are justified in developing a model and which are not. In the case of botanical illustrations, this depends on how far one can simplify or exaggerate

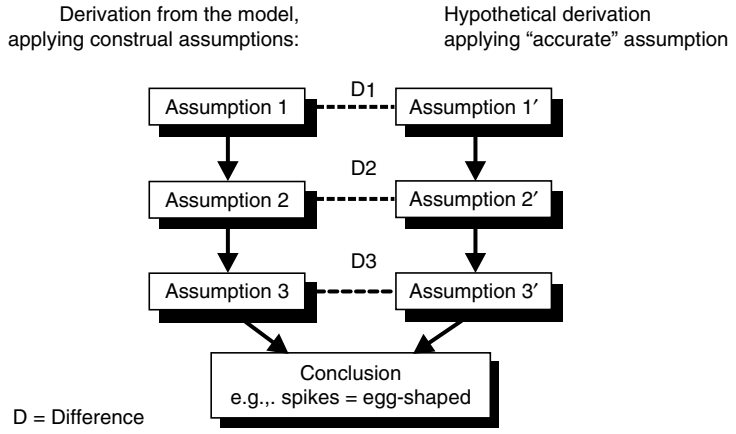

Fig. 3.4. Examining the approximation condition: there is a noticeable di erence (D1, D2, D3) between the properties of the modelled objects as they enter the model in the form of idealizing construction assumptions (1, 2, 3) and the actual properties of the objects (1', 2', 3'). This di erence must be irrelevant for deriving the conclusion (close approximation or of minor relevance (a good to poor approximation). The arrows symbolize the derivation processes.

the properties of actual specimens in a picture without jeopardizing the aims of the illustration. Since a model never takes into account all the properties of the examined object, one frequently speaks of a model "approximating" its objects. The requirement of deriving from a model statements that one would likewise formulate when observing its actual instances is part of what is called the "approximation condition", which allows one to test whether the construction assumptions are justified or not. The following condition applies: the simplifications and omissions of a model (or in the content of what is suspected of being a model) are justified only as long as the difference between the actual properties of the instances and the altered properties assumed in the model are irrelevant or, at the very least, almost irrelevant to the desired hypotheses. In order to do so, a model must meet the following requirements:

- The object under study behaves in certain respects as if it had the properties assumed in the model.
- Differences between the properties assumed in the model and the object's real properties are (almost) irrelevant to the desired hypotheses.
- Any additional properties of the object under study that are not included in the model are (almost) irrelevant to the desired hypotheses.

A model approximates its objects closely if the aforementioned conditions of irrelevance are completely fulfilled. If the differences between the model's properties and the properties of the modelled object are not irrelevant but

still of only minor influence, one can speak of a good approximation. As the influence of the omitted factors grows, so the approximation gradually deteriorates. In order to judge a model's approximation, two different ways of deriving the target hypotheses have to be compared (fig. 3.4, p. 101): on the one hand, the derivation of the hypothesis from the model with the assumed properties (assumptions 1, 2, 3) and, on the other hand, a hypothetical derivation based on the actual properties of the objects in question (assumptions 1', 2', 3'). These assumptions inevitably differ from each other to a certain degree (D1, D2, D3) and one has now to decide whether this difference can be tolerated or not. It may be tolerated if the assumptions 1, 2, 3 and the assumptions 1', 2', 3' both support the derivation of the desired conclusion. Under these circumstances, one can prove that the difference between the actual and the approximated hypotheses is irrelevant with regard to the target hypothesis, which is, therefore, justified.

This explains why eighteenth-century botanical illustrations, despite their distorting characteristics, allow for the derivation of correct hypotheses. The inflorescence of living sweet vernal grasses may look nothing like the grasses in Sturm's image but one can still derive the hypothesis that specimens of the sweet vernal grass have egg-shaped inflorescences; and the same hypothesis could be formulated if Sturm had used the properties of real grass specimens, without exaggerating this feature to the extent that he did. With regard to this hypothesis, the approximation condition is fulfilled and the construction assumptions are, therefore, justified. The same applies to the construction assumption of combining several stages of development in the drawing of one coltsfoot specimen, as Curtis did. As long as the hypotheses to be formulated concern only one single stage, no fault can be found in this method. If, however, the intention of Curtis's picture had been to support hypotheses on the external appearance of a coltsfoot specimen at one given moment, one would get into difficulties, for the picture's content does not suit this type of hypothesis.

3.4.6 Hypotheses

A model supports the derivation of many hypotheses but not all hypotheses will apply to the model's instances, and their potential inaccuracy should not be taken into account when judging a model. Therefore, it makes sense to distinguish between hypotheses the model is meant to support in view of its instances and other hypotheses. The former can be called a given model's "hypothesis space". Hereto belong those hypotheses that (i) can be derived from a model and (ii) apply to its instances. The hypothesis space in its narrowest sense includes only those hypotheses for whose derivation the construction assumptions made in the model are irrelevant or, at the very least, are of only minor importance. What, however, is meant when one speaks of the "derivation" of a hypotheses from the botanical illustrations' content?

Derivation

The term "derivation" is here used in its broadest sense, namely as the application of any means of evidence not confined to logical calculus.[64] Examples of these additional forms of evidence are, for example, the rules and definitions of Linnean theory but also systems of rules of interpretation, which determine how certain pictorial expressions are expected to be understood. In the case of botanical illustrations, a set of conventional rules allows one to derive (non-logically) the represented content. These rules refer first of all to pictorial expressions. In the plant pictures, a form of symbolism is used that corresponds generally to respected and established conventions for the genre and which allows observers to attribute meanings to the pictorial elements, without the addition of a caption.[65] Furthermore, this system of rules includes specifying plant pictures as model representations, that is, this type of image is not to be interpreted as being depictions of single objects but is intended to convey general statements that apply to all instances, taking into consideration, of course, the restrictions imposed by the construction assumptions and the approximation condition. These rules did not form part of a standard reference work; and presumably few manufacturers and recipients would have been able to report explicitly and comprehensively which conventions and rules they had used to make or interpret the plant pictures. Neither the tacit application of these rules, nor the identification of mistakes, however, would usually present any problems. By applying these rules of interpretation, the pictorially represented statements of a model can be "derived" from a picture.

The derivation of hypotheses that are not expressed in the pictures themselves, for example, hypotheses on the taxonomic classification of the modelled species of plant, is a different matter. These hypotheses are not only based on a correct interpretation of the image according to specific rules and conventions but can be derived according to logical rules, for instance the rules of the *Barbara* syllogism, which allows the following inferences:

All Ms are Ps. (*major premise*)
All Ss are Ms. (*minor premise*)
All Ss are Ps. (*conclusion*)

If one wanted to use this syllogism to establish the position of the sweet vernal grass in the Linnean system, the following classes of objects would have to be assigned to Ms, Ss and Ps:

[64] This approach is based on a suggestion of Gerd Graßho 's. Nancy J. Nersessian in Magnani et al. (1998) also argues for a new and broader concept of scientific derivation and its arguments and conclusions, albeit with very di erent objectives in mind. See also Nersessian (1998).

[65] See also Chapter 5.

P = Plants that belong to the class *Diandria*, order *Digynia*. These plants have the following properties: (i) unconcealed reproductive organs; (ii) hermaphrodite flowers; (iii) independently growing stamens; (iv) stamens of the same length; (v) two stamens per floret; (vi) two pistils per floret.
M = Plants with the above-mentioned properties.
S = Plants that belong to the species *Anthoxanthum odoratum* L.

The first premise is of the form "All Ms are Ps". In this case, M includes all plants that have reproductive organs with the properties mentioned in the caption above. P includes all plants belonging to the class *Diandria*, order *Digynia*. The second premise reads "All Ss are Ms", where S includes all representatives of the species *Anthoxanthum odoratum* L. According to the syllogism, from these two premises follows the conclusion "All Ss are Ps", that is, all representatives of the species *Anthoxanthum odoratum* L. are plants that belong to the class *Diandria*, order *Digynia*. This inference is deductive and therefore truth preserving: the truth of the conclusion depends solely on the truth of the premises. The first premise is determined by the rules of the Linnean system, while the second premise can be taken from the illustration's content by interpreting it as explained before. This brief argument demonstrates the function of the Linnean system's theoretical principles in deriving hypotheses from a model: they determine the major premise, which can, therefore, be formulated independently from the minor premise, which depends on a correct interpretation of the illustration's content.

In order to derive statements from the model, the audience not only had to be equipped with a certain technical knowledge, it also had to know how to interpret the image and which hypotheses it could expect to be applicable and which not. Within the circle of eighteenth-century botanists, one rightly assumed that one's colleagues would correctly understand an image executed in a certain way. At the same time, one had to meet specific expectations, and not every botanical work was well received simply on the grounds that it was voluminous and richly illustrated. In 1802, for example, the *Ministre de l'Économie de la République Batave* offered the Berlin Academy of Sciences a copy of the lavish *Flora Batava*,[66] the end product of a prestigious national project. It was hoped that regular correspondence would arise from this gift; indeed, the Batavians suggested in a letter that they would appreciate receiving a Berlin periodical or journal in exchange, in particular, if one reads between the lines, the Berlin Academy's renowned *Mémoires*. The Berlin botanist Karl Ludwig Willdenow was asked to assess the luxurious work – and harshly criticized it. Despite its scale and grandeur, he considered it superfluous: "The illustrations are colourful but not accurate, and the depicted plants grow all over Europe and have already been represented many times."[67]

[66] Kops (1800-49).

[67] Original German: "Die Abbildungen sind bunt aber nicht getreu und die vorgestellten Pflanzen durch ganz Europa gemein und schon oft abgebildet." See AdW [Archives of the Berlin-Brandenburg Academy of Sciences] for the Batavian

Following this pronouncement, the exchange of writing understandably never took place.

An illustration was not, in itself, of any value; it was always made for a certain group of users, and the model and its representation thereby had to fulfil certain functions. What were these functions? Why were the botanists not satisfied with Linnaeus's textually given definitions? To be able to answer these questions, one needs to examine the uses of botanical illustrations, together with their relation to the accompanying texts, which will be done in the next chapter.

request and for the Ministry's letter to the Academy's commission of 2 October 1802, I-V-9, f. 92. For Willdenow's comment, see, in the same archives, his note of 7 January 1803, I-V-9, f. 92.

4

The Role of Botanical Illustrations

4.1 The Audience

4.1.1 Private Individuals

Who were the users of eighteenth-century botanical illustrations? The pictures appeared in a variety of works of different format and cost, covering a wide range of topics. They included popular manuals in the tiny duodecimo format as well as lavish, large-format volumes; floras of general interest and treatises dealing with specific taxonomic questions; agricultural compendia and pharmaceutical textbooks. These works correspondingly addressed an audience that included forest wardens and water officials, botanical experts and wealthy collectors of aesthetically valuable plant drawings, doctors and pharmacists. That these groups of people actually bought these books can be drawn from the lists of subscribers that were frequently included in the introductory pages of a work: these lists cite all those who had paid a deposit on the first volumes of a work or who had at least committed themselves to buying them.[1] Fortunately for the historian, not only were the names of these people given but frequently also their places of residence and professions. Publishers printed these lists first to prove the value of the work – by citing, where possible, famous experts as subscribers – and thereby obtain additional subscribers; second, they were also seen as being a service to the subscribers, who were rewarded by having their names immortalized in the book. For what reasons these water officials, forest wardens, botanical experts, collectors, doctors and pharmacists utilized the pictures, however, can only be reconstructed by examining those cases in which the uses were put down in writing, for example in the form of letters.

A quick examination of any exchange of letters between individuals interested in botany shows how frequently plant pictures were mentioned.

[1] See, e.g., the lists of subscribers in Curtis (1777-98), Hayne (1805-37), Kerner (1783-92), Kops (1800-49).

Eighteenth-century botanists would refer their colleagues to new or particularly outstanding plates in the technical literature; they discussed which species a plate did or did not show; and they debated whether the represented species had been correctly classified, as will be seen in the examples cited in this chapter. Original illustrations were exchanged so that copies could be made and added to inventories. Albrecht von Haller, for example, had draughtsmen make copies of numerous mushroom illustrations from the collection of his Swiss correspondent Benedikt Stähelin,[2] and he was loaned even more plates of this plant group by Christoph Jacob Trew, with whom Haller corresponded for approximately thirty years. This exchange of mushroom illustrations was surely not carried out for aesthetic reasons – most other groups of plants would have served this purpose far better – but arose out of an interest in their content. Trew considered illustrations of mushrooms essential for classifying and understanding this plant group, which eighteenth-century botanists still found rather puzzling. "I very much doubt whether this type of plant will ever be sufficiently explained without the help of naturalistically coloured images," Trew wrote in a letter to Haller.[3] Trew occasionally asked Haller for advice when he had trouble deciding which species or variety an illustration represented. Furthermore, illustrations were of particular use in discussions that took place over long distances, since they could serve as a common reference point, as will be shown by the correspondence that took place between Carl Linnaeus and the Scottish botanist David Skene. Finally, illustrations were sent to colleagues as a way of providing observational evidence.

4.1.2 Learned Societies

Learned societies, that is, private associations for people interested in studying a wide range of scientific topics, became more and more popular in the eighteenth century; particularly during the second half of the century, learned societies were founded throughout Europe. Members were mostly middle-class naturalists, who regularly participated in evening lectures, discussions, excur-

[2] See, e.g., TRWC. Haller, A. von to Trew, 23 August 1752: "I have copies of most of Stähelin's fungi, with the kind permission of this friend of mine." The original German text reads: "Von den Stähelinischen Schwämmen habe ich die meisten in copie, mit genehmhaltung meines freunds". Cited Steinke (1999), p. 117. The word "Schwamm", that is, "fungus", was at that time used as a generic term for higher and lower fungi. For the correspondence that took place between Haller and Trew, see Steinke (1999). The originals quoted here and in the rest of the chapter have been taken from this volume.

[3] Original German: "[I]ch zweifle sehr, ob jemals diese Art von Gewächsen werde genugsam können erläutert werden, wann nicht eine Vorstellung mit ihren natürlichen Farben zu Hilfe kommet." Trew, C. J. to Haller, 2 February 1753. Cited Steinke (1999), p. 120.

sions and other activities.[4] The following two examples of learned societies illustrate the part played by botanical illustrations or comparable natural history images in this particular context.

The Gesellschaft Naturforschender Freunde

One of the first societies in the German-speaking areas of Europe to deal exclusively with natural history was the Gesellschaft Naturforschender Freunde zu Berlin (GNF; Society of Friends of Nature Research), which was briefly mentioned in Chapter 2 (p. 38). It was also one of the most important societies: almost all the renowned naturalists of the eighteenth and nineteenth centuries numbered among its members.[5] The GNF was founded in 1773, largely thanks to the efforts of the naturalist Friedrich Heinrich Martini. Before forming the society, he published in the Berlin journal *Neue Mannigfaltigkeiten* a detailed plan for setting up a learned society, whose main subject and purpose would be the exploration of natural history. All collections, libraries and other means and resources owned privately by members of the society should be made accessible to members, and every week they should meet up for a friendly exchange of learned conversation.[6]

In this first fundamental outline of the aims and activities of the society, it is clear that illustrations were considered to be an essential contribution to the progress of science. Martini encouraged prospective members of the society to pick out those pieces from their collections that had either not yet been described and drawn at all or, at the very least, not correctly. The objects were to be discussed at society meetings and were to be made "of more use to the

[4] The most comprehensive treatise on learned societies in the eighteenth century from a history of science perspective is still McClellan (1985), which contains many further references. For a collection of articles on the culture of learned societies in central Germany during the period 1650-1820, see Döring & Nowak (2000-02). An examination of Enlightenment societies from a social historical perspective see, e.g., Zaunstöck (1999) and et al. (2003).

[5] On the history of the society, see, e.g., Martini (1773) and Becker (1973). Jahn (1991) explains the role of the society in the international exchange of scientific ideas in the nineteenth century; Böhme (1998) focuses on the development of nineteenth-century botany within the society; and te Heesen (2004) gives an account of the society's collecting activities. All of these titles contain extensive bibliographies. The society's estate is preserved in Berlin's Natural History Museum. I am grateful to Dr. Hannelore Landsberg and Dr. Katrin Böhme for their support in accessing and studying the relevant documents.

[6] The *Neue Mannigfaltigkeiten* (New Miscellany), with *Gemeinnützige Wochenzeitschrift* (Weekly Journal of Public Use) as its subtitle, appeared from 1770 onwards in Berlin; Martini was one of its principal editors. Excerpts of his plan for a nature-inquiring society were published again in the first issue of the GNF's own journal, the *Beschäftigungen der Berlinischen Gesellschaft Naturforschender Freunde* (Proceedings of the Berlin Society of Nature-Inquiring Friends). See Martini (1773).

public through clear descriptions and correct drawings".[7] This quote reveals Martini's longer-term plans: he hoped that the illustrations and descriptions would reach as wide an audience as possible. One of the most important aims of his prospective society was that it would publish its own periodical, whose subject matter he sketched out as follows:

> To make it easier for non-local promoters of our institute to select their contributions, we assure them that we do not only greatly welcome kind contributions of completely unknown or as yet undescribed phenomena but also more correct descriptions and illustrations of objects or observations of animals, insects, their economy [way of life] and construction that are already known.[8]

Besides texts, in this quotation illustrations are mentioned as a vital part of the new journal, and Martini again stressed that the society would not only be interested in representations of totally new subjects but would also publish "more correct" illustrations of already known subjects. Like scientific texts, it seems, these kinds of illustrations were subject to regular appraisal and could be proved wrong or become obsolete with time.[9] The GNF was, therefore, prepared to give over precious space in its journal for such faults to be rectified. The minutes of the society's weekly meetings attest to the fact that the status afforded to the pictures was also granted in practice: scientific illustrations are regularly mentioned as topics of debate. In most cases, a member would give a presentation at one of the society's meetings of some illustrations, usually together with the article to be published, followed by a detailed discussion. In February 1778, for example, the minutes reported that "our worthy friend, *Kadettenrath* Mr. Herbst, submitted to the society correct drawings of a rare species of ant, which were received and described by Dr. König from Tranquebar";[10] and in June 1787 "Mr. von Wangenheim [delivered] a treatise to our journal, namely a *Description of the many-leaved*

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[7] Original German: "in deutlichen Beschreibungen und richtigen Zeichnungen gemeinnütziger". Martini (1773), pp. 9f.

[8] Martini (1773), p. 33. Original German: "Um den auswärtigen geneigten Beförderern unseres Instituts die Wahl der einzuschickenden Beyträge zu erleichtern, versichern wir, dass uns nicht bloss Nachrichten von ganz unbekannten oder unbeschriebenen, sondern auch richtigere Beschreibungen oder Abbildungen von bereits bekannten Körpern, Wahrnehmungen an Thieren, Insekten, ihrer Oekonomie und Einrichtung, [...] unter ihren gütigen Beyträgen höchst willkommen seyn werden."

[9] The way in which natural history and particularly botanical illustrations could be considered "correct" or "incorrect" is discussed in Chapter 7.

[10] Original German: "Unser würdiger Freünd, H. Kadettenrath Herbst, übergab der Gesellschaft richtige Zeichnungen der von dem Dr König aus Tranquebar erhaltenen u. beschriebenen seltenen Ameisenarten." GNF, 10 February 1778, TB (Tagebuch [diary]) II, p. 164.

kalmia and the yellow-flowering horse chestnut, together with a drawing"[11] – to single out two arbitrarily chosen examples. Treatises with accompanying illustrations were also sent in by post. The meetings report that in 1783 "a letter by Count Mattuschka was once again received on 20 January, together with an enclosure of a drawing of a brightly coloured monkey".[12]

After the submitted contributions had been read out and any accompanying drawings presented, both were handed over to a member of the society to be revised. The annotations and corrections made by the proof-reader were subsequently "circulated for the opinion of the experts",[13] as the members referred to it; only afterwards was a favourable contribution then passed for press. The illustrations were corrected just as carefully as the texts in this reviewing process: improvements were requested if necessary and faulty illustrations were occasionally done completely from scratch.[14] For the engraving of the copperplates, the society mostly engaged the services of the Berlin draughtsman and engraver Friedrich Guimpel, who has been mentioned in previous chapters of this book.

The Regensburger Botanische Gesellschaft

Images were handled a little differently by the members of the Regensburger Botanische Gesellschaft (RBG), another important eighteenth-century society. Founded in 1790, it was the first society of the German-speaking countries to focus solely on botany; it is also the oldest for the society is still active today.[15] Botanists belonging to the RBG were expected to meet up at least once a week during the summer, either to go on excursions to the surrounding countryside or to survey Regensburg's gardens. In addition, the society's statutes stated that its members should carry out "chemical and botanical experiments" as well as set up a library and herbarium for all its members, the collections of which were to be enlarged by what the members had gathered on their trips.

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[11] Original German: "Der Herr von Wangenheim [übergab] zu unsern Schriften eine Abhandlung, nemlich *Beschreibung der Poleyblättrigen Kalmia, u. der gelbblühenden Rosskastanie*; nebst einer Zeichnung." GNF, TB V, p. 241, 26 June 1787. This treatise was published with its plate in the *Schriften der Berlinischen Gesellschaft Naturforschender Freunde*, Vol. 8, 1788, pp. 129-138.

[12] Original German: "Abermals war ein Schreiben vom Grafen von Mattuschka unter dem 20. Januar eingelau en, nebst Beylage eines mit lebendigen Farben abgebildeten A en." GNF, 28 January 1783, TB IV, p. 475.

[13] Original German: "Zum Gutachten circuliren".

[14] A maple illustration by Johann Philipp du Roi, e.g., was considered unacceptable and was redrawn by another member, Friedrich August von Burgsdor . See GNF, 28 January 1783, TB IV, pp. 475f.

[15] For a history of the RBG (the Regensburg Botanical Society), see, in particular, Ilg (1984), Ilg (1990) and Bresinsky et al. (1995). The society's archive is almost completely preserved and can be accessed in the University Library Regensburg. I am grateful to Dr. Angelika Reich for her support in studying these documents.

The plants were then to be pressed and, during the winter months when botanizing was impossible, ordered and classified at the society's meetings. At these meetings during the winter, other technical "questions", as they put it, were also to be discussed; unfortunately these questions were not gone into any more detail in the statutes.[16]

Lectures on new findings were only rarely given at the RBG's meetings and neither did the society in its early years regularly maintain its own periodical, in which new drawings could have been published.[17] Therefore, there was no place for discussions of submitted illustrations, as at the GNF. Nevertheless, the entries in the society's minutes' book do reveal that presentations of illustrations were given. In February 1804, for example, Mr. Schmidt from Weltenburg sent in "a description and an image of the *Peziza leucoloma* Pers., newly discovered by him, to Prof. Duval, which Prof. Duval had asked Prof. Hoppe to read out and present at the meeting".[18] In April of the same year, "Count Sternberg gave the society some colour plates of roses for viewing, which were applauded by all those present on account of their correct depiction and exquisitely fine drawing"[19], while in August, a Mr. West sent a letter to the society about the *Scabiosa moria*, "together with an illustration of it".[20]

Printed illustrations were also held in high regard; illustrated works made up a large share of the society's library, the collection of which was gradually being built up and was open to all members. The first book to be acquired was a recommendation of one of the society's founders, David Heinrich Hoppe, who stressed that the book included plates of rare plants.[21] In 1805, the

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[16] See *Plan und Gesetze der Regensburgischen Botanischen Gesellschaft*, published in *Denkschriften der Regensburgischen Gesellschaft*, Vol. 1, 1792, pp. 49-62. See also Ilg (1984), pp. 279f. for details on the *Plan und Gesetze* and the whole enterprise.

[17] This, of course, later changed. In 1818, the society began publishing the renowned journal *Flora* as well as *Hoppea*, the journal of the society's proceedings, both of which are still published today.

[18] Original German: "H. Schmidt aus Weltenburg sandte dem Herrn Prof. Duval eine Beschreibung und Abbildung der von ihm in dieser Gegend entdeckten *Peziza leucoloma* Pers. ein, die H. Prof. Duval durch H. Prof. Hoppe in der Sizung vorlesen u vorzeigen liess." ARBG (Archives of the RBG), 6.2.10, p. 23. To this day, *Peziza* is still a genus of higher fungi.

[19] Original German: "theilte H. Graf von Sternberg der Gesellschaft colorirte Abbildungen von Rosen zur Einsicht mit, die durch ihre richtige Darstellung und ungemein feine Zeichnung den Beyfall aller Anwesenden erhielten". ARBG 6.2.21, para. 57.

[20] Original German: "nebst Abbildung derselben". ARBG 6.2.10, p. 24, para. 63.

[21] "[Ho mann's *Botanical Almanac*] costs 1 fl 48 x and is decorated with 12 copperplates of rare German plants." The abbreviation "fl" was used for the Gulder (from florin), a currency used in some German-speaking areas at the time; "x" was the abbreviation for Kreuzer, that is, pennies. Original German: "Er [=Ho - manns *Botanischer Almanach*] kostet 1 fl 48 x und ist mit 12 Kupfertafeln seltener deutscher Pflanzen geziret." Hoppe, D. H. to the society's members, 13 August

society considered publishing an illustrated botanical work itself, to be entitled *Icones Plantarum Horti Botanici Ratisbonensis* and to feature the *Scirpus*, *Eriophorum* and *Tussilago* species.[22] However, for reasons that are unknown, the plans to do so were dropped.

The importance that the RBG attached to illustrations is confirmed by the fact that the copper-engraver Johann Mayr and another engraver called Körnlein were elected as honorary members (the first to receive this honour) only a few months after the society had been set up.[23] However, these two engravers were admitted largely because of pragmatic reasons, as can be taken from the vote of the society's president, Johann Jakob Kohlhaas: "Mr. Mayer, the copper-engraver, and Mr. Kernlein, the engraver, can be admitted as members – for artists of this kind are useful and indispensable to any institute dealing with natural history."[24] Thus, Mayr and Körnlein were admitted as members of the RBG not because of their botanical expertise but principally because of their technical abilities, which were considered "useful and indispensable" for a nature-inquiring society. Kohlhaas presumably expected to make use of Mayr's and Körnlein's abilities at some point. New members were also expected to make a donation of some kind as acknowledgement of their gratitude to the society: self-serving thoughts along these lines may well have contributed to Mayr being accepted as a new member.[25] This require-

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1790, ARBG 1.1.24. A catalogue of the library's collection is reproduced in Ilg (1984), Appendix IV; see ibid., pp. 148f., for a description of the society's more luxurious works.

[22] See Hoppe's note of March 1805, ARBG 7.1, cited Ilg (1984), p. 198. (*Scirpus* = rush; *Eriophorum* = cotton grass, *Tussilago* = coltsfoot.)

[23] The term "honorary member", however, did not then have the connotation it has today. In its early years, the RBG had ordinary members and honorary members, two categories that were mainly distinguished by members' places of residence. "All plant experts resident in Regensburg" ("alle in Regensburg anwesende[n] Pflanzenkenner") were eligible for "ordinary" member status. Honorary members included "all non-resident experts, non-resident and local enthusiasts of botany, regardless of their profession or class" ("alle auswärtigen Kenner, auswärtige und hiesige Schätzer der Botanik, ohne Rücksicht auf Amt und Stand"). See *Plan und Gesetze*, Ilg (1984), p. 279. Only when the Erlangen gardener Rümmelein became a member of the society in 1792 was the new grade of "extraordinary" member introduced, principally because the Erlangen-based Professor Schreber did not want to be placed in the same category as his gardener. See ARBG 1.3.39, 40, 41, 42a, 42b.

[24] Original German: "Herr Kupferstecher Mayer und Herr Graveur Kernlein können als Mitglieder aufgenommen werden – denn Künstler dieser Art sind jedem Institut, das sich auf Naturgeschichte bezieht, nützlich und nöthig." Kohlhaas, J. J. to members, 13 August 1790, ARBG 1.1.25. In the documentation, Kernlein is more usually referred to as Körnlein.

[25] The negotiations for the prospective candidature of Candid Huber in 1792 provides a good example of the way the society went about selecting new members. The correspondence that took place between society members clearly shows that

ment was duly fulfilled, for, as a token of his esteem, Mayr promptly promised to give the society "a complete copy of his botanical work".[26]

4.1.3 Academies

Academies, which in contrast to societies were mostly state-funded, provided an important institutional framework for eighteenth-century botanical activities.[27] Frequently, like some of the learned societies, the academies published their own periodicals in which members' presentations or treatises were published: the *Journal des Savants* of the Paris Académie Royale des Sciences

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they were far more interested in the candidate's collection of di erent woods ("wood library" or *Holzbibliothek* in the original German text) than in his future contributions to society meetings. See, e.g., the following letter by Kohlhaas to the society: "As for the wood library of the lay vicar, Mr. Huber of Ebersberg, Bavaria, that is for sale, I have proposed our secretary's suggestion, namely that we o er him the equivalent in books in exchange for this library. Mr. Herzer firmly believes that Mr. Huber will agree to this, particularly if we beguile him with a diploma as an honorary member and provide him with a copy of our journal. Since this collection would be an asset to our library, I shall vote in favour of accepting him, and then Mr. Haas could draft a letter to Mr. Huber to this e ect." A response to this note reads even more bluntly: "An unexpected diploma might have unexpected e ects. I vote in favour. Bergfeld." Original German: "Was die von Hn. Pfarrvikar Huber in Ebersberg in Bayern zu verkaufende Holzbibliothek betri t, so hab ich ihm den Vorschlag des Hrn. Sekretär gemacht, Hrn. Huber für diese Bibliothek ein Aequivalent an Büchern anzubieten. H. Herzer glaubt fest, dass H. Huber sich darauf einlassen werde, wenn wir ihn durch ein Diplom als Ehrenmitglied und 1 exemplar unserer Schrift captiviren. Da jene Bibliothek eine Zierde für unsere Bibliothek sein würde, so stimme ich für die Aufnahme, und, alsdann könnte H. Haas ein Schreiben an H. Huber dissfalls aufsetzen"; "Ein unerwartetes Diplom thut vielleicht eine unerwartete Wirkung, ich gebe also meine Stimme. Bergfeld." ARBG 1.3.69.

[26] ARBG 1.1.34; letter of thanks from Mayr, 23 August 1790. The botanical work mentioned is identified in the society's minutes as being a copy of the *Ectypa Plantarum Ratisbonensium* [see Hoppe (1787-93)], which Mayr had printed for Hoppe, who edited the work: "August. 23. Mr. Mayr, the copper-engraver, expressed his thanks for the diploma we granted him on 18 August extremely obligingly and promises to present the society with a collection of Hoppe's plant prints." Original German: "August. 23. Herr Kupferstecher Mayr dankt für sein unterm 18 August ertheiltes Diplom in sehr verbindlichen Ausdrücken und verspricht eine Sammlung der Hoppeschen Pflanzenabdrücke der Gesellschaft zum Geschenk zu machen." ARBG 6.1., p. 9.

[27] The literature on the history of academies is immense. In addition to the already cited McClellan (1985), which covers not only learned societies but also academies, the following two books deal specificallywith the academy in question here: Grau (1993), a comprehensive study on the history of the Berlin Academy of Sciences, which contains many references to more specific literature; and Harnack (1900), still the most fundamental and important work on the topic.

and the *Philosophical Transactions* of London's Royal Society were the very first scientific journals to be published at all.[28] The treatises published in these journals were often accompanied by plates that had previously been discussed by the academicians at their meetings. The Parisian Académie Royale des Sciences and the affiliated Jardin des Plantes were renowned for employing draughtsmen of plants on a permanent basis: Claude Aubriet, Madeleine Basseport and Pierre Joseph Redouté, to name only the most celebrated, all worked for the Académie in this capacity. The Berlin Academy of Sciences, founded in 1700 as the Brandenburgische Sozietät der Wissenschaften, cannot be compared with the two academies above in terms of artistic renown but nevertheless employed its own draughtsmen, and the scientific illustrations prepared by them (or by members themselves) were regularly discussed in a variety of contexts. From the very first of the Berlin Academy's regular gatherings, the presentations of drawings and illustrations were reported in the minutes. In particular, the naturalist Johann Leonhard Frisch showed his colleagues a whole series of zoological illustrations, depicting either complete birds and fish or just their beaks and teeth.[29] Some of these presentations included a written article, such as, for example, Frisch's presentation of the *Gobi capitato*, which had, up until then, not been described:

> And this is why [Frisch] delivered a correct drawing of this species of fish and read out the accompanying description. He left it [to the society] to decide whether one wanted to have this drawing engraved and hand-coloured for the *Miscellanea*,[30] which remains to be negotiated with the society's *Concilio*.[31]

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[28] The *Journal des Savants* appeared from 1665 onwards, although only from 1701 was it o cially connected to the Académie. The year 1665 also saw the appearance of the first issue of *Philosophical Transactions*. According to the criteria defined in McClellan (1985), the Royal Society should be counted as a learned society not as an academy, although it was surely a much richer and renowned society than those cited in the previous subsection.

[29] Frisch demonstrated, e.g., the beaks of a pelican and a shoveler (*Löffelgans*, fol. 107), the tongues of wild ducks and general views of diving ducks (*Tauchenten* as well as *Tauchhühner*), the teeth of a carp (fol. 123), the teeth of unknown species of fish (fol. 121 and fol. 134), an unknown species of bird (fol. 146), a river lamprey (fol. 134) and several other species of the *lampetra* genus (fol. 155). For all of these, see AdW (Archives of the Berlin-Brandenburgische Akademie der Wissenschaften), I-IV-36.

[30] The full Latin title of the journal was *Miscellanea Berolinensia ad Incrementum Scientiarum* (Berlin Miscellanies to the Advancement of the Sciences).

[31] Original German: "daher [Frisch] von dieser Art Fische eine richtige Zeichnung überliefert und die dazu verfertigte Beschreibung verlieset. Stellet anheim, ob man in den Miscellaneis besagte Zeichnung in Kupfer stechen und demnächst mit der natürlichen farbe illuminiren lassen wolle, welches dann im *Concilio* der Societaet auszumachen seyn wird." AdW, I-IV-36, fol. 154.

Drawings were sometimes presented as independent contributions. In October 1741, for example, Frisch had informed the society of "a blue-headed red blackbird, drawn life-size and in natural colours and he promised to provide a description with it as soon as a new issue of the *Miscellanea* was due to be published".[32] In a similar manner, the physician Augustin Buddeus presented, in 1727, "numerous sketches of a *situ foetus in utero praeternaturali* [fetus positioned in an abnormal womb], which he had drawn from life and on which he thought to deliver some observations".[33]

For some time, these illustrations were made by the scholars themselves or by draughtsmen specifically engaged to carry out a particular commission, although Johann Gottlieb Gleditsch, the academy's botanist during a great part of the eighteenth century, had pleaded as early as 1751 for the society to engage a gardener who would also be able to prepare plant drawings.[34] It was only in 1768, however, that Johann Bernhard Gottfried Hopfer was engaged on a permanent basis as the academy's first specialist draughtsman of animals and plants – on the personal approval of King Friedrich II – and for which he received an annual salary of 200 Prussian thalers.[35] After Hopfer's death, two new draughtsmen were taken on: one to draw anatomical subjects, the other botanical ones. The details of how the vacancy left by Hopfer's death was filled have been described elsewhere and shall not be repeated here.[36] Suffice it to say that the Berlin Academy attached great importance to the production and discussion of images, which, in most cases, were subsequently published in the academy's journal.

4.2 Uses

It is clear from the documentation that eighteenth-century botanical illustrations were an important topic of discussion, as shown in the introductions to the three contexts outlined above. But it is still not entirely plain what their

[32] He delivered "die nach ihrer natürlichen Gestalt und Farbe abgemahlete blauköpfige rothe Amsel, und verspricht die Beschreibung dazu zu geben, so bald ein neuer Theil der Miscellaneorum wird gedrucket werden". AdW, I-IV-36, fol. 169. The description was finally handed over five months later, in March 1742, when Frisch read out "his description of a bird called *Merula rupicola*, whose drawing he had already handed in some time ago". Original German: "[Frisch verliest] seine Beschreibung des Vogels so *merula rupicola* genannt wird, dessen Zeichnung er schon vor einiger Zeit gegeben." AdW, I-IV-36, fol. 172.

[33] Original German: Buddeus presented "etliche risse [...], von einem situ foetus in utero praeternaturali, die er nach dem leben abzeichnen lasse, und worüber er seine observationes herauszugeben gedenket". AdW, I-IV-36, fol. 95.

[34] AdW, I-XIV-35, fol. 56 and fol. 57. For a complete transcription of Gleditsch's requests for an "academic" gardener, see also Nickelsen (2000), pp. 68f.

[35] AdW, I-III-11, fol. 75.

[36] See Nickelsen (2000), pp. 76 .

function was. Although botanical illustrations have been widely discussed in the history and philosophy of science, there has been little debate on the purposes they served – although authors have suggested a variety of functions, usually, however, without giving much concrete evidence. Brian J. Ford, for example, considered the main purpose of scientific illustrations to be their "didactic function",[37] without going into any more detail. And in his standard book of 1966, Claus Nissen claimed that botanical illustrations, understood as "documentary plant images", were meant to "replace the actual plant specimen for fellow researchers at a distance in time or place";[38] this notion was picked up in many subsequent surveys of the topic: henceforth, authors predominantly tried to establish whether an illustration fulfilled this documentary function (and thus was able to replace an unavailable plant specimen) or not. However, few authors have seriously analysed whether this function in fact corresponded to the ideas of eighteenth-century botanists.[39]

4.2.1 Classifying Species

There is a general agreement in the literature that botanical illustrations were intended to be used as aids for classifying unknown plants. Indeed, in the prefaces of their botanical works some authors explained that the aim of the book was to make it easier for readers to get to know certain species of plant. William Curtis, for example, stated that the primary purpose of his *Flora Londinensis* was "to facilitate a knowledge of the plants of our own country, and establish each species and variety on a firm basis".[40] In a similar vein, the German author Christian Schkuhr pointed out in the preface to his *Botanisches Handbuch* that he had depicted "all those parts that are necessary for recognizing the genera and species".[41] The Frenchman Nicolas François Regnault also wrote his work "to teach [people] how to recognize them [plants]".[42] So, following the notion of the documentary value of images, one might think that the botanists were expected to observe the unknown plant in question, then examine the picture and then the plant again. And if

[37] Ford (1992), p. 2; Ford recognized that a secondary purpose of botanical illustrations, seen from a present-day perspective, is the "recording of the state of human understanding"; see ibd.

[38] Nissen (1951), p. 6. In the original German, the quote reads: "[den Gegenstand unserer Abhandlung bildet] das dokumentarische Pflanzenbild, welches dem zeitlich oder örtlich entfernten Mitforscher die Pflanze selbst ersetzen soll."

[39] For a critical view on this practice from the art historical perspective, see Lechtreck (2000), p. 223f.

[40] Curtis (1777-98). Preface.

[41] Original German: he had "alle diejenigen Theile abgebildet, welche zur Erkenntniss der Gattungen und der Arten erfordert werden". Schkuhr (1791-1803), Vol. 1, Preface, p. VII.

[42] Original French: "pour enseigner à les [plantes] bien connoître", in Regnault & de Nangis Regnault (1774), Vol. 1, Preface.

picture and plant were similar, one would conclude that the plant belonged to the species represented in the picture.

Assigning plants to species indisputably formed a core part of the study of botany, so it is obvious that great importance would be attached to producing correct illustrations that were used to this purpose; it also provides good reason for the observation botanists presented their illustrations at society meetings and informed other colleagues of particularly outstanding images in their correspondence. The assumption that the pictures served as classification aids also seems to tie in with the findings concerning their content: the species models depicted in the images should, as a rule, be instantiated only by members of a single species; belonging to the species would preferably be a necessary condition for a plant to instantiate this model. Vice versa, this should mean that if one finds that a plant instantiates the depicted model, then one should be able to infer that this plant also belongs to the depicted species. But it then becomes clear that using the pictures in a way suggested above, would not do. The idea of directly comparing the properties of a living plant with the properties of a picture in the search for similarities clearly contradicts the complex relations that exist between pictures, their content and their instances that were discussed in Chapter 3.

Visualizing De“ning Properties

Whether an object instantiates a model or not can only be settled by comparing the properties of the object with the statements that can be gathered from the model on the properties of its instances. If these statements agree, the examined plant can then be taken to be an instance of the represented model – at least regarding the hypotheses in question. In order to infer from this finding that a certain plant specimen actually belongs to species x, referred to by the model, one has to make sure that the plant in question instantiates the model as a species model, and not as a model of plants, trees or grasses in general. This means that it must instantiate the model with respect to a certain selection of hypotheses. This further difficulty is caused by the fact that deciding whether a plant belongs to a species or not is based on a concept definition, whereas other criteria apply when it comes to instantiating a model. In order to examine whether an unknown plant belongs to species x (with the help of a botanical illustration showing species x), one must proceed as follows. First, one has to acquire from the picture the taxonomically relevant properties that define the species within the system of taxonomy being used, for example, the principles and definitions of the Linnean system. Second, one has to examine whether the unknown plant exhibits all these properties. If this is the case, the plant can be identified as belonging to the species in question. If the plant exhibits none of the properties, it can be ruled out as a member of the species. By supporting the species determination of unknown plants in this sense, eighteenth-century botanical illustrations could undoubtedly be used as classification aids.

Difficulties arise, however, if the plant to be determined exhibits some but not all of the taxonomically relevant properties as stated by the model. In such cases, one cannot automatically infer that the plant does *not* belong to the modelled species, as if one were applying a traditional definition of equivalence. The use of botanical illustrations in the described manner presupposes that (i) the depicted model includes correct statements on all the defining properties of the species and (ii) that these statements were correctly derived. These two premises should, at least in questionable cases, be carefully checked. Does the depicted model really include statements on all the defining properties? The meadow saffron model by Johann Hedwig, for example, does not (fig. 3.3, p. 88). And is one's interpretation correct? Were the statements correctly derived? At this point, the limited value of this method becomes obvious. Correctly deriving exact statements on defining properties is no easy task, even if one is familiar with the picture's visual language. Is Jakob Sturm's sweet vernal grass spike only ovoid or more oblong-ovoid in shape? And anyway does this difference matter? Issues of this kind can only be settled by examining written definitions, which was one of the reasons why Linnaeus categorically rejected using illustrations to classify genera. As he wrote in the introduction to his *Genera Plantarum*, "No one can ever derive any firm argument from a picture; very easily, however, from the written word."[43] Linnaeus's objection is justified if one is identifying plants strictly by using their taxonomically relevant properties in the narrowest sense, as already indicated: to determine a plant by its systematically defining properties through the use of pictures meant making a detour – and frequently a quite unsafe one at that. If one uses pictures alone, there is a high risk that mistakes in identification will be made, since even small variations in hypothesis derivation can have a decisive influence on the result. To minimize this risk, it was necessary to consult the written species definitions, which implies that one could have done without looking at the pictures in the first place, since taxonomically relevant properties can usually be expressed much more precisely in words.

It would be surprising if this had been the only purpose for which botanical illustrations were prepared and used. If they were merely to visualize the Linnean taxonomy and nothing else, such detailed illustrations would have been unnecessary. Why does Sturm show the sweet vernal grass's complete habit, with stalk, roots and leaves, if it would have been enough to classify the plant by showing just the ear and individual flowers? And why did Curtis go to the trouble of showing the different stages of the plant's development in his picture of the coltsfoot?

[43] Original Latin: "Ab icone enim quis potest unquam aliquod argumentum firmum desumere, sed a verbis scriptis facillime." Linnaeus (1960), p. VIII. On Linnaeus's attitude to illustrations, see also Müller-Wille (2002).

Visualizing Indicator Properties

An important reason for integrating additional properties into a model so that it could serve as an aid to classification can be found in Linnaeus's writing. In his *Philosophia Botanica*, after having explained the taxonomically relevant and irrelevant properties at length, Linnaeus described how a plant's genus should be identified:

> 168. The habit (163) [of a plant] should be studied in private to prevent an incorrect genus being applied out of ineptitude.
>
> Experience, the master of everything, often divines the natural categories[44] of plants from the first glimpse of their external appearance. [...]
> The habit should be studied in private to prevent it entering the ranks of distinctive characters and thereby disarrange the genera.[45]

Linnaeus defined the habit in an earlier aphorism:

> 163. The HABIT is a certain conformity of plants that are allied and related, among other things, in their *placentation, radication, ramification, intorsion, gemmation, foliation, stipulation, indumentum, glandulation, lactescence, inflorescence.*[46]

It is commonly held that Linnaeus was a rigid Aristotelian essentialist,[47] yet this paragraph proves how little this notion applied to his method of working. Despite the detailed system of rules that he had set up and despite the fact that he wanted to see genera defined only by their fructification properties, Linnaeus did not consider the practice of identifying a plant's genus and species as a merely mechanical process, restricted to checking the small number of properties included in the definitions. Other characteristic properties of the plant – its habit – could also contribute to the classification process. A plant's habit, though, was not to be understood in its colloquial sense, that is, as a diffuse, general impression of a plant's external appearance to which one could (spuriously) also include its accidental properties, such

[44] Linnaeus used the Latin word "familia" in his writings to denote a natural taxon of any level, that is, a natural class, order, genus or species.

[45] Linnaeus (1753), para. 168, p. 117. (Original Latin: "Habitus (163) occulte consulendus est, ne genus erroneum laevi de caussa fingatur./Experientia rerum magistra, primo intuitu ex facie externa, plantarum familias seaepius divinat. [...] Occulte consulendus est habitus, ne intret cohortem notarum characteristicarum & genera disterminet."

[46] Linnaeus (1753), para. 163, p. 117. Original Latin: "HABITUS est conformitas quaedam Vegetabilium a nium & congenerum, in *Placentatione, Radicatione, Ramificatione, Intorsione, Gemmatione, Foliatione, Stipulatione, Pubescentia, Glandulatione, Lactescentia, Inflorescentia*, aliisque."

[47] See, e.g., the seminal monograph on his system, Larson (1971). An alternative account can be found in Müller-Wille (1999).

as the absolute size or luxuriance of the specimen. Rather, Linnaeus defined in detail which properties he considered to be part of this habit and which would, therefore, influence a plant's classification, namely, the number and shape of the placenta or cotyledons, the mode of ramification, the shape of its buds, the foliage, and so forth. But even these restricted aspects of a plant's habit remained subordinate to the actual criteria of taxonomic relevance. The habit may influence one's first impression and prevent wrong inferences being made, which can easily occur when one classifies a plant by rigidly sticking to the rules. It is easy to miscount the number of stamens and pistils in a flower, particularly when using small samples, and thereby take the wrong path from the very beginning, whereas if one had initially observed the habit of the plant, one might have ascertained its natural genus (or any other natural category) straight away. Thus, consulting the habit could be said to be of strong heuristic value. However, to classify a plant's class, order, genus and species, it was essential that the defining, characteristic properties were carefully checked after a first, rough identification based on a plant's distinctive habit had been made. Linnaeus stressed this point so that his precise taxa definitions would not be affected.

If one takes the example of the meadow saffron, *Colchicum autumnale* L., for example, Linnaeus characterized the *Colchicum* genus by its fructification properties, that is, the properties of the calyx, flower, stamens, pistil, fruit, seed and receptacle. Within this genus, he distinguished three species:

1. The most common species of meadow saffron, prevalent in central Europe, has the specific name *Colchicum foliis planis lanceolatis erectis*, that is, meadow saffron with flat, lanceolate, upright leaves.[48]
2. A second species was called *Colchicum foliis linearibus patentissimis*, that is, meadow saffron with lineally shaped, far outspread leaves.[49]
3. A third species *Colchicum foliis undulatis patentibus*, that is, meadow saffron with undulate, outspread leaves.[50]

Thus, the specific characters Linnaeus chose to differentiate the species within the *Colchicum* genus concerned only the different properties of the leaves. If one were to use only these distinctive properties to identify an unknown specimen belonging to the *Colchicum* genus, one would not be able to determine the species when the plant was in flower, since the leaves only appear after the flowers have wilted. It would be equally difficult to identify this plant's genus from the defining properties of its fructification when in foliage, since the flowers would no longer be present, while the fruit and seed would not yet have developed. These are not far-fetched and hypothetical problems

[48] See Linnaeus (1753). As previously mentioned, the Linnean *nomen specificum* was also the species' definition. The trivial name of this species was, as is well known, *Colchicum autumnale*.

[49] Linnaeus (1753); Linnean trivial name: *Colchicum montanum*.

[50] Linnaeus (1753); Linnean trivial name: *Colchicum variegatum*.

but are part of a botanist's daily work. Coming up with a precise definition is one thing – being able to apply it in practice at any given moment is quite another.

Nevertheless, many plants were correctly classified, even at unusual and difficult times of the year. The problem mentioned above can be solved if one knows the additional typical properties of a genus or species which reliably indicate that a particular plant is a specimen of species x, even when there are no taxonomically defining features at hand. These additional properties act as indicators to the observer for the characterizing properties of the Linnean system. For example, the bulbs, sheaths and petals of the meadow saffron do not give any taxonomically defining evidence of the species' classification; nevertheless, it might well be the case that the presence of these organs – and other properties that Linnaeus included in the plant's habit – are always found in plants that also show the specifically defining properties of one of the three species of the *Colchicum* genus, for example, the shape of the flower. Therefore, these properties pertaining to the flower may correlate perfectly with the defining properties of the leaves, and so be something of an epiphenomenon: both defining and indicator properties spring from one and the same cause, which results in plants of this species usually developing these particular properties and no others. Even if the given plant has, at a particular time, no leaves but only flowers, one can infer that under normal circumstances the plant will, at some point, develop the defining type of leaves. And on this basis one can safely identify the plant as belonging to a certain species, without having applied one single defining property. This method of proceeding is well supported by eighteenth-century botanical illustrations, with their wealth of additional and, at first glance, superfluous information. A user can take many more specifically characteristic properties from these illustrations than from the entries in Linnaeus's *Species Plantarum*, and it is these further properties that allow the user to determine, with the help of the images, whether a real specimen belongs to a particular species or not.

These properties not only meant that unknown specimens could be identified from a pictorially represented species, they also helped eighteenth-century botanists decide which species a given illustration represented, which was not always entirely clear. Trew repeatedly asked his correspondent Haller for help in identifying plates he was unsure about. In July 1752, for example, he asked Haller about a plate from Conrad Gessner's extensive estate, which Trew had recently acquired for his collection: "What does Your Honour think is figure V?"[51] As Haller failed to reply, Trew made the following suggestion six months later:

> I have explained my views concerning figures IV and V of the hand-coloured proofs in an enclosed note, from which I conclude that fig. V is completely unknown: not only is the *vasculum seminale simplex*, indicated by Gessner

[51] Original German: "Wofür halten wohl Euer Hochwohlgeb[oren] Fig[ur] V.?" Trew, C. J. to Haller, No. 8, 22 July 1752. Cited Steinke (1999), p. 111.

> himself, rather unusual, so are the numerous stalks with single flowers. If you can put me right on this point, I would be very pleased.[52]

The properties that Trew believed decisively indicated that the plant belonged to a new species were the plant's *vasculum seminale simplex*, its simple seed capsule, and its unusual inflorescence. That is, Trew referred to certain anomalies of the fructification, which he had not observed in any other plant. In reply, Haller wrote:

> Fig. V, Vol. I, is, in my opinion, the *Saxifraga foliis ciliatis* etc., which grows in the Alps and around Berne – the *habitus distubus*, the first *ovarium* and several other signs indicate this. At first, the *Tubae* grow closely together but gradually they separate, and the whole character has been imperfectly depicted.[53]

So, in contrast to Trew, Haller believed that the figure depicted an already known species of the large genus *Saxifraga* and he accounted for his viewpoint by his use of a completely different set of properties than those mentioned by Trew. The actual "character" of the plant, from which the defining properties could have been derived, had been imperfectly depicted, Haller wrote. Nevertheless, he recognized "several other signs" that confirmed to which species the depicted specimen belonged, without having used the distinctive generic and specific features of the plant. However, Haller too made mistakes when classifying plants using only illustrations. Early in 1733, in his first letter to Trew (in whose periodical he had published what he considered to be the discovery of a new species of orchid), he had written the following:

> On this occasion I also have to admit that the orchid which I described this year is actually Micheli's *Pseudorchis alpina* with herbaceous flowers and the *Limodorum montanum* with green, white variegated flowers in the *Mémoires de l'Académie*, 1705, p. 517 [in fact, p. 519]. An illustration of the flowers is given there, which totally di ers from nature, which is why I did not immediately notice that my plant did not match the one drawn by Chomel.[54]

[52] Original German: "Meine Meinung von fig. IV. et V. der illuminirten Probplatte habe in einer beygefügten nota erkläret, nach welcher ich fig. V. für noch gantz unbekannt halte: das von Gesnero selbst angezeigte vasculum seminale simplex ist nicht nur alleine gantz besonders, sondern auch die einzeln blumen auf so vielen Stengeln. Würden Sie mich hierüber eines bessern belehren, solte es mir sehr angenehm seyn." Trew, C. J. to Haller, No. 9, 2 February 1753. Cited Steinke (1999), p. 119. The enclosed "nota" Trew mentioned has, unfortunately, not survived.

[53] Original German: "F[igura] V. T[omi] I ist meines erachtens die auf den Alpen und um bern wachsende Saxifraga foliis ciliatis etc. der habitus distubus, das erste Ovarium, mehrere Zeichen verrahten sie. die Tubae sind anfangs einander ganz nah, u spalten sich nach u nach, u der ganze Charakter ist unvollkommen gemahlt." TRWC, Haller, A. von to Trew, No. 159, 14 February 1753. Cited Steinke (1999), p. 124.

[54] Original German: "An dieser selben Stelle muss ich eingestehen, dass die in diesem Jahr von mir beschriebene Orchidee die Pseudorchis alpina mit krautiger Blüte

In this letter, Haller pointed out to Trew that, in the *Commercium Litterarium*, he had erroneously declared that a plant he had collected was a new species, although it had already been described on two occasions before and given two different names. Haller explained that he had failed to notice that his plant was the same as the one depicted in the *Mémoires de l'Académie Royale des Sciences* because the illustration had been so badly done that he had not recognized that his plant belonged to the same species. In this case, the model contained in the illustration could not be used as the basis for deciding whether a plant belonged to the depicted species or not. It is interesting to note, however, that Haller was convinced that he could use the illustration to reach such a decision. Determining whether or not a plant belonged to a species depicted in an illustration was obviously one of the functions that he expected an image published in a renowned journal to fulfill.

So it would seem that one of the roles of a picture was to support the classification of unknown plants, primarily through using a plant's indicator properties. However, this explanation is not totally convincing. One can certainly gather many properties along these lines, say, from the illustration of the grapevine published in Trew's *Herbarium Blackwellianum* (fig. 4.1, p. 125).[55] Yet this picture includes far more information than would be required if this was the sole purpose of the image. Trew shows, for example, the individual flowers of the grapevine from a number of viewpoints: whole as well as in separate parts, in different stages of development and from a variety of angles. One cannot adequately account for this wealth of detail by assuming that Trew only wanted to provide information on the grapevine's defining and indicator properties in order to make it easier for people to recognize specimens of this species. This also applies to many of the other illustrations under study. After having examined the plates that Johannes Gessner had done to illustrate the new sexual system, Linnaeus wrote: "When I saw your plates engraved on copper as beautiful as they are fine, suitable and select, I was thunderstruck and felt myself to be filled with new problems."[56] Since Linnaeus had himself defined the species of plants that were depicted by Gessner, the "problems" he

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des Micheli und das Limodorum montanum mit grüner, weiss zersetzter Blüte, in den Mémoires de l'Académie 1705, S. 517 ist. Dort wird eine Abbildung der Blüten gegeben, die völlig von der Wirklichkeit abweicht, und die schuld ist, dass ich nicht sogleich die Uebereinstimmung meiner Pflanze mit der Chomelianischen bemerkte." TRWC, Haller, A. von to Trew, No. 144, 24 November 1733. Cited Steinke (1999), p. 59. On the 21 January 1733 Haller's article, entitled *De orchide palmata Alpina, spica densa albo- viridi*, had appeared in Trew's *Commercium Litterarium*. The works referred to in Haller's quotation are the *Nova Plantarum Genera* (Florence, 1929) by Pier Antonio Micheli and an article by Pierre-Jean-Baptiste Chomel in the *Mémoires de l'Académie Royale des Sciences*, 1705, p. 519 and Plate 8.

[55] Taken from Trew & Blackwell (1750-73).

[56] See Boschung (1996), p. 14. Gessner occasionally corresponded with Linnaeus on the former's *Tabulae Phytographicae* and repeatedly sent Linnaeus first versions

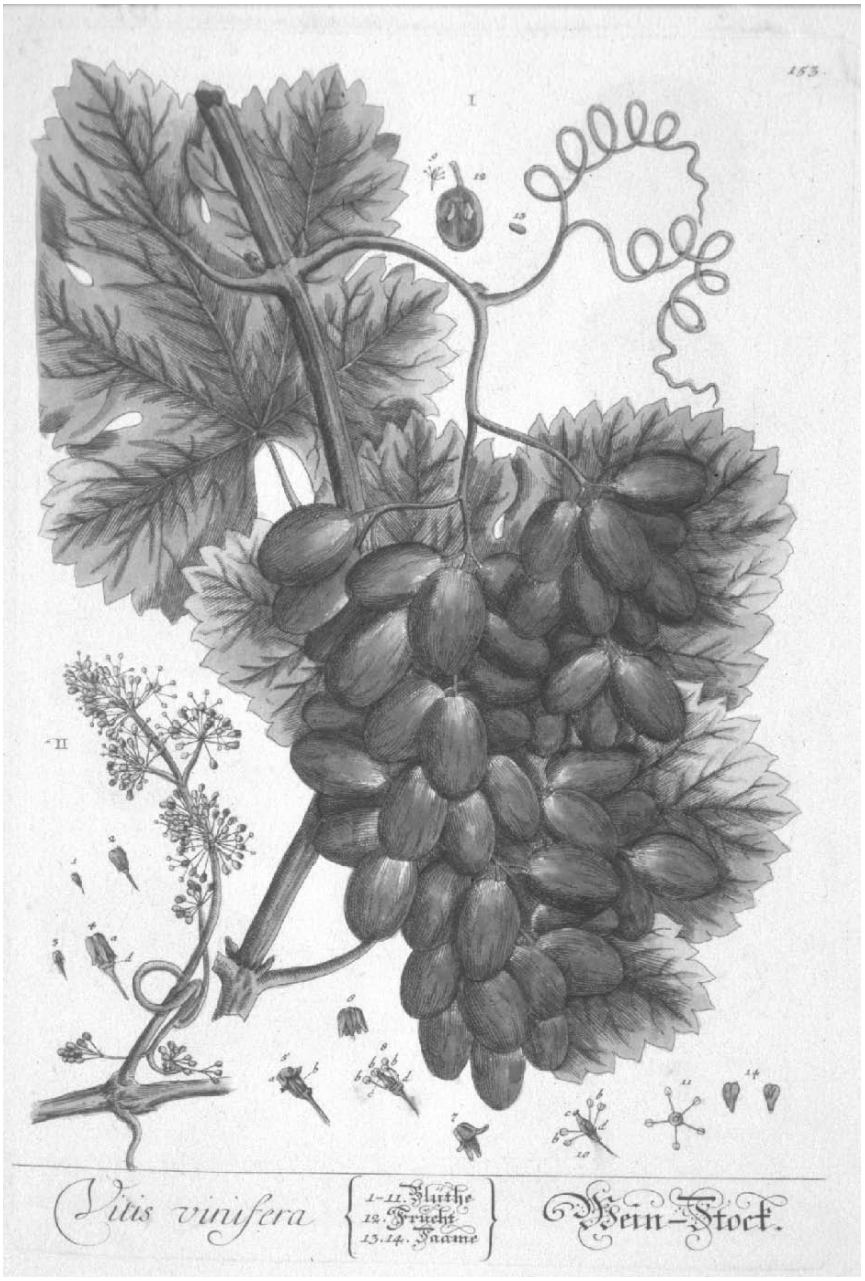

Fig. 4.1. Grapevine – *Vitis vinifera* L. Trew & Blackwell (*Herbarium Blackwellianum*, Vol. 2, 1754).

was beset with could not have concerned the species' classification but must have related to something else. At least in some cases, it appears that the illustrations fullfilled additional functions.

4.2.2 Describing Species

In the prefaces to their works, the authors repeatedly stressed that readers should get to know the species of plants by familiarizing themselves with the published plates, as the quotes on page 117 shows. One begins to wonder, however, whether this covered only recognizing and classifying plants, aided by the information provided in the picture. This uncertainty is corroborated if one studies the authors' opening remarks a little more closely, for example, a section towards the end of Curtis's preface to the *Flora Londinensis*:

> The Student of Botany, for whom it [the work] is more particularly designed, from carefully observing the Plants and Flowers as dissected and delineated, and comparing them with the Descriptions, will not only acquire an Idea of the *Linnean System* but likewise become acquainted to the greatest Part of the Plants growing wild in *Great Britain*.[57]

This description of the uses of the work's illustrations contradicts what was understood to be Curtis's standpoint from the earlier parts of his preface. He now recommends that the plates be thoroughly examined, especially the detailed views of the fructification organs, and that they should then be compared with their descriptions. Working this way would help readers to understand the Linnean system and introduce them to the wealth of Britain's native vegetation. He makes no mention of using pictures to classify unknown plants with the help of pictures. Rather, the work is considered worthy of study in its own right. Curtis was not alone in considering botanical illustrations in this way. A similar point of view can be taken from the preface to the silvicultural compendium published in 1815 by the Berlin draughtsman and engraver Friedrich Guimpel, in collaboration with Friedrich Gottlob Hayne and Karl Ludwig Willdenow:

> His [the forest warden's] enterprise can only be successful if his knowledge runs deep, that is: that he has a systematic knowledge of the vegetable kingdom at his command, that he knows the characters of genera and species and that he is familiar with the correct botanical terms. He can acquire some systematic knowledge of the vegetable kingdom by taking a textbook of botany and studying the classes and orders; this book will introduce him to the genera and species and to their more exact di erences if he strives to find the plants drawn and described in the book in the countryside.[58]

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of his plates. Linnaeus's reaction of 27 July, quoted above, was handed down by a private collector of autographs in the English translation cited above.

[57] Curtis (1777-98), Preface.

[58] Original German: "Sein [=des Forstmanns] Unternehmen kann nur glücklich sein, wenn seine Kenntnisse gründlich sind, das heisst: dass ihm die systematische

Once more, the plates are recommended to be used for purposes that differ considerably from the procedure of identifying species, as explained earlier in the chapter. The aim described here is not to collect plants and classify them; rather, Guimpel recommends his readers first to study the book in the studio and then to go and examine real specimens of the depicted plants in the countryside. As in the Curtis quotation, the illustrations are not presented as a way of helping readers to determine plants but in order to provide a general introduction to the properties of genera and species of a certain group of plants, which should enable the reader to recognize real specimens of the depicted plants without having to use the book again. Using the plates to classify collected plants does not even get a mention.

This alternative use of botanical illustrations convincingly explains why taxonomically irrelevant properties are depicted in these images in such detail. For eighteenth-century botanical illustrations were more than just an aid for classifying plants. The pictures contain comprehensive information on many different properties of plant species, which are certainly not restricted to those characteristics that make it easier to recognize which plants belong to a certain species and what distinguishes them from other species. The content of botanical illustrations rather resembles Linnaeus's descriptions of species, which were supposed to contain *all* the properties of a species, not only those of direct or indirect taxonomic relevance. The fact that the pictures could also be used to assign plants to one or another species then appears to be an inevitable secondary effect: it was shown in Chapter 3 that Linnaeus's species' descriptions were the basis for his species' definitions, that is, that the latter could be derived from the descriptions; in the same vein, one can extract from the botanical illustrations, in addition to numerous other things, which properties a plant must exhibit in order for it to be classified as belonging to a particular species. It is well known that Linnaeus even defined a number of species not from his own observations of living or dried plants but from images.[59] Quite a number of the plates of the *Flora Zeylanica*,[60] for example, which Linnaeus edited, today serve as systematic "types" for the species described therein, that is, as "that constituent element of a taxon to which the name is permanently attached, whether as an accepted name or as synonym",

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Kenntniss des Gewächsreichs nicht fehlt, er die Merkmale der Gattungen und Arten inne hat, und ihm die richtige botanische Benennung bekannt ist. Systematische Kenntniss des Gewächsreichs erwirbt er sich, wenn er irgend ein Lehrbuch der Botanik nimmt, und nach diesem die Klassen und Ordnungen kennen lernt; mit den Gattungen und Arten, sowie mit deren genaueren Unterschieden wird ihn dieses Buch bekannt machen, wenn er die hier abgebildeten und beschriebenen Gewächse darnach in der Natur aufzusuchen bemüht ist." Guimpel et al. (1810-20), Preface.

[59] See, on this point, e.g., Stearn (1957), pp. 128 . or Blunt (1994), p. 122.

[60] Hermann et al. (1747).

as the official definition of a species' "type" reads;[61] in more everyday language, a type in this sense is the specimen which served as starting point for the first description and definition of a species – and this "specimen" was, for some of Linnaeus's species, an illustration. Others also resorted to this means. After insects had irretrievably destroyed the herbarium specimens of Nikolaus Joseph Jacquin, some of the preparatory drawings that he made during his travels in the West Indies and tropical America during the period 1754-59, also served this purpose.[62] At times, Linnaeus even based some of his generic definitions on illustrations alone; in a short treatise of 1736, for example, he referred readers to drawings in Henrik Adriaan van Rheede tot Draakestein's *Hortus Malabaricus*.[63]

Thus, a botanical illustration such as, for example, Curtis's image of the coltsfoot (fig. 1.2, p. 5), can certainly help to classify individual plants as belonging to the *Tussilago farfara* species; but this constitutes only the smallest part of the picture's value, since a host of additional information can be taken from the picture's content. On the one hand, the complete depiction of all the life stages of the coltsfoot helps one to identify many of the individual specimens that belong to this species by providing a number of useful indicator characteristics. On the other hand, and this might be especially important, Curtis's illustration allows the reader to predict which properties a young coltsfoot specimen, say, is going to develop at a later stage. The flower head will open and the stalk will lengthen; at some point, the flowers will fade and the flower head will close again and decline, although when the seed is mature the flower head will rise again and present a fully developed clock. At the same time, the rosettes of the leaves will develop, connected to each other by underground horizontal shoots – and so forth. This descriptive information on the species' properties will be of value to very different groups of people. It might be important for a gardener, for example, to know that there is a massive network of subterranean coltsfoot shoots in his flower bed, which might give him a clue as to how to get rid of it; the information that can be derived from the picture, however, could also satisfy genuine botanical interests of no specific purpose. Trew's illustration of the grapevine, for example, is worth consulting even if one is not interested in discovering whether a particular specimen belongs to the *Vitis vinifera* species but only wants to find out more details on the different stages of development of the flowers of the grapevine, whether these flowers produce nectar, or whether they are

[61] According to the International Code of Botanical Nomenclature, 1956, Article 7. Cited Stearn (1957), p. 125.

[62] See, on this episode, e.g., Blunt (1994), p. 156. These were the preparatory drawings for the illustrations to Jacquin's *Selectarum Stirpium Americanarum Historia* (Vienna, 1780).

[63] Rheede & Casearius (1678-1703). The treatise referred to is Linnaeus's *Musa Cliffortiana Florens Hartecampi 1736 Prope Harlemum*. For a discussion of this point, see also Stafleu (1971), pp. 131f. Stafleu also reproduces a page of this treatise in facsimile.

pollinated by the wind. The way botanical illustrations were published in the eighteenth century would also seem to support the assumption that they were primarily intended to serve as species-describing compendia: the illustrations mostly appeared in large-format, multi-volumed works that nobody would want to take with them on an excursion, even if one expected to find large numbers of unknown plants just waiting to be classified.[64] So readers were meant to use these books and their illustrations either to obtain additional information on plant species already known to them – on their morphological structures, propagation mechanisms and similarities between different species and genera – or to inform themselves on particular groups of plants, that is, either thematically defined types, such as medicinal plants, or plants growing in certain topographical areas. In this sense, the books were also intended as preparations for excursions, as can be taken from the introductions to the works by Curtis and Guimpel. The fact that the illustrations would, in addition, also determine unknown plant specimens almost went without saying.

Assuming that the pictures primarily offer comprehensive descriptions of species also makes it clear why the images – or rather the models contained in them – could retain their value even after the theoretical framework had fundamentally changed, and thereby also the properties and characteristics that were deemed taxonomically important. Many species were changed only slightly over the course of later taxonomic systems; there are, for example, species that, from Andrea Cesalpino's system in the early seventeenth century until the natural system established by Augustin-Pyramus de Candolle 200 years later, had basically the same extension. This also implies that the species' general properties, such as the shape of the leaves, flowers, roots, ovaries, and so forth, remained the same, whether taxonomic relevance was attached to them or not. And if the draughtsmen and authors had observed the features carefully and comprehensively, had included statements on these properties into their models and had represented them in the pictures, the illustrations could largely come through the changes in theory without losing much of their informative value. Linnaeus, for example, based his plate of the twinflower in the *Flora Lapponica* on a drawing by his former teacher Olof

[64] The only exception to this rule was Johann Zorn, who expected his plates to be used in the field and thus recommended that they remain unbound: "Whoever chooses to keep the illustrations in individual sheets will at any time easily be able to re-order them according to any taxonomy, alphabetically, or when they flower, so that the work can be taken, without too much inconvenience, separately into gardens and fields." Zorn (1779-90), Preface. Original German: "Wer die Abbildungen in einzelnen Blättern aufbehalten mag, wird jeder Zeit die Bequemlichkeit haben, sie nach jedem beliebigen System, oder nach alphabetischer Ordnung, oder nach der Blüthezeit legen zu können, so, dass das Werk in einzelnen Theilen ohne grosse Beschwerde in Gärten und Felder mitgenommen werden kann."

Rudbeck (junior), even though this drawing had been prepared long before Linnaeus had even thought of establishing the sexual system.[65]

4.2.3 Observational Evidence

A slightly different use to which botanical illustrations were occasionally put can be interpreted in a similar vein. It has already been mentioned that natural history images were frequently presented and discussed at the meetings of scholarly societies and academies to give evidence of new or revised observations. It has been seen, for example, that Frisch gave many presentations of drawings of animal species at the meetings of the Berlin Academy that had not been described before, such as, for example, the picture of the *Gobi capitato* (see p. 115), and that Martini encouraged potential contributors to the GNF's journal to send in new or at least more correct natural history illustrations. Presenting evidence of new findings in the form of a picture had its limitations, however: did all the drawings sent in for examination show newly discovered specimens or were some of them fictitious? The GNF occasionally had to ask its contributors to send in the original specimen with the image, so that members could double-check the picture's correctness – as in the case of a certain notary called Hübner, who offered to send in the drawing of a "small elephant borne of a dog":

> Since it [the dog] had been hit by an elephant a few days before giving birth; he [Hübner] had a copperplate engraved of this event, which he would send to the society free of charge. The society accepted this o er gratefully but wishes to see the animal *in natura* beforehand.[66]

In order to avoid this kind of situation, occasionally specimen and drawing were presented at the same time. This practice was common at the Berlin Academy. On 13 July 1737, Frisch presented:

> An upright capercaillie accompanied by a drawing from which one could see that its tongue was situated in the middle of the crop below the beak, since its diet consists partly of sharp and acuminate items and which it therefore has to bite o first.[67]

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[65] For Linnaeus's illustration, see Linnaeus (1737c), Plate VII. The original drawing by Rudbeck is reproduced in Blunt (1971), p. 13.

[66] GNF, TB IV, p. 374, 20 February 1782. Original German: "eines von einem Hunde geworfenen kleinen Elephanten, indem er [=der Hund] einige Tage vorher, ehe er geworfen, von einem Elephanten geschlagen worden; er [=Hübner] habe hiervon eine Kupfertafel stechen lassen, die er unentgeltlich der Gesellschaft einschicken wolle. Die Gesellschaft nahm zwar dieses Anerbieten mit Dank an, wünscht aber vorher das Thier *in natura* zu sehen."

[67] AdW, I-IV-36, fol. 158. Frisch presented "einen aufgestellten Auerhahn nebst einer Zeichnung, woraus zu ersehen, dass seine Zunge mitten im Kropfe unterm Schnabel liege, weil seine Nahrung zum Theil aus solchen Sachen bestehet, welche scharf und spitzig sind, und die er also vorher abbeisen muss."

This drawing showing the unusual position of the bird's tongue could well have been questioned by the audience. However, by presenting a stuffed specimen with the drawing, those present were able to observe directly the morphology of the tongue shown in the drawing against a real specimen. In addition to proving the drawing's correctness, this simultaneous presentation of specimen and image had the advantage that the content of the two forms of representation complemented each other well. The drawing showed a detail that most observers would probably have failed to notice by simply looking at the specimen itself but which nevertheless explained the bird's morphology and habits. Presenting the stuffed animal and the drawing together made it unnecessary to give the audience an additional general view explaining the detail.

Illustrations were also occasionally used as observational evidence in people's private correspondence. Thus, in April 1746 Trew wrote the following to Haller:

> *HofRath* Mr. Schmiedel from Erlangen sent me a curious note, together with a meticulous drawing, which testifies that in his observations of the Elatine he saw the same metamorphosis of the flower that Dr. Linnaeus had noticed in the Linaria: space did not allow us to publish it last year in the *Commercium Litterarium*.[68]

Some time before, Haller had sent Trew a review of a well-known dissertation, supervised by Linnaeus, that gave an account of a recently appeared variant of the toadflax. In this plant, which Linnaeus called a "pelory-mutant",[69] the flowers were arranged in radial symmetry, not in bilateral symmetry as is usual in the flowers of the toadflax. Even more confusing, the new variant had five not four stamens, which contradicted its species' incorporation into the Linnean classes and was, therefore, causing considerable debate among botanists. A colleague of Trew's, Professor Casimir Christoph Schmi[e]del of Erlangen, claimed that he had observed the same phenomenon in the Elatine, which he meant to prove by sending Trew an illustration that he wanted published in the *Commercium Litterarium*.[70] Haller, though, was not impressed; he did not go so far as to doubt the drawing's correctness straight away but he nevertheless commented that, in his entire career as a botanist, he had never observed any of these phenomena.[71] Serving as evidence of new discoveries

[68] Trew, C. J. to Haller, No. 4, 9 April 1746. Cited Steinke (1999), pp. 94f. (Original German: "Herr HofRath Schmiedel in Erlang[en] hat eine curiöse Anmerkung nebst einer accuraten Zeichnung mir zugeschicket, welche bezeugen, dass Er bey der Elatine eben dergleichen metamorphosin floris observiret, welche H. Dr. Linnaeus bey der Linaria wahrgenommen: der platz hat es nicht gestattet, dass solche noch im vorigen Jahr durch das commerc[ium] litt[erarium] hätte können public gemachet werden."

[69] The Greek word "pelor" ($\pi\varepsilon\lambda\omega\rho$) means monster.

[70] Since the *Commercium Litterarium* was discontinued after 1745, neither this illustration, nor the accompanying text was ever published.

[71] Cf. TRWC, Haller, A. von to Trew, No. 155, 19 May 1746.

was thus an occasional function of eighteenth-century botanical illustrations. However, since the authenticity of the pictures' content could not always be vouched for, this function remained marginal and controversial.

4.2.4 A Common Reference Point

Natural history images and botanical illustrations in particular had a fourth function in the context of scientific discussions, especially when led over long distances: they provided a common reference point; this, arguably, is the function that comes closest to Nissen's idea that images can replace real specimens. An example of this use can be found by examining Linnaeus's correspondence with the Scottish doctor David Skene.[72] These two naturalists corresponded with each other between December 1765 and February 1767. In his letters, Skene expressed among other things reservations about the appropriateness of the distinctive characters Linnaeus had chosen for some genera of the so-called zoophytes; he even questioned Linnaeus's zoophyte theory altogether. Skene lived and worked in Aberdeen, northern Scotland, while Linnaeus was then living in the Swedish town of Uppsala. Since they never had the opportunity to meet, their discussions were restricted to an exchange of letters across the North Sea, which is fortunate for today's historians. Although the issues raised between Skene and Linnaeus deserve to be examined in their own right, the following analysis focuses solely on how the two scientists used illustrations in their written discussions.

In his first letter to Linnaeus, Skene described his observations of the *Sertularia* genus, a polyp-like marine creature that Linnaeus had included in his system as a zoophyte, that is, as an animal-like plant or plant-like animal.[73] Skene compared his findings of the *Sertularia* with some of his further observations of a *Serpula*, a genus that was unambiguously classified by Linnaeus as an animal. In view of their similarities, Skene wondered whether it was appropriate to classify these two organisms into two different divisions of nature:

[72] Their correspondence was transcribed and translated from the original Latin into German in Andree (1980). The Latin quotes, on which the English translations are based, have been taken from this edition. I am grateful to Dr. Kai Torsten Kanz (Lübeck) for having pointed out this exchange of letters to me, albeit in a di erent context.

[73] Freshwater polyps of the *Hydra* genus had been classified as animals, since, in 1740, the Swiss naturalist Abraham Trembley had observed that these organisms move spontaneously and feed in the same way as animals; for the original treatise, see Trembley (1744). In the mid-eighteenth century, marine organisms of a similar kind, however, were still thought of as *zoophytes*, that is, something in between the realms of animals and plants. Linnaeus defined this group in the tenth edition of his *Systema Naturae* (1759) as "vegetating plants with beast-like animated flowers". In the twelth edition of the same work (1766), meanwhile, which, incidentally, Linnaeus was in the process of preparing while corresponding with Skene, he described them as "composite animals with a plant-like inflorescence".

> Some days ago, I observed under the microscope a *Sertularia*, which I had recently discovered and with which you might not yet be familiar. By chance, some *Serpula* tubes were attached to it, and to my great pleasure I was able to observe how the appendices of the *Serpula* and the hydranths of the *Sertularia* stretched out their tentacles ad libitum, moved them around and drew them back again. Overwhelmed by this so-to-speak visual evidence, I could not but acknowledge that these two forms of life were of the same nature and both at the same time inhabitant and creator of their dwellings.[74]

In answer to this, Linnaeus raised, among other things, the following objection:

> One can observe *Sertularia* that are attached to a *Taenia* in which the lowest limbs that were previously animated have dried out into a woody substance. How would you be able to reconcile your opinion with Ellis's Plate V A, B, Plate VIII, Plate IX N. 14, Plate XII N. 19, 18, Plate XIII A, Plate XVIII A, Plate XX A, B, Plate XXVII N. 1. [...]
>
> It is beyond doubt that the florets of the zoophytes are animated, since they move spontaneously and provide the centre with nutrition. That these florets sometimes develop into seed-bearing capsules like plants, I have learned from many of my specimens and Ellis's Plate VII B.[75]

Here and later in this letter, Linnaeus was opposed to classifying the *Sertularia* into the animal kingdom, which Skene first implicitly, then later explicitly, suggested that he do. Linnaeus argued that the properties of this group resembled the general properties of plants too greatly for them to be considered as animals: properties such as the tendency of older organs to lignify or the fact that they give rise to flowers that later develop seed-bearing capsules. However, unlike Skene, Linnaeus not only provided a description of these properties, he also referred Skene to corresponding illustrations in the standard reference work for this group of organisms – a book written by John

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[74] Skene, D. to Linnaeus, 16 December 1765. The last sentence refers to one of Linnaeus's criteria for identifying zoophytes. Cited Andree (1980), p. 57: "Paucis abhinc diebus in Microscopio contemplatus sum sertulariam, quam nuper detexi & tibi forte adhuc non visam, casu a xae fuere serpulae aliquot spirorbes & magno cum oblectamento vidi & serpulae teredines & sertulariae hydras tentacula sua ad lubitum exserentes, moventes & retrahentes tali quasi testimonio oculari perculsus non potui non agnoscere quin utrumque animal ejusdem fuerit indolis aeque & incola & fabricator sui domicilii."

[75] Linnaeus, C. to Skene, 21 January 1766. Cited Andree (1980), p. 59 (italics here and in the following according to the edition): "*Sertulariae* videntur Taeniae fixae, in quibus infimi articuli, antea animati, exaruere in substantiam fusticuli. Anne poteris cum Tua sententia conciliare Ellisii tab. V a, b, tab. VIII. Tab. IX n. 14. Tab. XII. n. 19, 18 tab. XIII. A., Tab. XX. A.B., Tab. XXVII n. 1. [...] *Flosculos* in *Zoophytis* esse animatos a motuspontaneo et quod centro cibum ingerant, dubium esse nequit. Quod hi flosculi in variis transeant in capsulas seminiferas ut in plantis, docent plurima mea specimina ut in Ellisii tab. VII B."

Ellis.[76] Since Skene had introduced himself as a close friend of Ellis's in his first letter to Linnaeus and had indirectly also referred to Ellis's works,[77] Linnaeus could assume that Skene either possessed the Ellis book himself or at least had access to a copy, so that he would be able to consult the plates to which Linnaeus referred.

Being able to refer to Ellis's illustrations served Linnaeus in two different ways. First, the illustrations provided a common starting point for the discussion. Since Linnaeus and Skene could not look through the same microscope together and point out to each other the phenomena in question, Linnaeus perhaps thought it useful to refer to a pictorially represented reference in order to make clear which properties of the *Sertularia* they were discussing.[78] Second, Linnaeus used the illustrations for the purpose discussed in the previous section, that is, to corroborate the correctness of his assertions: Skene did not have to rely only on Linnaeus's word but could refer to independently produced illustrations that supported Linnaeus's views. Thus, on the one hand, published pictures helped Linnaeus to strengthen his own argument; on the other hand, he could argue against Skene's objections, since the content of the pictures contradicted Skene's observations, at least from Linnaeus's point of view. One should also bear in mind that Linnaeus did not refer to just any illustrations of zoophytes but to those executed by Ellis, who at the time was the acknowledged authority on this group of organisms, and against whom Skene would have to adduce some very strong arguments indeed.

In response to these remarks, Skene entered into an eloquent, theoretical discussion. He still cited illustrations from Ellis's work but neither as points of reference for following up the contentious issue a little further, nor as a means of independently supporting his own observations. Rather, Skene targetted Ellis's illustrations for criticism. Starting with one of his own observations, Skene compared it with an image in the Ellis work:

> Please allow me to add some excerpts from my notes of recently observed occupants of certain marine tubes. If one does not examine marine organ-

[76] Thought to be Ellis (1755).

[77] "Encouraged by my very close friend Dr. Ellis (who very much admires you) I now turn to you yourself." – "Most of Ellis's *Sertularia* are to be found on our coastlines – I also discovered a new one which I discussed with him." Original Latin: "Incitatus vero ab amico meo eximio Dro. Ellisio (qui te maxime colit) ad te ipsum memet converto." (p. 57); "Plurimae ex Ellisii Sertulariis in nostris littoribus inveniendae sunt – aliquot etiam novas detexi, quas cum illo communicavi." (p. 58) Both quotes, Skene, D. to Linnaeus, 16 December 1765. Latin originals cited Andree (1980), p. 66.

[78] Johns (1998) has argued that in the eighteenth century hardly any two copies of the same book were identical, particularly with respect to illustrations. However, Linnaeus obviously assumed the contrary, otherwise he would not have referred to the pictures in the Ellis book as a matter of course. Likewise, Skene thought that Linnaeus had the same species in mind when he mentioned "Ellis's *Sertularia*" in his first letter.

> isms alive in water, it is not possible to determine their structure. [...] I saw an animal of the *Serpula triquetra*, which has not yet been described, except rather badly by Baster.[79] It is of the same genus as the animal in Plate 38, No. 2 in Ellis, and has the same kind of tentacles; it does not have a serrated-edged calyx attached to a peduncle, although it has a similar peduncle, which, however, thickens at the apex and on which sits a small, circular shell. Its convex exterior is armed with three small spikes that divaricate. [...]
>
> On cutting open a living specimen of the *Serpula teres* species, Plate 38, No. 2 in Ellis, I found a double calyx. [...] I don't think that Ellis ever saw a living specimen of this creature moving in the sea. Hence, he also did not see the tentacles, nor the front part of the body that is divided ad libitum, as if the animal were two-headed. In some other respects, Ellis's image is also misleading, perhaps because either a dead or an immobile animal was drawn.[80]

In this letter Skene first described how he had discovered a new species of a genus depicted in one of Ellis's plates, and while doing so mentioned several features in which the species he had found differed from the earlier one. In the second paragraph, however, Skene criticized this image of Ellis's, since his own observations of a specimen of the depicted species contradicted the illustration's content. Skene suspected that Ellis might have drawn his image from a dead specimen or without having observed a living specimen of this *Serpula* species moving in water, which would explain why Ellis had made a number of errors.

Linnaeus only briefly commented on Skene's bold criticism of Ellis's work: "The teeth of the *Serpula triquetra* are situated directly at the edge of the mouth of the shell and not of the animal." However, in the same letter, Linnaeus asked Skene's opinion on another illustration from Ellis's work: "I don't

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[79] Probably a reference to Baster (1759-65).

[80] Skene, D. to Linnaeus, 27 February 1766. Cited Andree (1980), pp. 60f. Original Latin (italics according to the edition): "Sinas ut pauca notis meis excerpta addam quae nuper observavi de incolis tubulorum quorundam marinorum, nisi in aqua marina animalia viva examinentur, structura nequaquam eruenda. [...] Animal Serpulae 3quetrae nunquam nisi male a Bastero, descriptum vidi – ejusdam generis est ac animal no. 2 pl: 38 Ellis., eodem modo tentaculatum, loco vero calycis margine denticulato pedunculo insidentes, habet pedunculum similem incrassatum apice cui insidet testa parvula orbiculata, latere externo convexo spinulis tribus divaricantibus armato [...] In Animali vivo (Serpulae teretis) no. 2. pl. 38 Ellis, invenio Calycem duplicem enim acu separavi. [...] Ellisi um credo hunc non vidisse vivum & moventem in Aqua Marina, hinc non vidit tentacula, nec corporis partem anticam ad lubitum fissam, quasi Animal esset biceps – in aliis etiam fallit figura Ellisii ex Animali vel mortuo vel non movente forte dipicta."

exactly know which shell Ellis's Plate 36 concerns. Is it correctly assigned to the *Tubipora*?"[81] Skene seemed to have been waiting for this question:

> You ask me to which marine organism Ellis's Plate 36 belongs – well, hardly to the *Tubipora*. I have examined many specimens of this kind but have never seen such a regular and funnel-shaped structure as depicted by Ellis. I often find solitary tubes, at times also two or three, occasionally even a large group of them firmly attached to each other, but never in such a constant or regular order.[82]

The focus of criticism had turned to another illustration (Plate 36) and again Skene criticized the image for supporting the derivation of statements that contradicted his personal observations. This time he emphasized that he based his claims on not just one example but on many, none of which revealed the properties that Ellis had depicted in his illustration of the species. Skene finally tried to solve his differences of opinion over the Ellis illustrations by sending Linnaeus alcohol-preserved preparations of the species that he was disputing. Skene again referred to the pertinent illustrations in Ellis's work, this time to clarify the common points of reference as well as the contentious issues:

> Phial 3 contains *Serpula* specimens, one large and two smaller ones. The large one belongs to a rather large, flexible and red-coloured *Serpula teres*, which are always attached to larger shells or rocks (Ellis, Plate 38, fig. [No. 2]) [. . .]
>
> No. 4 [the specimen in phial 4] is your *Tubipora* [that is, Plate 36]. Ellis's warty-looking image was probably drawn from a bad specimen. It ramifies into two rows of tubes, each forming a circle. Each row consists of an arrangement of transverse, parallel tubes.[83]

Unfortunately, it is not known whether the preparations convinced Linnaeus of the need to revise Ellis's plates. Although Skene stressed that he had observed the phenomena in question many times "in natura", he could only

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[81] Both quotes, Linnaeus, C. to Skene, 14 April 1766. Cited Andree (1980), p. 62: "Serpulae triquetrae dentes sunt in ipso oris testae margine, et non in animalculo." – "Non scio bene quo referatur testa ista ab Ellisio tab. 36 delineata. an juste ad Tubiporas?" The *Tubipora* is a taxonomic division of shells.

[82] Skene, D. to Linnaeus, 28 May 1766. Cited Andree (1980), p. 62: "Quaeris quo referatur productio marina Ellis tab. 36. vix juste ad Tubiporas. licet multoties examinatam nunquam vidi structuram regularem & infundibuliformem ab Ellisio depictam – saepe invenio tubum solitarium, nunc 2 v. 3. nunc copiam ingentem fortiter agglutinatam, nullo vero ordine constanti vel regulari."

[83] Skene, D. to Linnaeus, 28 May 1766. Cited Andree (1980), p. 62: "In Phy 3. sunt Incolae Serpularum 1 major, 2 minores. major pertinet ad serpulam teretem flexuosam, rubram, majorem, passim testis majoribus & saxis a xam, Ellis pl. 38. fig. 2. [. . .] N. 4 est Tubipora vestra, verrucosa figura Ellisii ex malo specimine depicta fuerit. ramosa est duobus seriebus tubulorum ambulacro oradio [?] singulae series ex ordinibus transversis, parallelis tubulorum constantes."

send Linnaeus a single specimen of the genus represented in Plate 36, and an alcohol-preserved one at that; whether its properties were more representative of the whole species than the one depicted in the Ellis plate was not easy to prove. It is interesting to note the persistency with which Skene objected to Ellis's images and their content; this would be hard to understand were it not for the fact that these images were deemed as authoritative species descriptions, which also explains why Skene raised his objections with Linnaeus and not directly with Ellis, who would have seemed to be the obvious person with whom to discuss these illustrations, particularly if these two naturalists really were friends, as Skene had told Linnaeus. However, the images were only part of the problem; more important was how the depicted organisms were to be described and characterized in general. And in the eighteenth century, it was Linnaeus who was the authority in matters related to defining and describing species and genera. Furthermore, Skene probably knew that Linnaeus was preparing a new, revised edition of his *Systema Naturae* – the perfect time to have amendments incorporated and maybe even get a credit as Linnaeus's competent adviser from Scotland.

4.3 Image and Text

Having now identified various uses eighteenth-century botanical illustrations fulfilled, it is still unclear why these functions were served by pictures and not by text. Moreover, only on very rare occasions were these illustrations published on their own; most were accompanied by some form of text, which often included a description of the species. In her analysis of nineteenth-century American ornithological illustrations, Ann Shelby Blum plainly states her view on this question: "Illustration played its key role in natural history as a supplement to description".[84] Does this also hold for eighteenth-century botanical illustration?

4.3.1 Information Transmitted

In order to appreciate fully the importance of the illustrations (and the accompanying text), a comparison of the two means of representation needs to be made. Take, for example, the image and the text of the twinflower in Linnaeus's *Flora Lapponica* (1737). The text is reproduced in figure 4.2 (p. 138), while figure 4.3 shows the illustration (p. 142). What kind of information does this text reveal about the twinflower, and how does this information relate to the images' content?[85]

[84] Blum (1993), p. 13.

[85] Linnaeus's attitude to the usage of text and image is usually taken from the dismissive statements he made on images used for generic definitions that appear in the introduction to his *Genera Plantarum* (1737). An alternative account can

250. PLANTA *noſtra Tabula XII. figura 4.*
Campanula ſerpilliſolia. Bauh. pin. 93. prod. 35. Scheuch. alp. 131. Tournef. inſt. 112. Rudb. lap. 96. f. 1.

Num-

Nummularia norvegica, flore purpureo. Kyll. A. D. 2. p. 346.
Nummularia norvegica repens, ſolio dentato, floribus geminis. Petiv. cent. 76.
Nummularia maior, rigidioribus & rarius crenatis foliis, flore purpureo gemello. Pluk. alm. 264.
Windgræs. Angermannis.

α. Primarius huius locus natalis in noſtro ſeptentrione eſt, vbi in ſylvis vix vlla planta hacce vulgatior eſt. In Suecia inferiore, vt in Uplandia, Dalekarlia, Nericia, Oſtrogothia, Smolandia & Scania ſylueſtri, eadem licet rarius a nobis lecta fuit. In Finmarkia integra fere montium iuga tegit.

β. Characterem huius generis dedit *Clariſſ.* Botanicus D. D. *Gronovius* in Characteribus noſtris Genericis §. 523. ab omni parte perfectum, (qui eandem ex Alpibus Italicis habuit), cum illa Buxbaumii deſcriptio minus quadret.

γ. Cum *Rubeolis* nihil habet commune, nec præterquam foliis orbiculatis in vlla re cum *Nummulariis* conuenit, quæ quantum a *ſerpylli* foliis differant, patet inſpicienti.

δ. *Radix* fibroſa, perennis.
Caules radicati, plures, pedales, teretes, filiformes, ſimpliciſſimi, procumbentes, radices rarius ex geniculis emittentes, debiles.
Foliæ oppoſita, ouato-orbiculata, vnica alteraue crena vtrinque notata, dilute viridia, petiolis vix manifeſtis inſidentia, per primam hyemem perſiſtentia.
Scapus hinc inde ex alis foliorum, digiti longitudine, erectus, ſemibifidus, duos flores in apice gerens.
Flos nutat, extus albus, intus leuiter villoſus, incarnatus.

Fig. 4.2. Written description of the twinflower (*Linnaea borealis* L.). Linnaeus (*Flora Lapponica,* 1737), pp. 205 .

refers to a successful characterization of this genus in the work of Jan Frederik Gronovius but advises readers against consulting an alternative description by Buxbaum.[89] In this context, one should bear in mind that the *Flora Lapponica* was one of the first books to be written by Linnaeus, and appeared long before his *Genera Plantarum*, so that he could not refer readers to his own descriptions of genera. In the third paragraph, γ, Linnaeus gives his reasons for believing that some of the previous authors were incorrect to assign this species to other genera.[90]

The description of the plant's morphology is given in the paragraph marked δ. Linnaeus describes the roots, stems, leaves, scape and flowers of the species by listing a few characterizing attributes. The four dimensions that Linnaeus later so strongly emphasized in his theoretical treatises can already be identified in these descriptions: he explains the shape of the organs by describing, for example, the leaves as oval and the stems as thin and thread-like; Linnaeus also deals with the number of the organs by speaking of numerous stems and noting that each scape bears two flowers. He describes the position of the organs, for example, the fact that the stem may give rise to roots at the nodes and that the leaves are attached to the stem with virtually no stalk. The organs' proportion, however, is not mentioned. Linnaeus writes only that the scapes divide almost half way down. Furthermore, Linnaeus writes that the root is "perennial", whereas the stems are not. He states that the leaves are of a pale green and that they are to a certain degree frost-resistent. Finally, the flower is described as being white on the outside and red and hairy on the inside. The mention of all these details accords with the principles Linnaeus formulated later on – that a description should contain not only the taxonomic characteristics of the species but also the species' typical features, even though they may be of varying constancy. The paragraph labelled ϵ deals with the twinflower's fruit and seed – without, however, providing a detailed description of these parts of the (genus-)characterizing fructification. He mentions that usually only two seeds ripen, although three develop at the start. In paragraph ζ, Linnaeus reveals that he had personally observed that the plant's stem could reach eighteen feet in length, and, in paragraph η, he alludes to one particularly noteworthy aspect of the species' morphology: the fact that the pericarp and ovary of the twinflower are not in close proximity to the calyx and flower. Linnaeus had not observed this phenomenon in any other genus. The final paragraph, θ, describes how the people of Ångermanland used the plant for medicinal purposes.

[89] In this paragraph, Linnaeus refers to the Dutch botanist Jan Frederik Gronovius, a contemporary of Linnaeus's, who renamed the genus after Linnaeus (see footnote 81); the unfavourable remark probably pertains to a description given by the German botanist Johann Christian Buxbaum, another contemporary.

[90] See the list of synonyms beneath the headline: the first term always refers to the plant's genus. Whereas Bauhin, Rudbeck, Scheuchzer and Tournefort assigned the species to the *Campanula* genus, some other authors considered it to be a species of the *Nummularia* genus.

Thus, of these nine paragraphs in total, the first gives the species' name in several botanical works; the second paragraph discusses the plant's spread, the third and fourth its genus. Only in the fifth paragraph does one find the species' morphological description, and the remaining four paragraphs provide additional information, such as special observations of the plant as well as its uses. Details along these lines, with emphasis laid on one aspect or another, were regularly discussed in the eighteenth-century texts that accompanied botanical illustrations, although only rarely were they as strictly divided into thematic paragraphs as in this example of the twinflower. Each separate piece of information describes different aspects of the twinflower, using general, characteristic features. Empirical findings make up a large share of the text, such as the twinflower's natural habitat and its morphological properties. As in the pictures under study, however, these empirical observations are not presented in every detail but are largely simplified: the twinflower certainly cannot be found in every part of northern Sweden (on rocks and dry slopes, in glaciers and swamp areas, and so forth) and it is probably not entirely absent from the whole of southern Sweden, to mention only one example. Notwithstanding this empirical focus, one needs some theoretical background to understand the text fully. For example, one has to be familiar with the terminology used. And with some additional knowledge of the subject matter, one would then be able to derive hypotheses that extend further than the details that are explicitly represented. The text, for example, mentions that the twinflower's leaves are persistent to the frost. If one has some knowledge of botany, this could provide a starting point for formulating assumptions on the particular morphological, anatomical or physiological properties of the leaves that enable them to survive at low temperatures – they may be extraordinarily fleshy or covered with a layer of wax.

In view of these observations, I would argue that Linnaeus's text contains yet another model of the *Linnaea borealis* species, represented in a different way than the models examined so far – and this applies equally to the other texts accompanying the pictures under study. This insight makes the duplication of image and text even more puzzling, since only one model of the species in question should have been necessary. On closer examination, however, one finds that most of the statements conveyed by the textually represented model are not included in the picture. Indeed, with the exception of the δ paragraph, the information conveyed in the text deals with properties that cannot be shown in a picture at all (such as the plant's synonyms) or can only be drawn in a very complicated manner (such as showing the plant's medicinal uses). The observation that the flower and ovary are positioned at some distance from each other can easily be shown in a picture – indeed, the draughtsman has depicted it very clearly (fig. 4.3, p. 142, detail a). Only Linnaeus's written comment, however, reveals that this peculiarity cannot be found in any other genus of plants. If one wanted to communicate this statement visually, one would have to insert illustrations of all the other genera as well, in order to contrast them with the twinflower.

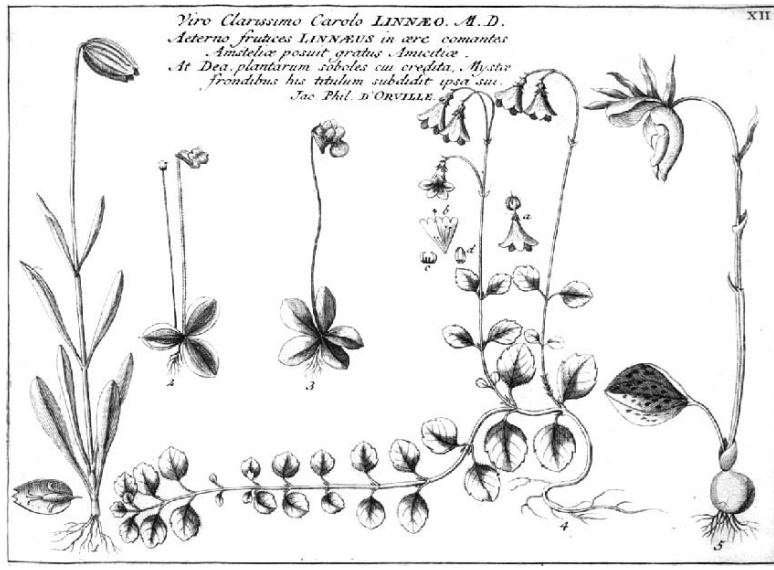

Fig. 4.3. Twinflower – *Linnaea borealis* L. Linnaeus (*Flora Lapponica*, 1737).

Text and image, it seems, represent two different models of the same species of plants that complement each other rather than duplicate the same information. But what of the written description of the plant's morphology in the section marked δ? Is not the image superfluous if there is a written description of the species' morphology? Or, alternatively, is there any need for a written description if there is an illustration? In order to answer these questions, one has to take a closer look at the paragraph and compare it with the corresponding illustration. In his text, Linnaeus describes the twinflower's morphology as follows:

> *Root:* fibrous, perennial.
> *Stems:* with roots, numerous, one foot long, thin, thread-like, very simple, procumbent, occasionally giving rise to roots from the nodes, annual.
> *Leaves:* opposite, oval-orbicular, on either side one or two conspicuous crenates, pale green, with barely visible stalks, almost sessile, persistent to the first frost.
> *Scape:* here and there rising from the axils, one digit long, upright, divided halfway, bearing two flowers at the apex.
> *Flower:* nodding, white exterior, interior slightly hairy, red.[91]

[91] Linnaeus (1737c), pp. 205 . For the reproduction of the original text, see p. 138, paragraph δ of this chapter.

Is all this information fully revealed in Linnaeus's illustration of the twinflower? The root, to start with the first organ, is clearly represented in the picture: it forms one main strand with several finely ramified side roots. However, whether it should be described as "fibrous" is hard to determine. In the illustration, this root develops smoothly into a creeping stem with many leaves, which almost immediately gives rise to two flower scapes. This also corresponds, on the whole, with the text, although the picture contains many more details than the text. However, looking at this picture one would certainly not think that the twinflower had "numerous" stems, as the text implies; only a single stem has been drawn, with no indication that further stems might have been left out for reasons of simplification. That the stem is "one foot long" can, likewise, not be ascertained from the drawing. As indicated in the text, the leaves are shown as being "opposite", roundish in shape with slightly crenate margins. Or are the margins dentate in the picture? None of the leaves, however, could be described as "sessile", as the text states. The scapes rise from the axils, and they divide into two flower stalks at the top, albeit not quite from half way down the scape, which bear two nodding flowers – all this accords with the text. As the illustration was not painted, there is no information on the colours of the flowers and leaves; the fine hairs on the flowers are also omitted in the image as are the "occasionally" rising, adventitious roots formed from the stem's nodes. The attributes "perennial" and "persistent to the first frost" are not depicted, either.

Thus, in a comparison of the morphological description of the text and the content of the image far less information has been duplicated than one would have first assumed. Too much significance should not be attached to the occasional inconsistencies one finds between the text and the picture; they may be due to the fact that Linnaeus used a predecessor's illustration rather than his own. Although the text is brief, it still offers some information that is not available from the picture: on the one hand, observations that would be difficult to visualize, such as the properties of a species that do not concern its morphological appearance; on the other hand, the text provides clear and unambiguous terms for the twinflower's morphological properties. An illustration can certainly give an idea of the shape of a leaf but it cannot determine beyond any doubt whether the leaf's margins are dentate or crenate, or something in between.

4.3.2 Cognitive E ort

What exactly then is the value of the image? If one confines oneself to the text, one can learn something of the plant's synonyms and its position in botanical systems; one can also get to know the exact terms of some of its morphological properties. But one would not obtain any concrete idea of the plant's general appearance. This might primarily be due to the fact that the text withholds many details; it would certainly be possible to describe the twinflower's morphology more comprehensively. However, the vocabulary for describing

spatial properties and morphological features is relatively restricted, so that it is generally quite hard to write precise descriptions. Furthermore, even if the vocabulary were rich enough, the sentences of a text are sequential, whereas the twinflower's organs are not arranged in a linear manner. Conveying their appearance and position in relation to each other in a sequence of sentences, therefore, would become much more long and complicated and far more difficult to grasp than a pictorial presentation of the same details. The written word is not the best medium for describing what a plant looks like, something which Curtis stressed in the preface to his *Flora Londinensis*:

> [A]s next to Objects themselves, nothing strikes us so forcibly, nor satisfies us with such Certainty, as their true and accurate Representations; so the Ideas of the Plants acquired by this Means, will be so impressed on the Mind as not easily to be erased.[92]

If one compares the models contained in the picture and text closely, one can see that Linnaeus chose his means of representation very carefully and revealed in each of them exactly those features for which the medium was best suited. So, while Linnaeus and his contemporaries were trying to inform their readers as comprehensively as possible on their subject matter, they also took great pains to use a means of communication that demanded the least possible cognitive effort. This aim is an essential element of scientific communication (and not only of eighteenth-century botany), which one has to acknowledge if one is to understand why illustrations were used at all.[93]

The strength of written models of plant species lies in their facility to communicate abstract properties; furthermore, it is easier to explain variations in a species in words than pictorially. A picture, however, is far more able to reveal visual information on a species' morphology in a dense but still readily accessible manner. This is why the different roles that botanical illustrations were found to serve could not be replaced by texts: all of the four uses mentioned above – classifying and describing species, providing observational evidence and a common reference point in scientific debates – are closely connected to the type of information most easily conveyed in a picture. Of course, in many cases texts were used in addition. But illustrations were a far better way of presenting a comprehensive description of a species' morphological properties – so much better that only a few books with this aim did without pictures altogether, and then mostly for reasons of cost, which people were quick to criticize. However, for simple definitions or for works that were intended to identify specimens within the strict framework of Linnean rules, illustrations could be superfluous. Linnaeus's own theoretical works, such as his *Species Plantarum* and his *Genera Plantarum*, have no illustrations at all; the main body of his *Philosophia Botanica* was also free of illustrations,

[92] Curtis (1777-98), Preface.

[93] See Chapter 7 of this book for more details on the "cognitive e ort" required to understand a picture.

although Linnaeus did include a series of plates in the appendix, to which I shall now turn.

4.3.3 The Written Word and Visual Language

In the first of these eleven plates, Linnaeus presented a collection of line drawings showing leaves of various shapes, numbered from 1 to 62 (fig. 4.4, p. 146). Next to this plate, he placed a list of Latin attributes describing the shapes of these leaves (fig. 4.5, p. 147), from *orbiculatum* (orbicular) to *teres* (smooth). The other ten plates in the appendix are also line drawings, each with a caption and dealing with, for example, the arrangement of the leaves, the stems, roots or auxiliary organs, such as thorns, and so forth. Surprisingly, these plates have been largely overlooked in the literature, although their role is of great interest: in these plates Linnaeus presented a visually represented explanation of botanical technical terms, many of which he had introduced and defined himself in this very book. Notwithstanding his objections to using images for certain classifying purposes (see the quotation on p. 119), here Linnaeus used visual images to explain exactly what was meant by the technical terms used to describe a plant's morphological properties.

Linnaeus was not the first botanist to use images to explain morphological terms. In his voluminous work, *Institutiones Rei Herbariae*, Tournefort introduced the readers to his classification system and also added an appendix of terminology in which he accounted for the technical terms he used. To do so, Tournefort included plates in his work specifically for this purpose, as for example, the one reproduced in fig. 4.6 (p. 148). Tournefort referred readers to this plate for his definition of the term "axil":

> The term AXIL is used [...] for the concave curve or inflection at the point between the stem and a leaf or branch from which new shoots (A) usually rise (Plate 466).[94]

Tournefort obviously believed that an additional explanation in the form of a picture would help readers to grasp the term's meaning; again, an image was better suited to communicating this information than a string of words.[95] In this way, both Linnaeus and Tournefort not only explained and standardized the technical terms they used in their texts, they also established a set

[94] Original Latin: "ALA sumitur, [...] pro cavo illo anfractu seu sinu inter caulem & folium vel ramum posito, unde nova proles A egredi solet. (Tab. 466)." Tournefort (1700), Vol. 1, p. 667.

[95] Incidentally, this image o ers a good example of the many interpretations of an illustration: in this image, Tournefort shows a section of a grapevine plant that could easily be understood to represent a model of this species; it very much resembles other representations of the grapevine that were used for exactly this purpose. However, Tournefort himself only used this image to represent the model of an "axil"!

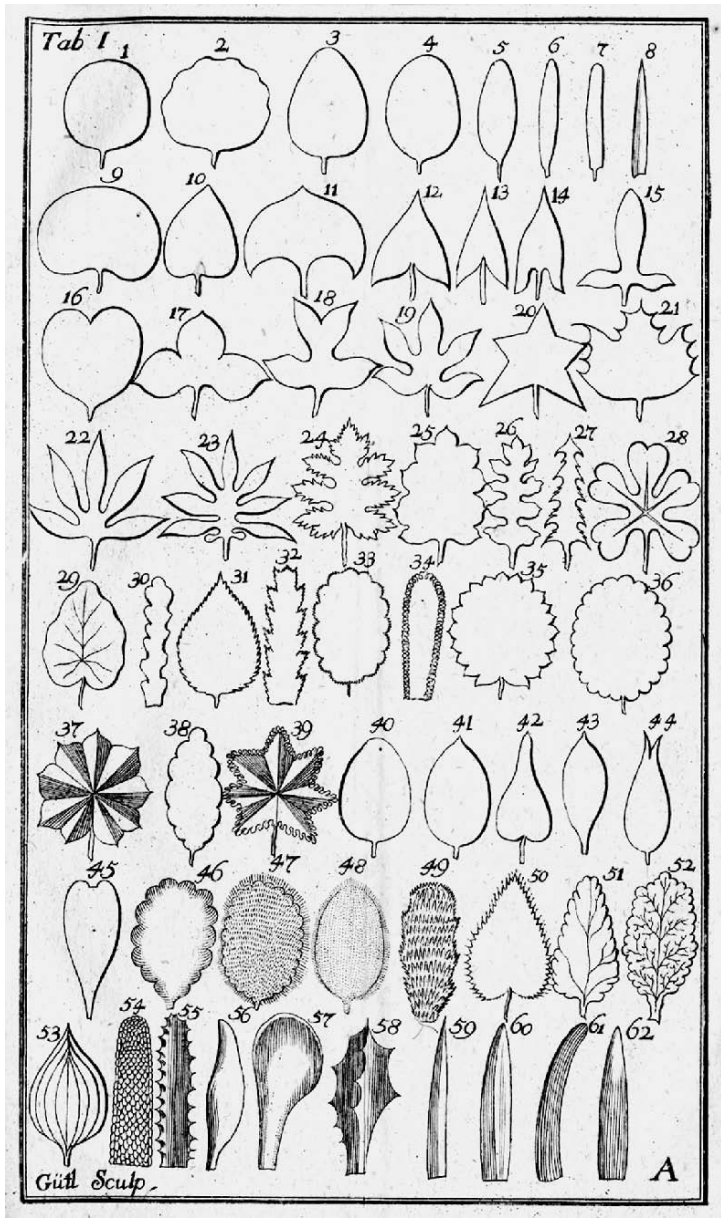

Fig. 4.4. The first plate in Linnaeus's *Philosophia Botanica* (1751) on the various shapes of simple leaves.

TABULA I.

FOLIA SIMPLICIA.

Fig. 1. Orbiculatum.
2. Subrotundum.
3. Ovatum.
4. Ovale ſ. *Ellipticum.*
5. Oblongum.
6. Lanceolatum.
7. Lineare.
8. Subulatum.
9. Reniforme.
10. Cordatum.
11. Lunulatum.
12. Triangulare.
13. Sagittatum.
14. *Cordato-ſagittatum.*
15. Haſtatum.
16. Fiſſum.
17. Trilobum.
18. Præmorſum.
19. Lobatum.
20. Quinquangulare.
21. Eroſum.
22. Palmatum.
23. Pinnatifidum.
24. Laciniatum.
25. Sinuatum.
26. *Dentato-ſinuatum.*
27. *Retrorſum ſinuatum.*
28. Partitum.
29. Repandum.
30. Dentatum.
31. Serratum.
32. *Duplicato-ſerratum.*
33. *Duplicato-crenatum.*
34. Cartilagineum.
35. *Acute crenatum.*
36. *Obtuſe crenatum.*
37. Plicatum.
38. Crenatum.
39. Criſpum.
40. Obtuſum.
41. Acutum.
42. Acuminatum.
43. *Obtuſum acumine.*
44. Emarginatum acute.
45. *Cuneiforme emarginatum.*
46. Retuſum.
47. Piloſum.
48. Tomentoſum.
49. Hiſpidum.
50. Ciliatum.
51. Rugoſum.
52. Venoſum.
53. Nervoſum.
54. Papilloſum.
55. Linguiforme.
56. Acinaciforme.
57. Dolabriforme.
58. Deltoides.
59. Triquetrum.
60. Canaliculatum.
61. Sulcatum.
62. Teres.

Fig. 4.5. Explanatory note on Linnaeus's first plate in the *Philosophia Botanica* (1751).

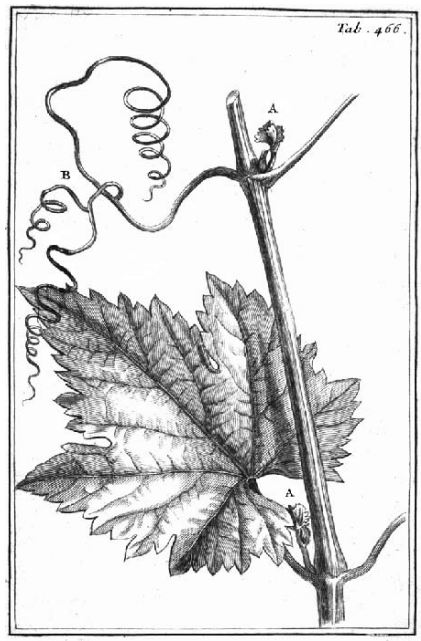

Fig. 4.6. Representation of a grapevine's axil in the terminology appendix to Tournefort's *Institutiones Rei Herbariae* (Vol. 3, 1700; Plate 466).

visual language for representing certain morphological structures by relating each term to a corresponding, authoritative image. Linnaeus's plates in particular reached a very broad audience, thanks to the widespread use and reception of his *Philosophia Botanica*; generations of botanists – and possibly also botanical draughtsmen – were schooled in how to perceive and represent morphological properties by studying these plates. This creation of an unambiguous visual language to explain technical terms, whether done consciously or not, throws a completely new light on the pictorial design of botanical illustrations, which is the main topic of the next chapter.

5

Visual Language

5.1 The Language of Botanical Illustrations

What does it mean precisely when one speaks of the pictorial or visual "language" of an image? In the narrowest sense of the term, an image is made up of patches of colour of different dimensions and intensity on a surface, which can be produced by a number of techniques. From this perspective, figure 5.1 (p. 150)[1] is nothing more than a mass of black areas, points and lines on a brownish piece of paper, and so in this respect does not differ very much from any other black and white illustration, or even from a text printed in black on similarly coloured paper. However, few people would think of describing this illustration of a hazel by the British botanist Robert Thornton as a set of black patches. On looking at the picture, one automatically combines the individual areas and lines into meaningful units to which certain meanings can be attached – just as one would treat a typed-out text that one can read and is written in a language that one understands. In the case of Thornton's illustration, the meaningful units are, for example, the leaf of the lower branch, the branch itself, the hazelnuts and the catkins. The leaf can be subdivided further into its blade, petiole, veins, dentate margins, and so on. Thus, a meaningful element within a picture, such as this leaf, can, in fact, be a complex unit, composed of smaller elements, which can also be understood to have distinct meanings – right down to the lines and dots, which are no longer meaningful in themselves. In this respect, the meaningful elements of an image can be compared with the elements of written languages, which also can be described as being made up of composite words, simple words, letters and, finally, of single lines and dots. In both cases, one has learned that the elementary lines and dots combine to make complexes to which a conventionally determined meaning has been attached; no one would have any trouble recognizing the leaf, stem and catkins in Thornton's illustration, for example.

[1] Image taken from Thornton (1812).

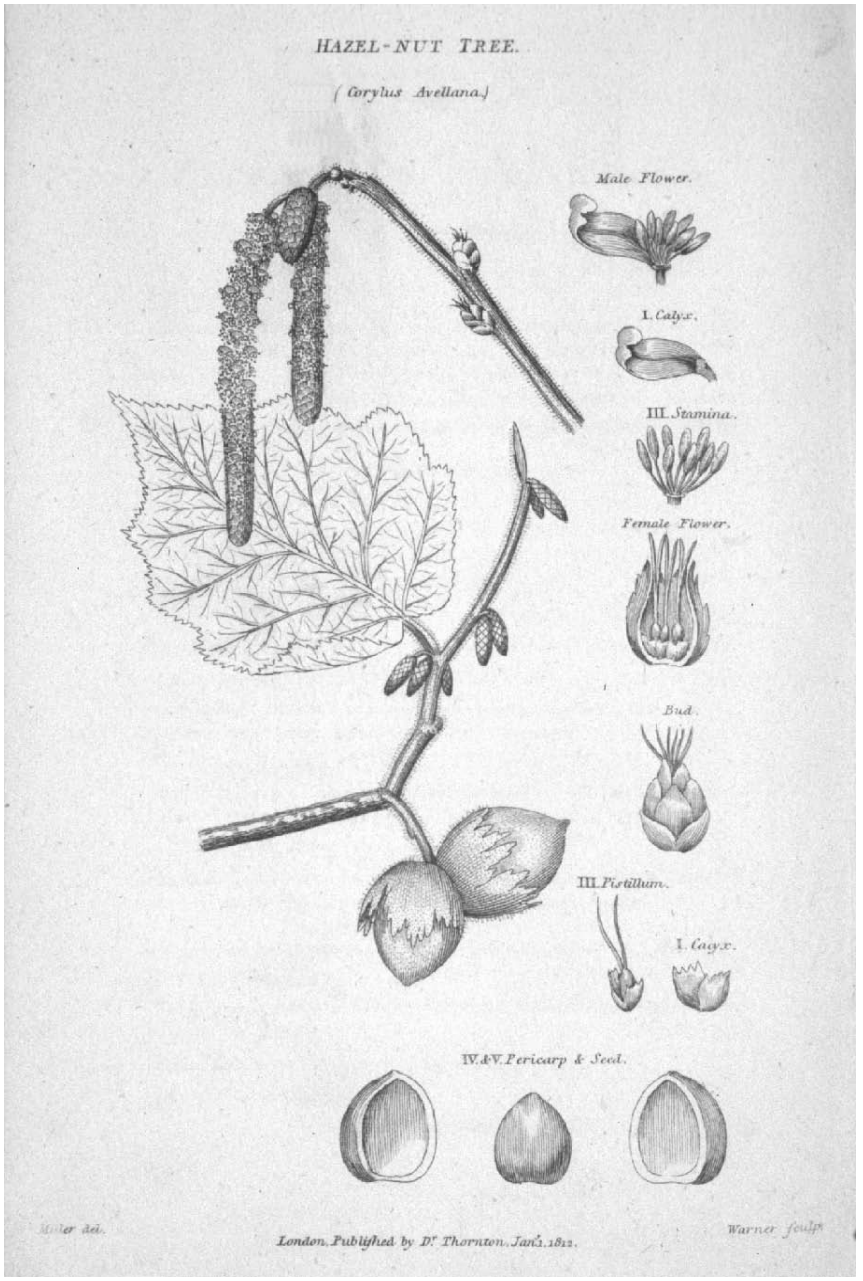

Fig. 5.1. Hazel – *Corylus avellana* L. Thornton (*The British Flora*, Vol. 3, 1812).

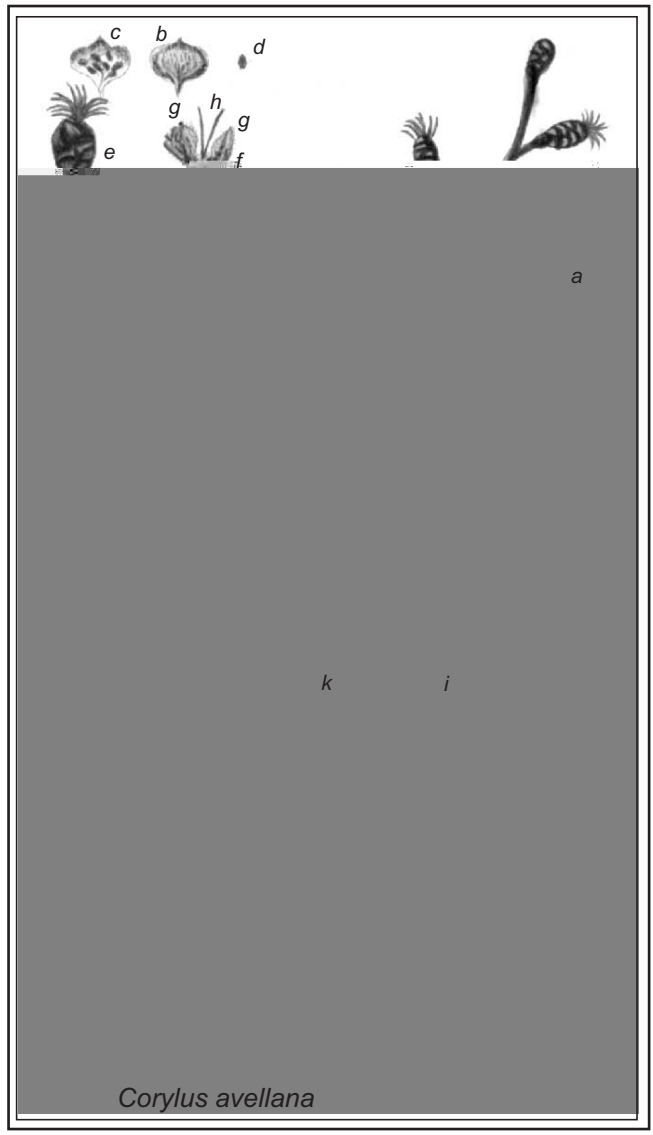

Fig. 5.2. Hazel – *Corylus avellana* L. Zorn (*Icones Plantarum Medicinalium*, Vol. 3, 1781).

Figure 5.2 (p. 151) shows another drawing of the hazel, this time by the German botanist and draughtsman Johann Zorn (fig. 5.2, p. 151).[2] Again, one can easily recognize certain pictorial elements, such as the hazel's leaves, its fruit and catkins, the meanings of which are quite familiar. Since this illustration was produced in order to convey a similar content to Thornton's illustration, these parallels in meaning should come as no surprise. What is surprising, however, is that the visual language used to communicate the content is so similar. Both Thornton and Zorn made use of a pictorial vocabulary that is well established in Western European cultural traditions. Within this context, leaves, to cite only one example, are represented as areas that are bordered by lines and in which netlike patterns indicate their veins. Furthermore, no one would have any trouble understanding that the curve of the central vein of the right-hand-side leaf in Zorn's drawing is a way of showing that the leaf is three-dimensional: the vein itself should not be understood as being curved; rather, the curve indicates that the leaf is drooping. Although this mode of representing three-dimensional structures is very familiar, it was by no means natural, as one soon learns from looking at drawings executed before the introduction of linear perspective. Similarly, traditional artists from East Asia did not use shadows to represent three-dimensional structures, which makes their drawings appear strange to Western eyes.[3]

5.1.1 Syntax and Semantics

On closer examination, one realizes that the similarities between the images by Thornton and Zorn work on two levels. On the one hand, in both images similarly shaped pictorial elements have been used that are composed along analogous principles and are related to each other in analogous ways. This level is referred to in this chapter as the "syntax" of the visual language, and includes the design and the combination of the patches of colour and shapes in the picture and the way they relate to each other. On the other hand, the visual languages used by Zorn and Thornton also resemble each other in that analogous meanings have been attached to analogous pictorial elements. This is referred to in this text as the visual language's "semantics". In both cases, unwritten and perhaps never consciously stated rules and conventions can be formulated that were applied to the images by Thornton and Zorn. Syntactic rules state which combination of pictorial elements are permissible in an illustration, while semantic rules define their meaning. One of the syntactic rules applied to the images is, for example, the axiom that all the parts of composite pictorial elements should always be seamlessly connected – one would be very surprised to find an unexplained space between the petiole and

[2] Taken from Zorn (1779-90).

[3] On the influence of linear perspective on scientific illustrations, see, e.g., Edgerton (1976) and Edgerton (1991). Edgerton (1980) contains some fine comparisons of European and Asian means of representation.

the blade of the leaf. And one of the picture's semantic rules is to state which meanings can be attached to which pictorial elements, such as the "petiole" or "leaf blade", for example. These conventions included many fundamental principles on how to draw and understand an eighteenth-century illustration in general that were not confined to scientific genre. This applied, for example, to the rules of linear perspective mentioned earlier. But the conventions implemented in Zorn's and Thornton's images also included principles that applied only to botanical illustrations – for example, the convention that botanical illustrations were not to be understood as depicting individual specimens but the general properties of the species. And, finally, additional and quite specific conventions were used in individual images to determine the syntax and semantics of that illustration alone.

None of these rules should be understood as being cast in iron. Rather, they are to be seen as maxims that draughtsmen adhered to when preparing their illustrations and which the audience was also expected to apply to understand the picture correctly. Interestingly, Zorn and Thornton seem to concur on many of these rules and conventions, although they never discussed these things with each other; and both seemed to assume that their respective audiences would not have any trouble understanding this visual language with no additional commentary.

5.1.2 Unwritten Conventions

The two draughtsmen had good reason for assuming their illustrations would be correctly interpreted by their colleagues. The syntactic and semantic rules of a visual language are acquired, passed on and used within larger or smaller communities, like the grammatical principles of a spoken language. Most of these rules were not usually expressed in the books by the draughtsmen or botanists, particularly if the illustrations were representative of a certain genre and were made only following accepted principles in this context. For example, today, the common symbols for towns, rivers, railways or streets on maps are frequently not explicitly explained; only those symbols that have been recently introduced or are used in an unusual way tend to feature in captions. In the same vein, the authors of books of botanical illustrations could assume that their readers would understand the pictures without any further commentary, as long as the established conventions of the time for the genre in question had been followed.

People living and working in a certain context are seldom aware that they have grown accustomed to representational conventions, particularly when they only come across illustrations whose visual language corresponds to the usual customs of perception. One only notices the validity of unspoken conventions when they are broken, as, for example, when one tries to understand an image that contradicts the common traditions of representation for the genre. With botanical illustrations, for example, there is an unwritten convention that the upper and lower sides of a leaf are pictorially distinguished

by the upper side being painted in a darker shade of green than the lower side. This difference in shade can be found in many plants: the lower side of a leaf is frequently covered with fine hairs, while the upper side, which is exposed to sunlight, has a higher concentration of the green pigment chlorophyll, making it darker in colour. However, this contrast in colours has been so exaggerated in the pictures that it cannot be explained simply as a way of imitating nature. Rather, a sharp distinction in shade between the upper and lower sides of a leaf primarily helps the onlooker to gain a better understanding of the arrangement of the plant's leaves, which can, at times, be confusing.[4] However evident this system of colouring might appear to Western eyes, it was not a convention of which everyone was necessarily aware. This is nicely demonstrated by the illustration of a Chinese plant species reproduced in figure 5.3 (p. 155).[5] Eighteenth-century explorers were keen to bring home illustrations of the exotic flora they discovered, and many expeditions had their own draughtsmen, although by no means all. And since few scientists were able to draw themselves, they occasionally commissioned drawings from local draughtsmen. However, they often had been trained in totally different traditions of perception and execution than their European clients, so that it was not unusual for the resulting images to contain odd elements, as figure 5.3 shows.

In this picture, a flowering plant of the species *Plumbago indica* with luxuriant foliage has been drawn. At first glance, nothing appears unusual. On closer examination, however, something does strike one as strange: as one would expect, most of the leaves have a dark upper side and a lighter lower side; however, in some instances, the draughtsman has painted the upper side of the leaves lighter than the lower side (numbered 1 to 3 in the picture). This inconsistency causes considerable confusion if one is trying to work out how the leaves grow; one tries to interpret the curve of the leaf (see 2, for example), so that the different colours of the two sides still "fit" expectations; and this confusion demonstrates that this is one of those conventions to which one has become so accustomed that any deviation is irritating. The fact that the Chinese draughtsman composed his drawing so differently is confirmation that Western European representational conventions and habits of perception are by no means universal but depend very much on the cultural context.

One does not have to go to China, however, to come across cultural limitations in visual languages. Although eighteenth-century botanical illustrations have much in common with other types of illustrations, they nevertheless have some unusual features that could give the layman difficulties. Take, for example, the system of representation that Zorn chose to depict the appearance of the hazel plant at different times of the year (fig. 5.2, p. 151): Zorn shows

[4] See, on this point, section 5.2 of this chapter, pp. 161 .

[5] Reproduced from Saunders (1995), p. 75. See ibid. for further details on the conflict between the demands of Western European explorers concerning the making of scientific botanical illustrations and the conventions of local draughtsmen.

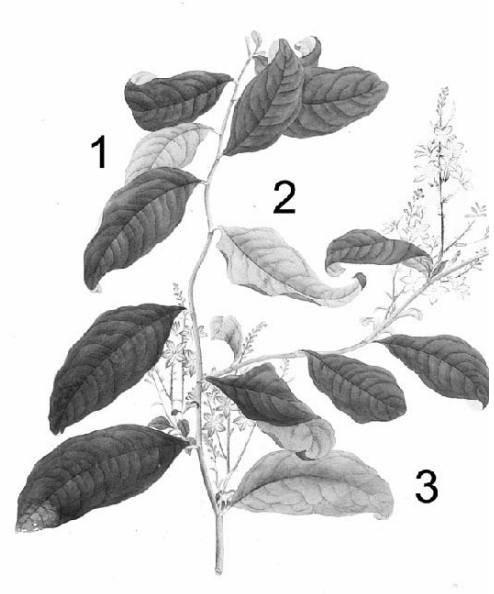

Fig. 5.3. Chinese drawing of the *Plumbago indica* from the late eighteenth or early nineteenth century (watercolour). Saunders (*Picturing Plants*, 1995), p. 75. With kind permission by the Victoria & Albert Museum, London.

the fruit, leaves and flowers of the hazel on the same branch but surely not with the intention of suggesting that all these organs appear at the same time (which they do not). Instead, Zorn has used a condensed and spatially economic way of making an illustration by combining the plant's different stages of development into one image – very much like William Curtis's drawing of the coltsfoot in Chapter 1 (fig. 1.2, p. 5). Today, people are more used to seeing the different plant development stages drawn as separate details, as in Thornton's image of the hazel (fig. 5.1, p. 150), so that one stops short in front of an image that looks as if it has been wrongly composed. On closer consideration, however, one has to admit that, from another point of view, this familiar mode of illustration could be just as confusing as Zorn's image: by splitting up the various stages of development of the plant into different details, one presumes that the audience knows how the details relate to each other; one has to know that different areas of the illustration reflect different times of the year. This is not a natural way of representing a plant, and only appears so since it is something that has become familiar to Westerners.[6]

[6] See, on this point, the discussion of "realism" in art, particularly in Gombrich (1960). Goodman (1969) has also taken up this theme: "Realism is relative, determined by the system of representation standard for a given culture or person at a given time. Newer or older or alien systems are accounted artificial or unskilled." (p. 37, quoted from the second edition, 1976).

However, not all botanists took it for granted that everyone would easily understand an unusually chosen visual language. One example, albeit of an earlier period, can be found in the renowned herbal by Leonhard Fuchs, published in 1543, in which he included what is believed to be the first European illustration of a maize plant. In the accompanying text, Fuchs made the following comment:

> From the top of the sheath, fine hairs hang down, sometimes white, then yellow, at times even speckled with purple, as the image shows clearly enough, which, however, represents to you all variations in one. In one and the same sheath, you are shown the grains in four colours, although each single one always has grains in only one colour, namely in either yellow or purple, red or whitish. This we thought should be pointed out, so that no one would be misled by the picture.[7]

This remark reveals that, first, Fuchs intended his herbal to be coloured by hand, although the copies that have survived are mostly only in black and white, and, second, that, although he regarded using different colours on the same corn cob as a licit option, he was not as convinced as Zorn that his audience would understand this device.[8] It was to avoid any kind of misunderstanding that Fuchs included the commentary above.

5.1.3 Changes and Continuity

Visual languages do not only differ between different ethnological and professional cultures; even in the same culture, traditions of perception and representation can change considerably over time. In the eighteenth century, botanists and draughtsmen used a very figurative visual language to represent models. Two hundred years later many botanists prefer to use abstract, symbolic representations of a flower's details in the form of so-called "flower diagrams".[9] Compare, for example, figure 5.4 (p. 157) with the illustrations of the hazel by Zorn and Thornton discussed earlier: although the pictures could hardly

[7] Meyer et al. (1999), Vol. II, p. 824, Chap. CCCXVIII. Original Latin text reads: "E fastigio uaginarum capilli tenues, iam candido, iam luteo, nunc purpureo colore maculati dependunt, ut pictura satis ostendit, que unica quidem tibi omnia genera repraesentabit. Haec in una uagina quatuor tibi granorum colores monstrat, cum tamen quaeuis unius duntaxat coloris grana, nempe aut lutea, aut purpurea, aut rusa, aut subcandida omnia habeat. Quod nos, ne aliquem pictura deciperet, monendum esse duximus."

[8] According to Meyer et al. (1999), in the original manuscript of Fuchs's herbal, which is known as the *Vienna Codex*, the maize really has been drawn with a cob bearing grains in four colours: brown, white, yellow and purple (op. cit., p. 120). In the published version that is reproduced in Meyer et al. (1999) in facsimile, the cob has also been painted in a number of colours (op. cit., Vol. II, p. 825).

[9] According to Wagenitz (1996), the first flower diagrams were done by Turpin in 1819; today, flower diagrams are very common in systematic botany. The example given in fig. 5.4 was taken from Sitte et al. (1991), p. 773.

be more different in their visual language, in content and function they are very similar – both are model representations of the hazel's flowers (and other parts in the case of the images by Zorn and Thornton). This example also takes one back to the cultural context of a visual language: just as botanists of earlier ages, laymen interested in botany today would also need a detailed caption and commentary to interpret these diagrams of male and female hazel flowers correctly.

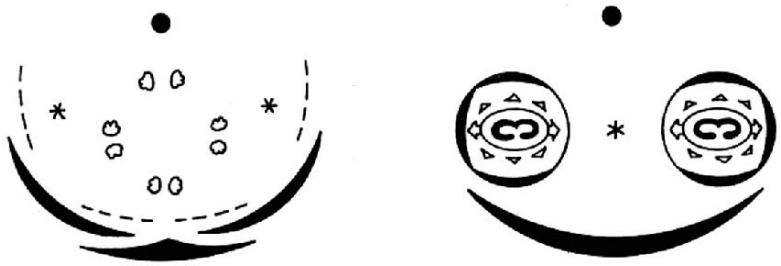

Fig. 5.4. Flower diagram of the hazel. Sitte et al. (*Lehrbuch der Botanik*, 1991), p. 773.

5.1.4 Communicability

One might get the impression from the points made above that, apart from certain artistic subtleties, the visual language of botanical illustrations was obvious and clear-cut and simply reflected the draughtsman's observation of the drawn object. However, as was argued in Chapter 3, the images were not intended to reflect the outer appearance of natural objects. For their purposes, that is, representing models of plant species, eighteenth-century botanical draughtsmen theoretically could have defined a totally new visual language. However, the consequences would have been considerable: for the more new or unusual elements or rules one included in a visual language, the harder it became for the audience to understand the picture as a whole. Single, unusual features, such as combining the different stages of development of the hazel on the same branch, can easily be integrated into the usual system as long as the rest of the picture provides enough clues as to how the unknown elements should be understood; whereas an illustration composed in a completely new visual language, which contradicts all customs and conventions, requires a detailed explanation if it is to be understood. On its own, such a picture would not be able to pass on its information unambiguously to its audience.

Ambiguity in meaning is not necessarily a disadvantage in the fine arts. On the contrary, at times artists consciously try to compose their images in such

a way that people will be able to interpret them differently. This also applies to a literary text. It is a different matter, however, with scientific illustrations or technical literature, since their prime function is not aesthetic; nor are they supposed to stimulate individual interpretations within their readership. Their primary role is to communicate information to an audience. In order to fulfil this function as a medium of communication, the visual language of botanical illustrations could not differ so much from the conventions of the genre that they became difficult for the audience to understand. The design of an illustration had to ensure that the intentions of the manufacturer were communicated to the audience. I shall refer to this requirement of a scientific illustration as its "communicability", which includes all those features of an image that make it easier or possible for an observer to understand an illustration correctly.

In this sense, an illustration is communicable if its visual language minimizes the probability of misunderstandings occurring regarding its content. Several strategies were used in the production of botanical illustrations in order to achieve this goal; the use of a conventional visual language that was probably familiar to the audience is the most important among them. Pictorial innovations were introduced only cautiously and then integrated into the image in such a way that the illustration remained comprehensible. In addition to that, attempts were made to establish a visual language suitable for communicating information on species of plants that was almost as unambiguous as an exactly defined, written terminology. This strategy deserves more detailed consideration: the struggle of eighteenth-century botanists and draughtsmen to establish a technically exact visual language, parallel to the precise written terminology introduced by Carl Linnaeus.

5.1.5 The Technical Language of Pictures

Remember the plates used by Linnaeus, Joseph Pitton de Tournefort and other botanists (fig. 4.4, p. 146 and fig. 4.5, p. 147). On the one hand, they illustrated the meaning of morphological technical terms that would otherwise have been hard to explain without any visual aids. This point was examined in Chapter 4. On the other hand, these plates also introduced the idea of a technical terminology for the visual language to be used in botanical illustrations. The advantage of this procedure was considerable: by assigning certain pictorial elements to particular technical terms, the derivation of hypotheses from the model became ever more reliable. And if the defined pictorial vocabulary (or vocabulary of shapes) was consistently used, it could even be as equally reliable as written statements. The importance of these plates, therefore, cannot be overestimated: given a detailed pictorial vocabulary, combined with a set of established semantic and syntactic rules, the communicability of the illustrations could be guaranteed to be far-reaching.[10]

[10] A visual language of this kind would make the images similar to "notations", as discussed by Goodman (1969), however absurd this idea might seem at first.

A similar practice was used in many of the drawing manuals of the time, for example, in the *Botanical Drawing-Book*, dated 1788, by the Englishman James Sowerby, one of the most renowned botanical draughtsmen of the time who led a thriving family business that greatly influenced British natural history illustration for more than a hundred years.[11] Sowerby's four children plus additional employees were engaged in his workshop, all of whom had to be trained in some way or other; hence, Sowerby's treatise may well have been influenced by his teaching practices. The original English version of this manual was printed twice and both editions were translated into German and possibly other languages, that is, it undoubtedly received considerable attention.[12]

Sowerby's booklet is quite thin and, without any introduction, goes straight into the subject matter. Interestingly, Sowerby does not start his discussion of botanical drawings with advice on how to hold a brush, arrange a plant's motives correctly, or even how to mix colours; rather, he begins his text with a short commentary on the principles of the Linnean system and an introduction of the seven fructification organs. Subsequently, each of these organs is described in a short section, with an accompanying plate. Sowerby started the first of these sections as follows:[13]

> We begin with the *Third* division, or Stamen, because most simple and easy for Learners to imitate. – This is generally composed of Three Parts, viz. The *Filament*, or *Thread*, which sustains the *Anther*; in which is contained a fine Dust, the *Pollen* or *Farina*. These are called the *Male* Parts of a Flower; and on them are founded the *Classes* of Plants.
>
> Fig. 1. A *Filament*. (a) the Anther detached from it.
> 2. A double Anther (which is most common) joining the Filament.
> 3. The Anther opening, showing the Pollen. This is an Example of all the Three Parts composing the Stamen.
> 4. Anther, pointed at the Top or Apex.
> 5. Filament, continuing above the Anther.

Here, too, Sowerby writes nothing of drawing techniques or shading but, after giving a summary of the principle parts of the stamen, lists the possible shapes of these organs, which he carefully describes. The entries of this list are numbered consecutively and refer to the corresponding details of a plate, where examples are given of a number of specific forms of stamens or other organs (fig. 5.5, p. 160). As in Linnaeus's book, these details give a more exact idea of the concepts described in words. But, despite the similarities with Linnaeus's treatise, this booklet was still a drawing manual, not an

[11] Sowerby (1788).
[12] See Nissen (1966), Vol. II, p. 173.
[13] Cited: Sowerby (1788), p. 4. I am grateful to Dr. Donn Evans (Oakham, UK) for having loaned me photocopies of the rare English original of this work.

introduction to Linnean technical terms – so explaining specific expressions was probably not one of Sowerby's principle aims. Rather, the purpose of these details can be taken from one of the sentences of the paragraph quoted above. The author begins with the stamens because, as he put it, they were the "most simple and easy for Learners to imitate". With the enclosed sample of standard examples, the readers of this booklet received an introduction to a pictorial vocabulary or visual language of botanical illustrations in which they could achieve proficiency themselves by copying the samples.

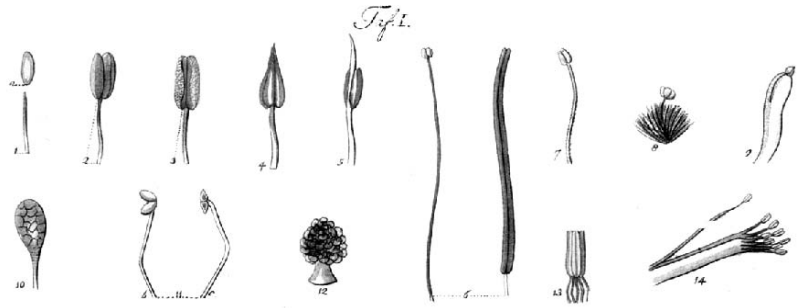

Fig. 5.5. First plate of Sowerby's *Botanical Drawing-Book*: stamens. Sowerby (1788), unnumbered page.

As already mentioned, copying samples or the works of approved draughtsmen and painters was typical of the training apprentices underwent at the time. The same procedure can be found in many other contemporary drawing manuals,[14] and it was common practice in both academies and workshops.[15] In some ways, this educational strategy reflected the future struggle of the aspiring botanical draughtsman to communicate effectively; at least in Sowerby's manual, aesthetics are of subordinate interest. By copying the examples of their predecessors, trainee draughtsmen were, right from the start, introduced to the conventions of the genre. In Sowerby's manual, this introduction was not limited to the general use of forms and colours; the draughtsmen were offered specific examples to which they could refer whenever they wanted to draw a similar structure or one that had been described by a botanist in similar terms. This specific means of expression corresponded to the importance

[14] See, e.g., Friedrich (1786) for a contemporary botanical drawing manual published in Saxony, Germany, which centres on the technical execution of drawing far more than Sowerby's manual; the basic principle of training apprentices by having them copy standard examples of botanical objects, however, is the same. I am grateful to Professor H. W. Lack (Berlin) for having pointed out this manual by Friedrich to me, of which only a few copies have survived.

[15] For the education of draughtsmen at academies and elsewhere, see, e.g., Pevsner (1986), Dickel (1987) and Rümelin (1996).

attached to content. For the illustrations to be used as a scientifically valuable description of plant species, from which, among other things, experts would be able to determine unknown plants as belonging to the drawn species, one had to use a visual language that was as precise and unambiguous as possible. At the example of the colouring of images, this struggle shall be examined in more detail.

5.2 The Question of Colour

5.2.1 Standardization

As was demonstrated at the example of the *Plantae Selectae* in Chapter 2, producing a hand-coloured botanical illustration was not an easy task in the eighteenth and early nineteenth centuries.[16] Even if the authors were particularly attentive, the hand-colouring of the plates frequently remained unsatisfactory, so much so that the colouring of illustrations was often a target of criticism. The German botanist Friedrich Ehrhart, for example, who was renowned for his sharp tongue, commented tartly on a new illustrated work that he had just received: "He [the author] could have omitted half the engravings, and I would have found the others just as nice in black and white."[17] The most urgent problem was the lack of standardized colour recipes and names plus the lack of standardization in the ways they were used and referred to. Eighteenth-century botanists were used to this muddled state of affairs. Linnaeus explicitly excluded colours from the qualities that he considered eligible for characterizing species, not just because the colours of plants vary depending on the plants' location but also because it was at that time impossible to reproduce identical colours.[18] Since hardly two draughtsmen used the same colour recipes, the same subject matter could be quite differently coloured in different illustrations. And this uncertainty did not only arise when one compared two illustrations of different origin but also with different copies of the same work: if several colourists were working together, all of them badly trained and under constant pressure to work quickly, two copies of the same work could turn out to be considerably different in their colouring. Trew criticized Weinmann's *Phytanthoza Iconographia* for the fact that the range of

[16] For a study on hand-coloured woodcuts and copper-engravings from the Baroque and Renaissance times, analysed from an art-historical perspective, see Dackerman (2003b). Bosters et al. (1989) includes a chapter on the hand-colouring of maps in the sixteenth to seventeenth centuries. A comparable study focusing on scientific illustrations (in the largest sense) of later periods has yet to be written.

[17] Cited Alpers (1905), p. 299. Ehrhart to an unknown addressee, 26 December 1787. The work in question was probably Albrecht Wilhelm Roth's *Botanische Abhandlungen und Beobachtungen; mit 12 illuminierten Kupfertafeln*, published in Nuremberg by Winterschmidt, 1787. Original German: "Die Hälfte Kupfer hätte er weglassen können, und die andern wären mir schwarz eben so lieb gewesen."

[18] For the paragraph in question, see Chapter 3 of this book, p. 79.

colours in a number of copies of the book was too broad ("for in three copies that I compared, there were considerable differences here and there")[19] even though he was well aware of the problems an author faced trying to get a work hand-coloured in good quality.

Furthermore, one could not even be sure that the colouring of a work's illustrations had been carried out following the standards and ideas of the author. As a rule, part of each edition of an illustrated work was sold uncoloured, so that they could be bought more cheaply. In some cases, the buyers of uncoloured plates had their copies hand-painted at a later date, under their own instructions. As previously mentioned in Chapter 2, Ehret was once employed in Regensburg by a banker to colour the plates of the latter's personal copy of the *Hortus Malabaricus* (see p. 25). Which criterion Ehret used to carry out this commission is unclear – and just as unclear is whether the result can be considered successful or not. For an impressive example of the diverse character that colouring carried out at a later date could adopt, one has only to examine the preserved copies of the famous *Hortus Eystettensis*: hardly any of the copies resemble each other in their colouring.[20] As the eighteenth-century French botanist Bernard de Jussieu noted in a brief history of the painting of plants in France, even books on embroidery were used as aids in the hand-colouring of botanical illustrations: "According to this instruction [in embroidery] presumably a good many set off to colour the books of *Brunfels*, *Matthiolus* and *Fuchs*. A wealth of copies are preserved that are very much spoiled, since they followed nature pretty badly."[21]

The Colour Chart of the Bauer Brothers

Not all draughtsmen readily accepted this unsatisfactory situation, however. Towards the end of the eighteenth century, in an area that was then part of Lower Austria, a small group of people tried to come up with a solution to this problem. The Bauer brothers – Joseph, Franz and Ferdinand – grew up in the small town of Feldsberg (since 1920 the town of Valtice in the Czech Republic), where their talent in drawing plants was recognized and promoted when they were still very young; in the 1770s, when they were teenagers, they were involved, to a considerable degree, in helping to produce

[19] TRWC. Trew, C. J. to Seuter, No. 724, 3 February 1735. Cited Schnalke (1995b), p. 115. Original German: "dann in 3en exemplarien, welche ich miteinander conferiret, hat sich da und dorten ein gar mercklicher unterscheid gezeiget."

[20] See Barker (1994) for a reproduction and comparison of a selection of these plates.

[21] Jussieu (1755), pp. 166f. I am grateful to Professor G. Wagenitz for having pointed out this rare article to me. Eighteenth-century German translation of the original article: "Nach diesem Unterrichte haben vermutlich so viele unternommen, die Bücher des *Brunfels, Matthiolus* und *Fuchs* zu illuminieren. Man hat davon noch viele Exemplare, die sehr verunstaltet sind, weil sie der Natur gar schlecht nachgegangen."

an extensive and spectacular collection of botanical illustrations.[22] The two younger brothers Franz and Ferdinand Bauer, in particular, were later held in high repute for their botanical illustrations: Ferdinand was employed as a botanical draughtsman on two important expeditions under British leadership[23] and Franz worked for Sir Joseph Banks as a botanical draughtsman at London's Kew Gardens. The early works of the three brothers also merit some attention, even though their images cannot, in many cases, be ascribed to a particular brother, since the pictures very much resemble each other. Fortunately, not only have many of their completed illustrations survived from this time, so have some of their preparatory sketches executed in pencil. One of these sketches is reproduced in H. Walter Lack's book on the *Codex Liechtenstein* – a study of two amaryllis flowers.[24] In addition to making an outline of the plants, the artist has used the technique of hatching to give the picture a three-dimensional effect. One peculiarity of this sketch is the fact that on almost every different organ of the amaryllis plants, and also occasionally on certain sections of organs, numbers have been inserted.

The meaning of these numbers remains mysterious if one looks at the illustration alone. However, after much research, Lack uncovered that these numbers were part of a colour code, which the Bauer brothers had begun to use when still based in Feldsberg.[25] Every number stands for a certain shade of colour that the organ in question should show in the finished illustration; numbers were assigned to the colours by means of a chart on which all the necessary colours were listed in tabular form. Lack tracked down a copy of this colour chart in a Madrid archive, its final destination after a circuitous route round Europe. This chart is reproduced in figure 5.6 (p. 164). The shades are arranged in seven rows of twenty small boxes; the tints of red, yellow and blue take up two rows each; the bottom row shows shades of green. Lack suspects that the Bauer brothers drew their sketches from living plants while out on excursions, since for some of the depicted plants they would have had to go to the University of Vienna's Botanical Gardens, to Vienna's Schönbrunn Castle or to the Prince of Liechtenstein's gardens. A particular concern on such trips was, of course, how to make best use of the limited time one had to work on the spot. Lack suggests that the brothers resorted to using a colour chart in order to determine and capture the colours of plants as quickly and as accurately

[22] This collection of about 3,000 hand-coloured botanical illustrations is known today as the *Codex Liechtenstein*, and was primarily put together by the abbott Norbert Boccius, who encouraged and educated the Bauer brothers: Joseph (1756-1831), Franz (1758-1840) and Ferdinand (1760-1826). On Boccius, the Bauer brothers and the *Codex Liechtenstein*, see Lack (2000).

[23] During 1786-87, Ferdinand Bauer accompanied John Sibthorp on his travels in the Levant, which resulted in the splendid *Flora Graeca*. During 1801-03 he served as botanical draughtsman for Captain Flinders on the latter's expedition to Australia.

[24] See Lack (2000); the image is also reproduced in Lack (1997).

[25] See Lack (1997).

as possible, which they could then later refer to when finishing the coloured plates at leisure. Furthermore, Lack rightly points out that pencil drawings are more water-resistant than watercolours, which could easily be spoiled in a single downpour. If one used a colour chart and pencil sketches, only a single sheet had to be protected against the rain or dampness, and presumably this sheet was carefully looked after. In addition, one can assume that there was more than one copy of this colour chart in existence, since all three brothers used the same code. The existence of several copies also implied that losing one of them would not have been a catastrophe.

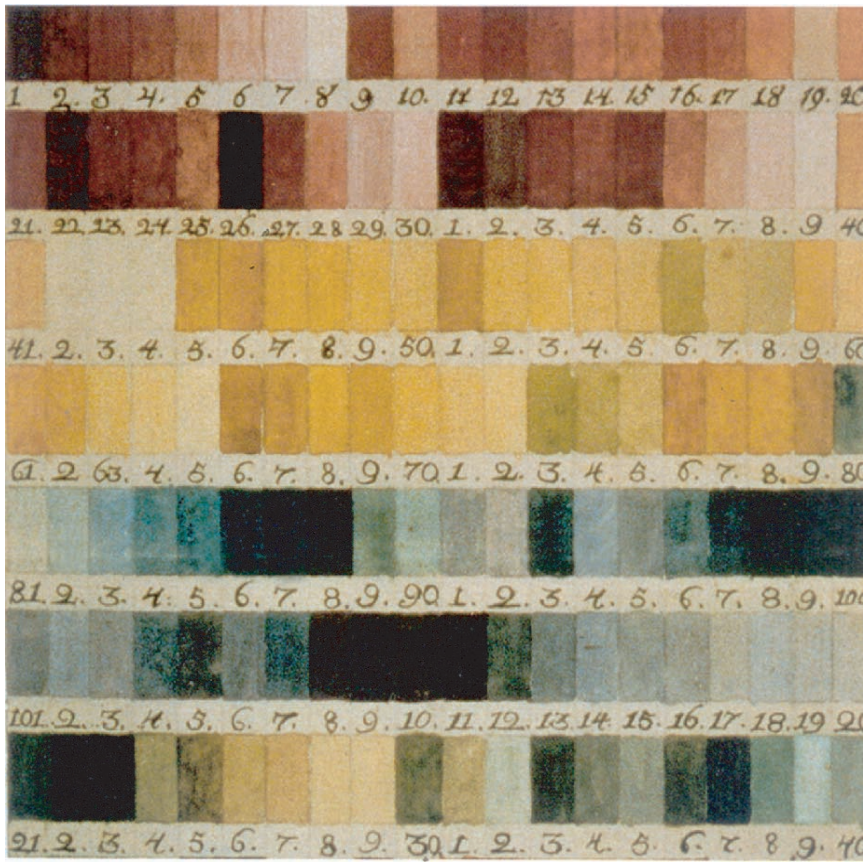

Fig. 5.6. Number-coded colour chart, probably used by the Bauer brothers before 1779. From Lack ("Recording Colour in Late Eighteenth Century Botanical Drawings" in *Curtis' Botanical Magazine*, 1997), Plate 317. With kind permission of the archives of the Real Jardín Botánico de Madrid.

This explanation is, to a certain degree, convincing. As an alternative to using a colour chart, the draughtsmen could have drawn coloured, or at least

partly coloured, studies on the spot. It is known that other draughtsmen made preparatory sketches in this way,[26] although every shade had then to be mixed up anew. One can imagine that, after some initial training, it would be far quicker for an artist to make a note of the number that referred to the colour in question than to apply a patch of colour – particularly if one was a young eighteenth-century draughtsman and had only limited equipment at one's disposal.[27] The numbers could later be easily converted into the corresponding shades in better and quieter working conditions, provided that the recipes for the respective colour mixes were also fixed, so that the hues of the chart could be clearly reproduced.

However, the Bauer brothers did not only work in remote botanical gardens, which would have meant undertaking a considerable journey. Lack himself stresses that the botanical illustrations of the Codex Liechtenstein include as many native species as exotic ones, and for the former one did not have to travel to Vienna or Liechtenstein.[28] In addition, the collection also includes copies of plates from other botanical works of the time, for example, copies of the works of Jacquin.[29] The advantage of working quickly but accurately would have been irrelevant in such cases: plants at the wayside can still be observed the next day, while the illustrated books by Jacquin were also presumably in Boccius's library and so permanently at the brothers' disposal. Enabling a draughtsman to work faster and keep his sketches water-resistant were not the only advantages of using a number code. These colour charts can also be interpreted as the first attempt of a small circle of people to standardize colours and colour recipes. The work of the individual draughtsman is made much easier if he can produce hand-coloured plates in exactly the same colours as the preparatory sketches he drew outside. Spontaneously mixed colours are hard to reproduce but if one has a rich set of standard recipes to which one can constantly refer, reproducing a certain colour becomes problem-

[26] Lack writes that Sydney Parkinson worked in this way on his journey with Captain Cook; see Lack (1997).

[27] See, on this point, the brief comment, "Notes on Using a Colour Chart" that the botanical draughtswoman Christabel King added to Lack's article, King (1997). Stimulated by Lack's findings on the Bauer brothers, King tried to use a colour chart when drawing unknown plants on an expedition in 1987. She eventually abandoned this attempt, since she found the method to be more time-consuming than making partly coloured preparatory studies. However, she did admit that this could have been due to her lack of experience with this procedure and to the fact that she always used a drawing table and chair: in less convenient conditions, the mixing of colours would have become substantially more laborious and the advantages of a colour chart might then have become more obvious.

[28] For a list of the species represented in the *Codex Liechtenstein*, see Lack (2000), Appendices 6-8, pp. 319 . A detailed list of all the species, prepared by Lack himself and still maintained in 2004, is also available at http://www.bgbm.fu-berlin.de/BGBM/research/data/lack/CodexAnhang7.htm.

[29] See Lack (1997), p. 91.

free. With the colour chart, the Bauer brothers had a system that had all the virtues of an unequivocal system of notation, in which information on colours was fully communicable.[30]

The advantage of using a fixed colour code of this type becomes even more obvious when more than one draughtsman are involved in a project. With the help of a colour chart, the Bauer brothers would have had no trouble completing the final version of a sketch that had been drawn by someone else; a sketch drawn by Franz could have been completed in the studio by Ferdinand, and vice versa, without any of the draughtsman's original aims being distorted. The brothers could even have handed drawings over to someone who had never worked closely with them before. This applies, for example, to the plates for the *Flora Graeca*, for which Ferdinand Bauer used a similar colour code while executing the sketches. After the Levant expedition, the editors were able to persuade none other than the renowned Sowerby to engrave this work and also to supervise the hand-colouring of the plates in his workshop. The exact details of the colours noted down by Ferdinand Bauer presumably were greatly welcomed by the workshop's colourists, and perhaps contributed to the fact that, in this case, the hand-colouring of the plates was particularly successful and highly praised.[31]

The Bauer brothers did not invent these colour charts themselves. In view of their youth and lack of experience while they were working in Feldsberg, one would suspect that they were introduced to this working method by their employer and patron Boccius. The botanical draughtsmen working with Jacquin are also reported to have used colour charts, and it has been shown that the German painter and engraver Albrecht Dürer also used a similar process.[32] But it was Ferdinand Bauer who, in later years, brought this colour chart method almost to perfection: for the illustrations he drew on his journey to the Levant with Sibthorp he used a colour code that included numbers from 1 to 250;[33] on his great expedition to Australia, Bauer extended this code to

[30] On systems of notations and their principle requirements, see Goodman (1969), especially Chapter IV.

[31] For a detailed history of the *Flora Graeca*, see Lack & Mabberley (1999). On the production of the copperplates, see especially pp. 209 . Lack's findings confirm the working process, as described in Chapter 2, of the *Plantae Selectae*.

[32] See Lack (1997), p. 98.

[33] According to Lack (1997), p. 96, some number-coded sketches made during this journey have survived. Furthermore, evidence that Ferdinand Bauer used a colour code can be taken from a letter by Sibthorp to John Hawkins, a member of the same expedition, after their return. Sibthorp wrote that he would have to employ Bauer after his return to England, since "what artist can possibly divine the Colour or make out the numberless Shades of those Tints which correspond to the Numbers of his Sketches". Sibthorp had clearly missed the point here, for it was exactly these numbers that would have enabled him to engage other artists to carry out the work, provided that Bauer had disclosed his colour recipes. Cited Lack (1997), p. 97.

999 and also added letters.[34] Unfortunately, the corresponding colour charts have not survived.

No numbered sketches exist of the botanical drawings Ferdinand Bauer made in England during the last years of his life; there is also little evidence that Franz Bauer used colour charts while working as a botanical draughtsman at Kew Gardens. One might take this to be an indication that the number codes were used primarily to facilitate and accelerate sketching work done outdoors, which became obsolete when the botanists were working quietly at home or in the studio. Seen from a different perspective, these later works drawn in the gardens of England were mostly done for internal use only. None of them was intended to become the blueprint for a hand-coloured copper-engraving: communicating exact information on the different shades of colour and recipes, therefore, was irrelevant. By contrast, the illustrations that were drawn in the Levant and Australia were clearly intended to be published.

However, for all the advantages of these colour charts, which were used by only a small number of people, they did not solve the problem of standardization altogether – and, indeed, that was not their intention. There is no evidence to suggest that the Bauer brothers tried to make their working process more popular and thereby achieve a standardization of colour conventions on a greater scale. Other players, however, were more ambitious in their attempts to solve these problems.

Jacob Christian Schae er•s •FarbenvereinŽ

This was the case, for example, in the town of Regensburg in Bavaria, Germany, where the parson and naturalist Jacob Christian Schaeffer (1718-1790) had, at around the same time as the Bauer brothers, worked out his own solution to the colouring problem. Schaeffer worked as a scientist and inventor in a number of fields. He was a natural history enthusiast, being particularly interested in the taxonomy of fungi, insects and ornithology; he also experimented with electricity and optics, tried to manufacture his own lenses and paper and became famous for having made one of the first washing machines.[35] Many of Schaeffer's works and treatises are richly illustrated with engravings – most

[34] Confirmation that Ferdinand Bauer used a colour code on this journey can be taken from a comment by Sir Joseph Banks, who mentioned Bauer's sketches in a letter to the naturalist and then Secretary to the British Admiralty, William Marsden, in 1806. He wrote that the sketches were "prepared in such a manner by reference to a table of colours as to enable him to finish them at a leisure with perfect accuracy". Cited Lack (1997), p. 97. In addition, some of the sketches that Bauer drew in Australia have survived and prove the range of the number code. Some of these sketches are reproduced in Norst (1989); for subjects of a botanical nature, see, e.g., pp. 66, 69, 70 and 80.

[35] For a detailed description of Schae er's life and work, see, e.g., Reich (1993) with its lengthy bibliography.

of them hand-coloured – so it can be assumed that he knew the difficulties involved in this task.

The booklet that is of particular interest for the purposes of this study was published by Schaeffer in 1769 with the title *Plan for a Universal Relationship of Colours; or Research and Model for Determining and Naming Colours in a Way that is Useful to the General Public.*[36] Schaeffer writes that he based this work primarily on the difficulties he experienced while producing a work of hand-coloured illustrations of insects, and initially he restricted his proposal to finding a solution in the field of entomology, although he was convinced that his approach could also be extended to other disciplines.[37] Schaeffer described his intentions and motivation in writing this book as follows:

> One of the di culties, which, both in natural history in general and also particularly in the field of insectology, is still prevalent and causes no minor obstacle to the furthering of the latter, is, without any doubt, among other things, the lack of a totally exact and generally understandable determination and naming of colours. [...] Thus, I shall dare to propose how this di culty and obstacle could possibly be remedied by artistic painters, colourists, etc., maybe not immediately but certainly in time and after repeated attempts. To me the following seems of prime importance: the manifold and considerable di erences in the seven main colours have each to be noted down and painted, so that whoever wants to describe an insect or whatever, can find its colour e ortlessly in these colour charts and determine it accordingly.[38]

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[36] Schae er (1769). The original German title reads: *Entwurf einer allgemeinen Farbenverein; oder Versuch und Muster einer gemeinnützlichen Bestimmung und Benennung der Farben.*

[37] Shortly before, in 1766, Schae er had published his comprehensive work on insects, the *Elementa Entomologica*, which contains a total of 135 hand-coloured copper-engravings. He presumably based his solution to the colouring problem on these experiences. See Schae er (1769), Preface: "Since for this plan for a universal relationship of colours, my aim is, in the first place and almost exclusively, to describe and impart some knowledge of insects; one will not expand it any further than this, and will not demand and expect any more of it than this destination [particular purpose] implies." Original German: "Da bey diesem Entwurfe einer Farbenverein meine Absicht vorzüglich und bey nahe ganz allein auf die Beschreibung und Kenntniss der Insecten gehet; so wird man ihn auch nicht weiter als dahin ausdehnen, und nicht mehr, als diese Bestimmung mit sich bringet, von ihm fordern und erwarten."

[38] Schae er (1769), pp. 6f. Original German: "Zu den Schwierigkeiten, welche wie in der Naturkunde überhaupt, so sonderlich auch in der Insectenlehre, annoch vorwalten, und der ausgebreiteten Förderung derselben keine geringe Hinderniss verursachen, gehöret, ohne alle Wiederrede, auch der Mangel einer ganz genauen, und allgemein verständlichen Bestimmung und Benennung der Farben. [...] Ich will es also wagen, und einen Vorschlag thun, wie etwan dieser Schwierigkeit und Hinderniss, wo nicht sogleich, doch mit der Zeit, und nach wiederholten Versuchen, von kunstverständigen Mahlern, Illuministen sc. könnte und mögte

In this quotation, Schaeffer describes the problem of colouring not only as a disagreeable nuisance in the practice of publishing but also as a major obstacle in furthering the progress of natural history. According to him, the core of the problem lay in the lack of a systematic taxonomy for determining and naming various colours, the consequence of which was a non-systematic use of colours and their names that did not conform to any standards. In order to solve this problem, Schaeffer suggested that fixed criteria for discerning different colours should be defined, that each defined colour be given an unambiguous name and that this combination of colour and name should be made available to the public by way of samples. Schaeffer, thus, recommended that colour charts be made, sample copies of which he enclosed in his booklet. These charts had to follow a number of rules. First, Schaeffer maintained, one should try to systematize the simple or unmixed colours. For each of the seven main colours – red, yellow, blue, green, brown, white and black – a field should be provided on a chart, containing a section or box for the different shades. Then "one should insert into each such box the simple and natural colour and give it a number or cipher".[39] Schaeffer presented one example of this arrangement in an enclosed plate (fig. 5.7, p. 170). Simple colours, wrote Schaeffer, were those "which nature gives herself and from which all [others], and the huge number of composed colours, can be mixed";[40] that is, simple colours are those colours whose pigments can be found as natural substances and can be applied without adding any further components. In the case of red, these were, according to Schaeffer, the tints *Mennig* (agrimony), *Cochenille* (cochineal) and *Zinnober* (cinnabar).

Schaeffer suggested that similar charts should be made for composed colours, which are made when two or more simple colours are combined:

> Now take a second sheet of paper; divide it into as many smaller boxes as space permits; add a number or cipher to each box; and entitle this sheet with the name of one of the main colours: red, green, yellow, etc.[41]

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abgeholfen werden.
Es kommt, wie mich dünket, die Hauptsache darauf an: Es müssen die so mannigfaltigen und starken Abweichungen der sieben Hauptfarben Jedermann sinnlich in ihrem eigentlichen Aussehen angezeiget und vorgemahlet werden, damit derjenige, so ein Insect oder was es sonst ist, beschreiben will, die Farbe desselben ohne grosse Mühe in solchen Farbenmustern finden, und sie nach demselben bestimmen könne."

[39] Schae er (1769), p. 7. Original German: "trage [man] in jedes solches Fach, die einfache und natürliche Farbe, und bezeichne sie mit einer Nummer oder Zi er".

[40] Schae er (1769), p. 7. Original German: "welche die Natur selbst giebet, und aus welchen alle anderen, und die ganze grosse Menge zusammengesetzter Farben können gemischet und gebrochen werden".

[41] Schae er (1769), p. 8. Original German: "Man nehme also ein zweytes Blatt Papier; theile solches in so viele kleinere Fache ein, als es der Raum leidet; setze jedem Fache eine Nummer oder Zi er vor; und überschreibe dieses Blatt mit dem Namen einer Hauptfarbe: Roth, Grün, Gelb u.s.w."

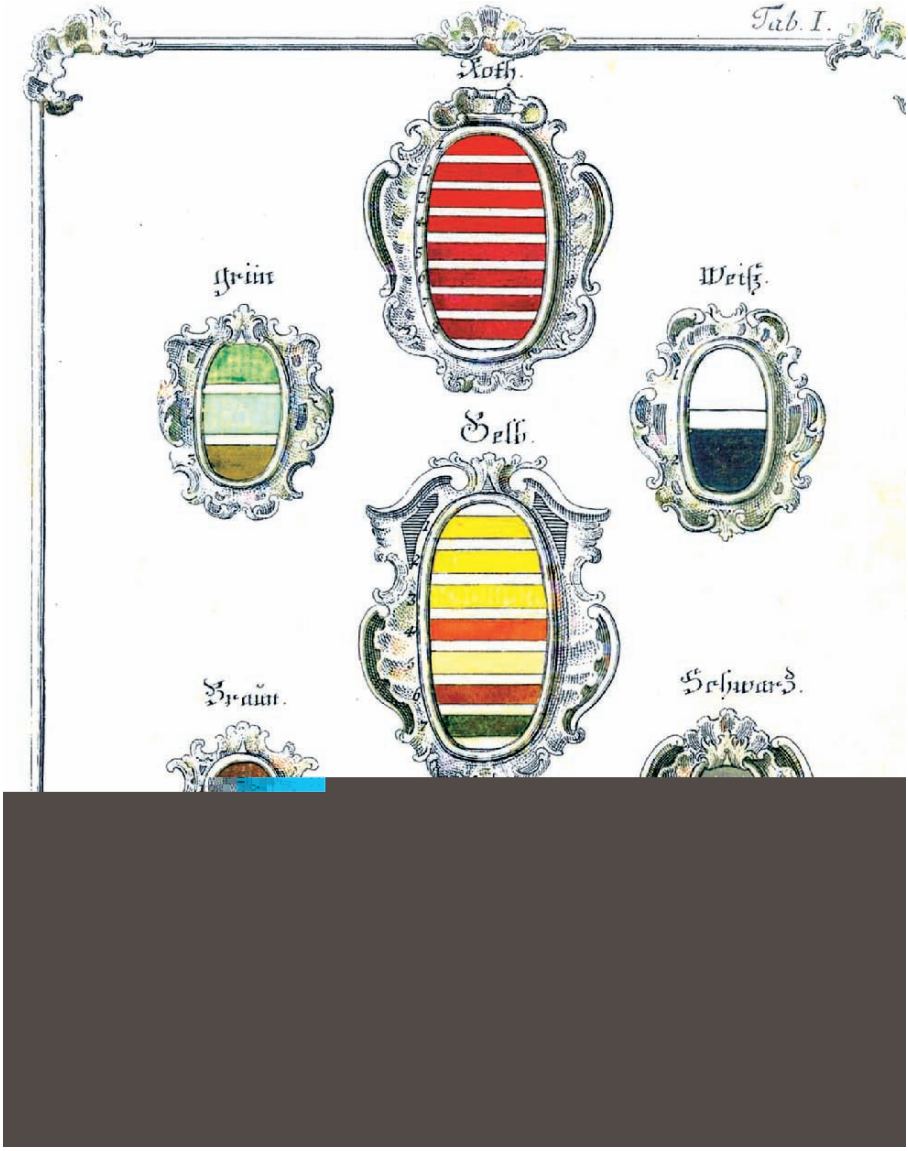

Fig. 5.7. The first plate in Schae er's *Plan for a Universal Relationship of Colours*: simple colours. Unfortunately, the colours are no longer in their original condition. Schae er (*Entwurf einer allgemeinen Farbenverein*, 1769).

Erklärung der Kupfertafeln.

Erſte Tafel.

Farbenmuſter der ſieben einfachen und natürlichen Hauptfarben.

Erſte Hauptfarbe. Roth.

1. Mennig.
2. Cochenille.
3. Zinnober.
4. Carmin.
5. Rugellack.
6. Braſilienroth.
7. Florentinerlack.
8. Engliſchroth-oder Braunroth.

Zweyte Hauptfarbe. Grün.

1. Berggrün.
2. Diſtillirter Grünſpan.
3. Saftgrün.

Dritte Hauptfarbe. Weis.

1. Venetianiſches Bleyweis.
2. Fein Silber.

Vierte Hauptfarbe. Gelb

1. Gummi Gutti.
2. Aurum oder Auripigment.
3. Schüttgelb.

Fig. 5.8. The caption to the plate of simple colours. Schae er (*Entwurf einer allgemeinen Farbenverein,* 1769).

To clarify this second step, Schaeffer also provided an example in the form of an engraved colour chart. The corresponding simple or composed colours were then to be applied to the boxes as samples, so that one ended up with a number of charts containing sample patches of colour for all colours available in the three realms of nature. When it came to mixing the colours for the charts, Schaeffer recommended that one should imitate as closely as possible the colours that one found in plants and animals. Only if one needed a colour for which no natural example could be found did Schaeffer acknowledge that:

> One has to resort to hand-coloured or illuminated works of entomology or other books of this kind; and prepare the remaining mixed colours that are missing on the colour chart, following these [works] and enter them into their boxes.[42]

Schaeffer thus considered it acceptable to turn to existing natural history illustrations for help in composing a colour chart when the actual objects were unavailable. This supports the interpretation that Schaeffer was primarily interested in standardizing and unifying the use of colours, not in a closer imitation of nature: if a useful colour had already been mixed and established as a suitable shade, it made sense to reproduce it in one's own illustration.

After these colour charts had been constructed, Schaeffer considered it necessary to set up a "specific and individual colour register", so that "no confusion arises from the large number of mixed colours and that the manner in which the mixture was made is remembered; and that, in general, the actual aim of these colour charts would be fully achieved".[43] This colour register should include each number listed in the charts, the natural object – the animal, plant or mineral – for which the colour had been mixed (and from which, as a rule, it was named) as well as the colour's recipe. In a caption to his colour charts, Schaeffer provided some examples of how the names should be assigned (fig. 5.8, p. 171). Then, the colour charts were to be engraved as copperplates and finally published in a sufficient number of copies, together with all their registers. Thus, Schaeffer's ambitious goal was to establish a generally valid, widely accepted colour reference chart, similar to those that exist today in the various professional fields that use colours in one way or another. By means of set recipes, each colour should be able to be reproduced by anyone at any time and in any place; each numbered pigment (and the name by which it was referred to) was given its own clear definition. The

[42] Schae er (1769), p. 10. Original German: "[. . .] so muss man seine Zuflucht zu ausgemahlten oder illuminirten Insectenwerken, oder andern dergleichen Ausgaben, nehmen; und die auf der Farbentafel noch abgehenden gemischten Farben nach denselben mischen, und in ihrem Fache eintragen."

[43] Schae er (1769), p. 11. Original German: "ein besonderes und eigenes Farbenregister", so that "unter der grossen Menge der gemischten Farben keine Unordnung vorgehe, die Art, wie ihre Mischung geschehen, erinnerlich bleibe; und überhaupt der eigentliche Zweck dieser Farbenmuster vollkommen möge erreichet werden."

advantages that Schaeffer foresaw from using these charts are described at the end of his booklet:

> The first benefit will arise for those naturalists and other scholars or amateurs of natural objects and rarities, who have neither the opportunity, nor could or would they wish to spend the money, to have the objects that they describe drawn, engraved in copper and then hand-coloured. These [people] could express themselves, as I explained before, by quickly and precisely referring to the colour charts, without having to spend painstaking time naming and describing the colours, inventing suitable expressions and, despite all that e ort, [the result] remaining ambiguous and incomprehensible.
>
> The second benefit concerns all those who want to learn something about natural objects, and in particular insects, from the description of others; and who want to be convinced whether this or that insect actually and beyond any doubt is the one to which this or that colour is ascribed. This person needs only, as I already mentioned when describing how to use the charts, check the given number and cipher in his colour chart; and his own eyes will teach him if he is accurate or not.
>
> Finally, the third benefit will be of enormous advantage to painters, and particularly colourists, not all of whom know how to make this or that colour, and frequently waste more than a little time trying to attain the adequate mixture. These people could easily, and with certainty, find what they are looking for, if they looked up the desired colour in the colour charts and consulted the colour registers. This is an advantage that certain painters and colourists will surely not consider as being of minor importance but will recognize [its value] with gratitude.[44]

[44] Schae er (1769), pp. 17f. Original German: "Der erste Nutzen wird denenjenigen Naturforschern und andern Gelehrten oder sonstigen Liebhabern natürlicher Sachen und Seltenheiten zu statten kommen, welche weder Gelegenheit haben, noch die Kosten aufwenden können und wollen, dasjenige, was sie beschreiben, zugleich mahlen, in Kupfer stechen und illuminiren zu lassen. Diese können bey den Farbenmustern sich angezeigtermassen kurz und deutlich ausdrücken, ohne der Benennung und Umschreibung der Farben mühsam und zeitverderblich nachzusinnen, auf Ausdrücke zu denken, und bey alle dem doch zuletzt noch zweifelhaft und unverständlich zu bleiben. Der zweyte Nutzen betrift diejenigen, die aus der Beschreibung Anderer die natürlichen Sachen, und sonderlich die Insecten, wollen kennen lernen; und überzeuget seyn mögten, ob dieses und jenes Insect ganz eigentlich und ungezweifelt dasjenige sey, welchem die und die Farbe zugeeignet wird. Ein solcher darf nur, wie schon beym Gebrauche erwähnet worden, die angezeigte Nummer und Zi er in seinem Farbenmuster nachsehen; so wird ihn der Augenschein lehren, wie er daran ist. Der dritte Nutzen wird endlich Mahlern, und sonderlich Illuministen, ungemein wohl zu statten kommen, die nicht gleich wissen, wie diese und jene Farbe herauszubringen, und oft nicht wenig Zeit verderben, bis sie die gehörige Mischung tre en. Diese können, was sie suchen, leicht und sicher finden, wenn sie die verlangte Farbe in den Farbenmustern aufsuchen und das Farbenregister zu Rathe ziehen. Ein Vortheil, den gewisse Mahler und Illuministen gewis nicht klein und geringe ansehen, sondern mit Danke erkennen werden."

From Schaeffer's perspective, three different groups of people would benefit from this new system: first, the authors of natural history works, who could dispense with hand-coloured illustrations in their texts. A range of colours – the names, appearance and recipes of which were fixed in colour charts and registers – would enable them in future to describe the colours of their objects of study concisely and, even more importantly, unambiguously. Thus, Schaeffer himself recognized and underlined the gains to be made in communicability as a major advantage of his system, although he did not put it in these terms. The readers of such descriptions form the second group of people to profit from the system, since tints assigned with set names would allow readers to understand to which particular colour a written expression referred. Finally, Schaeffer saw considerable advantages for painters and colourists, who, through the standardization of different colour recipes, would have the possibility of reliably mixing the correct tint of colour.

The problem Schaeffer faced was very similar to the difficulties that Linnaeus and later Sowerby tried to solve. How can one clearly communicate certain technical information when one is forced to use a visual or written language that is open to a number of interpretations? How can one modify this language to render it communicable? The solution proposed by Schaeffer resembles the strategies mentioned earlier for establishing an inventory of shapes to which fixed meanings were attached. Schaeffer, in turn, tried to establish a vocabulary of colours by assigning set names to certain colour tints and recipes; and, like Linnaeus and others, Schaeffer chose, as his means, a clear, tabular arrangement of these three related elements. The benefits Schaeffer hoped to gain from this system were considerable. If standardized colour charts had been published and widely distributed, it would have become possible to formulate exact hypotheses on the colour properties of species represented in images – whether they were species of plants or insects. Unfortunately, his system was not widely accepted; various ideological and practical difficulties stood against it. Yet even so, it still offers a notable example of an attempt to make the language of colours as communicable as a written technical language.

5.2.2 The Role of Colour

Colour as a Model Property

Despite all difficulties, illustrations continued to be published hand-coloured; and so one may wonder to which purpose. The most obvious function of colour in eighteenth-century botanical illustrations was to describe a species: like the lines and shapes of copper-engravings, colours can be used as meaningful elements within a visual language, from which one can take information concerning the represented species. This was presumably the intended function of colour in quite a number of the illustrations under study. Trew, for example, attached particular importance to the fact that his illustrations were

hand-coloured in order to communicate the colours of real specimens of the species, as some of his letters suggest. In the following quote, he criticized one plate of the proofs for the *Plantae Selectae*, which Haid had sent him in 1750:

> Now to the bocconia in particular. It is exceptionally beautiful; but not in all the leaves – only in those on the stalk – are the veins di erentiated with the colours as in the original, in which they are yellowish on the upper, dark green side but whitish [...?] on the lower, light green side, and not only on the central, major vein but also on the side veins, and in a way that the colour fades slowly into the green. In the proof that Mr. Beurer received, this was even less attentively observed than in mine; in the former the light green is also still too green, since it should be more whitish than [green?]ish: it again turned out better in my proof [...?] [...?]. This and other similar accuracies are what I meant earlier when writing of details that may go unnoticed and uncriticized by someone who neither knows the original nor nature [...], but which will be highly appreciated by experts.[45]

Thus, Trew wanted the colouring of the prints to resemble exactly Ehret's original watercolour drawings, even down to the details that would usually be overlooked and which only those with some knowledge of the plants or familiar with Ehret's original drawing would notice. Trew presupposed that Ehret's drawing was unsurpassable in this respect and therefore should be copied exactly. From Trew's point of view, the slight variations in the colour of the veins of the leaves, for example, formed a typical characteristic of the species in question, so that Trew wanted to see it documented in the hand-coloured engraving. Incidentally, this quote proves again how difficult it was to ensure that all the copies of a work were hand-coloured equally well – even in the case of proofs, which presumably had been done with particular care. The two copies that were sent to Trew and Beurer differed so much that, although Trew was more or less happy with his own, he was concerned that the rest of the edition would be hand-coloured as unacceptably as Beurer's proof.

[45] TRWC. Trew, C. J. to Haid, No. 265, 3 January 1750. The original letter is unfortunately stained with ink in places and therefore some words are impossible to decipher. Undecipherable words that have been omitted in this quote have been marked with [...?]. Original German: "Was nun die Bocconiam insonderheit anlanget, so ist solche fürtre ich schön, aber nicht bei allen Blättern <sondern nur bey denen am Stengel> sind die Adern mit denen Farben wie im original unterschieden, aber bey welchen sie an der oberen dunkelgrünen Fläche gelblicht, an der unteren hellgrünen aber weisslicht [...?], und zwar nicht nur die mittlere Haupt Ader sondern auch die Neben Adern, doch so, dass diese sich gemächlich in das Grüne verliehren. Bey der Probe, welche Herr Beurer erhalten, ist dieses noch weniger als bey der meinigen beobachtet worden, so ist auch bey dieser das hellgrün noch zu grün, da es vielmehr weisslicht als [grün?]licht seyn solte: wie es in meiner Probe auch besser [...?] [...?]. Dieses und dergleichen acuratesse ist es, was ich oben unter dem nahmen der [Klei?]nigkeit angezeiget habe, die etwa wohl von einem der das original oder die natur nicht gesehen, nicht beobachtet oder getadelt, [...], hingegen von guten Kennern hochgeschäzet werden."

The possibility of integrating information on colours into the represented models of plant species presupposes that there *are* propositions on these properties that would make sense in the description of a species. However, information on the colours of plants' organs is inevitably vague, since they are so diverse and variable. Linnaeus therefore excluded colours from the properties eligible for defining a species. In his *Philosophia Botanica* (1751), Linnaeus described colour as one of the confusing and fallible properties of plants, which varies according to climate, soil and location, similar to the qualities of size, scent and taste.[46] Thus, although in some eighteenth-century botanical illustrations colours were used to communicate information on the represented species, colour was generally taken to be an unreliable property, albeit of a slight indicator value. Consequently, communicating colour information in written or visually represented models of species was frequently the subject of dispute. The most extreme position against using colours as part of the model was to renounce the hand-colouring of black and white prints altogether.

Doing Without Colours

Leopold Trattinnick, a Viennese botanist, was a particularly ardent advocate of uncoloured plates. Trattinnick's illustration of a twinflower is part of the selection under study and is reproduced in figure 5.9 (p. 178). In the preface to his collection of botanical illustrations, Trattinnick expressed his position on the question of hand-colouring as follows:

> I avoided hand-colouring [the illustrations] as anxiously as [I avoided] the size of luxurious botanical co ee-table books. It is true that, at first glance, a hand-painted plant gives a far more lively and sensuous impression than a black and white engraving. Alone, only on rare occasions does it contribute something essential for recognizing the species and the genus – at no time is it indispensable! All the characteristics of plants that have been stated so far by the great masters were taken from the structures, which

[46] Cited Linnaeus (2003), p. 229: "266. Colour is remarkably changeable, and so is of no value in definitions. This is very clearly shown in the variations in colour of domestic animals. Nothing is more variable than colour in flowers; above all *red* and *blue* flowers change very easily and frequently into *white*. (313) The flowers of the *Mirabilis* and *Dianthus barbatus* bear di erently coloured corollas in the same plant. Colour especially attracts and delights the most refined of the senses. And so the attention of the ancients returned to the colours as the heads opened: but do not put too much trust in colour." Original Latin: "266. Color in eadem specie mira ludit, hinc in di erentia nil valet. Coloris inconstantia in animalibus domesticis praecipue elucet. Colore in floribus nihil inconstantius est. Rubri & caerulei flores inter omnes facillime & saepissime in album transeunt. (313) Flores Mirabilis & Dianthi barbati in eodem planta diversa colore ferrent corollas. Color maxime sensum subtilissimum attrahit & delectat. Summa itaque oscitantia facillime ad colores revocabant veteres, sed nimium ne crede colori." Linnaeus (1751), pp. 210f.

> are always more clearly discernible in black and white illustrations than in hand-painted copperplates. Wherever colours are in the least bit essential, I will not fail to say so and describe them. The slight e ort one still needs to transfer the powers of the imagination into action will be rewarded not only by a reduction in price but also by the purity and clarity of the pictorial representation.[47]

In this quote, Trattinnick raised the fact that in none of the taxonomies of the time were colours held to be of any classificatory importance: hand-coloured illustrations may be more agreeable to readers, since colourful plates remind them more easily of the outer appearance of living plants; for the species' and genus' definition and description – if one thus interprets Trattinnick's expression of "recognizing" these taxa – colours are mostly irrelevant. If they are occasionally of interest, Trattinnick assured his readers, he would certainly give them in his text.[48] His view that the audience would have no trouble imagining the colour nuances in question, however, may be slightly too optimistic, bearing in mind the ambiguity of colour terms discussed earlier.

Trattinnick argued that the "characteristics" of plants, that is, their relevant, typical features, had been taken exclusively from the "structures" of plants, not from their colours; and Trattinnick finds that the structures are "always more clearly discernible" in black and white illustrations than in hand-coloured ones. In addition to the far lower cost, this conclusion led Trattinnick to the most substantial argument for doing without colours: in his eyes, uncoloured plates showed a higher degree of "purity and clarity". If one interprets this phrase as a means of measuring the accuracy and comprehensibility of an illustration in respect of its content, one is confronted with a surprising

[47] Trattinnick (1812-14), p. XV. Original German: "Die Illumination vermied ich [in meinem Werk] eben so wohlbedächtlich, als das Format Botanischer Prachtwerke. Wahr ist es wohl, eine gemahlte Pflanze erweckt auf den ersten Anblick eine viel lebhaftere sinnliche Vorstellung, als eine schwarzgedruckte Kupfertafel! Allein, zur Erkenntniss der Art und der Gattung trägt jene nur sehr selten etwas Wesentliches bey – unentbehrlich ist sie niemahls! Alle characteristischen Merkmahle der Pflanzen, die von grossen Meistern bisher sind aufgestellet worden, sind von der Organisation hergenommen, und dies ist in Abbildungen, wenn sie schwarz sind, allemahl deutlicher zu sehen, als in illuminierten Kupfertafeln. Wo die Farbe auch nur im mindesten wesentlich ist, da werde ich nicht ermangeln, sie anzugeben, und zu beschreiben. Die geringe Mühe, die man dann noch nöthig hat, um seine Einbildungskraft in Thätigkeit zu versetzen, wird nicht allein durch die Ersparniss im Preise, sondern auch durch die Reinheit und Deutlichkeit der bildlichen Darstellung ersetzet."

[48] This negative view of colours may remind readers of the famous comment made by Erasmus von Rotterdam in 1528 on the possibility of Dürer's engravings being hand-coloured: "These things he places before the eye in the most pertinent lines – black ones, so that if you should spread on pigments, you would injure the work." Cited Panofsky (1943), p. 44. However, Susan Dackerman convincingly argues that this attitude influenced twentieth-century art history more than Erasmus's contemporaries. See Dackerman (2003a), pp. 11 .

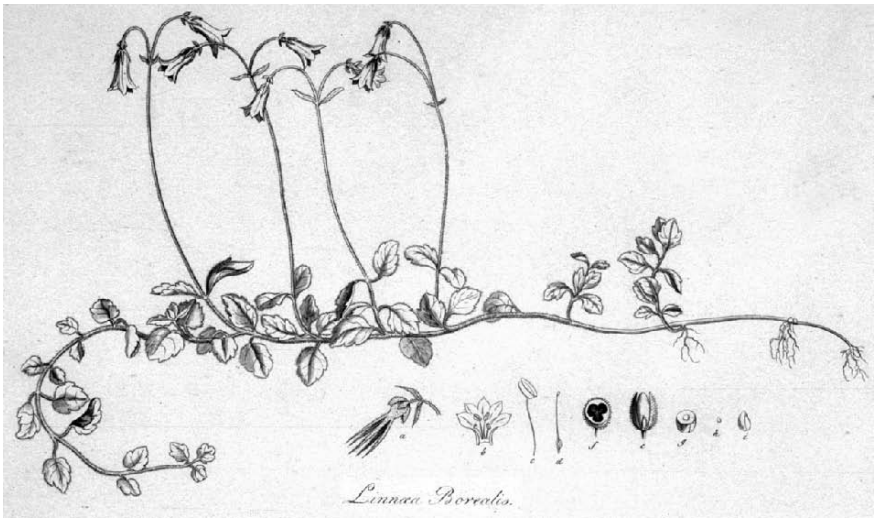

Fig. 5.9. Twinflower – *Linnaea borealis* L. Trattinnick (*Archiv der Gewächskunde,* Vol. 2, 1814).

about-turn: not only were no substantial pieces of information lost in black and white illustrations; in Trattinnick's opinion, they were even more accurate in content and easier to understand than hand-coloured ones.

To help clarify this point, I would like to draw attention to the unusual system of representation applied by two authors of illustrated botanical works in the selection under study: John Miller in his *Illustratio Systematis Sexualis Linnaei*[49] and Joseph Liboschitz in his *Flore des Environs de St.-Pétersbourg et de Moscou.*[50] Both authors had each plate of their books printed twice, first in black and white, then in a hand-coloured version, although no explanation is given why this had been done. One example of this procedure in the work by Miller can be taken from his representation of the sweet vernal grass. The coloured version is reproduced in figure 5.11 (p. 180), the black and white version in figure 5.12 (p. 181). If one takes a closer look at the black and white illustration, one will notice that, unlike the hand-painted version, not only are the class and order of the represented species specified in the illustration's

[49] Miller (1777).
[50] Liboschitz & Trinius (1811).

headline, several details are also numbered and their organs marked with letters. In the accompanying text, the meaning of these letters is explained; each organ was given its accurate name and sometimes a short description. A direct comparison of two corresponding details taken from both versions is given in figure 5.10 (p. 179). Miller specified the (structural) details that he found essential for his definition only in the uncoloured plates; he does not refer to them in the hand-coloured ones. This indicates that Miller considered that these details were more recognizable in the uncoloured plates. When one compares the two versions of the sweet vernal grass, his decision appears well-founded: first, the colours do obscure some of the delicate lines of the copperplate, so that the contours appear more blurred; second, the colours draw so much attention to themselves that it is easy to overlook the details of the organs' structure. Nevertheless, Miller and Liboschitz obviously did not think colours totally superfluous as both also showed the same copperplate again in a hand-painted version.

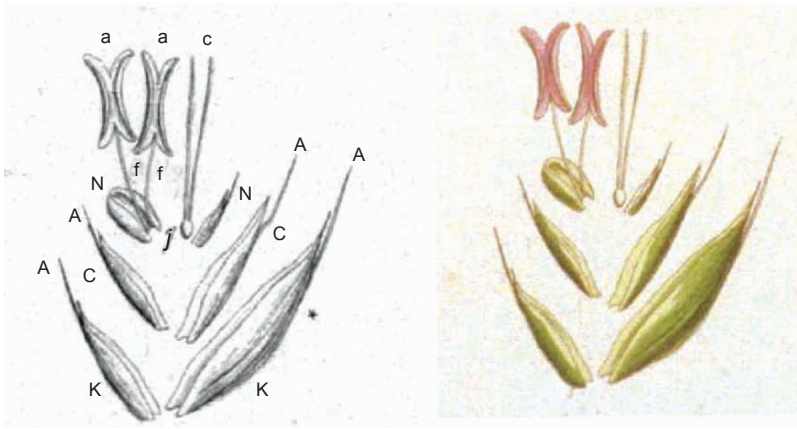

Fig. 5.10. Two sections of the illustrations of the sweet vernal grass by Miller: left, the uncoloured version in which the organs have been marked with letters; right, the unmarked hand-coloured version. Miller (*Illustratio Systematis Sexualis Linnaei*, 1777).

A first attempt to explain this procedure would be to postulate that Miller presented this second version in order to provide his readers with a model of the species that also included information on the plant's colours. If one takes a closer look at the colours themselves, however, doubts arise as to whether one would actually be able to gather reliable and relevant statements from this illustration on the sweet vernal grass's colour properties. At best, the information one does find – that the grass's fresh leaves are greenish and the dried

Fig. 5.11. The hand-coloured sweet vernal grass – *Anthoxanthum odoratum* L. Miller (*Illustratio Systematis Sexualis Linnaei*, 1777).

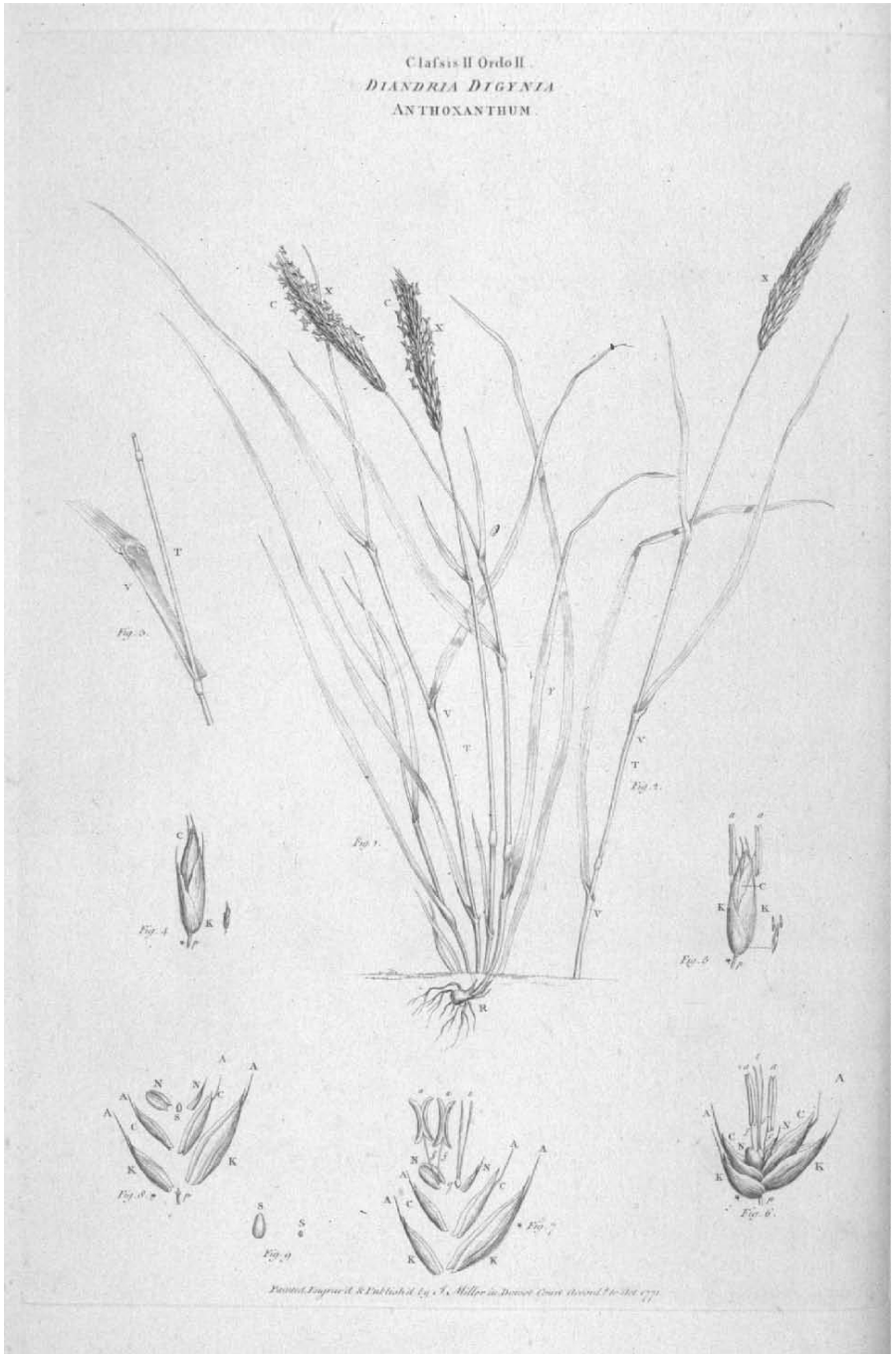

Fig. 5.12. The black and white version of the sweet vernal grass – *Anthoxanthum odoratum* L. Miller (*Illustratio Systematis Sexualis Linnaei*, 1777).

ones yellow – is very basic. The image allows hardly any further statements to be made on the plant's colours, except for the over-conspicuous pink colouring of the anthers. Thus, so little extra information is contained in this coloured version that one wonders whether the considerable effort required to produce it was worth while. One alternative explanation would be that a coloured version was made for aesthetic reasons; indeed, Trattinnick suggested that a hand-coloured illustration conveyed a livelier image of the model's instances and was more pleasing to the eye. However, although Miller's illustration could certainly be considered "beautiful" in one sense, one wonders whether the coloured version is so much more aesthetically pleasing than the black and white picture that the enormous additional effort and expense involved in producing it was justified. One could even argue that the coloured version gives a far less vivid picture of the real structures of the grass, since the finer details are hidden by the colouring.

Colour as a Means of Reducing Cognitive E ort

As a possible alternative, I would like to turn again to an example that I have previously discussed in a different context: the convention of colouring the upper and lower sides of leaves in botanical illustrations differently, that is, painting the upper sides in a darker shade of green than the lower sides. The resulting contrast frequently did not correspond to the actual colour properties of living plants of the represented species; indeed, the contrast often seems to have been highly exaggerated. Similarly, the parts of the plant that are growing underground were coloured brown and thereby clearly differentiated from the green organs growing above the surface. Again, this usage has some equivalent in nature (although usually the organs underground are pale and whitish and not really brown); many of the illustrations, however, show this contrast much more sharply and suddenly than one would observe in nature, where there is always a gradual change in the colour of a stem as it turns into the root. Not so, though, in the drawings of the coltsfoot by Regnault, Sowerby and Elizabeth Blackwell.[51] One could explain Miller's use of colours in a similar vein: the way the stalks and leaves of the sweet vernal grass grow can be more easily followed in the hand-coloured version than in the black and white one; and the yellow colour of dried-up stalks with ripe ears and seeds in the general view corresponds to the colour that Miller used for ripe flowers and seeds in the details, which makes them easier to be identified as such. In addition, by choosing a bright pink colour for the anthers, which immediately strikes the observer, Miller stresses the taxonomic importance of these organs. These paired stamens not only provide the basis for determining the plant's class and order within the Linnean system; the sweet vernal grass is also one

[51] See the corresponding illustrations in Regnault & de Nangis Regnault (1774), Sowerby & Smith (1790-1814), Blackwell (1737-39), all of which can be accessed from the electronic edition of Nickelsen & Graßho (2001).

of the few grasses that has two not three stamens per floret. This valuable characteristic makes identifying the sweet vernal grass comparatively easy and is thus worth remembering, so that representing the anthers as strikingly as possible in an illustration may have served this end.

From this perspective, one can understand why so many other botanical draughtsmen used a wide range of unnatural colours for the anthers of the sweet vernal grass in their illustrations. Figure 5.13 (p. 184) shows a compilation of a number of different versions of the sweet vernal grass's ear, taken from the selection under study. There are anthers in bright pink, shiny red, yellow, green and even twice in blue. This range of variation in tones by far exceeds the natural spectrum. Presumably the draughtsmen or colourists knew that the anthers of the sweet vernal grass are not so striking in colour. But by using such conspicuous colours, they succeeded in emphasizing these highly relevant organs. In addition, the paired arrangement of the stamens is often so exaggerated that observers could not fail to miss this fact. The effectiveness of this device becomes particularly clear if one compares the images in question with the quite differently designed illustrations of some other English draughtsmen. Martyn, for example, chose an unobtrusive shade of greenish brown for the sweet vernal grass's anthers (fig. 6.8, p. 195); as a result, they can hardly be discerned from the other parts of the ear.

Emphasizing particularly important parts of the plant – such as the anthers – and structuring the illustration by applying different colours for different organs or parts of organs – such as the upper and lower sides of a leaf – are different ways of reducing the cognitive effort of the observer. Since no common standards existed and since technical difficulties prevented draughtsmen and botanists from including reliable colour information in their models, they often made a virtue of necessity: if colours could not be employed to communicate relevant information, then the draughtsmen were free to put them to other uses. However, as I explained earlier, draughtsman and botanist were not as free to decide on the design of his illustrations as one might have thought. How deeply they were rooted in existing traditions of design can be shown, for example, by examining the numerous copying links that exist between the images: a phenomenon that is discussed in the next chapter.

Fig. 5.13. Di erent versions of the ears of the sweet vernal grass (*Anthoxanthum odoratum* L.), all taken from the eighteenth-century works under study. Note the di ering treatment of the anthers. Columns to be read from left to right, illustrations from top to bottom; column 1: Kops (*Flora Batava*, Vol. 2, 1807), Kerner (*Abbildungen oekonomischer Pflanzen,* Vol. 1, 1786), Curtis (*Flora Londinensis*, Vol. 1, 1777); column 2: Martyn (*Flora Rustica*, Vol. 1, 1792), Sturm (*Deutschlands Flora* Vol. 1, 1798); column 3: Miller (*Illustratio Systematis Sexualis Linnaei*, 1777), Palmstruch & Venus (*Svensk Botanik*, Vol. 1, 1802), Sowerby & Smith (*English Botany*, Vol. 9, 1799); column 4: Schreber (*Beschreibung der Gräser*, Vol. 1, 1769); Oeder (*Flora Danica*, Vol. 4, 1777).

6

Links with Tradition

6.1 The Sweet Vernal Grass Visualized

6.1.1 Sturm, Leers & Sandberger

In order to describe the phenomenon of the "copying links" more thoroughly and investigate its use and dissemination, I shall return once more to the now familiar illustration of the sweet vernal grass by Jakob Sturm. In figure 6.1 (p. 186) this image (centre) is accompanied by two additional representations of the same species: to the left of Sturm's image, a composite plate from Johann Daniel Leers's *Flora Herbornensis*, published in 1775, with the sweet vernal grass in the top left-hand corner of the picture; on the right, a watercolour drawing by the German botanist Johann Philipp Sandberger, which was executed at the beginning of the nineteenth century.[1]

Figure 6.2 (p. 187) shows two magnified views of the illustrations by Sturm and Leers placed side by side.[2] The greatly enlarged detail marked E in Sturm's illustration shows a half-open spikelet of the vernal grass: there are two pairs of glumes (bracts), between them the (green) ovary, two red, x-shaped anthers atop long, straight filaments and two considerably shorter, furry, horizontal stigmas that curl up at the ends like a twisted moustache. It is this curious form of the stigmas that first makes one suspect that there might be a connection between the two illustrations, no matter how different they appear at first glance; the same strikingly curled stigmas can be found

[1] Taken from Leers (1775) and SC (Sandberger Collection). Sandberger's watercolours are housed in the natural history collection of the Wiesbaden Museum, Germany. Unfortunately, no expert has yet been able to date the watercolours more precisely.

[2] Detailed descriptions of all the images and copying links are given in Nickelsen (2000). Consult the digital images of these illustrations to verify my assumptions; see Nickelsen & Graßho (2001). Graßho et al. (2001) includes an introduction to using the COMPAGO program, which was specifically developed to handle comparisons of the images examined in this study.

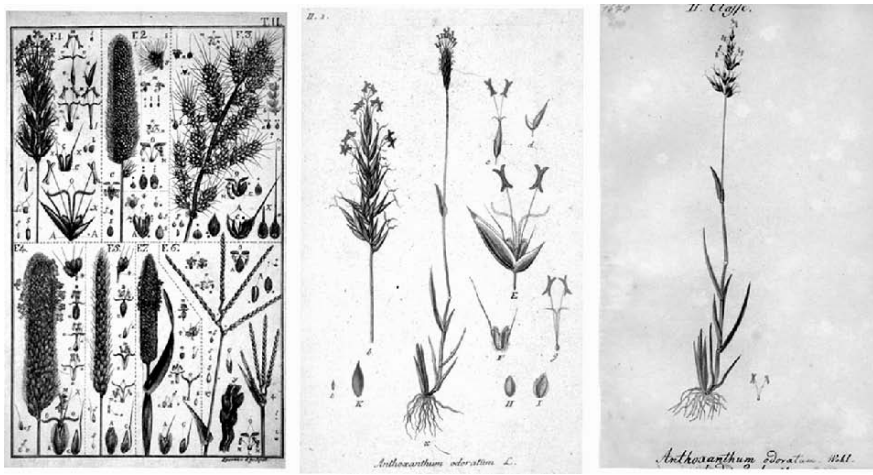

Fig. 6.1. Three versions of the sweet vernal grass – *Anthoxanthum odoratum* L. Left, a plate by Leers (*Flora Herbornensis*, 1775) – the grass can be seen in the top left-hand corner; centre, Sturm's familiar illustration (*Deutschlands Flora*, Vol. 1, 1798); and right, a watercolour drawing by Sandberger of the early nineteenth century.

in Leers's illustration, which was drawn more than twenty years earlier. In other aspects, Sturm's detail E is also strongly reminiscent of Leers's bottom right hand detail of a spikelet. Not only do they have the same curly stigmas, the very subject matter, its treatment and other subtleties also resemble each other. This cannot simply be explained by the fact that both draughtsmen were drawing the same structure; a number of other images of the sweet vernal grass clearly demonstrate that this spikelet can be drawn in very different ways. It is highly unlikely that the two draughtsmen, who never worked together, would have chosen such a similar means of representing a particular structure purely by coincidence. It is much more probable that Sturm knew the earlier illustration by Leers and used it as a reference drawing for his own image.[3] And Sturm did not only borrow one motive from the Leers illustration. On closer examination, one can see that he used the earlier image as a reference drawing for other details: the closed spikelet (c), the isolated pairs of interior and exterior glumes (d, F), the view of the floret without glumes (g) and the "honey vessel" ("Honigbehältniss"), that is, the outer and upper bracts known as the lemma and palea (H, I) which contain the floret and

[3] A specific method for proving these copying links has not been developed: the connections are usually so obvious that I felt that there was no need to verify them systematically. However, a method for proving less obvious (but also less complex) copying links has been developed by Hans-Christoph Liess in his study of astronomical diagrams of the early Middle Ages. See Liess (2000), Liess (2002).

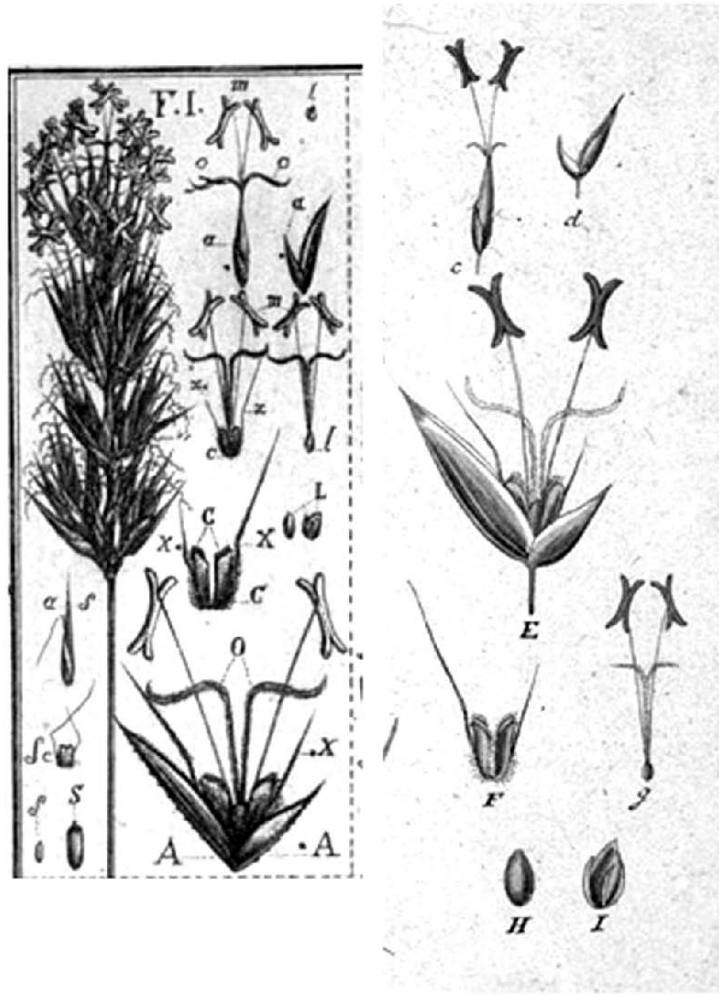

Fig. 6.2. Sweet vernal grass – *Anthoxanthum odoratum* L. Left, the version by Leers; right, details that Sturm has partially copied from Leers's illustration.

which Leers erroneously called the nectary.[4] Detail H shows the exterior of this structure, detail I its interior.

Sturm did not use any of the other details in Leers's illustration; furthermore, the copied details differ in a number of areas from their reference drawings. Sturm's depiction of the ripe caryopsis is clearer and quite different from Leers's. Sturm shows this grain both life-size (k) and enlarged (K). Unlike

[4] See the accompanying texts in question: Sturm (1798-1855), Vol. 1 (no pagination) and Leers (1775), p. 7.

Leers, Sturm shows the anthers of the half-opened spikelet from the front (E), thereby obscuring the point where the anthers and filaments meet. Leers's side-view version of anthers was only reproduced by Sturm in the detailed view of a floret (g). The glumes of the spikelet are keeled in Sturm's version (E) but they are not dentate as in Leers's version; furthermore, the stigmas of Sturm's closed spikelet (c) are shorter than Leers's. Sturm has also changed the single floret in one minor detail: he has clearly shown its short stem (E, c), which is absent in Leers's version, although Carl Linnaeus included it as one of the characteristic features of the species in his *Species Plantarum*. Finally, Sturm's detailed view of the inflorescence is quite unlike Leers's (see the general view in fig. 6.1); his inflorescence is far more loosely arranged than Leers's, which makes the structure of the ear much more visible.

Sturm had obviously given much thought to which elements to copy in which ways. He did not borrow from the whole picture but took some of Leers's details, modified them and then integrated them into his own illustration. This sequence is carried further in Sandberger's watercolour. Figure 6.3 (p. 189) shows the two images side by side. Sandberger has taken over the vegetative structures of the grass stalk of Sturm's main view virtually unchanged; however, he has disregarded Sturm's peculiar egg-shaped ear and reproduced Sturm's detail of the inflorescence in its place. Of the details, Sandberger chose to depict only the individual floret with stamens and stigmas (detail g) and painted the anthers pink, not red like Sturm's.

6.1.2 Thornton, Miller, Curtis & Martyn

In order to learn a bit more about the dissemination of this practice of copying from earlier images and about the character of these links, I shall examine a few other examples before proceeding to a more general discussion of the phenomenon. Several representations of the sweet vernal grass by British botanists – namely, Robert Thornton, John Miller, Curtis and Thomas Martyn – are, for example, connected in a similar way. Take first the depiction of the sweet vernal grass in the work by Thornton, whose illustration of the hazel was looked at in Chapter 5. His image of the grass is reproduced in figure 6.4 (p. 190).[5] Thornton shows this species of grass in an even more simplified form than Sturm: not only has he not given any idea that the grass grows in a clump-like fashion, he has also omitted the ground leaves, roots and nodes as well as any form of colouring. His uncoloured engraving shows a single stalk with an ear and a flag leaf. The stalk has been cut at the level of the leaf's sheath. To the right of the general view, Thornton has drawn several details of the floret.

Like Sturm, Thornton was also very much influenced by his predecessors in the design of his illustration. His details of the floret, for example, closely resemble John Miller's illustration of the sweet vernal grass, which was introduced in Chapter 5 (fig. 5.10, p. 179; fig. 5.12, p. 181). In figure 6.5 (p. 191)

[5] Taken from Thornton (1812).

Fig. 6.3. Sweet vernal grass – *Anthoxanthum odoratum* L. On the left, the version by Sturm; on the right, Sandberger's partially copied version.

the details of the sweet vernal grass by Thornton and Miller have been placed side by side: in particular, Thornton's two views of a tightly closed spikelet with parallel anthers clearly refer back to Miller's reference drawing; in both versions, the detail is shown life-size as well as enlarged. The two views of the opened spikelet have also been copied virtually unaltered: in the first detail, Thornton shows a loosely joined spikelet with two closed parallel anthers; below this detail, he shows a dissected spikelet, this time with fully opened anthers. Thornton has, however, not shown Miller's detail of the spikelet when the seed is mature; instead, he has made do with a view of the lemma and palea with the caryopsis (ripe seed) placed between the two bracts. The ripe

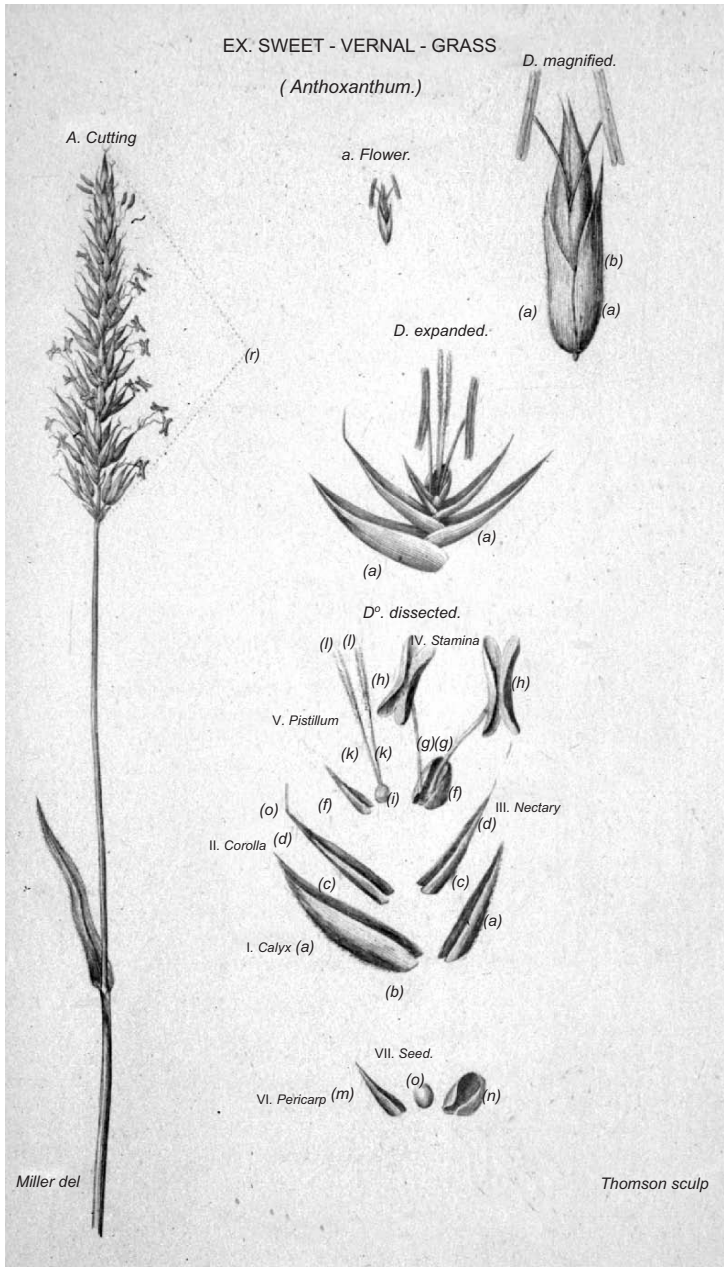

Fig. 6.4. Sweet vernal grass – *Anthoxanthum odoratum* L. Thornton (*The British Flora*, Vol. 1, 1812).

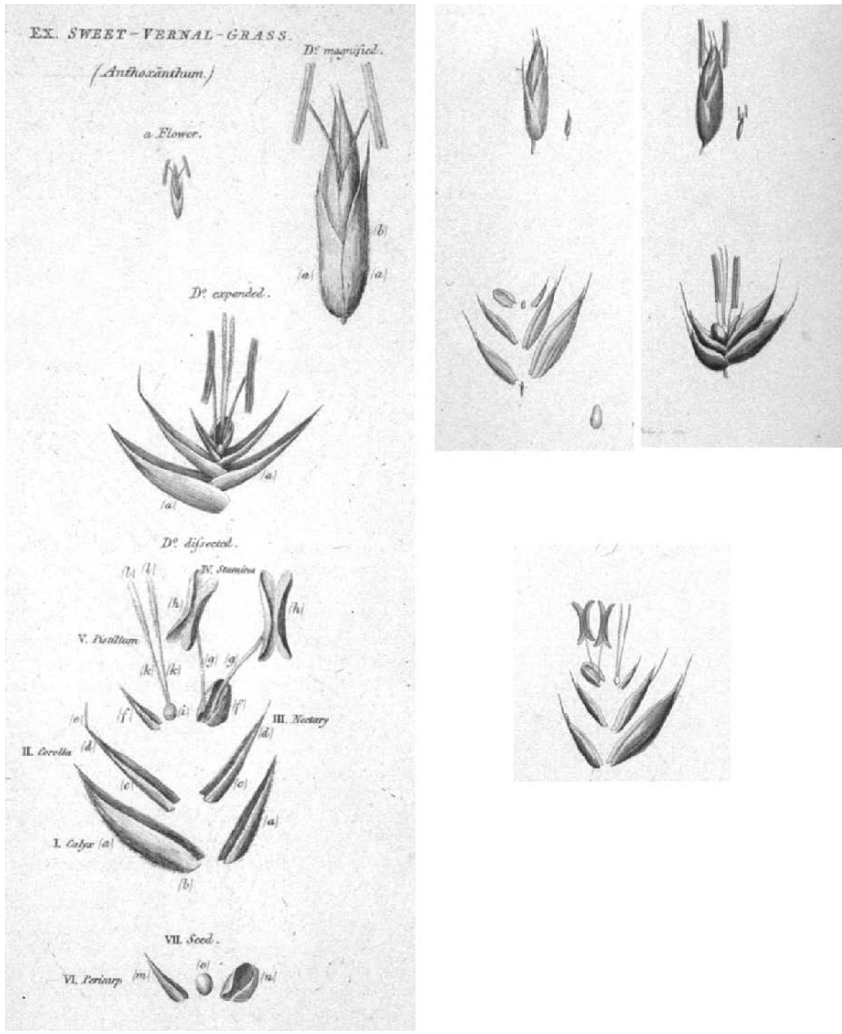

Fig. 6.5. Comparison of the details of the sweet vernal grass by Thornton (*The British Flora*, Vol. 1, 1812) and Miller (*Illustratio Systematis Sexualis Linnaei* Vol. 2, 1777). Left, Thornton's details; right, those by Miller.

seed – the only new piece of information in this detail – is larger in proportion to its glumes than the caryopsis in Miller's earlier version.

The fact that Thornton's draughtsman borrowed from Miller's image is, on closer examination, not too much of a surprise. Towards the bottom left-hand corner of Thornton's image is a signature that reads "Miller del[ineavit]", which is Latin for "Miller drew it". For Thornton employed, among others,

Fig. 6.6. Sweet vernal grass – *Anthoxanthum odoratum* L. Curtis (*Flora Londinensis*, Vol. 1, 1777).

Fig. 6.7. Comparison of the stalk of the sweet vernal grass. Left, Thornton's version; on the right, Curtis's version.

Miller's son, John Frederick Miller, who was certainly well familiar with his father's earlier work. However, Thornton had his draughtsman not copy everything from Miller senior but additionally used another illustration as a reference drawing, namely Curtis's representation of the sweet vernal grass (fig. 6.6, p. 192). From this other image, only one element has been copied: the upper part of the longest stalk with an inflorescence, the only inflorescence in Curtis's image with both mature stigmas and stamens. The two details treated by Thornton and Curtis are shown in figure 6.7 (p. 193). Thornton has reproduced Curtis's stalk virtually unaltered, although it does appear to be a mirror image of the earlier work: Thornton's leaf grows to the left not to the right of the stalk, as Curtis's does; this reversed element is a result of the illustration having been transferred directly onto the copperplate (see the explication of this procedure in Chapter 2, section 2.2.3, pp. 48ff.).

Thornton's representation of the sweet vernal grass offers yet more evidence that draughtsmen and botanists did not use just any illustration as a reference drawing for their own versions but, on the contrary, selected their reference drawings very carefully. Whereas Thornton obviously found the details in Miller's image instructive enough to have them copied, he was not as content with Miller's general view of the grass – even if Miller was the father of his draughtsman! For the stalk and full inflorescence, Thornton found an alternative reference drawing in Curtis's illustration, although the latter's details did not meet his approval. The result is a hybrid: Thornton took what he considered to be the best elements from the two illustrations to create his own composition.

If one examines the two images even more closely, one realizes that Thornton's creativity was not confined to choosing the best reference drawings for copying. It is only on very close inspection that one can see that Thornton has copied elements from Curtis's very detailed illustration. For Thornton has radically reduced the wealth of information contained in his predecessor's version to those aspects which he thought essential. He has completely omitted the vegetative structures of the grass present in Curtis's version, including the inflorescence's different developmental stages. Rather, Thornton's illustration focuses on the taxonomically relevant organs of the grass: the leaves and mode of growth only rarely help one to identify a specific species of grass, whereas the individual inflorescence and its spikelets and florets substantially do so. Thus, although the reference drawing he presents contains much less information than Curtis's comprehensive version, the aspects Thornton has chosen are presented much more clearly. The way Thornton used Miller's image reveals how critically he assessed the earlier reference drawing. He did not reproduce Miller's duplicated view of the outer glumes with mature seeds but only the views of the flowering spikelet, both with closed and open anthers. However, Thornton did pick out Miller's ripe caryopsis, which he placed between the lemma and palea, albeit slightly enlarged.

Thornton was not the only botanist to turn to Curtis's illustration of the sweet vernal grass. If one looks at the illustration of the same species by

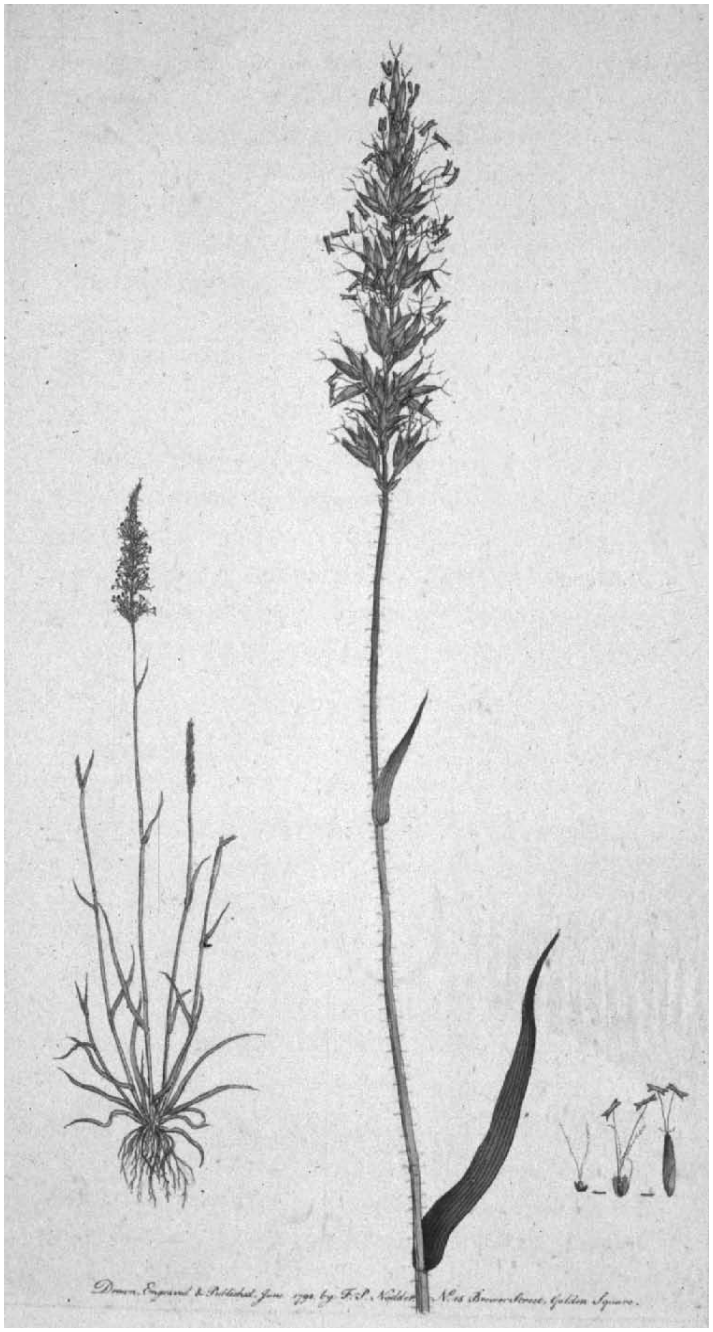

Fig. 6.8. Sweet vernal grass – *Anthoxanthum odoratum* L. Martyn (*Flora Rustica*, Vol. 1, 1792).

Martyn, dated 1792, one finds another clear reference to the earlier example (fig. 6.8, p. 195).[6] In his work, Martyn has reproduced Curtis's general view as a background detail and instead used Curtis's stalk in full flower as a reference drawing for his main view. Neither of these two elements was copied unchanged: Curtis's general view of a complete grass plant has not only been reduced in size, it has also been greatly simplified. There are fewer leaves and roots, the wilted lower leaves have only been roughly drawn and the left-hand-side inflorescence has been dropped or perhaps replaced by an ear which is not fully open – it is hard to tell exactly from the small detail. The remaining details of Curtis's general view that Martyn took over are the fully mature inflorescence, the half mature stalk on the right and the short shoot on the lower right that is only just emerging, although it is barely recognizable. Nodes or sheaths cannot be identified either. However, the similarity with Curtis's general view is, nevertheless, unmistakeable. Martyn's close-up of the single stalk has been similarly adapted. Unlike Curtis, Martyn has covered the stalk with bristles but a characteristic element that he has retained from the earlier work is the crowning spikelet of the inflorescence, which has stigmas pointing vertically upwards but no stamens. It would be taking coincidence a bit far to assume that two botanists working independently would come up with exactly the same unusual detail.

Martyn also took over three of Curtis's details, placed to the right of his general view. They are all dissected views of the spikelet. With the exception of the first detail, they have not been directly copied from the earlier illustration but instead have been made into new compositions: the closed spikelet (far right) has been reproduced unaltered; then Martyn combined Curtis's isolated pair of interior glumes (detail 4) with the floret (detail 5) to make a single detail (centre); Martyn's third detail (left) shows only the female parts of the flower between the two glumes – if one examines it closely, it corresponds exactly to Curtis's detail 6, albeit without filaments and anthers.

6.1.3 Schreber, Kerner & Schkuhr

As a third and final example I would like to introduce two copying links that are related to the sweet vernal grass drawn by Johann Christian Daniel Schreber in 1769. The illustrations in question are shown in figure 6.9 (p. 197): on the far right, the image by Johann Simon Kerner (1786); in the centre, the drawing by Schreber (1769); and on the far left the illustration by Christian Schkuhr (1791). Complete views of the images can be found in figures 6.10 (p. 198, Schreber), 6.11 (p. 199, Kerner) and 6.12 (p. 200, Schkuhr).

In their versions, both Kerner and Schkuhr have made only slight modifications to Schreber's sweet vernal grass, although the subject matter has been simplified and schematized so much that one only recognizes the reference

[6] Taken from Martyn (1792-94).

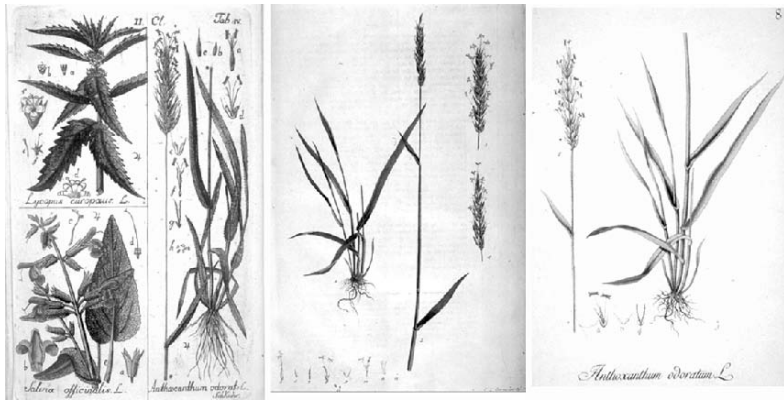

Fig. 6.9. Sweet vernal grass – *Anthoxanthum odoratum* L. Left to right: Schkuhr (*Botanisches Handbuch*, Vol. 1, 1791), Schreber (*Beschreibung der Gräser*, Vol. 1, 1769), Kerner (*Abbildungen oekonomischer Pflanzen*, Vol. 1, 1786).

drawing on very close inspection.[7] Only by making a direct comparison of both partially copied images with Schreber's illustration do the similarities become clear, as can be seen in figures 6.13 (p. 201) and 6.14 (p. 202). In his image of the sweet vernal grass, Schkuhr has added two wilted ground leaves, he has totally altered the roots and he has drawn fine hairs on the margins of the leaves (whereas in Schreber's version only the sheaths have hairs). Kerner has shown not only the sheaths but also the stalks covered with hairs, whereas the margins of the leaves have none. So, although Schreber's grass has been in many respects simplified, both Kerner and Schkuhr at the same time complemented their versions by adding some new information.

Furthermore, both Schkuhr and Kerner chose to disregard Schreber's additional views of the inflorescence in different stages of development. In Schreber's illustration, the ear on the stalk is in its first developmental stage in which only mature stigmas are visible; the two details to the right of the main stalk show the increasing number of mature anthers, which in grasses is an unusual order of maturing. The two copyists each chose an intermediate stadium for their inflorescences: both show spikelets either with stigmas only or with both anthers and stigmas. Their details also show that the grass's flowers are hermaphrodite, that is, all have both stigmas and anthers. These two pieces of information may well give the observer the decisive clue that, in florets of the sweet vernal grass, the stigmas mature first, followed by the anthers.

[7] Neither draughtsman referred to their reference drawing, even though in the preface to the *Botanisches Handbuch* Schkuhr wrote that he would notify his readers of the instances in which a predecessor's material had been used. See Schkuhr (1791-1803), Vol. 1, Preface.

Fig. 6.10. Sweet vernal grass – *Anthoxanthum odoratum* L. Schreber (*Beschreibung der Gräser*, Vol. 1, 1769).

Fig. 6.11. Sweet vernal grass – *Anthoxanthum odoratum* L. Kerner (*Abbildungen oekonomischer Pflanzen*, Vol. 1, 1786).

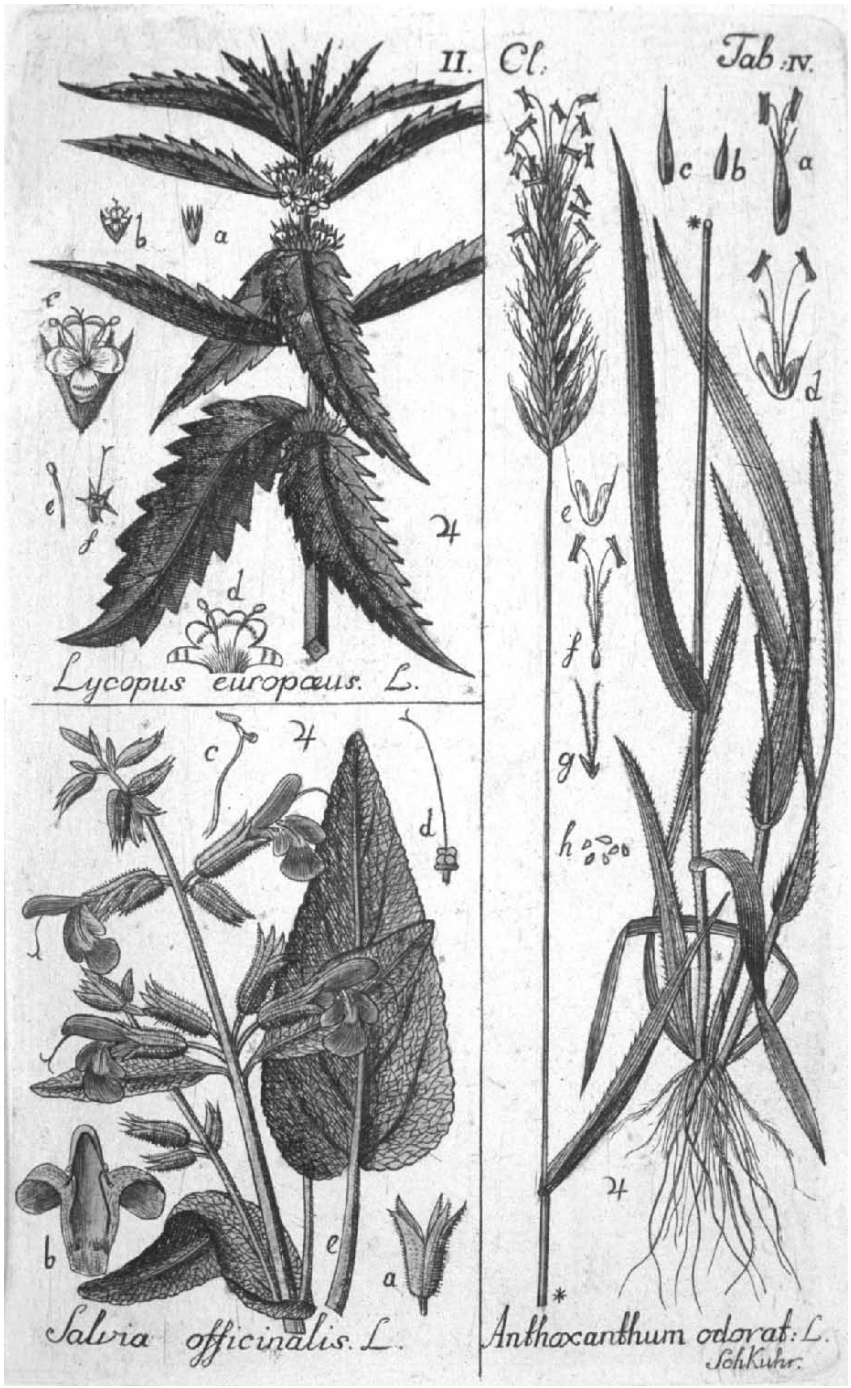

Fig. 6.12. Sweet vernal grass – *Anthoxanthum odoratum* L. Schkuhr (*Botanisches Handbuch,* Vol. 1, 1791).

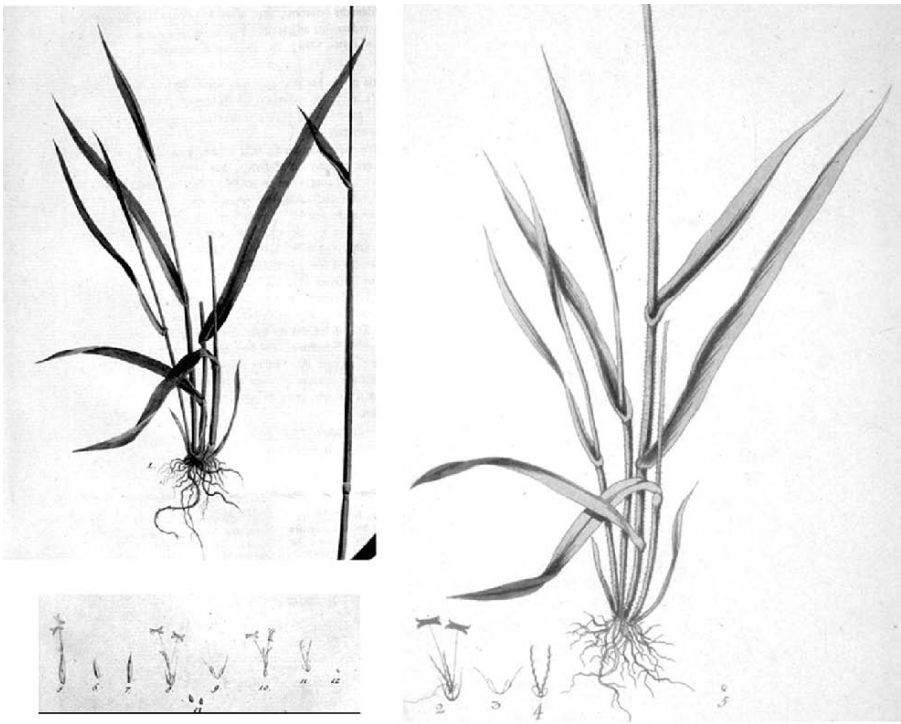

Fig. 6.13. Sweet vernal grass – *Anthoxanthum odoratum* L. On the left, the vegetative structure of the grass in Schreber's version; on the right, the same section in Kerner's image.

Additional inflorescences are, therefore, not really needed to communicate this fact.

In addition, Kerner did not paint the paired anthers in pink as Schreber did but in both his general view and in the details he used a strong blue, which clearly emphasizes them. Apart from this, his four details, excluding the inflorescence, are not very informative. Schkuhr also used pink for his anthers, like Schreber, but in his general view he did not show the paired arrangement of the stamens in such an exaggerated form as Schreber. However, he clearly attached great importance to the details: Schkuhr has copied all but one of Schreber's details,[8] which he also lettered in the same order as Schreber. Only Schreber's view of the ovary detail is absent (detail 12 in Schreber's version). Perhaps Schkuhr found that the little information this unspecific globule communicates was not worth copying. Schkuhr has also hand-coloured

[8] Which, incidentally, proves that Schkuhr copied Schreber's illustration and not the one by Kerner.

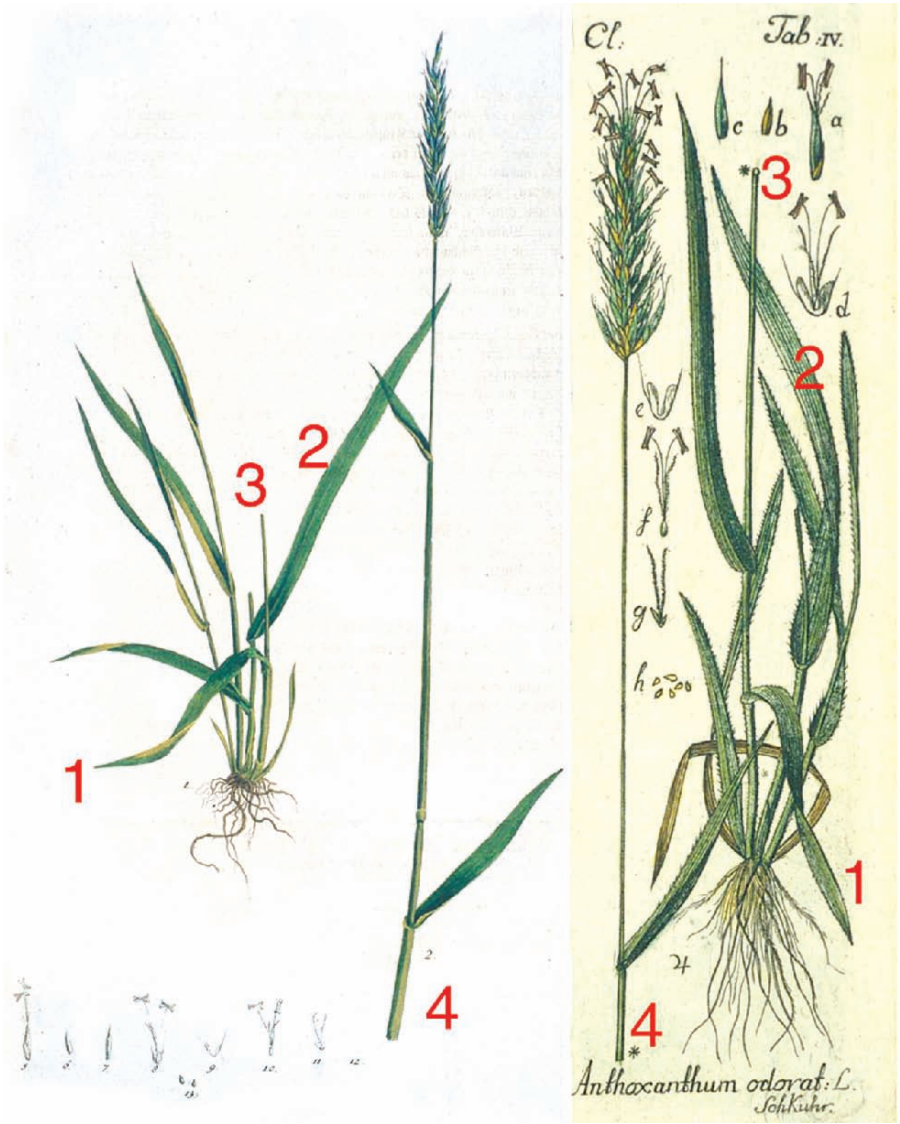

Fig. 6.14. Sweet vernal grass – *Anthoxanthum odoratum* L. Four corresponding points in the illustrations by Schreber (left) and Schkuhr (right) have been numbered to make it easier to recognize the elements that have been copied.

his details, unlike Schreber's pencil outlines. Each structure has been given a separate colour, which was used again in the general view, a device that makes it easier to understand, for example, the arrangement of the outer glumes of the spikelets.

Conclusion

Those were a few examples of the copying links that exist between botanical illustrations of the selection under study. A thorough analysis of all the selected sweet vernal grass images shows that out of twenty-one illustrations, fifteen are connected through links of this type. A similar result can be gathered from the analysis of illustrations of other species: about three-quarters of the illustrations selected for this study were connected through copying links – that is, they either contained copied elements, served as reference drawings, or a mixture of the two. This was most unexpected: although it has been known for some time that earlier illustrations were used as reference drawings for new images being produced for the herbals of the Renaissance,[9] it was not known that this practice was also widespread within eighteenth-century botanical illustrations. This is maybe due to the fact that the copied elements are not usually as obvious as in the Renaissance works; indeed, they could only be identified by comparing as many illustrations as possible of one species of plants, covering a specific period of time.[10]

6.2 Copying Links

In this study, a "copying link" refers to the relationship between two illustrations, one of which was used as a reference drawing for the other, regardless of how many elements were taken from the earlier work. The examples given above should have made it clear that these copying processes are a complex phenomenon that have very little to do with the usual idea of copying someone else's work. The concept of copying usually has a thoroughly negative connotation. When speaking of a copy or of a person who has copied someone else's picture, one often concludes that the draughtsman is incompetent and has reproduced a predecessor's image because he could not think of anything original. Furthermore, one usually assumes that copyists inevitably introduce errors. A copy is never of the same standard as the original: such is the widely

[9] Besides the general reference sources of Blunt (1994) and Nissen (1966), see also Arber (1986) and Baumann (1998).

[10] Being able to use digital images was essential for this approach: in archives or libraries, one usually has access to only one or two works at a time; but when illustrations can be reproduced in digital form, comparing even the smallest details by zooming in on the images becomes e ortless. I am grateful to the Berlin-Brandenburg Academy of Sciences and the Max-Planck-Institute for the History of Science (Berlin) for supporting this part of my project.

held view. "Each generation of copying takes one further from reality", claims Brian J. Ford in his book on scientific images; and he adds: "A living specimen, well portrayed, becomes wooden and stiff as it is copied and re-copied".[11] The truly valuable image, then, would be drawn by the independent draughtsman, who relies on his own observations and creativity and produces high-quality illustrations without being influenced by the work of other people. These ideas form the standard view in the technical literature on botanical illustrations and have rarely been challenged.[12] However, the findings of my study present a totally different picture. A copy in these instances should not be seen as a careless reproduction of someone else's ideas. The examples presented above are typical in many respects: only a few elements were copied and these were frequently modified by the later draughtsman. Only in exceptional cases were elements copied without any modifications having been made, and even then the copyist made a careful selection of which elements to copy and which to omit.[13]

Only two of the books examined in this study were based explicitly on an earlier archetype: Johann Wilhelm Weinmann's *Phytanthoza Iconographia*,[14] which was an enlarged and revised version of his unprinted *Herbarium Pictum*,[15] and Christoph Jacob Trew's *Herbarium Blackwellianum*,[16] a translation and revised edition of Elizabeth Blackwell's *Curious Herbal*.[17] And only twice did botanists mention that earlier illustrations had been consulted for

[11] Ford (1992), p. 3.

[12] See, e.g., Lack (2000), who believes that establishing whether an image is an original or a copy is "the first and foremost question" (p. 99: "die erste und wichtigste Frage") to be asked in any study of zoological and botanical illustrations: the originals are held to be far more interesting. Even more pronounced is Blunt (1994), albeit in view of illustrations of earlier periods: "[For the earliest flower drawings] Realism was desired and soon to a surprising degree achieved, for there can be little doubt that the illustrations provided for herbals nearly two thousand years ago were highly naturalistic. Gradually, however, unintelligent copying led to a debased and stylised type of figure which was nothing more that a decorative embellishment to the text." Ibid., p. 23. With respect to the early days of letter press printing, this "unintelligent" type of copying could sometimes be a problem. But transferring this attitude to all instances, whenever someone copied something of a predecessor, as Blunt suggests elsewhere in his text, is highly questionable.

[13] Of course, there was also a di erent type of copying prevalent at this time. Trew, for example, had copies made of a number of Ehret's drawings, either by Ehret himself or by other draughtsmen. The resulting images were either destined for his own collection or for other people; Calmann (1977) gives a number of examples; see also Ludwig (1998), e.g., p. 160. In these cases, the whole purpose was to copy the original image as accurately as possible in order to create an illustration identical in appearance to the original.

[14] Weinmann (1735-45).

[15] Weinmann (1717).

[16] Trew & Blackwell (1750-73).

[17] Blackwell (1737-39).

some of their images: Friedrich Gottlob Hayne in the text accompanying his depiction of the grapevine[18](although only one of the three reference drawings which he used was named) and Schkuhr in the preface to his *Botanisches Handbuch*.[19] All the other authors stated that their illustrations had been prepared under close supervision, with the utmost care and following new designs: "Here every thing is from Nature only",[20] John Hill praised the images of his *Vegetable System*, to quote only one example. Whether the authors consciously intended to deceive their readers or whether the statements reflected the conviction of the authors will be clarified after a closer analysis of the practice itself.

Two main types of copying links can be identified: partial copying and complete copying. A complete copy is an image or an element of an image that a draughtsman has reproduced unchanged from an earlier image. Although this practice can be seen to have taken place in a few examples, it remains, however, the exception. Far more common was the practice of partial copying, which is when an image or one of its elements has been reproduced from an earlier illustration with deliberate modifications made to it, although the origin of the motives remains recognizable. There is also a third type of copying link, albeit a tenuous one, which I have called the unproven motive factor. This refers to the relationship between two images for which a copying link cannot be undeniably proven, although the two illustrations strikingly resemble each other in content and design.

Complete Copying

In some instances, later draughtsmen limited their output to making identical copies of earlier images. In the selection under study, there is only one example where this was done with a complete illustration: the copy of Blackwell's hazel in Trew's revised edition of her work (fig. 6.15, p. 207). Trew had set himself the task of translating Blackwell's English herbal into Latin and also of enlarging and amending the book. It was mainly the draughtsman Nicolaus Friedrich Eisenberger, one of Trew's closest employees, who worked with him on this project – the same Eisenberger that Trew had employed for his anatomical work (see Chapter 2). In most cases, Eisenberger's plates follow Blackwell's reference drawings quite closely and Eisenberger engraved all of his illustrations using the mirror technique, which means that in his images the plants appear the right way round. A few of his illustrations are included in the selection under study but the hazel is the only example that can be described as being a complete copy of the entire image.[21] It is unlikely that Trew found it unnecessary to introduce any changes, such as inserting new

[18] Hayne (1805-37).
[19] Schkuhr (1791-1803).
[20] Hill (1759-75), Preface; no pagination.
[21] Eisenberger also made a complete copy of Blackwell's illustration of the pomegranate (and probably other images), which is one of the four additional species

and more clearly drawn views of the male and female flowers, since this was the raison d'être behind the new edition;[22] some unknown reason probably lay behind this.[23] Only the colouring is a little greater in contrast in Trew's version: the leaves are a darker green, the nut is not beige but yellow and the petioles are differentiated by their green colour from the brown twig. However, these differences in shade could also be due to the different states of preservation of the two images.

Other examples of copying links that could be considered to be complete copies can be found in the German translation of Henri Louis Duhamel du Monceau's treatise on the trees and shrubs of France.[24] In addition to a host of general information on forestry, in this work Duhamel also introduced the most commonly occurring species of plants. At the beginning of each article, he included an engraving showing in detail each species' flower and fruit – and all these engravings were based on the illustrations of Joseph Pitton de Tournefort's *Institutiones Rei Herbariae*.[25] A comparison of the respective representations of the hazel are reproduced in figure 6.16 (p. 208). Duhamel obviously did not have Tournefort's copperplates reprinted directly but had them copied by his own employees. In some cases, the details have been scaled down, with the result that his engravers could not reproduce all of the subtleties of the earlier version. Furthermore, the details have frequently been arranged in a different way, occasionally even with two details overlapping. For example, Duhamel has drawn the male catkin of the hazel not hanging down vertically, as in Tournefort's version, but placed horizontally, going along

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of plants examined in this study, albeit less thoroughly than the six principal species. See the comments on the method of this study in Chapter 1, p. 270.

[22] See Trew's remarks in the preface to the first volume: "Since the particularly small details of the flowers, fruit and seeds are so untrue to nature that one cannot recognize the characteristics of the genus with the accuracy that would be required today: Mr. Eisenberger has mostly kept them [Blackwell's details] unchanged but has also tried whenever possible to draw these parts more exactly and he especially tried to show the number and form of the dissected stamens and pistils." Original German text reads: "Weil in dem Blackwellischen Exemplar die besonders kleinen Figuren der Blüthe, Frucht und Saamen am wenigsten der Natur so ähnlich kommen, dass daraus die Kennzeichen des Geschlechts nach der heutigs Tags erforderten Accuratesse können erkand werden: so hat Herr Eisenberger solche zwar unverändert beybehalten, zugleich aber sich bemüht, eben diese Theile, so oft es möglich gewesen, genauer und nach ihrer Zergliederung nachzuahmen fürnehmlich auch die Zahl und Bildung der Staubfäden und Stempel anzuzeigen." Trew & Blackwell (1750-73), Preface, Vol. 1, p. C 2.

[23] In his preface to the second volume, Trew wrote that, for a number of reasons and despite his best e orts, new details could not be added to all of the illustrations, although this would have been desirable. See Trew & Blackwell (1750-73), Preface, Vol. 2, no pagination.

[24] Duhamel du Monceau & Oelhafen (1762).

[25] Tournefort (1700).

Fig. 6.15. The hazel – *Corylus avellana* L. On the left, the image taken from Blackwell (*A Curious Herbal*, Vol. 2, 1739); on the right, the one from Trew & Blackwell (*Herbarium Blackwellianum*, Vol. 3, 1757).

the bottom of the plate. Presumably, these adaptations were done because of space restrictions and the new format of the engraving.

However, there are a few alterations that might have been carried out for other reasons: Duhamel, for example, has differentiated the individual scales of the male hazel catkin more clearly than Tournefort, and the shape of the scales in the whole catkin matches more exactly the scales in the neighbouring details, although this can only be seen on close inspection. Furthermore, Duhamel usually did not reproduce all of Tournefort's details. Duhamel had less space for each species than Tournefort: if he had reproduced all the details, he would have had to reduce them greatly in size. In the example above, Duhamel did not duplicate Tournefort's scale-less catkin axis of the hazel, which admittedly is a detail of doubtful relevance. Thus, even in this example, which most closely resembles a complete copy of an earlier work, the copied elements were not taken over mechanically. Much thought was given to the whole procedure: details with little or redundant information were omitted and copied elements were occasionally discreetly optimized. These slight modifications could be interpreted as constituting cases of partial copying;

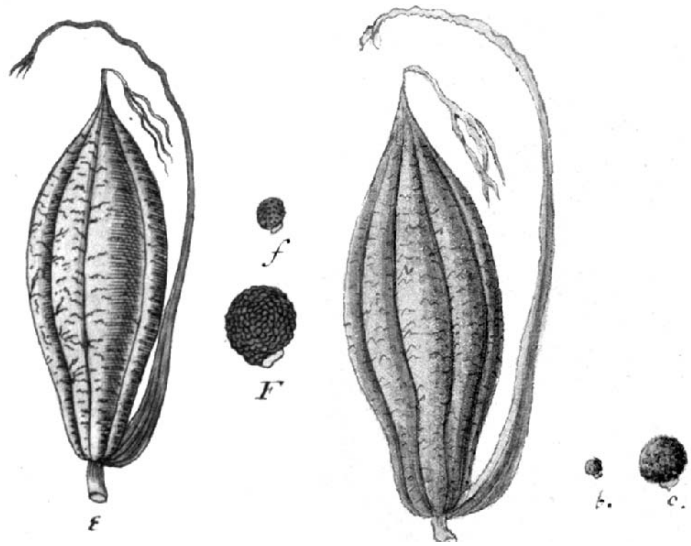

Fig. 6.17. The fruit of the meadow sa ron – *Colchicum autumnale* L. On the left, the representation by Sturm (*Deutschlands Flora*, Vol. 1, 1797); on the right, Sandberger's version.

however, they are borderline cases and arguing over terms is not the main scope of this chapter.

More examples of elements that have been copied unchanged can be found in the remaining plates of the selection. For his representation of the meadow saffron, for example, Sandberger adopted both the fruit of the species drawn previously by Sturm (fig. 6.17, p. 209) and a detail of the female reproductive organs. For his image of the hazel, Friedrich Guimpel used Schkuhr's views of a male catkin scale and a stamen virtually unaltered; Guimpel's version was then copied by Sandberger – and so forth.[26] Far more frequent, however, was the practice of making partial copies of earlier works.

Partial Copying

In contrast to a complete copy, a partial copy contains elements that have been modified to some extent. At times, only subtle alterations mark the difference between a completely or a partially copied element. When I discussed Sandberger's copy of Sturm's sweet vernal grass, I mentioned that Sandberger reproduced the vegetative structures of the grass virtually unaltered (fig. 6.3, p. 189). In addition to varying the ground leaves, the later draughtsman also

[26] The similar arrangement of the details in the images by Guimpel and Sandberger suggests that Sandberger used Guimpel's illustration as a reference drawing, although one cannot totally rule out that Sandberger took these elements from Schkuhr's original version.

changed a further detail. If one closely observes the flag leaf in both images (fig. 6.18, p. 210), one sees that in Sturm's image the leaf is growing directly from the stem, whereas in Sandberger's version the base of the leaf blade is wrapped around the stem, forming a fine, dark line at the front. This alteration was a conscious decision on the part of Sandberger: he has included the leaf sheath, a typical property of many grasses, which he found essential, whereas it is absent in Sturm's illustration.

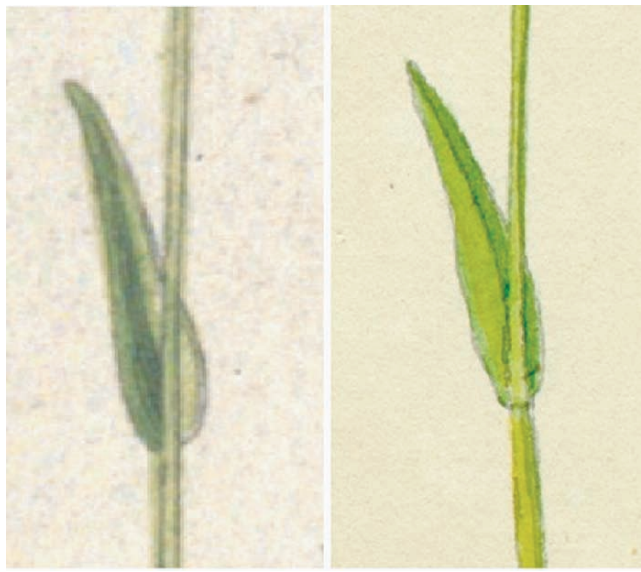

Fig. 6.18. Comparison of the sweet vernal grass's flag leaf. Sturm's version (left); and Sandberger's version (right).

These variations in the details that have obviously been copied are the characteristic features of a partial copy. However, the copied elements are not always as evident as in the versions of the sweet vernal grass by Sturm and Sandberger. The copying link between the images by Leers and Sturm was already less obvious, as Sturm copied far more selectively than Sandberger. It also takes some time to work out the partial copy mentioned in Chapter 1 – at first glance, it is not at all clear that the Swedish botanist Palmstruch really reproduced certain elements of Curtis's coltsfoot. Details of the two coltsfoot illustrations are reproduced again in figure 6.19 (p. 212). The copying link becomes clearer when one looks at the shape and treatment of the rosettes in both images: as in Curtis's version, the bases and petioles of the leaves in the Palmstruch image are broad in dimension and clearly wrapped around each other. Palmstruch's treatment of the unfurled leaf between the two fully grown leaves also corresponds to the earlier Curtis version. However, Palmstruch has

not copied any of Curtis's rosettes unaltered but has combined their properties to make a new rosette of his own composition. Also, the image's character has changed. In some respects, Palmstruch's image is a simplified version of his reference drawing, not only on account of what he chose to colour. Palmstruch was, for example, satisfied with only two fully grown leaves and it is difficult to say which sides of the leaves (upper or lower) are displayed (which, by contrast, is very clear in the Curtis image). On the other hand, Palmstruch has developed some other details more fully, such as the two scale leaves at the base of the rosette. Palmstruch has also given the rosette a vertical taproot instead of Curtis's creeping rhizome – an alteration that he would have done better to avoid, since it gives misleading information on the coltsfoot's underground organs.

The Unproven Motive Factor

The last and weakest form of copying link is what I refer to as the unproven motive factor, that is, the relationship between two images for which no direct copying link can be proven, although the illustrations are so similar that it is very unlikely that the later draughtsman was unaware of the earlier image. One example of this kind of relationship can be seen by looking at two illustrations of the twinflower (*Linnaea borealis* L.). Figure 6.20 (p. 213) shows the plates in question: above is the twinflower in a version by Zorn, published in 1779; below, the same species in a version by Sturm of 1804. At first glance, Sturm's representation resembles the earlier one by Zorn both in the general habit of the plant and in its details. On closer inspection, however, it is difficult to justify the assumption that they are part of a partial copying process. Rather, I believe that they are connected to a common predecessor that both draughtsmen copied, namely the twinflower illustration by Trew (fig. 6.21, p. 214). However, their treatment of the subject matter still displays so many similarities that it is highly probable that Sturm was additionally influenced by Zorn's image, although he did not copy this illustration in detail.

Let me explain the relationship between the three images a little more thoroughly to justify this statement. In Sturm's image, immediately after the root there is a vegetative shoot that closely resembles the one in the images by Trew and Zorn, although they show two shoots of this type. Sturm only copied the longer shoot, not both shoots. Unlike in his predecessors' versions, Sturm's shoot does not grow directly from the main stem but arises clearly from the axils of the first pair of leaves.[27] The shoots in Sturm's version also appear comparatively longer than in Zorn's, since Sturm did not enlarge the flowers

[27] This topological assignment of the shoots to the axil is less clearly demonstrated in the three flower shoots though, so that one cannot be certain that Sturm had recognized this connection as a systematic feature.

Fig. 6.19. Coltsfoot – *Tussilago farfara* L. Top, two details of the image by Curtis (*Flora Londinensis*, Vol. 1, 1777); below, a detail of Palmstruch's illustration (*Svensk Botanik*, Vol. 1, 1802).

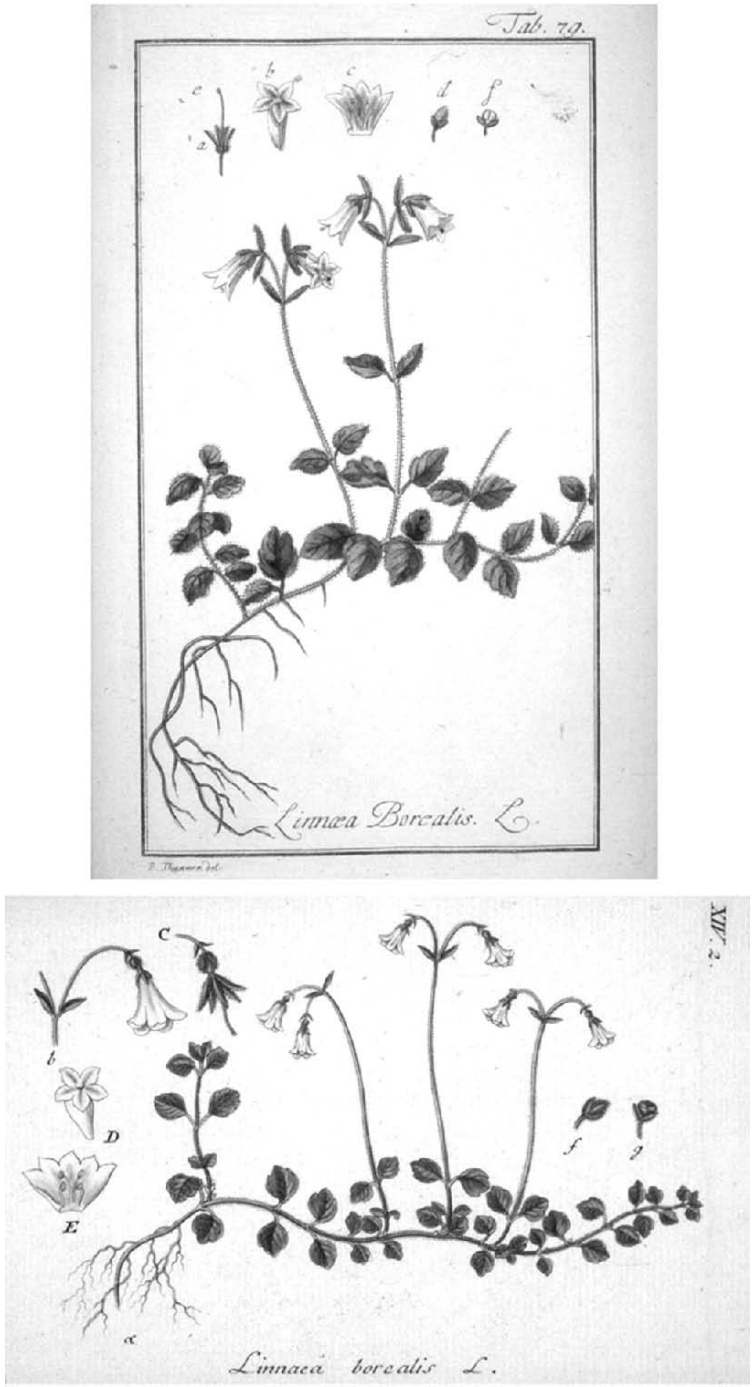

Fig. 6.20. Twinflower – *Linnaea borealis* L. Top, as represented by Zorn (*Icones plantarum medicinalium*, Vol. 2, 1780); below, as represented by Sturm (*Deutschlands Flora*, Vol. 5, 1804).

Fig. 6.21. Twinflower – *Linnaea borealis* L. Trew & Blackwell (*Herbarium Blackwellianum,* Vol. 6, 1773).

as Zorn did.[28] The shape of the flowers also differs in the two images by Sturm and Zorn: the flowers are more widely open in Sturm's version, and they look more like a funnel than a bell, with clearly rounded tips. Furthermore, like Trew, Sturm has shown the spherical, inferior ovary clearly separated from the rest of the flower (c) – a detail that Zorn chose to omit.

The two details of the flower itself – one showing the flower upside down, the other a dissected view – are the same in all three images. The nectar guide and the interior of the petals are more brightly coloured in Sturm's than in Zorn's version and also more orange than pink. Sturm has also increased the scale of his details in comparison with his main view (a). The four stamens clearly rise from the base of the flower – one even sees the anthers' two thecae (E). As in the images by Zorn and Trew, the central filaments in Sturm's version are longer than the two on the sides; the anthers of the shorter stamens point inwards, as in Trew's image. In Zorn's version, they are pointing outwards – a minor detail but further proof that Sturm used Trew's image as a reference drawing for his illustration and not Zorn's. Sturm's two details of the fruit and seed (f, g) are also closer to Trew's version than to Zorn's: the first view of the whole fruit (f) differs from the corresponding detail by Zorn in the colour of the calyx and the fruit, and the second view (g) does

[28] Zorn's method of zooming in on the flower to make the plant's essential features more visible was explained by way of his illustration of the coltsfoot in Chapter 1, p. 7.

not resemble Zorn's version of a yellow seed but rather Trew's green-coloured cross-section.

Thus, there is much to favour the proposition that Sturm copied elements of Trew's image and not Zorn's. Nevertheless, the visual language chosen by Sturm and the way the subject matter is treated very much resemble Zorn's – so much so that it is unlikely that the two of them developed this approach independently. Taking into account both these observations – the differences as well as the similarities – the relationship between Sturm's and Zorn's images (and between analogous cases) was vaguely described as the unproven motive factor. There are some other examples of this kind of copying link within the image selection but they are far less frequent than partial copies and thus did not play a major role in my analysis.

6.3 Dissemination of the Practice

6.3.1 Overview

Copying links of one kind or another appear frequently within the image selection; the following table gives an overall view of the quantities of demonstrable and potential copying links, listing those images that served as reference drawings and/or contain copied elements, itemized for each of the six species of plants examined. Where two numbers are given, the lower figure relates to clearly established complete or partial copying links, while the higher figure includes the more speculative cases.[29]

Species	Number of Illustrations	Reference Drawing	Copy
Sweet vernal grass	21	8	9/10
Meadow sa ron	36	13/15	11/14
Hazel	23	7/8	7/8
Twinflower	14	6/8	8
Coltsfoot	22	5/6	5/6
Grapevine	21	8/9	7/8
Total	137	47/54	47/54

More than a third of the 137 images examined, that is, forty-seven illustrations, could be demonstrated to have served as reference drawings. If one includes those links that are not as certainly established, the number goes up to fifty-four. Copied elements were found in at least forty-seven of the 137 illustrations, and also for these one comes to a figure of fifty-four when one

[29] The evidence for these figures is documented in the database of the digital edition of the material in Nickelsen & Graßho (2001); each of the copying links can be checked there by comparing the relevant illustrations in detail.

includes the less reliable cases.[30] Not all the species were copied to the same extent. The most frequent copying links occurred within the set of images of the twinflower and the sweet vernal grass, while the images of the coltsfoot were less frequently copied. But even in the latter case, a good quarter of the examined illustrations served as reference drawings, and as many contain copied elements. Copying links, on the whole, are far too common to ignore in any investigation of eighteenth-century botanical illustrations. The practice was not only used in exceptional cases but was regularly applied as a common procedure of the genre.

Interestingly, the number of images that served as reference drawings corresponds exactly to the number of images that contain copied elements. This match may mislead people to assume that copying links worked in a direct 1:1 relationship: that is, each draughtsmen copied elements from only one earlier illustration, which was not used by anyone else. A more thorough analysis, however, proves the opposite. One could list quite a few examples in which an illustration served as a reference drawing for more than one later image. Schreber's representation of the sweet vernal grass, for example, was copied by at least three later draughtsmen. And in several cases draughtsmen used more than one picture as a reference drawing, as I have already shown in the example of Thornton's illustration of the sweet vernal grass. And finally, one should bear in mind that I can only make definite statements on those illustrations that were part of my selection. I cannot make any assumptions as to whether the draughtsmen copied other elements from images that were not examined in this study or whether their images served other unknown draughtsmen as reference drawings. Thus, the number of illustrations that served as reference drawings within the selection and the number of illustrations that contain copied elements are only identical by chance and should not lead anyone to make any rash inferences.

The copying links between the examined illustrations can be illustrated more comprehensively through a graphical representation in the form of tree diagrams for each species of plant (figs. 6.22, p. 218, to 6.27, p. 223). In most cases, a copying link could be safely established as being either a complete or a partial copy; arrows in continuous lines indicate these in the tree diagrams, beginning at the image that served as the reference drawing and pointing towards the image that contains copied elements. Dashed arrows indicate the unproven motive factor cases, while illustrations that served neither as a reference drawing, nor contain copied elements have been accentuated in grey.

The images were labelled with a shorthand expression of the form "Author (Date of Publication)", with no mention of the draughtsmen and engravers involved. This is not to be taken as a depreciation of the draughtsmen's contribution but was merely done for pragmatic reasons, so that all the images

[30] A more detailed discussion of these figures is given in Nickelsen (2000) and Nickelsen & Graßho (2001).

would be uniformly treated: the authors of works can be named without difficulty but one frequently cannot assign a certain illustration to its draughtsman. In some cases, the draughtsmen are not named at all; in other cases one knows of several draughtsmen who were employed to work on a book, but which draughtsman executed which illustration is often hard to tell. Listing the date of publication may also not appear very precise, since it hardly ever coincides with the date of its production. As the discussion of the production of Trew's *Plantae Selectae* in Chapter 2 demonstrated, it could be years before an image was printed. But again, an image's publication can usually be accurately dated, whereas the date of production is frequently far from clear.

6.3.2 Patterns

The copying links are not spread arbitrarily over the image selection. Certain pairs of works can repeatedly be observed, in addition to the specific relationship between Weinmann's two works, the two versions of the *Herbarium Blackwellianum* and between Duhamel's forestry work and Tournefort's illustrations. Sandberger, for example, frequently used Sturm's images as reference drawings, Hayne repeatedly used those of Schkuhr, Zorn copied more than once from Trew, and Thornton from Sowerby. National or regional preferences seem to stand out: both Thornton and Sowerby are from Britain, Hayne and Schkuhr lived and worked in Prussia, Zorn and Trew in Nuremberg and Tournefort and Regnault in Paris. Other examples, however, show that finding a pattern is not that easy: Sandberger never lived near Sturm, the Frenchman Redouté liked to copy from the Swabian Joseph Gaertner, the Swedish botanist Palmstruch copied from Curtis or Sowerby in England, and draughtsmen and botanists from all over Europe referred back to Linnaeus's version for their images of the twinflower.

Nevertheless, it is striking how many of the draughtsmen and botanists chose reference drawings that had been produced fairly closely to their own places of work. One reason for this regional preference was presumably the limited distribution of printed works in the eighteenth century. Selling books abroad or purchasing foreign literature entailed considerable logistical problems as well as additional costs, so that in many cases authors might have been forced to cut down on the number of reference drawings they used.[31] If a draughtsman and botanist had a choice of reference drawings, however, these were critically weighed up against each other. On more than one occasion, details were taken from one source, while the main view of the species was

[31] See, e.g., the correspondence between Trew and Peter Collinson, a wealthy London cloth merchant interested in natural history, well-known as an ardent collector, in which contemporary literature formed one of their most frequently discussed topics. Trew regularly asked Collinson – as well as Ehret – to send him the latest publications from London, which were not available in Nuremberg. See the relevant letters in TRWC; for a complete list of the individual file numbers, see Schmidt-Herrling (1940).

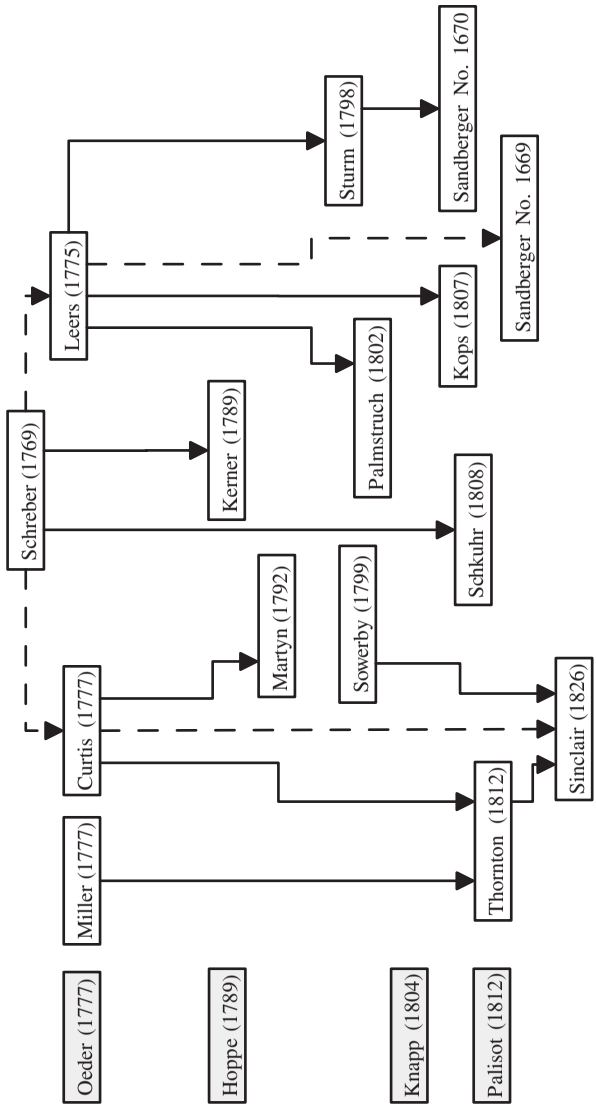

Fig. 6.22. Copying links between the images of the sweet vernal grass.

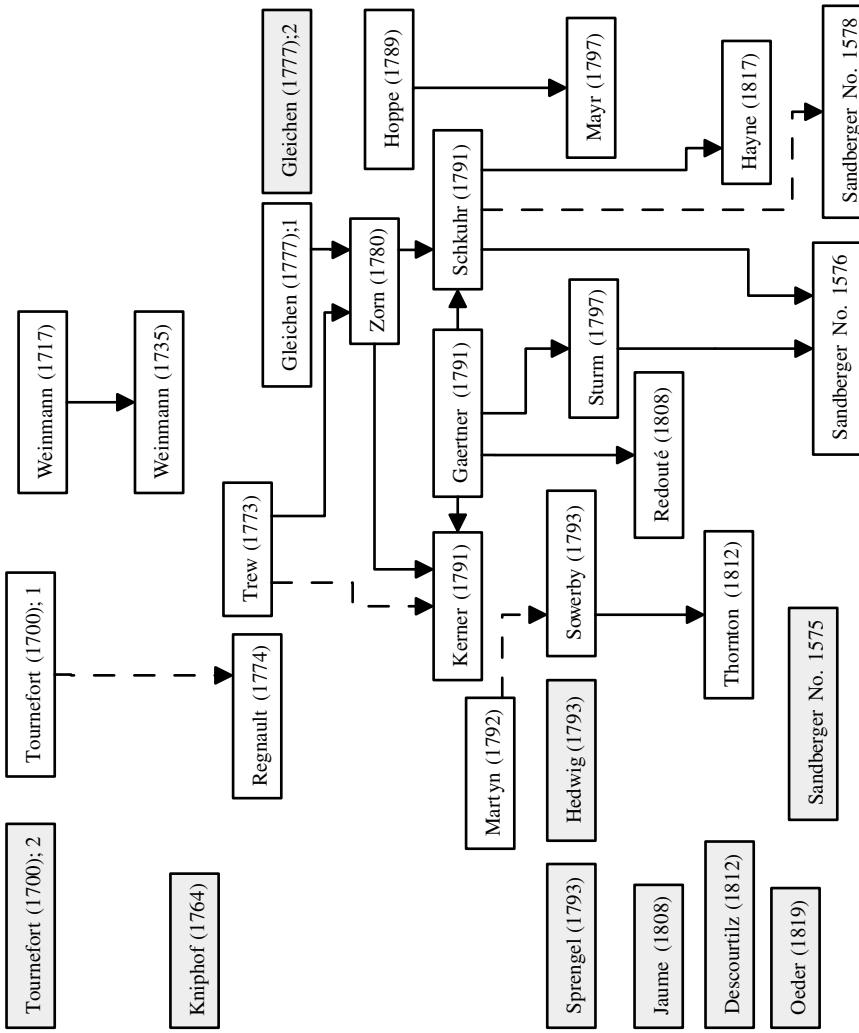

Fig. 6.23. Copying links between the images of the meadow sa ron.

taken from another, even if the former would also have provided information for the main view. Both Thornton's and Sinclair's representations of the sweet vernal grass were designed in this way: Thornton chose Curtis's image as the reference drawing for his individual stalk, whereas he turned to Miller for his details; Sinclair in turn took his grass stalk from Thornton but his details from Sowerby.

Still other cases demonstrate that often one reference drawing was consciously chosen in preference to others. For example, Hayne chose the images by Schkuhr as a reference drawing for his representations of the coltsfoot, the meadow saffron and the beech. For his drawing of the grapevine, however, for which he also could have used Schkuhr's *Handbuch*, Hayne went back to

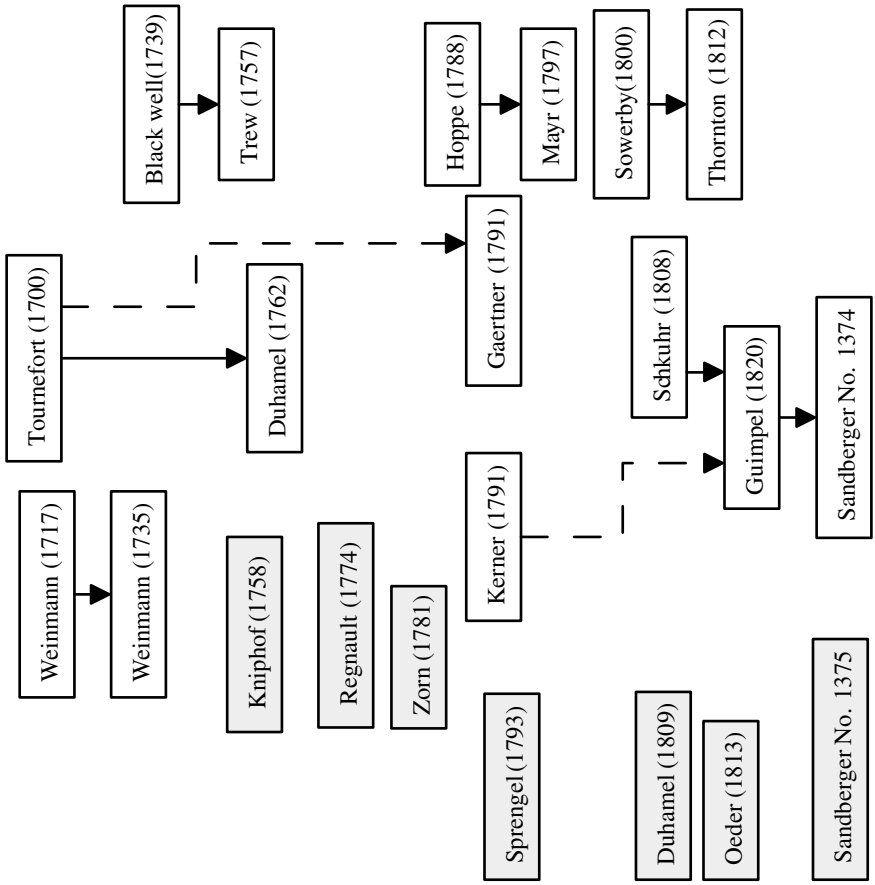

Fig. 6.24. Copying links between the images of the hazel.

the far more sophisticated reference drawing of the *Flora Graeca*, to which he added elements from Duhamel's book on trees and shrubs and from Gaertner's carpology. Since at this time there was no copy of the rare *Flora Graeca* in Berlin, Hayne – or his draughtsman – must even have travelled at least as far as Dresden to find a copy.[32] Similarly, Sandberger copied elements for his representation of the hazel from Kerner's work; for his sweet vernal grass and his coltsfoot, however, Sandberger turned to Sturm's images, although these species were also illustrated in Kerner's work. This again confirms how carefully the reference drawings used for copying were selected and underlines the inaccuracy of the commonly held notion of copying being a thoughtless and uncreative activity. It is also important to note that a work in which

[32] I am grateful to Professor G. Wagenitz (Göttingen) and Professor H. W. Lack (Berlin) for having pointed out this difficulty of Hayne's to me. Lack, who has written an extensive monograph on the history of the *Flora Graeca*, believes that the Dresden copy would have been the nearest available version.

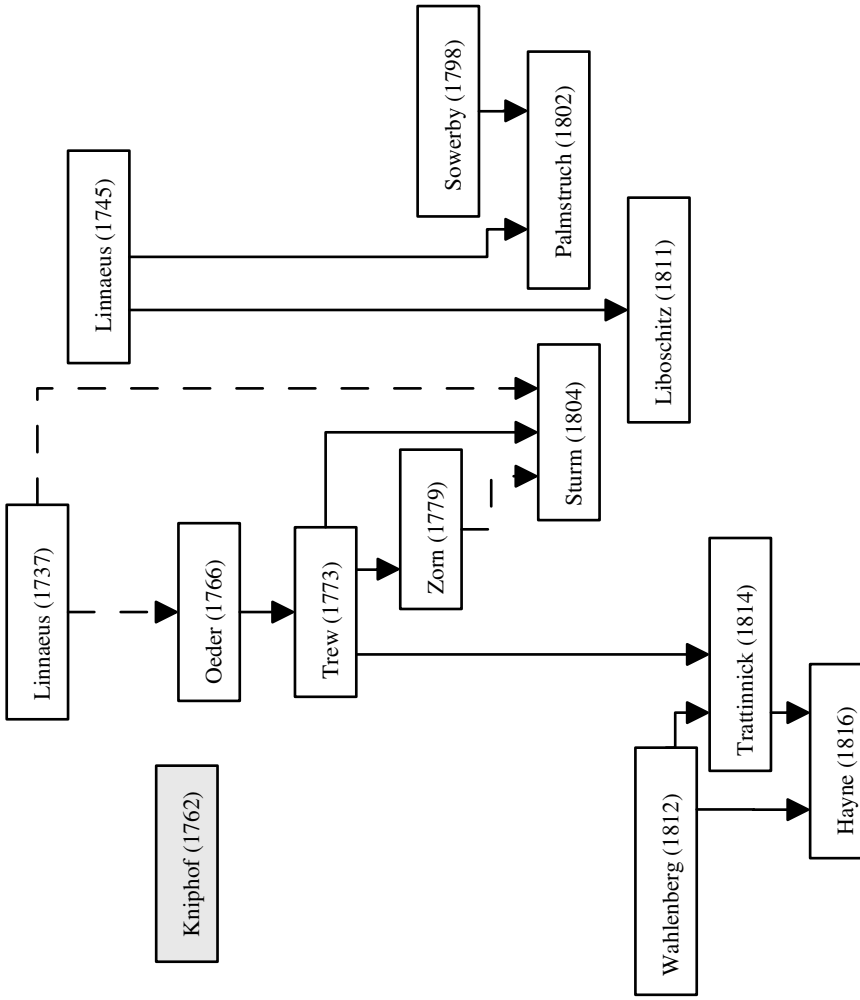

Fig. 6.25. Copying links between the images of the twinflower.

elements have been reproduced from elsewhere does not necessarily diminish its artistic value; even Redouté used Gaertner's earlier image of the meadow saffron as a reference drawing for his more elaborate depiction of the plant for his monograph, the *Liliaceae*, which became an object of national prestige.

For some works a copying link could be established only occasionally. For example, no reference drawings have been identified for the images of Oeder's *Flora Danica*; and the illustrations in this work were, in turn, only used once as a reference drawing for later representations. Likewise, several illustrations by Sturm were included in the selection but only Sturm's illustration of the sweet vernal grass could be shown to contain copied elements. This does not inevitably mean that Oeder and Sturm never used the copying process only

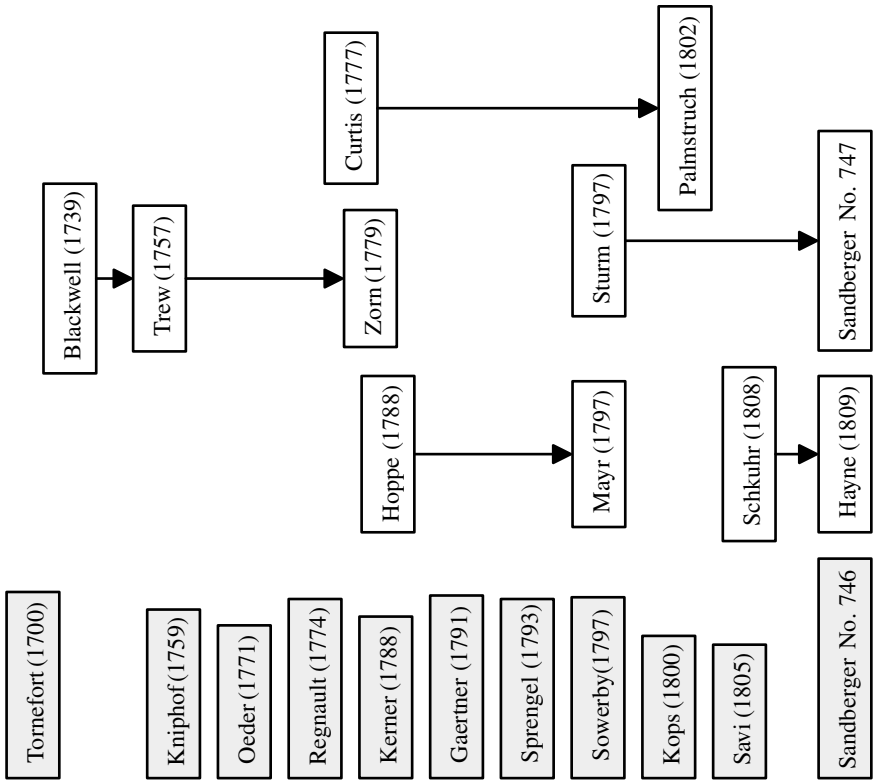

Fig. 6.26. Copying links between the images of the coltsfoot.

that their reference drawings were not among the images selected for this study.

6.3.3 General Findings

Thorough descriptions of the images connected through copying links, of the copied elements and the modifications made have already been given elsewhere and shall not be repeated.[33] However, the results of this detailed analysis can be summarized as follows:

1. Earlier illustrations were a common and frequently used source material in the preparation of new botanical illustrations: about three-quarters of the illustrations within the selection under study are connected with each other by copying links.
2. None of these copies can be described as being mechanical reproductions of a predecessor's work. Only one of the fifty-one works examined contained

[33] See Nickelsen (2000), Chapter V. See also the digital publication of the material in Nickelsen & Graßho (2001).

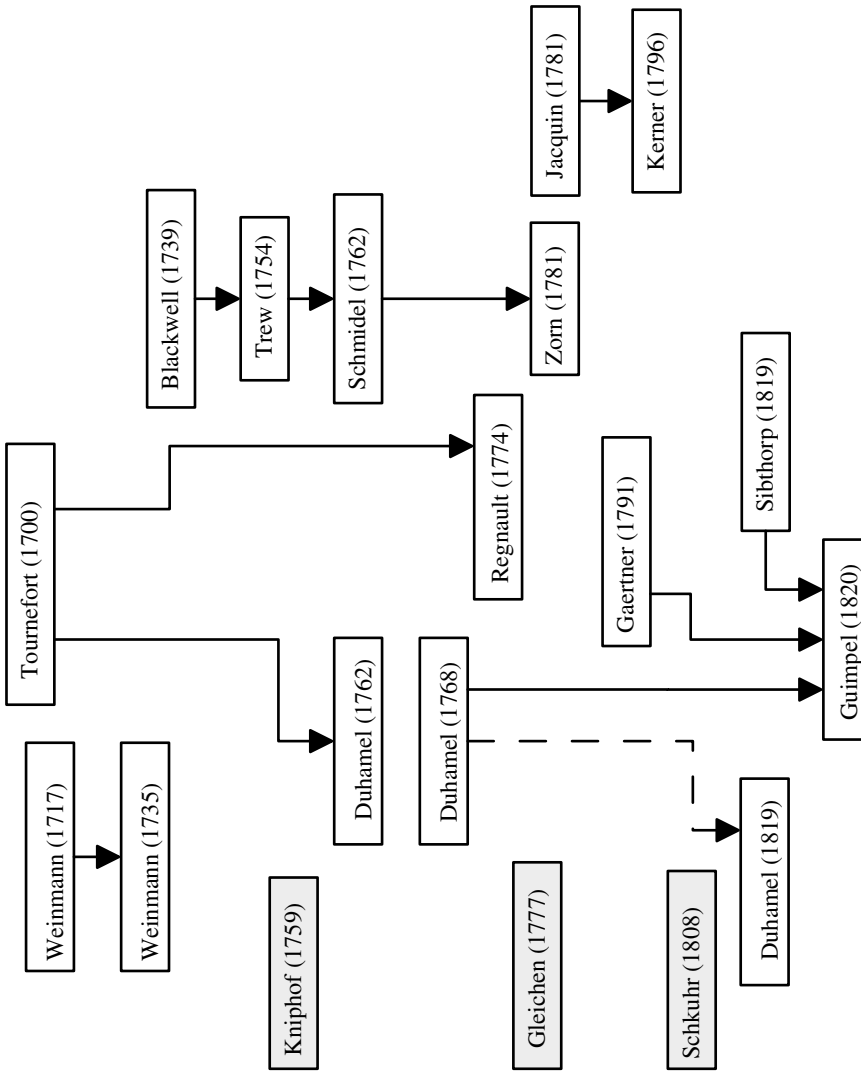

Fig. 6.27. Copying links between the images of the grapevine.

predominantly complete copies, that is, cases in which no modifications had been made. Even in this one case, however, the details that were copied unchanged had been picked out from a larger selection of details of the species.

3. Partial copies are far more common, that is, cases in which certain elements were taken from earlier images and integrated into a new picture. Often, elements from different reference drawings were combined to form a new structure or detail.
4. The information content of partially copied illustrations frequently exceeds the content of the earlier images. Hence, the process of copying was

not only a way of keeping information without losing any relevant details or introducing any errors but was also a strategy that brought with it additional information! The copies should not be described as corrupt or lesser versions of their original reference drawings. Rather, the later draughtsman used earlier images selectively as a basis for making new – and improved – illustrations, according to their own requirements.

5. To this end, the later draughtsmen and botanists modified the elements they had copied using a limited range of constantly recurring patterns. As a result, they came up with a representation that, they believed, better suited their purposes than previous illustrations.
6. The fact that, in almost all cases, the information content of the copy is greater than that of the earlier representation supports the thesis that several sources were consulted for the making of a botanical illustration, presumably also different types of sources, the information of which was collected and united in the new image.

From this perspective, the authors' affirmations of originality quoted at the beginning of section 6.2 appear justifiable: the illustrations published in their works really could be considered to be new, even if they had not been created from scratch but had been partly based on earlier designs. And it is entirely possible that this practice was so common in the period in question that it was not even considered worth mentioning.

6.4 On the Shoulders of Giants

How can the described observations and results be explained? Why was it that botanical draughtsmen of the period examined in this study regularly used earlier works? The first and perhaps most obvious conclusion to be drawn would be that the draughtsmen were not competent enough to draw suitable illustrations themselves and were therefore forced to compensate for their incompetence by referring back to earlier examples. So here he is again, the stupid copyist who knows he cannot do any better and therefore copies a precursor's work. However, this assumption does not seem very plausible when seen against the background of the complex and strictly monitored process of producing the plant images, described in Chapter 2 and elsewhere. The engaged draughtsmen, engravers and, if possible, colourists were selected with the utmost care.[34] In an earlier chapter, it was described how Albrecht von Haller sent his plates to be made in far away Nuremberg rather than entrust them to a local engraver of second choice in Berne, Switzerland, where he would have been able to control the work himself. Scientific illustrations were far too expensive and of far too great importance to leave their production

[34] See the reconstruction of the long-winded negotiations for employing a draughtsman of nature historical objects at the Berlin Academy of Sciences in Nickelsen (2000), pp. 76 .

to dilettantes! Furthermore, the draughtsmen were usually given a thorough introduction to the work being produced by the botanists and every stage in the production process was closely supervised. Of course, it is possible that at times draughtsmen of little talent succeeded in finding themselves jobs, which were consequently poorly executed; however, it is hard to imagine that very many of the plant images of the eighteenth century were made by draughtsmen so incompetent that they could think of nothing better than copying earlier illustrations.

An alternative explanation might be that certain draughtsmen were not able to find suitable living objects as source material for the images, and therefore depended on the information they could glean from earlier illustrations. In this sense, for example, Trew believed he was justified in turning to approved works of the discipline for the illustrations of some foreign plants depicted in the supplement of his *Herbarium Blackwellianum*,[35] including, among others, the twinflower, which he copied from a picture in Oeder's *Flora Danica*. Similarly, when employed to depict a plant imported to England for the first time, which had been in flower but would not develop any fruit, Ehret was said to have copied the fruit from a Chinese drawing. However, the species looked at in this study, with the possible exception of the twinflower, could be found all over Central Europe. Hardly anyone could seriously maintain that the draughtsmen in Britain, France or Germany would have lacked living examples of the sweet vernal grass, the coltsfoot or the grapevine. Therefore, this interpretation applies only to a few individual cases, and does not explain most of the copying links.

The same applies to a third possibility. One can assume that there existed a number of classic illustrated works, whose drawings simply could not be ignored, as, for example, the Linnean authorized representation of the twinflower, which, as Linnaeus's favourite plant, was personally connected with the great botanist. And it may be due to the eminent reputation of Gaertner's carpology as a standard reference work of the discipline that so many draughtsmen referred to his drawing of the meadow saffron's fruit. The other fruits depicted in this work, however, were not copied nearly as frequently, so that this assumption immediately enters shaky territory. Furthermore, it would be hard to ascertain which authoritative sources were used, since draughtsmen did not copy elements from only one particular work but from a range of

[35] "[I should like to add] that I borrowed the drawings of some few foreign [species of plants] that I was unable to get hold of from renowned authors (which will be indicated in the descriptions), and that I gave them their natural colours according to the author's descriptions if they were missing at the cited location." Original German: "[Ich setze dem hinzu], dass ich derselben etliche wenige ausländische [Pflanzenarten], deren selbst ich nicht habhaft werden konnte, von bewährten Schriftstellern (die in den Beschreibungen sollen angezeiget werden) abgezeichnet entlehnet, und derselben natürliche Farbe, wenn solche an allgezeigten Ort fehlet, nach des Schriftstellers Beschreibung vorzustellen besorgt habe." Trew & Blackwell (1750-73), Preface, Vol. 5, no pagination.

broadly scattered examples. Economic reasons also need to be taken into consideration. A draughtsman can produce a copy more quickly and easily, and therefore more cheaply, than a completely new version. Such considerations may have been crucial for those authors who wanted to produce inexpensive works that pharmacists or forest wardens could afford, such as the works by Hayne, Kerner and Schkuhr. The fastest and cheapest method of producing botanical images, however, would have been to make complete copies of easily obtainable earlier examples – but this was not observed at all among the picture selection. If one considers the authors' general way of proceeding, the speed and cost of picture production could not really have been given top priority. The efforts to improve the copied elements, the application of additional source material, the careful selection and combination of motives from different sources to make what was, in effect, a completely new version is at odds with the goal of making a bargain product.

A final alternative for explaining the botanists' and draughtsmen's motivation for the outlined course of action is epistemic. Just as the authors of textbooks and the written descriptions of scientific works, the draughtsmen naturally drew on the knowledge of their predecessors. It makes no sense to ignore established and approved results; a completely new version increases the potential for errors, which could clearly be reduced by focusing on good examples of the past. Earlier images of frequently well-renowned authors and draughtsmen acted as a knowledge base for their successors: a starting point from which improvements and additions could then be made. Take the example of the sweet vernal grass: at first glance, the close network of copying links between images of this species is surprising, since the sweet vernal grass is neither a particularly unusual nor a rare species of plant. There can hardly have been a lack of living (or dried) specimens in North or Central Europe at the time.[36] An interesting observation, however, is that it was mainly the details of the flowers and seeds that were copied. This fact makes the network of copying links a little less astonishing: analysing the spikelets and florets of a grass demands a great deal of manual skill and knowledge – for the actual dissection of the plant and for identifying and interpreting the dissected organs. However, an accurate depiction of the thus dissected spikelets and florets ought to be an integral part of an illustration that is serving as a comprehensive description. Therefore, it is no wonder that draughtsmen referred to the approved references of their predecessors, if only to guide them in their own dissections; indeed, maybe this was the only sensible way to precede. Schreber's monograph on grasses, in particular, was a standard reference work, and for a long period was the only available in-depth monograph on this plant

[36] However, the fact that draughtsmen used earlier pictures as reference drawings for their own illustrations does not imply that they did not consult natural specimens. Most of the illustrations contain elements that were not present in the earlier works, which proves that at least some additional source material was consulted, such as living plants.

family. The book, however, was comparatively rare and expensive, which may explain why many other draughtsmen turned instead to images in the works of Leers or Curtis.

An in-depth discussion of this approach, including an explanation of the modification strategies used, will be presented at the end of Chapter 7. But before that, I should like to point out one further aspect of the copying process that relates to one of the main functions of the images: to achieve maximum communicability through minimal cognitive effort. The draughtsmen and authors were compelled to design their visual language in such a way that their audience would not fail to understand the images. So what could be safer than referring back to the well-established pictorial elements of predecessors to ensure an image's communicability? Applying a visual language, which had already been approved of, not only in principle but also for this specific purpose, would seem to be the best way to prevent misunderstandings occurring. It would also require minimal cognitive effort on the part of the audience, since the visual language was linked with well-known habits of perception and representational conventions. As in other scientific fields, the botanical draughtsmen (and the supervising botanist) were part of a long tradition of already established knowledge. And, as in other disciplines, the cooperative nature of the science shows itself in the plant images in so far as progress was not achieved through radical new beginnings but through the constructive and innovative use of what was already well-known.

It then also becomes clear why certain authors did not refer back to the work of their predecessors. Take, for example, the French botanist Palisot de Beauvois, whose sweet vernal grass is one of the few images of that species that was not involved in any kind of copying link. De Beauvois aspired to nothing less than a sweeping reorganization of the entire grass family, which he held to be classified unsatisfactorily.[37] It is then plausible that someone so dissatisfied with the available results did not use the image of any of his predecessors. The intentions behind the drawing of the meadow saffron by de Beauvois's colleague Descourtilz, to take another example, were also so distinctive that his independent initiative comes as no surprise: he is the only author of the selection who published his image of the meadow saffron in an illustrated account of his travels.[38] In the work he does not include this species for its own sake but only to explain its character as the evil (and poisonous!) sibling of the profitable saffron crocus. This Descourtilz undeniably achieved: the black and ragged sheath around his meadow saffron flower arouses almost dragon-like, malicious associations. Here, too, one finds no earlier example in the selection to which Descourtilz could have turned.

[37] See Palisot de Beauvois (1812), Preface. In none of the other works in the selection did the botanists try to introduce a new method of classification or to reorganize a taxon. Thus, it is impossible to prove whether such a goal can also be linked to new types of representation in other cases.

[38] Descourtilz (1809).

On the whole, in view of the findings of this chapter, the relationship between applying copying links and producing original versions seems to have turned on its head. It rather seems to have been the rule that draughtsmen worked from earlier illustrations, re-using the content and the approved visual language in their own images, and that only in exceptional cases were images created autonomously, with no borrowing of elements from established predecessors. The plant images of the eighteenth century were, so to speak, created "on the shoulders of giants",[39] that is, within the context of innumerable predecessors and contemporaries to whose achievements they were willingly linked. How the modifications carried out fit into this approach and why they provide an insight into the working practices of eighteenth-century draughtsmen and botanists shall be examined in the next chapter.

[39] For a knowledgeable and amusing history of this quote, see Merton (1965) and later editions.

7

The Construction of Botanical Illustrations

7.1 Modifying the Copied Elements

Let me briefly recall the types of modification strategies mentioned so far. The copyists frequently supplemented their images with new elements, a practice that can be seen, for example, in the copying link between the sweet vernal grass images by Johann Daniel Leers and Jakob Sturm: for his details of the florets and the glumes, Sturm closely followed Leers's version. However, Sturm supplemented his image by adding a view of the grass's general habit not present in Leers's image (fig. 6.1, p. 186) as well as two details of the caryopsis. Similarly, Johann Simon Kerner added a slight indumentum to the culm that he had copied from Johann Christian Daniel Schreber's image of the sweet vernal grass. The numerous omissions in the partial copies can also be identified as a type of modification strategy. In his version of the partially copied sweet vernal grass, for example, Johann Philipp Sandberger omitted Sturm's inflorescence and most of the details (fig. 6.3, p. 189). Not an omission in the narrow sense but a reduction of the original motive can be observed in Thomas Martyn's illustration of the sweet vernal grass: he greatly reduced the scale of the general view of William Curtis's grass and used only a single culm with inflorescence as his main view (fig. 6.6, p. 192 and fig. 6.8, p. 195). In his image of the sweet vernal grass, Robert Thornton both supplemented and reduced the elements he copied: he took over single elements and parts of elements from the images by John Miller and Curtis but supplemented them by inserting several new details (fig. 6.7, p. 193 and fig. 6.5, p. 191). Consequently, Thornton's image has a higher information density than the work of his predecessor, which can be described as another type of modification strategy that is typical of partially copied images.

Furthermore, the later illustrations were not, as one might have expected, usually any more naturalistic in design than the earlier ones. On the contrary, the subject matter was frequently simplified – sometimes considerably more so. Only after repeatedly scrutinizing the images does one notice the copying link between the rather simplistic illustrations of the sweet vernal grass by

Kerner and Christian Schkuhr and the naturalistic earlier image by Schreber, although on the whole only slight amendments were made to the later versions. The sweet vernal grass nevertheless appears so much more schematized in the new images that one can hardly recognize the plant (fig. 6.13, p. 201): numerous details have been omitted, others exaggerated. In other examples, the opposite can be observed (that is, a simplified element of an earlier image is reworked in greater detail in the partial copy). This is the case, for instance, with Johann Wilhelm Weinmann's images of the hazel. The earlier illustration of the hazel in Weinmann's *Herbarium Pictum* was already so simplistically drawn that the draughtsman working on the later *Phytanthoza Iconographia* apparently felt obliged to make the copy more naturalistic. Also, one certainly could not claim that Pierre Joseph Redouté's depiction of the meadow saffron, for which he copied Gaertner's fruit, was more simplistic than its reference drawing. Simplifying copied elements was not, it seems, applied as a general rule but only in certain instances. Connected with this increasing simplification of the partially copied elements is the functional use of colour that can at times be observed, as, for instance, in Schkuhr's details of the sweet vernal grass. Not only has he simplified the details that he took from Schreber's illustration, he has also hand-coloured them – the effect of colouring was briefly looked at in Chapter 5: Schkuhr's differently coloured glumes and flower organs can be far more easily distinguished than the organs of Schreber's delicate sketch. The colours of the individual florets and glumes in the general view of the complete inflorescence are the same as in the details, so that here, too, the different components of the organs can be more easily identified.

It was perhaps not by chance that this functional use of colouring was applied to the details, which were frequently given greater emphasis in the partially copied versions, either through the addition of certain elements, through being hand-coloured or simply by being shown on a larger scale, as can be seen, for example, in Thornton's image in comparison with the earlier ones by Curtis and Miller (fig. 6.7, p. 193 and fig. 6.5, p. 191). As a final modification strategy, several kinds of corrections should be mentioned.[1] Sandberger, for example, changed Sturm's sweet vernal grass by fusing the edges of the flag leaf into a sheath (fig. 6.18, p. 210); and Palmstruch was apparently so dissatisfied with the creeping rhizome of the coltsfoot in the image by Curtis, which he used as a reference drawing, that in his own illustration he changed the rhizome into a vertical taproot (far from improving the image, he thus introduced a false piece of information, albeit presumably well-intentioned).

In their modifications, these examples are representative of the illustrations in the sample analysed in this study. Partially copied elements were

[1] I shall like to emphasis that that this notion of "correction" does not presuppose the existence of a fundamental and objective truth but only the actors' desire to adapt their images to what they themselves thought to be true (which could disagree).

systematically modified as they were integrated into the new images, following a limited range of constantly recurring patterns. The strategies mentioned so far are:

1. The supplementation of details: individual organs, parts of organs, detailed views or additional stages of development.
2. The omission of repeated elements or elements that were judged to be irrelevant for other reasons.
3. Increasing information density – mostly, although not necessarily, a result of the combination of supplementation and omission modifications.
4. The simplification of the design, which, however, does not necessarily imply less detailed information. (In cases of an already rather schematized example, the copied element might, on the contrary, be reworked in greater detail.)
5. The functional use of colouring, for example, to emphasize particularly relevant features or to structure the image.
6. Attaching greater importance to greatly enlarged details.
7. The correcting of the content.

In view of these modifications, it seems not far-fetched to assume that the draughtsmen and botanists were not only concerned with producing a good image; they wanted to "improve" the illustrations of their predecessors, in the largest sense of the word. Had they been satisfied with the images that existed, they could have simply copied them without making any amendments; but this was not the case. If one takes the modifications to reveal the result of actions the question arises which intentions were behind them. I want to suggest that the modifications carried out by botanists and draughtsmen were motivated by the desire to adapt their images to a set of construction criteria. Thus, a close analysis of the actions themselves could serve as a starting point for reconstructing the criteria themselves.

A list of these criteria would provide a completely new insight into the practices of making botanical illustrations in the eighteenth century. However, it is not immediately obvious how one should go about compiling such a list. Defining these criteria according to today's standards would be anachronistic; from a twenty-first century perspective, for example, the naturalistic hand-colouring of the images would seem to be an important aspect of judging the quality of a botanical illustration. But, as I demonstrated earlier, this was not always the case in the eighteenth century. Historical documents do not provide much evidence for the criteria in question, either. I have already discussed some sources in which the authors mentioned standards and criteria that were used in the making of their images. However, these sources are scarce and of limited value: the criteria described in the prefaces to illustrated works or in correspondence do not necessarily match the criteria used in practice. Therefore, in order to be able to compile a list of these criteria, one has to start with an analysis of the players' actions.

The cases that would suit this analysis best would be those in which the individual images of the players were connected to each other, weighed up against each other and judged, even it if was not explicitly stated which criteria were used. In the case of botanical illustrations, the copying links offer situations of exactly this kind: draughtsman and botanist chose one or more existing illustrations as reference drawings and copied a selection of elements, which were then integrated into their own images in a modified form. The examples discussed in this book demonstrate that these modifications cannot be seen as unintentional errors due to careless copying. No draughtsman would unintentionally simplify or enhance a copied element in his own version.[2] Assuming that these processes were guided by conscious decisions, which were made under the premise of producing an image that would satisfy certain standards, an analysis of these modifications should offer an exceptionally instructive approach for reconstructing the guiding principles. A detailed analysis of the process of partial copying might give historians an indication of the botanists' intentions and of the criteria that the result was meant to meet. Although this approach is fallible – as is every interpretation of a historical source – it is probably the best option available. Even if one were to find a detailed written account of how a botanist believed an illustration should be designed, the explicitly formulated criteria would still need to be cross-checked against the actual illustrations and their design. Analysing individual illustrations one after the other would not suffice, either; starting from a single image one could ascribe to the draughtsman and botanist a number of arbitrary construction criteria without being in a position to double-check the assumptions. Only the copying links can provide the clues as to why the players believed that the earlier works needed to be changed and how and why they constructed their own – improved – images. Thus, what remains to be done is to analyse thoroughly the copying links and the modifications carried out to the copied elements. Starting from the list of modifications that has already been provided in this chapter I shall reconstruct a set of criteria that should explain the different types of modifications used.

7.2 Construction Criteria

The modification strategies discussed so far concerned different aspects of an illustration. In many cases, they were intended to change the illustration's content: these include the aforementioned corrections and also some of the supplementations and omissions. Some modifications, however, concerned mainly the image's pictorial design – such as using colour functionally, simplifying certain elements or similar changes that did not alter the content of an image.

[2] For a method that was specifically developed to di erentiate between intentional and unintentional alterations in (comparatively simple) copying processes between diagrams of the Middle Ages, see Liess (2000), pp. 77 ., or for a more detailed discussion Liess (2002), Chapter V, pp. 139 .

These could also include cases of supplementation and omission. The making of corrections to an image is the strategy that can most easily be explained, since the very term "correction" implies a specific interpretation: the copyists, presumably, changed certain elements to ensure the correctness of an image. But which of the actual modifications can be taken to be corrections is not always that easy to establish, as I shall demonstrate. Identifying similar construction criteria as driving forces of the remaining modification strategies is more difficult. In the following discussion, these modifications are interpreted as arising from the desire to adapt an image's "appropriateness" to a specific context, which either concerns an image's information content or its design. However, I shall start with a closer analysis of the criterion of correctness.

7.2.1 Correctness

Many examples prove that eighteenth-century botanists attached the greatest of importance to the correctness of an illustration: not only are there many modifications that can be interpreted as being corrections of previously made mistakes, one finds a number of explicit remarks made by botanists, some of which have already been quoted, which reveal this preoccupation. The usual standard against which the content of an illustration would be considered "correct" were the accepted descriptions of the species in question, for example, as done by Linnaeus; however, there is no need to assume one common standard for all botanists against which they evaluated an image's correctness. People continuously disagreed on these questions and this disagreement is reflected in the continuous modification of the images. In many cases, the botanist, like Trew, managed to spot the error at one of the many proof-reading stages. On other occasions, it was the copyists who uncovered details in their predecessors' images with which they did not agree and which they then corrected in their own illustrations.

Examples of Corrections

A correction, as the term is used here, should be understood to be a modification of a partially copied element that results in a change of information but without the removal or addition of any other elements. Such a change was presumably motivated by the copyist's wish to represent the content more correctly than his predecessor. As this rather vague description implies, in practice a correction is not always easy to distinguish from an omission or supplementation done for another reason. Take, for example, the insertion of a leaf's sheath in the representation of the sweet vernal grass by Sandberger (fig. 6.18, p. 210): is this modification a correction of the copied element or has new information been added to the image? In this particular case, I would argue in favour of classifying this modification as a correction. One can only understand Sandberger's modification as being a supplementation if one assumes that the earlier botanist, Sturm, from whom Sandberger was copying,

Fig. 7.1. Grapevine – *Vitis vinifera* L. Sibthorp & Smith (*Flora Graeca*, Vol. 3, 1819). A single asterisk (*) marks the point from where the twice-splitting tendril arises; *1 and *2 mark the two points at which the division occurs.

had not transmitted any information on this particular detail, that is, the structures of the leaf and stalk of a grass had not concerned him. However, if one assumes that Sturm did indeed transmit some information on this detail – that is, information on a leaf that has no sheath – Sandberger's change should be taken to be a correction. I shall now examine a few more cases to help clarify this concept of correcting partially copied elements.

The most convincing examples are those in which an element of the earlier image was copied almost exactly except for a minor, inconspicuous detail that was deliberately drawn in a different way. These changes cannot be explained on the grounds of space restrictions, aesthetics, or other practical concerns, so there is good reason to assume epistemic motives. A good example of this kind can be seen in the copying link between the grapevine image by Friedrich Gottlob Hayne (fig. 7.2, p. 236) and the earlier image of the same species published in John Sibthorp's *Flora Graeca* (fig. 7.1, p. 234). At first glance, one would not think that Hayne had copied from the earlier work – looking at it again, though, one cannot fail to acknowledge this fact. Hayne's image is certainly not as subtle as Sibthorp's more sophisticated version. The colours of the copy are far bolder and simpler; and where Sibthorp has indicated a fine indumentum, Hayne's draughtsman has drawn robust bristles that not even a layman would fail to notice. Some details have been omitted in Hayne's image or only taken over half-heartedly, as for example, Sibthorp's skilful suggestion of the spatial orientation of the nodes or the small pherophylls in the inflorescence. However, for the moment I shall concentrate on a detail of the tendrils, which features extensively in both images.

Sibthorp's image clearly shows how these tendrils arise from the nodes of the axis and how they coil around each other and the stems. He has also demonstrated how the tendrils divide into points, which is a typical feature of the grapevine and was frequently depicted in other images of the examined selection. However, if one takes a closer look at the tendril that has been marked with an asterisk (*) in figure 7.1, one notices a peculiar variation: the tendril splits not once but twice (marked with *1 and *2). This unusual detail is not shown in Hayne's version. If one finds the corresponding tendril – in figure 7.2 also marked with an asterisk – one realizes that the third point of the lower tendril is missing, that is, the one point that in Sibthorp's version coils around the petiole of the youngest leaf after the tendril has divided a second time. The two sections are shown again in an enlarged view in figure 7.3 (p. 237). Hayne has depicted the tendril dividing only once (marked with *1) and has omitted the second time it occurs. However, Hayne copied exactly all the other windings and curls of Sibthorp's image. This indicates that Hayne deliberately chose not to include this second splitting of the tendril, which cannot be explained by a lack of space or carelessness on the part of the draughtsman. Rather, it should be seen to be a correction. Sibthorp's image supports the hypothesis that tendrils of the grapevine divide twice – not all the tendrils but a sufficient number of them to suggest that it should be seen as a typical feature worth entering into a general description. Hayne, however,

left out this feature, which indicates that he was not convinced that it should be included in a model of the species. Perhaps he was unable to confirm that it occurred in nature or it appeared in so few instances that he decided to omit it.[3]

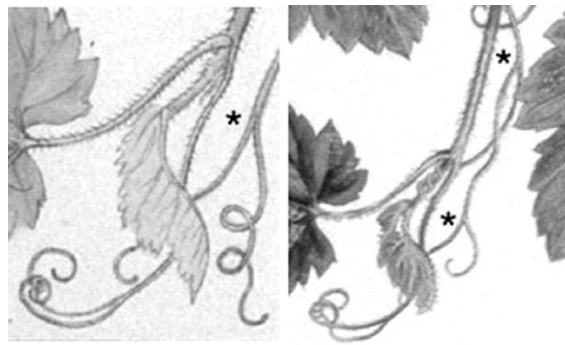

Fig. 7.3. Hayne's correction of Sibthorp's grapevine tendril. Left, Hayne's corrected version; right, Sibthorp's earlier image with the twice-splitting tendril.

A similarly subtle correction can be found among certain representations of the twinflower. For his version of the twinflower published in the *Herbarium Blackwellianum* (fig. 7.5, p. 238), Trew adhered very closely to the slightly earlier image published in Georg Christian Oeder's *Flora Danica* (fig. 7.4, p. 238). Trew had almost every shoot and leaflet copied unaltered; only at the sixth shoot counting from the root has a single pair of leaves been left out, the position marked in the figures with an asterisk. This difference between the two images can be observed more clearly in the close-ups in figure 7.6 (p. 239), where the two versions have been placed side by side. It is always possible that Trew omitted this pair of leaves inadvertently, indifferent to the fact that his image had either slightly fewer or slightly more leaves than the original. However, all the other leaves were meticulously copied, not only in number but also in orientation and size. If one takes a closer look at the pair of leaves in Oeder's image, one notices that the leaves are considerably smaller and narrower in shape than all the others. Whether Oeder included leaves of a different shape in order to demonstrate a morphological variant of the twinflower's leaves or whether the narrowness is only due to an unusual perspective is unclear. Trew, however, had all the other leaves of the reference drawing copied as closely to the original as possible. These observations

[3] It is uncertain on which basis Hayne made this decision. Many cultivars of the grapevine have tendrils that divide twice or even several times. However, it is not recorded in standard references whether the wild variety of the grapevine also divides in this way.

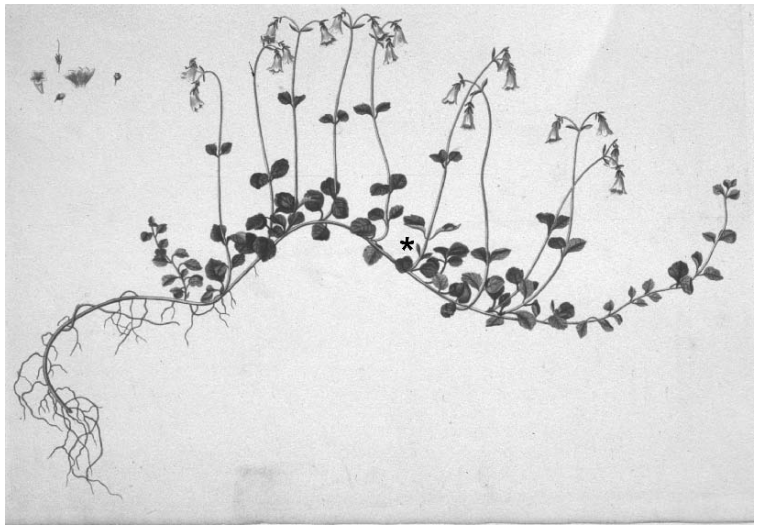

Fig. 7.4. Twinflower – *Linnaea borealis* L. Oeder (*Flora Danica*, Vol. 1, 1766). Immediately to the right of the asterisk (*) is a tiny, narrow pair of leaves unlike the others in the illustration.

Fig. 7.5. Twinflower – *Linnaea borealis* L. Trew & Blackwell (*Herbarium Blackwellianum*, Vol. 6, 1773). If one looks to the right of the asterisk (*), one can see that Oeder's oddly shaped leaves have been omitted.

Fig. 7.6. Close-up views of the two images of the twinflower by Trew and Oeder. On the left, Oeder's earlier version; on the right, Trew's later corrected version.

indicate that Trew omitted these leaves intentionally, in order to avoid including this unusual element which he, presumably, judged to be potentially false.

Another type of correction can be found in the copying link between the grapevine images by Nikolaus Joseph Jacquin (fig. 7.7, p. 240) and Kerner (fig. 7.8, p. 241). Although there is much to say about this link in general, I shall focus for the moment on the bunches of grapes in the two drawings. In Jacquin's version, the grapes are small, few in number and bluish-black in colour, which is typical of the wild variety of the grapevine. Strangely, the grapes do not hang down, as one would expect but point upwards. The leaves of the lower branch also seem to be growing unnaturally. Jacquin's image is wrong here: turned the other way round, the detail would make far more sense. It is possible that the engraver made an error at this stage: the two parts of the image, that is, the upper flowering branch and the lower fruit-bearing branch, could have been drawn on separate sheets of paper and when transferred to the copperplate, Jacquin's smaller drawing placed the wrong way round. Alternatively, the printer could have been responsible for the mistake: if the two parts of the images had been engraved on separate copperplates, it is easy to imagine that one of them could have been placed the wrong way round – such things happened in workshops all the time. Only in this case it went unnoticed by the botanist. If one compares Kerner's image with Jacquin's earlier representation of the grapevine, the copying link is not immediately obvious, just as with Sibthorp's and Hayne's images. That it takes some time before one realizes that a copying link exists is partly due to the fact that Kerner has turned the branch with grapes round and thereby corrected the error of the earlier image. In Kerner's picture the leaf of the fruit-bearing branch is reaching upwards and the bunch of grapes is hanging down, according to the laws of gravity. This correction concerns less an incorrect piece of information in the content of the earlier illustration than a mistake committed during the technical production of the image.

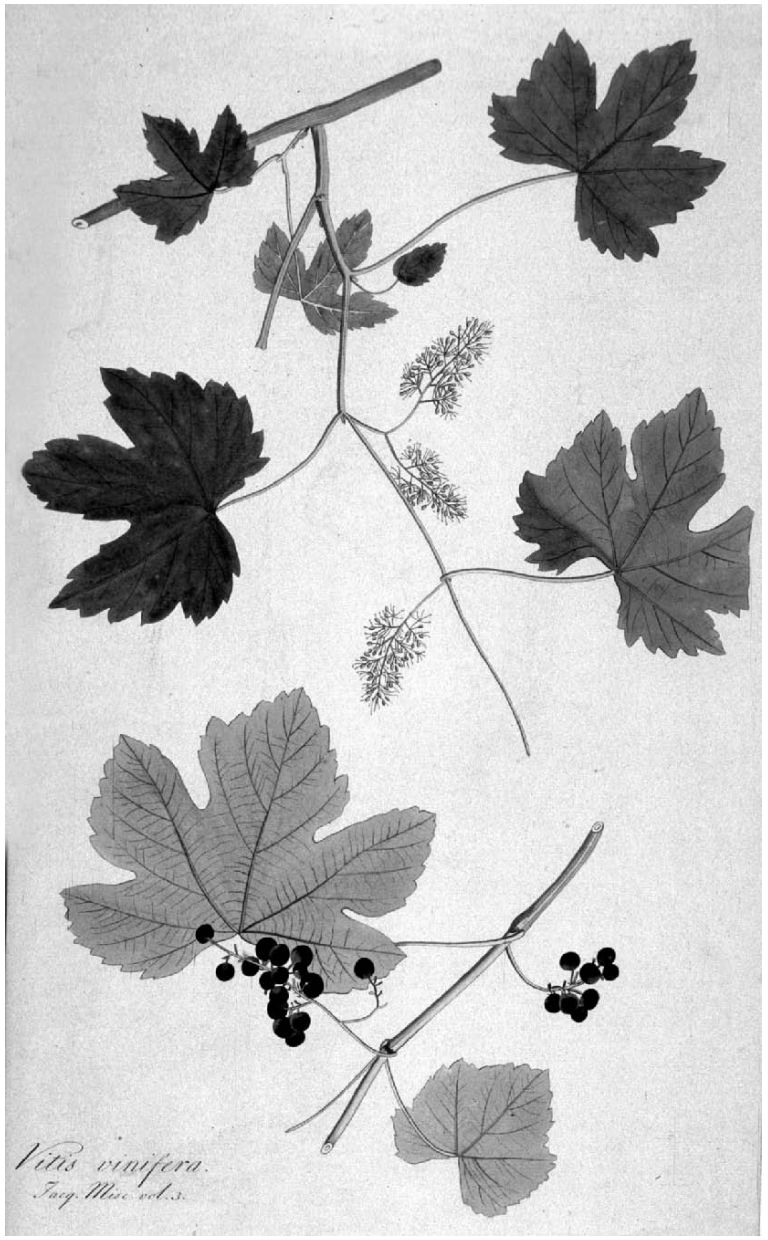

Fig. 7.7. Grapevine – *Vitis vinifera* L. Jacquin (*Icones Plantarum Rariorum*, Vol. 1, 1781).

Fig. 7.8. Grapevine – *Vitis vinifera* L. Kerner (*Abbildungen oekonomischer Pflanzen*, Vol. 8, 1796).

Although these and other corrections made to the copied elements of earlier images were presumably carried out with the best of intentions, they were not necessarily always successful. Palmstruch, for example, changed the creeping rhizome of Curtis's coltsfoot into a vertical taproot in his partial copy; Trew also made this correction in his partially copied version of Elizabeth Blackwell's coltsfoot (fig. 7.9, p. 242).[4] Both Palmstruch and Trew probably believed that they were correcting a mistake in the original and were thereby improving their own illustrations in terms of their correctness. Unfortunately, the contrary was the case.

Fig. 7.9. Introduction of a mistake by an incorrect modification of the coltsfoot's root. On the left, the correctly drawn creeping rhizome from Blackwell (*A Curious Herbal*, Vol. 1, 1737); on the right, the incorrectly changed taproot in Trew & Blackwell (*Herbarium Blackwellianum*, Vol. 2, 1754).

Correctness as a Construction Criterion

Against the background of these examples, I shall now try to summarize what the criterion of correctness entailed. First and foremost, assessing an image's correctness was based on judging the propositional information of its content: an image was correct if the depicted propositions were true. Hayne did not omit Sibthorp's twice-splitting grapevine tendril because he found it unattractive. Judging the correctness of the models depicted in botanical illustrations is not an easy task: the models contain general propositions that cannot be assessed by simply examining one individual object – more comprehensive studies are required; and even then, one presumably will find that the model's propositions are true in some respects and false in others. Furthermore, the relation between the model and real objects is only one dimension through which the correctness of a model representation can be assessed. The relation

[4] Images taken from Blackwell (1737-39) and Trew & Blackwell (1750-73).

of a model to its underlying theories also has to be taken into account. The criterion of correctness in its wider sense, that is, if used for judging model representations, should include both dimensions.

True and False Models

Whether a model is true – correct – in view of its relation to its underlying theories is comparatively easy to determine: a model's propositions are true relative to a theory if they do not contradict any of the theory's principles, rules or definitions. The model itself is true if all its propositions are true. Models are false relative to a theory if one or more of its propositions contradict the theory's principles, rules or definitions. The relevant representation should be assessed accordingly. Qualifying a model's truth or falsity as being relative to a certain theory is an important limitation; relative to an alternative theory, the model could be true. Given the natural laws on earth concerning energy conservation, entropy, mechanical processes and so on, any model of a *perpetuum mobile* must, by definition, be false, since it contradicts the fundamental principles of these theories. Given an alternative set of laws and a different theory, the model could be true. Whether this new set of laws is true or not is a different matter. Along these lines, an eighteenth-century model of a plant species would be false if it contradicted the principles of Linnean taxonomy and terminology or of any other fundamental principles of botany in use at that time. Such a model would be wrong if, for example, it contained a proposition saying that the stamens of a species arise from the roots of plants and produce fruits and seeds, since stamens were defined by Carl Linnaeus as pollen-bearing organs of the flower.[5] No false model representations in this sense were found in the selection of images under study; such blatant mistakes were doubtless prevented from getting through early on in the working process. Hayne's correction of the tendril should rather be interpreted in another way: the botanists was less concerned with contradicting theoretical principles but wanted to make sure that the content of their images communicated propositions that were true with regard to the desired instances. This concern does not come within the sphere of a model's truth in the strict sense but in the domain of the model's applicability.

Applicable and Non-Applicable Models

Relative to the model's instances, the categories "true" and "false" are not really suited to assessing a model. The hypotheses to be derived from a model on the properties of a species of plant can be assessed by examining a specimen of the species: if the specimen has the described property, the hypothesis is right; if not, the hypothesis is false. But a false hypothesis should not lead one to the conclusion that the whole model must be wrong. If one compares

[5] See Linnaeus (1751), paragraph 88.

the hypotheses that can be derived from Sibthorp's representation of a model with the properties of an actual grapevine, many of the hypotheses will prove to be false; nevertheless, this illustration was highly regarded. This may appear paradoxical, until one takes into account some of the typical properties ascribed to scientific models in Chapter 3: Models contain simplified not exact propositions on the properties of their instances; they contain many propositions that cannot be found in the same combination in any single instance; and finally they support the derivation of hypotheses that are irrelevant for the purpose of the model. Construction assumptions as well as the condition of approximation are always to be taken into account when judging a model in relation to its instances – but as soon as one does this, the attributes true and false no longer make sense. A better suited category of assessment, therefore, is the criterion of applicability: if a model supports the derivation of hypotheses that correctly describe certain properties of the model's instances, one may call the model applicable with regard to this hypothesis. If hypothesis and empirical data differ, the hypothesis is false and the model is not applicable in this respect. If one went into a vineyard and examined whether tendrils divide only once or more often, one could assess whether the models by Sibthorp and Hayne were applicable in this respect or not.

However, it was not a matter of individual choice relative to which hypotheses a model should be applicable and which were of minor importance. No model could evade certain silent expectations, which in the eighteenth century were mostly based on Linnean definitions and principles. To the negligible group of hypotheses belonged statements on, for example, the absolute number of flowers and leaves, the size of the plant and its luxuriance, and so on. A model's non-applicability in these respects was not only accepted but even expected. Statements on the morphology of a species' tendrils, on the other hand, belonged to the essential information of a Linnean model. An illustration that ignored these standards would, therefore, have to be rejected – like, for example, the image by Chomel that lead Haller to the wrong conclusion that he had found a new species (see quote p. 124).

7.2.2 Appropriateness

However, the changes made with regard to an image's correctness make up only a small part of the modifications carried out in copying links. There are numerous other changes that cannot be described as corrections but must have been done for other reasons. At the beginning of this section 7.2, such modifications were considered to be changes that were carried out to meet the criterion of appropriateness (see the short introduction on p. 233). In the discussion below, I shall try to explain this criterion in greater detail, among other things by dividing it into sub-criteria concerning either an image's content or its representation.

The Appropriate Content

Supplementing the information content of the earlier image was the most frequent type of modification applied to the illustrations in this study. These modifications are particularly interesting as they provide evidence that the copyist must have used at least one other source of information when drawing the image, such as personal observations of fresh or dried plants, the technical literature, or another illustration. Thus, these modifications again prove the complexity of the manufacturing process as described in Chapter 2. In many ways, this procedure resembles Linnaeus's concept of "collating species", which Staffan Müller-Wille identified in his book on Linnaeus as the central process of describing and defining species. In doing so, the botanist was required to collect the defining properties of the species from a number of different sources.[6] Putting together a botanical illustration that would be used to represent the description of a species involved a similar process of collation.

At times, the copyists' supplementations were very obvious. Take, for example, Hayne's image of the grapevine and Sibthorp's earlier version for the *Flora Graeca*: Hayne has clearly copied Sibthorp's main view but has added a number of new details, among these a bunch of ripe grapes (fig. 7.11, p. 246) and new details of the fruit and seeds (fig. 7.10, p. 245). It seems that Sibthorp considered that the information provided by these elements was unnecessary,

Fig. 7.10. Grapevine – *Vitis vinifera* L. On the left, the image by Hayne, the new details marked with asterisks; on the right, Sibthorp's image for comparison. Hayne (*Getreue Darstellung der Gewächse*, Vol. 10, 1827), Sibthorp & Smith (*Flora Graeca*, Vol. 3, 1819).

[6] Müller-Wille (1999), pp. 167 .

Fig. 7.11. Grapevine – *Vitis vinifera* L. On the left, the image by Hayne to which an additional view of a ripe bunch of grapes has been added, marked here with an asterisk; on the right, Sibthorp's image with no grapes.

while Hayne found them relevant. In addition, Hayne has also made some subtle additions to inconspicuous details. He has, for example, added extra details that are not immediately obvious, as, for example, a view of the cross-section of the grapevine's stem. Other examples of supplementations were mentioned at the beginning of the chapter in the discussion on the illustrations of the sweet vernal grass (see p. 229).

Besides supplementations, the strategy of omitting certain pieces of information was also very common. It is not always clear why particular details were left out. I have already described one type of omission: corrections motivated by the criterion of correctness, which consisted of omitting elements that supported the derivation of doubtful or incorrect hypotheses on the depicted model's instances. However, there are other cases in which correct details, probably judged irrelevant by the later draughtsmen and botanists, were left out. Distinguishing between these two types of omissions is admittedly not easy – and becomes even more complicated if one takes into account yet another type of omission, which has, as objective, improving the image's economy of design (see p. 247). Although the operation as such is the same, the alleged motivation behind the omissions differs considerably.

By omitting irrelevant pieces of information, a complex model of a species that included statements on a variety of properties could be reduced to a more simple form with a minimum of information. Take, for example, the grapevine images by Jacquin and Kerner, mentioned earlier in another context (fig. 7.7, p. 240 and fig. 7.8, p. 241). Jacquin has presented an exceptionally

comprehensive version of the grapevine. He has shown the stems and leaves not only in different stages of development but also in slightly varied morphologies. One sees variations of the inflorescence, the bunch of grapes as well as the plant's mode of ramification. On closer inspection, very few pieces of information are actually redundant, that is, repeated unaltered; Jacquin always presents his onlookers with a slightly different version of the leaf or the node. Kerner, by contrast, has focused on giving only a minimum of essential information. He has limited his image to two short segments of grapevine stems, bearing only one leaf per stage of development, only one tendril and one inflorescence. The main features of the grapevine are very alike but Jacquin's model offers considerably more information. For example, his model supports hypotheses on the anatomy of the wood, he shows that two inflorescences can grow from one and the same stalk, and so forth. These are correct and interesting pieces of information that Kerner chose to omit.

Thus, the optimal information content of an illustration did not always imply including as much information as possible, as one might have expected, but only as much as was deemed necessary. If a relevant piece of information was lacking in the model, these elements were then added to the copy; if the earlier version contained superfluous information, it was omitted. Kerner was working for an audience that was primarily interested in the basic characteristics of a species; his work was comparatively small in format and so relatively inexpensive. By contrast, Jacquin worked in the large (and so more expensive) folio format; his audience was interested in details and presumably appreciated information on morphological variants – and was ready to pay for it.[7] This suggests that an image's appropriateness played an important part in decisions concerning its content – that is, the image had to suit specific uses, purposes and demands. The content of an illustration would have been appropriate if it included as much relevant and as little irrelevant information as possible. Which pieces of information were considered relevant, however, depended on the specific function of the image.

The Appropriate Representation

The modifications discussed so far were first motivated by an attempt to adapt the content of the illustration. However, there were other modifications that were aimed at improving its pictorial representation and design. These could not always be reconciled with each other, so that it was up to the draughtsman and botanist to decide between the different demands. Take, for example, the copying link between the two illustrations of the coltsfoot by Sturm and Sandberger (fig. 7.12, p. 248), which shows an instance of the third type of omission mentioned previously. Although Sandberger copied from the earlier version by

[7] However, the cost of a work was not necessarily an indication of whether an image included many details or not. Sturm, for example, published his flora in the tiny, and therefore cheap, duodez format but still showed even the minutest of details.

Fig. 7.12. Coltsfoot – *Tussilago farfara* L. On the left, the image by Sturm (*Deutschlands Flora*, Vol. 1, 1797); on the right, Sandberger's image.

Sturm, he has omitted many of its details. Among other things, he chose not to repeat the two representations of the flower shoots: Sturm presents both the opened flower heads and the closed buds twice; in Sandberger's picture, one sees the same stages of development but each of them depicted only once. This omission is neither a correction, nor has the illustration's content really changed; it remains more or less the same, with or without the repetition of the shoots. The reason behind Sandberger's omissions can only be understood if one assumes that he was trying to design his composition as simply as possible. From this perspective, it is clear that it makes no sense to repeat pictorial elements if no new information is to be added. Along the same lines, Sandberger has also reduced the length of the rhizome and limited his rosette to two leaves: a younger one and a fully grown one. Sandberger is no exception in this respect; other botanists and draughtsmen also changed their images for the sake of simplicity. In many illustrations, there is a tendency to communicate the desired content with as few pictorial elements as possible; this underlying criterion can be called "economy of design".

A similar example can be found in the grapevine images by Jacquin and Kerner (fig. 7.7, p. 240 and fig. 7.8, p. 241). As I explained previously, Kerner omitted much subtle information in his version; however, he did not leave out as much information as one might at first suspect. Like Jacquin, Kerner shows the leaves in three different stages of development, the upper and lower sides of the leaves, an upright inflorescence and a bunch of grapes, hanging correctly from the branch. He has also reproduced the buds on the grapevine's

axils and a side shoot and clearly distinguishes the lignified old parts of the wood from young green growth. Kerner has also kept the entwined petioles and the (apparently) opposite-leaved mode of ramification. In short, most of the omissions in Kerner's image could be considered to be modifications in terms of improving the image's economy of design. For, although Kerner has excluded certain pieces of information, he has primarily omitted details that did not make any essential contributions to the image's content. Changes of this type can be identified whenever a copyist has chosen to exclude pictorial elements that repeat information that can be found elsewhere. Even though Palmstruch fused Curtiss's two rosettes of the coltsfoot into one in his image, he kept the same information content (fig. 6.19, p. 212); Thornton proceeded in a similar way in his copy of Miller's sweet vernal grass, that is, without repeating any of the details (fig. 6.5, p. 191). If the same information could be represented with less pictorial effort, then it made sense to optimize the later picture in this respect.

Beyond this desire to reduce an image's design, one can find other examples in which there was a tendency to present the subject matter in an increasingly simplified way, as in Schkuhr's partial copy of Schreber's sweet vernal grass (fig. 6.14, p. 202). Although Schkuhr copied Schreber's version very closely in many respects, most people would find it hard to recognize the copying link, since the character of the image has been changed from a naturalistic to a fairly simplified one. The same applies to the grapevine representations by Hayne and Sibthorp: Hayne's copy can almost be taken as a caricature of the sophisticated image of the *Flora Graeca* (fig. 7.1, p. 234 and fig. 7.2, p. 236). One obvious explanation of these observations would be to assume that Schkuhr and Hayne had not employed as talented draughtsmen as Schreber and Sibthorp – they were simply not able to present the sweet vernal grass in an equally naturalistic manner. Even though this might have been the case, the botanists and draughtsmen could still have intentionally enhanced the caricature-like style of their pictures. Among other things, simplifying an image's pictorial design can at times make it easier for the observer to grasp its content, that is, a change along these lines can minimize the cognitive effort required to understand an illustration. A simple and clear, maybe even exaggeratedly clear, presentation of the relevant information can certainly make it easier to understand the content more quickly.[8] "Things done in a Flat, tho' exact manner, may serve the Purpose of Natural History better in some Measure, than in a more bold and Painter-like Way", wrote, for instance, the British naturalist Mark Catesby.[9] The striving for minimal cognitive effort was identified in Chapter 4 as one of the reasons for using illustrations rather than

[8] Of course, simplifying an image's visual language also often entails simplifying its content. However, the two processes are by no means necessarily connected. The images of the meadow sa ron and the grapevine in Gleichen (1777), e.g., although simplistic are rich in detail.

[9] Cited Saunders (1995), p. 15. Mark Catesby was particularly famous for his work on the fauna of the American State of Carolina and the Caribbean; see Catesby

Fig. 7.13. Detail of Zorn's coltsfoot image: the draughtsman chose to enlarge the tubular florets to make the structure more visible. Zorn (*Icones Plantarum Medicinalium*, Vol. 1, 1779).

texts. Evidence also suggests that the illustrations were frequently designed in a way that suited this criterion best.

Simplifying partially copied images led to another strategy that also facilitated the understanding of certain aspects of an image. In Chapter 1, I referred to the selective enlargement of particularly important organs, discussed in the context of the tubular florets of Zorn's coltsfoot illustration (fig. 7.13, p. 250). In a specimen, one would normally never see these florets as clearly as Zorn has presented them unless one approached the flower heads very closely or observed them under a magnifying glass. But, although the image is not correct in that it is not true to nature, the structure of the florets is very clear, which makes it easier for observers to understand, for example, the dissected view of the florets. Alternatively, one could also emphasize particularly relevant elements through using colour functionally, as was demonstrated by the example of the brightly coloured anthers of the sweet vernal grass in Chapter 5. Colour was used in a similar way by Schkuhr in his partial copy of Schreber's sweet vernal grass: figure 7.14 (p. 251) shows a detail of the two versions: since Schkuhr used different colours for each structure, his version is easier to understand.

(1731-43). On the encouragement of Trew, Eisenberger reproduced Catesby's plates of this work for a German edition; see Eisenberger (1750-77).

Fig. 7.14. A functional use of colour: Schkuhr (right) used colour to di erentiate between the individual parts of the floret of the sweet vernal grass; by contrast, Schreber (left) left his sketch uncoloured. Taken from Schkuhr (*Botanisches Handbuch*, Vol. 1, 1791), Schreber (*Beschreibung der Gräser*, Vol. 1, 1769).

In addition, Schkuhr inserted two asterisks in his version of the sweet vernal grass, which indicate that the detached stalk has been taken from one of the stalks in the main view. Figure 7.15 (p. 252) shows this device in close-up. These asterisks do not increase the information content of the image. And according to the criterion of economy of design, this detail should have no place in the image. However, the simplest image with no unnecessary details is not necessarily the easiest to understand. These asterisks help the onlooker to grasp the connection between the two parts of the illustration more quickly, thereby reducing the cognitive effort required to understand the picture.

A too high information density could also make it more difficult to understand the content of an image, even if this density appeared desirable in terms of achieving the greatest possible economy of design. An example of what might be a reaction of the later botanist to an image too dense in information can be seen in figure 7.16 (p. 252). In his version of the twinflower (on the right), Hayne has copied some elements of the earlier image by Georg Wahlenberg (on the left), for example, the cross-section of the fruit. Wahlenberg had drawn the latter with the seed inside the capsule; Hayne, by contrast, has shown the cross-sections of the capsule and the seed in two details. This device required more space but communicated the same information more clearly: not everybody would recognize the cross-section of the seed in Wahlenberg's capsule as a separate structure, for example. A final example of an efficient modification strategy to reduce cognitive effort can be seen in figure 7.17 (p. 253). Sturm has copied the details for his representation of the twinflower (on the right) from Trew's earlier version (on the left).

Fig. 7.15. The addition of allegedly redundant elements to reduce cognitive e ort: marking elements that belong together with asterisks, as in Schkuhr's image of the sweet vernal grass, facilitates the understanding of this densely composed image. Left, Schreber (*Beschreibung der Gräser*, Vol. 1, 1769); right, Schkuhr (*Botanisches Handbuch*, Vol. 1, 1791).

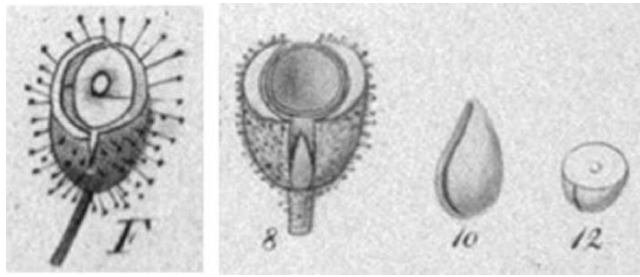

Fig. 7.16. Distributing information on more than one detail in order to reduce cognitive e ort: on the left, the capsule of the twinflower in Wahlenberg (*Flora Lapponica*, 1812); on the right, the same structure in two details (supplemented by a view of the whole seed) in the partial copy from Hayne (*Getreue Darstellung der Gewächse*, Vol. 4, 1816).

The structure of calyx, inferior ovary, stylus and stigma has been exactly reproduced, although Sturm has inverted it, that is, turned the structure 180 degrees. This new orientation does not affect the information content of the detail but makes understanding this unusual structure considerably easier. Sturm shows the structure as it would grow on the plant, corresponding to the main view of the plant next to the detail. By contrast, in his detail Trew demands an extra bit of thought on the part of his audience, that is, more cognitive effort.

Fig. 7.17. A detailed view of the twinflower's flower without petals. On the left, the earlier version from Trew & Blackwell (*Herbarium Blackwellianum*, Vol. 6, 1773); on the right Sturm's partial copy in which the pictorial elements have been re-arranged in a more natural way in order to minimize cognitive e ort. Sturm (*Deutschlands Flora*, Vol. 5, 1804).

A third way in which the content could be represented as appropriately as possible was by increasing the image's communicability, which was discussed in Chapter 5 (section 5.1.4). Botanists and draughtsmen made extensive use of their predecessors' works so that they could profit from an approved and established visual language that was familiar to the audience. Furthermore, it was usual for people to keep to certain common conventions of the genre, as explained in Chapter 5.

Thus, it transpired that eighteenth-century botanists and draughtsmen not only tried to optimize the content of their images in terms of appropriateness, they also strove to achieve the most appropriate pictorial design. This included the search for an optimal economy of design by communicating the desired information with as few and as simple pictorial elements as possible; furthermore, they tried to minimize the cognitive effort required of the audience to understand the picture. Botanical illustrations were designed in such a way that they would be understood as quickly and effortlessly as possible. This explains why some of the images (or parts of images) appear simplified and schematized in the partial copies, with the most relevant aspects exaggerated, and why some elements were inserted although they did not contribute to the illustration's information content, and so forth. Finally, the image's

communicability also played its part in how the most appropriate design for an illustration was chosen.

7.2.3 Permissibility

A third main criterion relating to the construction of a botanical illustration, implicitly discussed in Chapter 5, should be mentioned in passing: the "permissibility" of an image, which concerns the syntactic and semantic rules to which an image adheres. An image has to be permissible if it is to convey any meaning at all. One can check whether an image is permissible or not by examining whether the elements of its visual language denote something or not. Due to their syntactic and semantic properties, impermissible images cannot be interpreted in a meaningful and coherent way; they are incomprehensible and therefore devoid of meaning. This does not always apply to the whole picture; although single areas or elements might be impermissible, the rest could still be meaningful. There are many images of this type: the artist M. C. Escher is renowned for producing pictures that contain passages that can be interpreted in different, even contradictory, ways; indeed, this is one of the peculiarities of his pictures that make them so attractive. Take, for example, his many images with stairs, which regularly include steps that, from another perspective, can be seen to be the vertical part of a different stairway. Only in some cases can such a disregard of the principle of permissibility lead to the whole picture being misunderstood. In works of fine art, impermissible and ambiguous elements can be used intentionally; in scientific illustrations, however, any form of ambiguity is usually unwelcome. Within the selection of botanical illustrations under study, none of the images contained impermissible parts and in none of the partial copies were the copied elements modified in this respect. It is entirely possible that the strict supervision during the manufacturing process stopped errors of this kind from occurring. What form an impermissible element could take, however, can be seen by looking at the Chinese drawing of a plant, referred to in Chapter 5 (fig. 5.3, p. 155). In this case, the draughtsman applied contradicting principles when designing his image. Some of the leaves were drawn according to European conventions of the time, that is, the upper sides of the leaves were painted in a darker shade of green than the lower sides; in other places, however, the same dark green was used for the lower sides. Using two inconsistent conventions in the same image is impermissible, since the pictorial elements can no longer be clearly interpreted and so provoke misunderstandings. If a later draughtsman had used this image as a source for his own illustration, he would probably have changed this inconsistency in his version.

7.2.4 Summary

Against the background of analysing the copying links and their modifications, I proposed two main construction criteria according to which the images were

optimized by the draughtsmen and botanists: the correctness and the appropriateness of an image. The correctness refers to the content of an image and is only valid for illustrations that denote propositions. To assess a model image's correctness, one needs to differentiate between its truth relative to an underlying theory and its applicability relative to its instances. The criterion of appropriateness was broken down into several sub-criteria: the optimal information content of an image, its economy of design, its cognitive effort and its communicability.[10] To these were added the criterion of permissibility, which, although important, could not be demonstrated in any of the copying pairs.[11]

The three criteria of correctness, appropriateness and permissibility can be assessed independently, although they are not usually judged as being of equal weight. The permissibility of an image forms the basis for everything else. If the greater part of an image is not considered permissible, it will be impossible to assess its correctness. The criterion of appropriateness is usually subordinate to the two others: an image might be entirely appropriate in view of a certain purpose but if it does not meet the requirements of correctness at least in central respects, it is to be discarded. This is not to say that an image's appropriateness was not important. On the contrary, most of the modifications carried out in the plant illustrations studied can be interpreted as being changes carried out with regard to the various sub-criteria of appropriateness. In a given image, not all these subcriteria of appropriateness could be considered equally, since some of them contradict each other in their demands. Frequently, it appeared desirable to increase the information content of an image, like Hayne did with his grapevine, even though this rendered the image more complicated and thus might bring with it a rise in cognitive effort. In a similar way, others tried to condense the desired information, as Sandberger did by leaving out the peculiar version of the inflorescence, which made the picture simpler in terms of pictorial elements and thus lead to an improved economy of design. But a representation that is too dense is more difficult to understand, so that this change might be carried out at the expense of minimising cognitive effort. Thus, others decided, on the contrary, to distribute the content to more than one image, although this contradicted the requirement of a maximum economy of design – and so forth. In view of the different strategies chosen for image construction, it seems that people tried hard to achieve a compromise between possible options that best suited the

[10] These sub-criteria of appropriateness are not to be seen as a complete and self-contained list that applies to all scientific illustrations alike; on the contrary, analysing other types of images might require a thorough revision of this list. For the purposes of my study, however, the aforementioned sub-criteria of appropriateness proved to be su ciently adequate to explain the established modifications.

[11] I should like to stress again that these criteria are only thought to apply to botanical illustrations for scientific purposes in the larger sense. Pictures of flowers or illustrations made for other audiences and purposes were designed and assessed using very di erent criteria.

intended functions of their image. And to present this compromise in the best way possible was the task and the achievement of the collective of botanist, draughtsmen, engravers, colourists and printers.

If one assumes that botanists and draughtsmen tried to optimize their own illustrations regarding one or more of these criteria, it is then possible to explain (almost) all the modifications that were carried out to the partially copied elements within the image selection. Of the total 197 copying links, 165 were interpreted as being partial copies. Only in five of these cases could the modification not be explained as being motivated by one of the criteria. Seventeen modifications were assessed as being motivated by a wish to improve the image's correctness; in five of these a new error was mistakenly introduced. The remaining 143 modifications can be taken to be cases in which the criterion of appropriateness was applied, fifty-nine of which were interpreted to increase the economy of design, forty-six to enhance the information content and thirty-eight to reduce the cognitive effort. More detailed information on each copying link and a description of the modifications can be accessed from the electronic edition of the material in Nickelsen & Graßhoff (2001).

7.3 The Purpose of Copying

But why did people copy and modify their predecessors' work? A first attempt at answering this question was taken up in Chapter 6, without, however, the different modification strategies being taken into account. Against the newly introduced background of these strategies, the working process might emerge more clearly.

7.3.1 Optimizing the Model

I mentioned at the end of Chapter 6 that only in exceptional cases did it make sense for botanists and draughtsmen to start their work from scratch. Using the results of successful predecessors was the best way to avoid mistakes and allowed the players to start their work at a comparatively high level. There is nothing unusual in this – this is how scientific work precedes. Scientists do not usually work in seclusion but rather, metaphorically speaking, "on the shoulders of giants", to quote once more this famous saying of unknown origin. Although this quote may be well-worn by now, it still accurately describes the copying processes and their modifications. The botanists and draughtsmen made use of a common stock of approved knowledge. However, they could see a little bit further than their predecessors and therefore could promote the activity in question that little bit more. In the case of botanical illustrations, this was done by introducing supplementations, omissions and corrections to partially copied images. When these changes concerned primarily the illustration's content, I would argue that they were intended to improve the earlier depicted models in one respect or other.

If one looks at the changes that concern the illustration's content, they are by no means specific to images. Rather, these strategies of supplementation, omission and correction are fundamental operations in the modelling of scientific objects that have been identified in various other case studies. Scientific models typically start with a comparatively simple prototype, which includes only the main factors of the modelled object in question. If this first attempt proves successful, it will probably be expanded by the addition of details, step by step, as the knowledge of the object in question advances. Doing so, not only will new pieces of knowledge be integrated into the model but older information will also be modified as earlier inaccuracies or mistakes are corrected. At the same time, the relevance of certain features might change. In such a case, the model might be reduced by the omission of superfluous features. This process does not necessarily occur in a linear and determined order; however, these steps are an apt description of the fundamental principles of the way in which scientific models develop.[12] The established modifications of the illustrations' content correspond to these operations of model development. Of course, in the eighteenth century one sees these models of plant species in a rather advanced stage of elaboration and refinement. The supplementations, reductions and modifications were done on a much more sophisticated level, that is, it was mainly details that were omitted or modified and not the model's main features. It would be interesting to examine whether the models were modified more drastically in the nineteenth century, when anatomical structures gained a more important place in the descriptions of species.[13] These changes in the models did not develop in a straight and progressive line, at the end of which stood the one and only ideal model of the sweet vernal grass or the meadow saffron. On the contrary, at any one time there would have been a wide variety of visually depicted models of a plant species in use. Even when two botanists referred to the same earlier picture as a reference drawing, the outcome of their work was not only always very different but also impossible to predict.

[12] The process of model formation was thoroughly investigated in the study of the discovery of quasars as new objects of astronomy; see Graßho (1998) and a yet unpublished monograph on the theme by Gerd Graßho . Further case studies have confirmed these results, such as, e.g., an analysis of the discovery of the urea cycle by Hans Krebs and Kurt Henseleit and a detailed reconstruction of Johannes Kepler's working methods; see Graßho (1995).

[13] In the natural systems that became widely accepted in the first third of the nineteenth century, plant anatomy played an increasingly important role in the defining and describing of plant species. See the corresponding sections in Jahn (2000) for a survey. For a more detailed discussion of individual botanists and systems, see, e.g., Stevens (1994), who focuses on Antoine-Laurent de Jussieu but also deals with his precursors and successors; on Augustin-Pyramus de Candolle, see, e.g., Drouin (2001), Tesi (1982) and Miège (1979).

7.3.2 Optimizing the Visual Language

Whereas the changes concerning the content of illustrations can be understood as being modifications of the models, there are at least as many changes that concerned primarily the images' pictorial representation. I suggested earlier that the botanists' concern for communicability could be one motivation but it transpired that this criterion was only able to explain a few changes in the means of representation. Reducing cognitive effort and optimizing the economy of design were the other criteria that played their part in modifying an image's visual language. In this regard, too, the botanists were building on a long tradition of conventions, many of which can be explained to have served similar purposes. Drawing the subject matter against a light and neutral background, for example, was not only a convention that had long been accepted but was also a method that contributed to representing a species' morphological features as clearly as possible – that is, it reduced the cognitive effort required of the audience. Furthermore, although botanists could have drawn a large number of plants, they usually focused on just one specimen: an image that contained many individual specimens almost always presents its information less clearly than the straightforward presentation of the relevant features in one specimen. It seems that economy of design, combined with a desire to reduce cognitive effort, can also explain this common feature of the illustrations. The established conventions of the genre, it seems, are fitting smoothly into the set of construction criteria that has been developed from examining the modifications of the copied elements.

Whereas there is a long tradition of analysing the formation and development of the content of scientific activity, such as theories or models, systematically investigating the way content is represented is a comparatively new development in the history and philosophy of science. But it seems that, at least in the case of botanical illustrations, people were as much concerned with the pictorial design of an image as with its information content. As I have argued, one can even detect a set of common criteria and strategies that people used in order to improve their work. These criteria were confirmed to have been used in a selection of some other examples[14] and deserve further investigation, since it might be possible not only to find a heuristic for forming a model but also a heuristic for depicting a model! Studies like mine, where one type of illustration was followed over some period of time, are particularly well suited to tracing these processes. It is important to note, however, that the botanists and draughtsmen of one period did not share only one common goal, either in terms of content or design: no model could answer every single question and no visual language existed that suited the goals of all botanists.

[14] The construction criteria discussed in this study have, in a slightly modified way, proved their value, e.g. in the analysis of the modification of images by Alfred Wegener in di erent editions of his work on his theory of continental drift. They also helped to explain the intended modifications in copied versions of astronomical diagrams of the early Middle Ages; see Liess (2002).

Therefore, the players had to adapt what existed in order to reach their own objectives.

7.4 The Adequacy of a Botanical Illustration

The various criteria introduced in this chapter were originally thought to help explain the modifications carried out in cases of partial copying. But they do not only serve this limited purpose. These criteria also impart information on the working practices of eighteenth-century draughtsmen and botanists, and much more clearly than any written source. Since the players never expressed in detail how they proceeded in designing and improving botanical illustrations, and since they left only vague clues as to which criteria they used to assess other people's work, one can only reconstruct their objectives from the results of their actions. The copying links provide an excellent starting point, since one finds unaltered pairs for comparison from which one can make inferences on the botanists' methods and on the basis of their decisions. Interestingly, the botanists used only a small number of criteria and procedures when constructing and improving their partially copied images. The strategies and patterns they used recur repeatedly within the selection under study; no draughtsman used only one of the criteria: there were always attempts to optimize the illustration in several directions. Although none of these criteria was formulated by the players themselves, least of all in the same terminology that I chose for this study, there was still general agreement on the underlying requirements of botanical illustrations – even if not all the botanists attached equal importance to the various sub-criteria of appropriateness.

The criteria established in this chapter are to be understood as principles of action that guided the practice of eighteenth-century botanical illustrations. And they were not only applied by those botanists and draughtsmen who included partially copied elements in their images. Similar principles of design can be identified in the illustrations with no copying links, even if in these cases the application of definite criteria cannot be reconstructed as clearly as when comparing two versions of a partially copied element. Take, for example, the grapevine representation by Schkuhr shown in figure 7.18 (p. 260). It is impossible to prove that, when constructing this image, Schkuhr followed the same principles as in his sweet vernal grass image (fig. 6.12, p. 200). Within the selection under study, no reference drawing has been found for Schkuhr's grapevine, which means that one has no starting point from which to reconstruct the underlying reasons for the image's design. However, it would be surprising if a botanist applied totally different principles of design to different illustrations in the same work. The image of the grapevine, indeed, shares certain characteristics with the representation of the sweet vernal grass. In both cases, one notices, for example, that the subject matter has been greatly simplified. Schkuhr has emphasized the most relevant features in an exaggerated way, reducing the cognitive effort required in these respects. Since

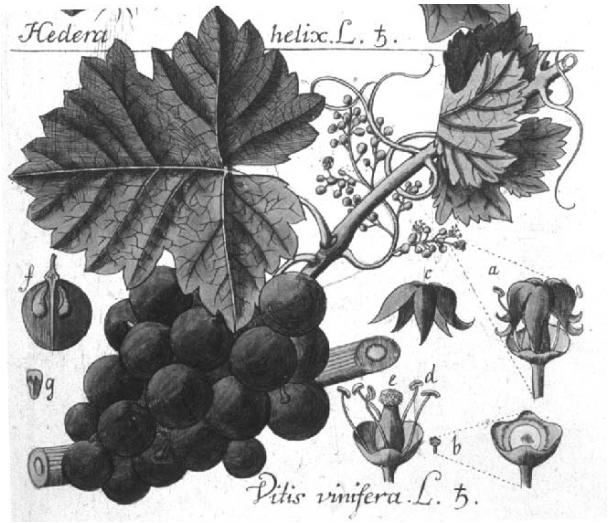

Fig. 7.18. Grapevine – *Vitis vinifera* L. Schkuhr (*Botanisches Handbuch,* Vol. 1, 1791).

Schkuhr only had half a page for both his grass image and his image of the grapevine,[15] it was particularly important that he present the information as clearly as possible and not waste any precious space on irrelevant elements. The clarity of the grapevine image is further enhanced by the way in which the details are linked by a series of dashed lines to the corresponding parts of the plant in the main view. Furthermore, Schkuhr has combined all the plant's stages of development into one single stem, from the flower to the ripe fruit – a typical solution to the problem of having to present the information content as optimally as possible while sticking to the best possible economy of design. As in other cases, the combination of these two sub-criteria has resulted in a high density of information, with no irrelevancies repeated.

In addition, one could examine the illustrations of Oeder's *Flora Danica*. None of the images in this work that were included in the studied selection could be demonstrated to contain copied elements but in their general design they do not differ so much from all the other illustrations that one would assume that they were made according to completely different construction criteria. Figure 7.19 (p. 261) shows Oeder's image of the meadow saffron.[16] Here, too, the different life stadia of the flowers have been combined in one bulb, a device that optimizes the information content as well as the economy of

[15] The upper part of the grapevine plate has an image of the ivy. The Latin name of this species, *Hedera helix,* can be seen at the top of the illustration reproduced in figure 7.18.

[16] Taken from Oeder (1766-1883).

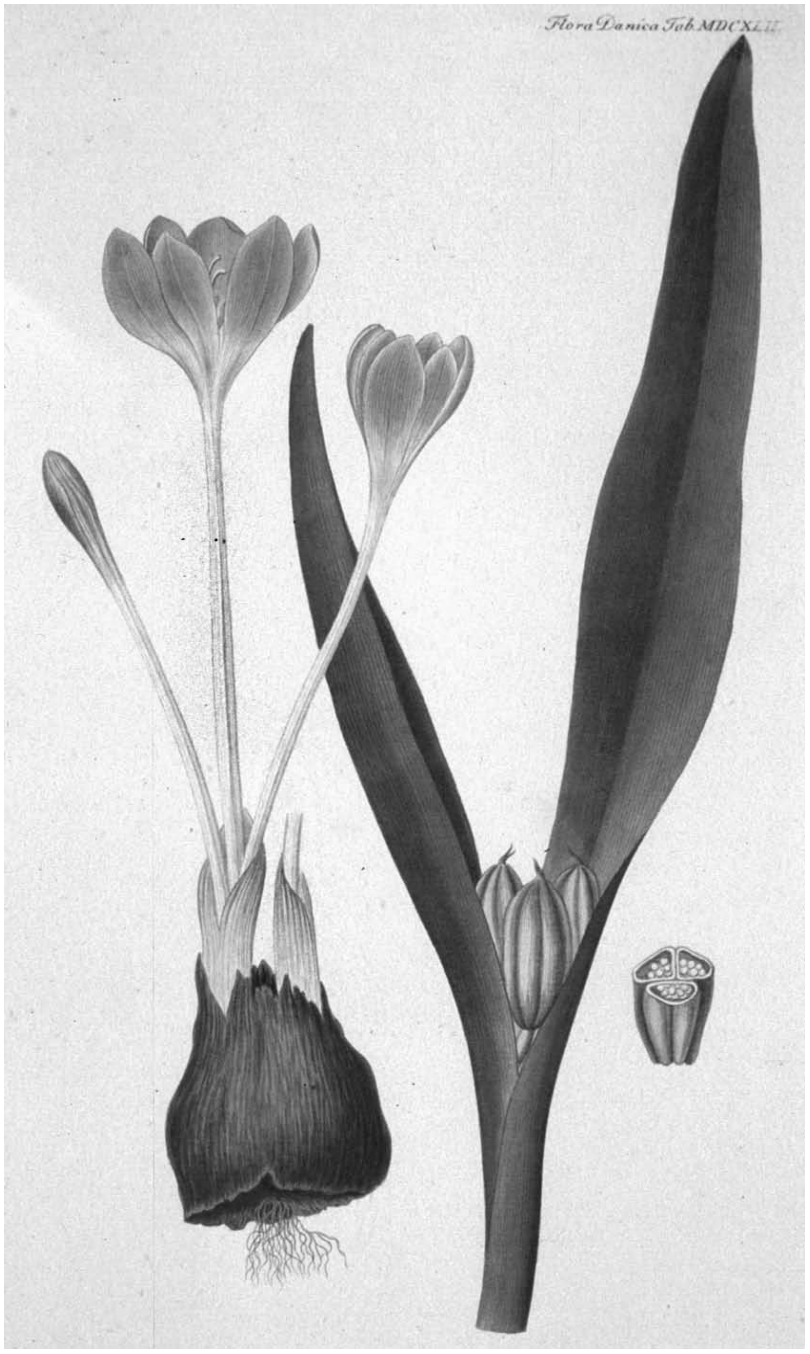

Fig. 7.19. Meadow sa ron – *Colchicum autumnale* L. Oeder (*Flora Danica*, Vol. 10, 1819).

design. In order to show the typical lanceolate-shaped leaves of the meadow saffron, which form a funnel around the fruit, Oeder drew only two leaves in total – the absolute minimum required for communicating this mode of growth. Again, economy of design while optimizing the information content can be identified as a design principle. Beyond these, Oeder was surely also concerned about the permissibility and correctness of his image, since his intentions, like those of all other botanists, included communicating a certain amount of technical information to an audience.

One could easily add to this series of examples. The construction criteria established in the copying links can be validated in many other illustrations of the picture selection; there are numerous details which one can use to demonstrate that botanists and draughtsmen oriented their work along the lines described above. What is astonishing is how many different illustrations were drawn and in use at the same time. Even the principal outline of the images, notwithstanding differences in style, differed to a large extent. In particular, the requirements of the diverse sub-criteria of appropriateness were contradictory. Which criteria had priority was up to each individual botanist. Was the image to be first and foremost informative, even at the expense of cognitive effort? Was the botanist interested in producing an image that most of all adhered to a maximum economy of design, even if the information content had to be reduced and the depicted model ended up being less applicable? A botanist that set out to make a botanical illustration had to decide between a number of alternatives that all led to different procedures being adopted. Why somebody chose to design an illustration guided by one criterion and not another is a complex question that I have not tried to resolve in this study; it is impossible to predict which criteria a particular botanist would have chosen to use for a particular image. It is only with hindsight, that is, starting from a finished drawing, that one can offer an explanation as to why and how an image was designed from the proposed set of construction criteria, which, however, is much more than could be done at the beginning of this study.

Whether the compromise reached between the different criteria was successful or not relative to their purposes can be expressed by assessing an image's "adequacy". Similar to the applicability of an image, this was an assessment that always referred to only one particular image and in only one particular context. An image's adequacy concerned, on the one hand, the content's correctness; in this particular case, one would judge whether all the relevant hypotheses were applicable to the model's instances. However, the adequacy of an image also included various aspects of appropriateness: relative to a given purpose the information content and the pictorial design had to be chosen in a way that supported the intended purpose best. From this perspective, it becomes clear why there could never be just one standard illustration of a plant species, similar to a standard reference in other fields of science for which no alternative existed for a certain period of time – such as the works by Nicolaus Copernicus, Sir Isaac Newton or Charles Darwin. Not so with botanical illustrations. Even long after the Linnean system had been widely

accepted in Europe, new and very different illustrations of plant species, all based on Linnean theory, were still being drawn and published, even though innumerable well-established and approved images were already available. All these models of species covered slightly different hypothesis spaces and were represented in different ways, destined for different audiences and with different objectives. Each of these illustrations could be judged to be more adequate than others relative to a certain context and function. Schreber's illustration of the sweet vernal grass appeared in a comprehensive monograph of the grass family, written for experts. Schreber thus had totally different requirements for his image than, for example, Schkuhr, who published a popular manual for everyday use, or for that matter, Kerner, who addressed an audience with primarily agricultural interests.[17] One should, therefore, not be too surprised that the results of their works were so different, although all three of these botanists presented model representations of the sweet vernal grass. However, the individual component is just one side of the story: certainly, a botanist could judge whether his work was adequate in all respects, but if he was alone in this consideration, his image was not worth the paper it was drawn on. The expectations and demands of the scientific community regarding content and design could not be ignored – at least not if the purpose of the botanical illustration was to serve more than just the botanist's pleasure. The botanists of the eighteenth century lived and worked within a scientific context that determined, as I discussed earlier, a stock of implicit and explicit requirements, which had to be met if a botanical image was to be regarded as adequate.

7.5 Explaining the Development of Scientific Illustration

Thus, from the approach taken in this chapter, the copying links become not only an understandable strategy but also one that is entirely recommendable: for the botanists solved their dilemma of satisfying the far-reaching requirements of the community as well as their own specific needs by linking themselves with existing pictorial traditions and, at the same time, subtly improving the images, depending on their own particular goals. The images are, therefore, the result of a joint undertaking, resting on decades, if not centuries, of cooperative research. Nevertheless, the community only determined the framework that an eighteenth-century botanical illustration had to fulfil. Each individual botanist had to decide for himself how to carry out this task in detail and which sub-criteria of appropriateness to choose to guide

[17] The titles of their works clearly demonstrate these differences: Schkuhr's book was entitled *Botanisches Handbuch* (Botanical Manual), Kerner's work *Abbildungen oekonomischer Pflanzen* (Illustrations of Plants of Economical Interest), whereas Schreber's work was called *Beschreibung der Gräser nebst ihren Abbildungen nach der Natur* (Descriptions of Grasses and their Illustrations after Nature). For detailed descriptions of the works and their content, see Nickelsen (2000) or Nickelsen & Graßhoff (2001).

the design of an image. And it was usually the responsibility of the draughtsman to implement the botanist's instructions as accurately as possible and the responsibility of the engraver to transfer an exact copy of the image onto copperplate. All these contributions need to be acknowledged and appreciated.

However, the surprising result of this study of botanical illustrations is that these individual contributions can also be seen to have been part of a constructive application of guiding principles of action, which were identified by an analysis of the copying links. In this regard, analysing the plant images not only made it possible to arrive at a new understanding of the images, as to their construction, content and function, it also shed new and unexpected light on the working practices of eighteenth-century scientific illustrators. It is particularly significant that the findings on copying links and guiding construction principles were established using a representative sample of eighteenth- and early nineteenth-century botanical illustrations that covered a broad range of illustrations and works, for which the same conclusions were reached.[18] The procedures of copying links and the systematic modification of copied elements were not restricted to the plant images of a particular subject, price range, geographical region, or even to individual artistic or botanical schools. They are to be found in a wide variety of images and works. This attaches far more relevance to the theses developed than had the findings been established by observing only a small group of arbitrarily selected images. There is even some indication that the findings could also be transferred to illustrations of totally different contexts and content, which would make the formulation of a general explanatory model possible.[19] However, such a comparative study – a global view of the dynamic changes seen in scientific illustrations, with due allowance given to individual differences – has yet to be written.

[18] The principles according to which this sample was chosen are described in detail in Chapter 8.

[19] Processes comparable to those used for botanical illustrations have been identified in studies of illustrations of Alfred Wegener's twentieth-century work on continental drift (by Kärin Nickelsen and Gerd Graßho ; remains to be published) and of diagrams found in the text margins of medieval manuscripts on planetary astronomy; for the latter see Liess (2002).

8

Methods and Materials

As an appendix to the actual study, the methods and source materials used in this book are outlined in the following. The principles for selecting the illustrations under scrutiny as well as detailed descriptions of all the images and works have already been published elsewhere;[1] the former are, nevertheless, repeated here in order to justify the sample selected for this study – in particular, for the analysis of the copying links – which has a considerable bearing on the validity of the theses developed.

8.1 Terms

In this study "botanical illustrations" or "plant images" are to be understood as the visual representations of certain types of plant that were intended to communicate information on the particular type of plant.[2] In the period under examination, that is, the eighteenth and early nineteenth centuries, these images formed a genre of their own, with certain standards and conventions. The actual illustrations were usually painted using the watercolour technique and were then converted into copper engravings for publication. Typically, a single specimen of the plant species in question was shown against a neutral background, with no further reference to its natural habitat. This particular method of presentation was not self-evident; zoological illustrations of the same period, for instance, frequently contain additional information on the natural environment of the represented animal species,[3] and occasionally this method was also used for botanical illustrations. Together with a general view

[1] Nickelsen (2000), Chapter I (on methods) and Chapter VII (descriptions of images and works).

[2] This definition resembles the famous "documentary plant image", termed by Claus Nissen, which was to be used by distant scientists instead of the plant itself; see Nissen (1951), p. 6. However, I am not convinced of the underlying realism of this explanation and, thus, avoided this term.

[3] See Blum (1993) and Knight (1977).

Fig. 8.1. Examples of two types of plant representations: on the left, a flower painting, on the right, a botanical illustration or plant image. Left: *Arrangement of Anemones and Jasmine* by M. B. Dietzsch, c. 1750 (painting undated), from Ludwig (1998), p. 204. Right: Turk's cap lily – *Lilium martagon* L., from Redouté (*Liliaceae*, Vol. 3, 1806).

of the plant, enlarged details of the plant were usually added to give an exact idea, for example, of the structures of the flower and its fruit.

This type of plant representation differs from conventional "flower images", a term that is used in this study to describe illustrations that served mainly decorative purposes, such as still-lifes, bouquets or views of single flowers. A comparison of the two types – plant image and flower image – can be found in figure 8.1 (p. 266). Flower images were very popular in the eighteenth century: although they cannot always be easily differentiated from plant images, generally, however, the qualities and features of flower images differ fundamentally from those of plant images, which served scientific interests in their broadest sense. The main purpose of a flower image was not to communicate correct and comprehensive information but to present an aesthetically attractive picture. Great importance was attached to depicting large, splendid flowers in bright colours while scant regard was given to the vegetative organs of the plant, such as the leaves, stems and roots, and certainly not to details such as pistils and anthers. With a plant image, on the other hand, it is precisely

these unspectacular details that are often the centre of attention, while the colour of the flowers and their arrangement play a subordinate role.

8.2 The Period under Examination

For this investigation, the botanical illustrations chosen were drawn (and also mostly published) between 1700 and 1830. This period of the eighteenth and early nineteenth centuries was a time of massive change in the field of botany as a science as it moved from a medico-pharmaceutical ancillary science to an independent discipline, and consequently from the leisure-time activity of amateurs to a profession.[4] The important progress made in physiological knowledge shall not be discussed here,[5] but the section of botany that falls into the branch of natural history also underwent profound changes during this period.

Within the time span from 1700 to 1830, a number of fundamentally different taxonomies were, in turn, developed, adopted and then abandoned. The year 1700 was chosen as the lower time limit for this study because it was in that year that the Latin version of Tournefort's *Institutiones Rei Herbariae*[6] appeared, the introduction to his taxonomy, which was one of the most influential systems before Linnaeus. Besides Tournefort, at the beginning of the eighteenth century, a variety of other systems and nomenclatures were in use, such as the systems of John Ray, August Quirin Bachmann (Rivinus) and Christian Gottlieb Ludwig.[7] Moreover, almost every botanist interested in taxonomy designed minor variants of these systems for himself, so that, in effect, few early eighteenth-century botanists worked on the same taxonomic basis. This state of affairs considerably complicated the work of botanists of the time and impeded communications on a national and international level: whenever a botanist wanted to inform a colleague about something new regarding a plant species, he had to cite all the synonymous names of the species in question to avoid any misunderstandings. Consequently, a botanist spent a considerable part of his time finding out whether, for example, the plant

[4] For a more thorough description of these processes of change and for a historical summary of the period see, e.g., Jahn (2000), Chapters 5-7. For monographs on the history of botany, see Sachs (1875), Möbius (1937), Jessen (1948), Greene (1983) and Mägdefrau (1992).

[5] This area of botany was, moreover, considered a branch of chemistry until the nineteenth century; see Klein (2003), Chapter 1.

[6] Tournefort (1700).

[7] John Ray's principal work was his *Historia Generalis Plantarum* (1686), Rivinus's was his *Introductio Generalis in Rem Herbariam* (1690) and Ludwig especially influenced his contemporaries with *Institutiones Historico-Physicae Regni Vegetabilis* (1742). For Ray, see Raven (1986); for a description of the di erent systems, see the previously mentioned general works on the history of botany as well as the specific literature they cite.

species x defined by A was identical to another species y defined by B. This situation changed towards the middle of the eighteenth century when the system of Carl Linnaeus – also known as Carl von Linné – became widely accepted throughout Europe. He proposed a taxonomy in which the plant species were organized primarily according to the qualities of their sexual organs, which led people – and, indeed, Linné himself – to call it the sexual system.[8] No less important was Linnaeus's introduction of a uniform, binomial nomenclature for botany and the definition of generally accepted technical terms. Despite its sweeping success, however, this system did not stay in place for very long. With the publication of Antoine-Laurent de Jussieu's *Genera Plantarum* in 1789,[9] the so-called natural systems began to be established and, by the first decades of the nineteenth century, with the publications of Augustin-Pyramus de Candolle,[10] they had completely superseded the Linnean order. The year 1830 was, therefore, fixed as the upper limit of the period under examination.

So, when the field of botany from 1700 to 1830 is examined, one observes a busy but also self-contained era, starting with the last pre-Linnean systems, including the beginning and heyday of the great Linnean reforms and ending with the superseding of the sexual system by the natural systems.

8.3 The Picture Selection

In order to obtain general statements on scientific plant drawings from 1700 to 1830, a selection of pictures representative for this period had to be compiled. Flower images were to be excluded; furthermore, it was also deemed necessary that the chosen illustrations had been accepted by botanists of the time as adequate representations of the species and that they had been used as sources of information, at least in certain contexts.

For these purposes, two specialist picture bibliographies, which give lists of references where scientifically accepted illustrations of many plant species can be found, were of particular help. They are Georg August Pritzel's *Iconum Botanicarum Index Locupletissimus*,[11] published in the mid-nineteenth century, and the comprehensive *Index Londinensis*,[12] published in the 1920s, which includes references to more than 20,000 botanical illustrations. Both works complement each other and were used to select the images for this study. Additionally, the final selection of botanical works was compared with the lists of references in other, well-accepted, eighteenth-century textbooks, confirming that the illustrations and works chosen for this study were regularly cited in these books.

[8] For a more detailed description of Linnaeus's taxonomic system, see Chapter 3, 3.1.1 of this book.
[9] Jussieu (1789).
[10] Candolle (1813) and Candolle (1824-73).
[11] Pritzel (1855).
[12] Stapf (1929-41).

For the picture selection, it was decided to follow up the depictions of ten plant species referred to in the bibliographies for the period as completely as possible. The subsequent database should then suffice to carry out both synchronic and diachronic comparisons. As a first step, a pre-selection of the species to be examined was taken according to how frequently they were represented – this was deemed essential to ensure that the selection was representative, no exceptional or outlandish plant images were examined but only depictions of everyday objects of eighteenth-century botanical practice. To this end, Pritzel's bibliography was scrutinized for plant species that had been cited at least eight times. The resulting 865 species were reduced still further by applying a higher limiting value of at least fifteen references.[13] Furthermore, it was decided that the publishing dates of the illustrations of the species selected should cover as long a period as possible within the examined time frame, that is, the illustrations should include a selection dating from early in the eighteenth century right through to 1830. Since Pritzel's bibliography does not cite the publishing dates of its references, their number at first only showed how frequently the species in question had been depicted up to the year 1855 (the publication date of the book), which was far too long for the purposes of a study covering only the period up to 1830. The preselection was, therefore, reviewed and narrowed down still further by using the more detailed *Index Londinensis*. Researching the data in Pritzel's work yielded, for example, a rather high number of references for some species of the genus *Erica*. By double-checking this finding with the dates given in the *Index Londinensis*, it emerged that most of these illustrations had only been published after 1800, that is, towards the end of the period under examination, so that, despite the frequency of their depictions, these *Erica* species were considered unsuitable for this study.

In the course of this research it transpired that exotic plant species were not the most popular subject matter, which is a far cry from today's coffee-table books featuring eighteenth- and nineteenth-century botanical images, which reproduce predominantly visually attractive, colourful plates of foreign plants. In fact, images of newly discovered, often splendid-looking plant species appeared only in a small number of eighteenth-century works. Far more popular were the local wood and meadow species, which were less notable for their beauty than for their usefulness.

Through the procedure described above, I arrived at a selection of ten plant species. This selection needed to cover a wide range of scientific botanical activities. It seemed preferable, for example, to include plant species that were relevant to medical and agricultural contexts as well as species of no practical value. This decision was based on methodical considerations: on the one hand, it is possible that eighteenth-century botanists and draughtsmen viewed, for example, ornamental plants differently to the way they viewed

[13] A complete list of the results of this enquiry can be found in Nickelsen (2000), Chapter X, pp. 559 .

pot-herbs, so that the corresponding representations might show a different range of attributes of the plant species depicted. On the other hand, as broad a range as possible of branches of botany and thus also of work types needed to be included to ensure that the selection was representative: besides compendia specializing in medicinal herbs, national and regional floras also needed to be taken into account. Furthermore, different plant species confront the draughtsman with different problems: drawing tall trees and bushes, for example, requires a different technique than drawing small herbs; with grasses, moreover, it would be crucial to show their complex flower structures. Finally, during the seasons many plant species appear in morphologically very different stages of development, all of which may have to be taken into account when making a comprehensive botanical illustration. Therefore, in order to follow up the different attempts of the draughtsmen to solve these and similar difficulties, the selection of species needed to be as diverse as possible.

Of the ten finally selected species, six have been analyzed in detail. They are as follows:[14]

1. *Anthoxanthum odoratum* L. – Sweet vernal grass.
   Sweet vernal grass can be grown for its nutritious hay, which made it popular in agricultural contexts. Representing the small but complex grass flowers is essential for taxonomic purposes: they pose, however, quite a challenge, since the tiny ears need to be carefully dissected.
2. *Colchicum autumnale* L. – Meadow saffron.
   This is a frequently depicted species of considerable medicinal and pharmaceutical value. It confronts the draughtsman with the problem of depicting different life stages that in nature do not occur simultaneously: the plant flowers in the autumn, whereas its leaves and fruit appear only in the following spring.
3. *Corylus avellana* L. – Hazel.
   This is an economically interesting shrub (its fruit can be used for culinary purposes, the rods for wicker work). The flowers are single-sexed and monoecious, that is, morphologically different male and female catkins grow on the same plant. The hazel catkins flower in early spring, long before the first leaves, let alone the fruit, appear.
4. *Linnaea borealis* L. – Twinflower.
   Linnaeus's favourite plant. The twinflower was one of the species with the most frequent references in Pritzel's bibliography, although it was not of any practical use. Typical features are its creeping, prostrate stem, which gives rise to adventitious roots and flower shoots; also remarkable is its peculiar, inferior ovary.

[14] The images of the remaining four species were only looked at in a cursory way, since it turned out that a thorough analysis would not have significantly altered the results. These were: the beech (*Fagus sylvatica* L.), hellebore (*Helleborus niger* L.), Turk's cap lily (*Lilium martagon* L.) and pomegranate (*Punica granatum* L.).

5. *Tussilago farfara* L. – Coltsfoot.
   Used pharmaceutically or as a vegetable. What at first glance looks like the flower is, in fact, a whole inflorescence: the so-called flower heads of the coltsfoot consist of numerous, tiny ligulate and tubular florets, the exact structure of which can only be seen under a magnifying glass. The flowers appear far earlier than the leaves, which poses again the problem of depicting different life stages that in nature do not occur at the same time.
6. *Vitis vinifera* L. – Grapevine.
   Used in wine-growing; a climber. From the rather meagre wild variety, numerous cultivars have been developed, which yield far more copious fruit. The type of grapevine selected for representation could well reveal something about the different concerns of those involved. The vine grows as a sympodial monochasium, resulting in a seemingly opposite-leaved structure.

For each of the six species, approximately twenty illustrations were closely examined, published in altogether fifty-one works of the botanical literature of the period. On average, about eighty per cent of the references in Pritzel's bibliography were used. Expressed numerically, the final examination of plant images was based on a selection of the following composition:

Plant species	Number of images
Sweet vernal grass	21
Meadow sa ron	36
Hazel	23
Twinflower	14
Coltsfoot	22
Grapevine	21
TOTAL	137

9

List of References of the Picture Selection

Anthoxanthum odoratum

Bibliographical reference of the illustration	Location of the used copy[1]	Year[2]
Schreber (1769-72), Vol. 1, pl. 5	2 Bot IV, 3185[3]	1769
Leers (1775), pl. II, F 1	8 HN Bot V, 4001	1775
Oeder (1766-1883), Vol. 4, pl. 666	2 HN Bot V, 5740	1777
Miller (1777), Vol. 2, pl. on p. 12	2 Bot III, 5370 Rara	1777
Miller (1777), Vol. 2, pl. on p. 13	2 Bot III, 5370 Rara	1777
Curtis (1777-98), Vol. 1 (Nos. 1-12), pl. on p. 49	2 HN Bot V, 5600	1777
Kerner (1786-96), Vol. 1, pl. 8	4 Oec I, 1045	1786
Hoppe (1787-93), Vol. 6, pl. 442	2 Bot V, 4447	1789
Schkuhr (1791-1803), Vol. 1, pl. 101	8 Bot IV, 1000	1791
Martyn (1792-94), Vol. 1, pl. 23	8 Oec I, 1038	1792
Sturm (1798-1855), Vol. 1, issue 4	8 HN Bot V, 2110	1798
Sowerby & Smith (1790-1814), Vol. 9, pl. 647	8 Bot V, 5457 Rara	1799
Palmstruch & Venus (1802-38), Vol. 1, pl. 11	8 HN Bot V, 5845	1802
Knapp (1804), pl. 1	4 HN Bot V, 5493	1804
Kops (1800-49), Vol. 2, pl. 3	4 Bot V, 5293 Rara	1807
Palisot de Beauvois (1812), pl. XII, fig. VIII	8 HN Bot IV, 3243[4]	1812
Thornton (1812), Vol. 1, pl. 30	8 HN Bot V, 5502	1812
Sinclair (1826), pl. p. 146	8 Oec I, 1618	1826
Sinclair (1826), pl. p. 19, fig. 1	8 Oec I, 1618	1826
Sandberger Collection No. 1670	Museum Wiesbaden (MW)	n.d.
Sandberger Collection No. 1669	MW	n.d.

[1] Shelf marks are only given for copies owned by the University Library (SUB) Göttingen; the first number of this shelf mark corresponds to the book's format (4 = Quarto, etc).

[2] Year of publication of the illustration.

[3] I examined the illustrations of the University Library Erlangen copy. At the time of my study, the Göttingen copy would be seen, under this shelf mark, in the restorations o ce of the SUB.

[4] Plates published in quarto format, i.e. to be found at 4 HN Bot IV, 3243

Colchicum autumnale

Tournefort (1700), Vol. 2, pl. 181	8 Bot I, 2630	1700
Tournefort (1700), Vol. 2, pl. 182	8 Bot I, 2630	1700
Weinmann (1717), Vol. 1, no pag. (7 images)	UB Regensburg	1717
Weinmann (1735-45), Vol. 1, pl. 403	UB Regensburg	1735
Weinmann (1735-45), Vol. 1, pl. 404	UB Regensburg	1735
Kniphof (1757-67), Vol. 12, pl. p. 1130[5]	4 Bot III, 825, Rara	1764
Trew & Blackwell (1750-73), Vol. 6, pl. 566	2 Mat Med, 190/25 Rara	1773
Regnault & de Nangis Regnault (1774), Vol. 1, pl. 106	2 Bot III, 1260	1774
Gleichen (1777), pl. XIX	4 Hist Nat I, 9658	1777
Gleichen (1777), pl. XX	4 Hist Nat I, 9658	1777
Zorn (1779-90), Vol. 2, pl. 133	8 Mat Med 170/17	1780
Gaertner (1788-1807), Vol. 1, pl. 18	4 Bot II, 3060	1788
Hoppe (1787-93), Vol. 4, pl. 314	2 Bot V, 4447	1789
Kerner (1786-96), Vol. 4, pl. 318	4 Oec I, 1045	1791
Schkuhr (1791-1803), Vol. 1, pl. 4	8 Bot IV, 1000	1791
Martyn (1792-94), Vol. 2, pl. 60	8 Oec I, 1038	1792
Hedwig (1793), Vol. 1, pl. IV	8 Bot I, 3210	1793
Sowerby & Smith (1790-1814), Vol. 2, pl. 133	8 Bot V, 5457 Rara	1793
Sprengel (1793), pl. XII, figs. 25-27, 30, 33-35	4 Bot II, 4988 Rara	1793
Mayr (1797-98), no pag.	UB Regensburg	1797
Sturm (1798-1855), Vol. 1, issue 3, p. 8	8 HN Bot V, 2110	1797
Redouté (1802-16), Vol. 4, pl. 228	2 Bot IV, 3692 Rara	1808
Jaume Saint-Hilaire (1808-22), Vol. 2[6]	4 HN Bot V, 1507	1808
Descourtilz (1809), Vol. 1, pl. XI	4 HN Bot V, 1507	1809
Thornton (1812), Vol. 3, pl. 287, p. 71	8 HN Bot V, 5502	1812
Hayne (1805-37), Vol. 5, pl. 45	4 Mat Med 170/5	1817
Oeder (1766-1883), Vol. 10, pl. 1642	2 HN Bot V, 5740	1819
Sandberger Collection No. 1575	MW	n.d.
Sandberger Collection No. 1578	MW	n.d.
Sandberger Collection No. 1576	MW	n.d.
Sandberger Collection No. 1576, back page	MW	n.d.

Corylus avellana

Tournefort (1700), Vol. 3, pl. 347	8 Bot I, 2630	1700
Weinmann (1717), Vol. 1, no pag.	UB Regensburg	1717
Weinmann (1735-45), Vol. 1, pl. 431	UB Regensburg	1735
Blackwell (1737-39), Vol. 2, pl. 293	2 Mat Med 190/5 Rara[7]	1739
Trew & Blackwell (1750-73), Vol. 3, pl. 293	2 Mat Med, 190/25	1757
Kniphof (1757-67), Vol. 1, pl. p. 19	4 Bot III, 825 Rara	1758
Kniphof (1757-67), Vol. 1, pl. p. 20	4 Bot III, 825 Rara	1758

[5] Pagination that was inserted into the Göttingen copy at a later date.
[6] Unnumbered plates have been arranged alphabetically.
[7] The Göttingen copy is uncoloured; for my study I therefore used the copy of the University Library Erlangen.

Duhamel du Monceau & Oelhafen (1762), part 2, p. 135	DD 92 A 33763	1762
Regnault & de Nangis Regnault (1774), Vol. 3, pl. 327	2 Bot III, 1260	1774
Zorn (1779-90), Vol. 3, pl. 228	8 Mat Med 170/17	1781
Hoppe (1787-93), Vol. 3, pl. 253	2 Bot V, 4447	1788
Gaertner (1788-1807), Vol. 2, pl. 89	4 Bot II, 3060	1791
Kerner (1786-96), Vol. 4, pl. 394	4 Oec I, 1045	1791
Sprengel (1793), pl. XXV, fig. 12	4 Bot II, 4988 Rara	1793
Mayr (1797-98), no pag.	UB Regensburg	1797
Sowerby & Smith (1790-1814), Vol. 11, pl. 723	8 Bot V, 5457 Rara	1800
Schkuhr (1791-1803), Vol. 3, pl. 305	8 Bot IV, 1000	1808
Duhamel du Monceau (1804-19), Vol. 4, pl. 5	2 Bot III, 1200	1809
Thornton (1812), Vol. 3, pl. 331, p. 119	8 HN Bot V, 5502	1812
Oeder (1766-1883), Vol. 9, pl. 1468	2 HN Bot V, 5740	1813
Guimpel et al. (1810-20), Vol. 2, pl. 151	4 Res Salt, 2260 Rara	1820
Sandberger Collection No. 1374	MW	n.d.
Sandberger Collection No. 1375	MW	n.d.

Linnaea borealis

Linnaeus (1737c), pl. XII	8 HN Bot V, 6050	1737
Linnaeus (1755), pl. ad pag. 219[8]	8 HN Bot V, 5831	1755
Kniphof (1757-67), Vol. 9, pl. p. 858	4 Bot III, 825, Rara	1762
Oeder (1766-1883), Vol. 1, pl. 3	2 HN Bot V, 5740	1766
Trew & Blackwell (1750-73), Vol. 6, pl. 597	2 Mat Med, 190/25	1773
Zorn (1779-90), Vol. 1, pl. 79	8 Mat Med 170/17	1779
Sowerby & Smith (1790-1814), Vol. 7, pl. 433	8 Bot V, 5457 Rara	1798
Palmstruch & Venus (1802-38), Vol. 1, pl. 1	8 HN Bot V, 5845	1802
Sturm (1798-1855), Vol. 5/6, pl. XIV.2, p. 16 (Vol. 5, issue 17)	8 HN Bot V, 2110	1804
Liboschitz & Trinius (1811), pl. before p. 93a	4 HN Bot V, 6223	1811
Liboschitz & Trinius (1811), pl. before p. 93b	4 HN Bot V, 6223	1811
Trattinnick (1814-16), Vol. 2, pl. 200	4 Bot III, 1110	1814
Hayne (1805-37), Vol. 4, pl. 13	4 Mat Med 170/5	1816
Wahlenberg (1812), pl. IX	8 HN Bot V, 6056	1812

Tussilago farfara

Tournefort (1700), Vol. 2, pl. 276	8 Bot I, 2630	1700
Blackwell (1737-39), Vol. 1, pl. 204	2 Mat Med 190/5 Rara	1737
Trew & Blackwell (1750-73), Vol. 3, pl. 204	2 Mat Med, 190/25 Rara	1757
Kniphof (1757-67), Vol. 6, pl. p. 596	4 Bot III, 825, Rara	1759
Oeder (1766-1883), Vol. 4, pl. 595	2 HN Bot V, 5740	1771
Regnault & de Nangis Regnault (1774), Vol. 2, pl. 249	2 Bot III, 1260	1774

[8] This plate was first published in 1745 in the first edition of the work, see Linnaeus (1745), after p. 188. However, for my study I used a reproduction of this plate that was published in the second edition, see Linnaeus (1755).

Curtis (1777-98), Vol. 1 (Nos.13-24), p. 6	2 HN Bot V, 5600	1777
Zorn (1779-90), Vol. 1, pl. 64	8 Mat Med 170/17	1779
Hoppe (1787-93), Vol. 3, pl. 254	2 Bot V, 4447	1788
Kerner (1786-96), Vol. 2, pl. 177	4 Oec I, 1045	1788
Gaertner (1788-1807), Vol. 2, pl. 170	4 Bot II, 3060	1791
Sprengel (1793), pl. XX, figs. 20, 22-25, 33, 35, 39, 40-44, 46	4 Bot II, 4988 Rara	1793
Sturm (1798-1855), Vol. 1, issue 2	8 HN Bot V, 2110	1797
Mayr (1797-98), no pag.	UB Regensburg	1797
Sowerby & Smith (1790-1814), Vol. 6, pl. 429	8 Bot V, 5457 Rara	1797
Kops (1800-49), Vol. 1, pl. 40	4 Bot V, 5293 Rara	1800
Palmstruch & Venus (1802-38), Vol. 1, pl. 2	8 HN Bot V, 5845	1802
Savi (1805), pl. 55	2 Mat Med 170/55	1805
Schkuhr (1791-1803), Vol. 3, pl. 242	8 Bot IV, 1000	1808
Hayne (1805-37), Vol. 2, pl. 16	4 Mat Med 170/5	1809
Sandberger Collection No. 746	MW	n.d.
Sandberger Collection No. 747	MW	n.d.

Vitis vinifera

Tournefort (1700), Vol. 3, pl. 384	8 Bot I, 2630	1700
Blackwell (1737-39), Vol. 1, pl. 153	2 Mat Med 190/5 Rara	1737
Trew & Blackwell (1750-73), Vol. 2, pl. 153	2 Mat Med, 190/25	1754
Kniphof (1757-67), Vol. 6, pl. p. 600	4 Bot III, 825, Rara	1759
Duhamel du Monceau & Oelhafen (1762), part 2, p. 270	DD 92 A 33763	1762
Schmidel & Keller (1762-97), Vol. 1, pl. VII	2 Bot III, 835 Rara	1762
Duhamel du Monceau (1768), Vol. 2, pl. VII	4 Oec I, 1918	1768
Regnault & de Nangis Regnault (1774), Vol. 1, pl. 67	2 Bot III, 1260	1774
Gleichen (1777), pl. LXII	4 Hist Nat I, 9658	1777
Zorn (1779-90), Vol. 3, pl. 276	8 Mat Med 170/17	1781
Jacquin (1781-93), Vol. 1, pl. 51	2 Bot III, 855	1781
Gaertner (1788-1807), Vol. 2, pl. 106	4 Bot II, 3060	1791
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