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On the maintained significance of botanical illustration in modern plant identification guides

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CHAPTER 1: PREFACE

This project began over 2.5 years ago when I, an artist by hobby, contacted Dr. Joey Shaw, the director of the Herbarium at the University of Tennessee Chattanooga, with a request to sketch from specimens in the UCHT collection. Dr. Shaw, fortuitously in need of an illustrator, prompted me with the opportunity to collaborate with him in the creation of illustrations for the second edition of the *Guide to the Vascular Plants of Tennessee.* From here, this project has grown as we have attempted to determine the most effective way to illustrate the guide, our questions manifesting in a myriad of interdisciplinary investigations, from an exploration on the historical development of botanical illustration, to a survey of the use of figures in modern botanical keys, and ultimately to our practical exercise in drafting illustrations for later inclusion into the *Guide to the Vascular Plants of Tennessee*. This document represents the products of these variable investigations, strung together by prevalent themes of convention, technology, and communication, to lend credence to the maintained significance of botanical illustration in the modern world of botanical science.

CHAPTER 2: HISTORY OF BOTANICAL ILLUSTRATION

2.1. Introduction

Determining the significance of botanical illustration to botanical pedagogy is integral in determining the significance of illustration to modern botanical science, because although the current relationship appears to be fairly weak, botanical science has been strongly influenced by illustration over the course of its development. Beginning from the manuscript era and traveling forward to the onset of the digital age, this analysis explores the evolving role of botanical illustrations in plant identification and documentation, particularly focusing on how technological advances have affected the accessibility and accuracy of these illustrations and, resultantly, how they have been perceived and utilized by the botanical community. In order to examine this long and convoluted history, this analysis is organized chronologically, and each section is delineated by a pivotal technological, scientific, or artistic advancement. The first two sections, *Early Development (pre-1500's)* and *Return to Natural Observation (1500-1600)* explore the original degradation and subsequent revival of illustration practices prior to and at the onset of the foundation of botanical science. The third section, *Aesthetics vs. Utility (1600-1800)* focuses on the artistic, technological, and scientific developments that influence the accessibility and overall

utility of the practice, and the fourth section, *Development & Decline (1800-2000)* addresses briefly the development of related printing and imaging technologies, drawing particular attention to the incongruent utilization of illustrations in botanical texts. Despite the chronological organization, this analysis is by no means intended as a comprehensive survey on the history of botanical illustration but rather a selective exploration, including only those artworks, scientific texts, technologies, and ideologies that are most representative of the larger prevailing trends and that ultimately help to place context to the current state of botanical illustration.

2.2 Early Development (Antiquity-1500)

Our analysis must rightfully begin in the hands of antiquity at the most basal origin of botanical illustration, from which we will follow its rather clumsy development through the medicinal herbals of the manuscript era and upwards until the start of the 16th century. The illustrations in these early herbals are largely characterized by the technological limitations of the manuscript era, in which the process of hand-copying over time promoted a strong reliance on authority without consultation of nature, resulting in the cultivation of stylized convention and myth. The term "development" therefore must be used loosely and perhaps ironically in this context, as the early practice of botanical illustration is mostly considered to be one of retrogression, although often congruent to the degree in which the herbals they illustrate fulfill the modern qualifications of botanical science. Wilfrid Blunt, a well-recognized authority on the history of botanical illustration, states in his comprehensive narrative, *The Art of Botanical Illustration,* that "the first millennium of the history of plant illustration shows, in fact, no steady advance from primitive work to naturalistic, but a gradual decline which was not fully arrested until early in the sixteenth century"[1]. This same sentiment is echoed by Julian Sachs, author of the *History of Botany (1530-1860),* in his discussion of early studies of plants, remarking that if one were to travel forwards in the track of botanical history, from Aristotle to Albertus Magnus, they would note "how it continually grows less and less valuable... as prolix as they [the botanical works] are deficient" and that one would subsequently be acquainted with the foundations of modern botany with the return to natural observation in the 16th century[2]. As we shall see, whist the degradation of botanical illustration and the devaluation of early botanical texts are highly

[1] Blunt (1994), pg. 13
[2] Sachs (1906), pg. 14

intermeshed, their deterioration as individual practices largely manifest as parallel results of the similar problematic conventions, which ultimately stems from a disconnection with natural observation, resulting in the perpetuation of inaccuracy and myth.

2.2.1 Illustration in Antiquity

From the beginning, we know that illustration has long been an important part of recording plant forms, but it is difficult to place the exact origin of this relationship due to a lack of surviving documentation. There is some scarce evidence from prehistoric times of carvings of plants onto bones, although, as noted by Charles Singer in his *Essays on Scientific Twilight*, uncivilized people generally did not make or record observations regarding plants, even though it is clear from cave art that they were of the habit of pictorially recording animals and people[3]. According to Singer, imagery of plants did not begin to appear until the formation of more complex civilizations, concurrent with the rise of agriculture. As people began paying more attention to plants, evidence of plant imagery becomes more abundant, although many of these pictures were originally decorative in nature rather than acting as a record of observation. This is an important distinction to keep in mind, as the difference between botanical art and botanical illustration is often neglected or obscured in discussion but will be integral to our investigation. Within the parameters of this analysis, botanical illustration will be defined as a form of botanical art that is created to supplement a scientific text or to stand alone as a scientific observation. This definition therefore does not include art of a decorative or horticultural nature, although, as we shall see in the later popularization of florilegia in the 1600's, this distinction resides on a gradient. Furthermore, this definition of botanical illustration relies on the intention of the artwork's application rather than on its accuracy or quality; however, these factors will ultimately determine the effectiveness of the illustration to botanical texts.

Thus, by this definition, the earliest surviving record of botanical illustration dates back to 1450 BC in Karnak, Egypt, where on the walls of the Great Temple of Thutmose III are carved outlines of at least 275 plants, a few of which are easily recognizable today by species[4]. According to Singer, this temple represents the first prototype in the very long tradition of the written herbal, which is in later forms a book that contains information on the mostly medicinal properties of

[3] Singer (1958), pg. 175
[4] Blunt & Stearn (1994), pg. 6

plants. Of course, the Great Temple was an exception of its time, and it would not be until the time of Antiquity that we find the next significant recordings of this practice, when in 100 BC, the Greek physician, Cratevas, began augmenting his pharmacological writings with paintings of plants. It is important to note, as was emphasized by both Singer and Sachs, that these early studies of plants were primarily bound to medicinal utility, as the development of botanical illustration actually predates the recognized foundation of botanical science. Unfortunately, we know only little regarding the nature of these first drawings, as the original works have since been lost, but we retain some evidence of their existence in Pliny the Elder's *Natural History*, written in 45 A.D. In his assessment, Pliny expresses the perceived limitations of Cratevas's and other's attempts to utilize botanical illustration for botanical description in the past century:

> "Among them, Cratevas, Dionysius, and Metrodorus, adopted a very attractive method of description, though one which has done little more than prove the remarkable difficulties which attended it. . . Pictures, however, are very apt to mislead, and more particularly where such a number of tints is required, for the imitation of nature with any success; in addition to which, the diversity of copyists from the original paintings, and their comparative degrees of skill, add very considerably to the chances of losing the necessary degree of resemblance to the originals. And then, besides, it is not sufficient to delineate a plant as it appears at one period only, as it presents a different appearance at each of the four seasons of the year. (Natural History, 25.4)

Although Pliny's concerns refer to the most primitive examples of botanical illustration, he casts an impressive prediction upon the greatest challenges in the early development of botanical illustration, namely, their loss of a "necessary degree of resemblance to the originals" and their subsequently misleading nature to the herbals which contain them.

2.2.2 De Materia Medica: *A case study on copying & convention*

A well-cited example of the degradation and misleading nature of early botanical illustration practices can be found in Dioscorides' *De materia medica.* Initially written in 70 A.D., *De materia medica* maintained prominence in the western world as a major botanical authority for over a thousand years, and was still being cited even in the 17th century by notable botanists such as John Goodyer and Thomas Johnson, who claimed that it was "the foundation and grounde-work of all that hath been since delivered in this nature."[5] Because of its longevity and prominence, *De*

[5] Taken from Arber (1970), pg. 10

materia medica provides an excellent case to observe the early development of botanical illustration in the herbals throughout the manuscript era.

While the original manuscript is no longer in existence, the oldest preserved copy, the Juliana Anicia Codex of Dioscorides (*Codex Vindobonesis*), dates back to A.D. 512 and is thought to contain illustrations derived from Cratevas' originals in 100 B.C.[6] As the earliest record, the Vienna Codex is considered to be fairly reasonable in its plant descriptions and illustrations, although it is obvious that they would have served minimally in species identification as they depict only the general appearance of their herbs. Nevertheless, according to Blunt, the Vienna Codex "displays a standard of excellence in plant drawing that was not to be surpassed for almost a thousand years."[7] Unfortunately, this excellence is not only unsurpassed, it is crudely forgotten in the younger, more derived versions, which contain stylized and fanciful drawings of plants that far from resemble the originals. During these thousands of years of maintained authority, *De materia medica* was reproduced by hand, over and over from previous copies, accumulating many point mutations between drawings and text so that the final myriad of products appears nothing like the original. This degradation cannot, however, be fully attributed to copier's error alone, because we know from the Vienna Codex that there was an original expectation for these illustrations to resemble nature and, from its preface, that Dioscorides himself insisted on botanical information being ultimately gathered by *autopsia* –to see for one's self.[8] It is evident, however, that this expectation was abandoned over time, evidenced by the replacement of these mostly naturalistic illustrations with increasingly stylized ones in later versions of the Middle Ages. The uptake of style could not have been solely the result of a copier's mistake but rather the result of conformation to new artistic conventions that accepted non-realistic and superstitious interpretation. Ultimately, by accepting these stylized conventions, illustrators did a great disservice to the early herbals by propagating false information when, despite the technological limitations of the manuscript era, it was well within their skillset to achieve some semblance of naturalism.

[6] Janick & Hummer (2012)
[7] Taken from Blunt & Stearn (1994), pg. 10
[8] Kusukawa 2012

2.2.3 Myth & the Printed Herbal

While initially provoked by the technological limitations of the manuscript era, the stylized conventions established in the practice of botanical illustration became maintained independent of hand-copying and leached into the printed herbals of the 15th century. According to Agnes Arber in her exploration of the history of the printed herbal, these already corrupt herbals of the manuscript era were among some of the first books to be printed with the invention of Gutenberg's press in 1450, although the illustrations would continue to be hand drawn until the utilization of woodblock printing in 1475. The woodblock brings about many novel advances to the process of reproducing botanical illustrations, but as these advantages would first be subject to the whims of past convention, it will accordingly do us no good to discuss these changes until after these conventions are replaced by naturalism in the 1500's.

Until then, the ideas and illustrations contained in herbals printed prior to 1530 were largely displays of shoddy science and ill-disguised plagiarism, relict of the precedents set by the manuscript era. The first book to include a printed botanical illustration for more than mere decoration was Konrad von Megenburg's *Das puch der natur* (1475), which contained a single illustrated plate depicting several roughly sketched plants, two of which are fairly recognizable as a violet and a buttercup.[9] The next most prominent, as described by Arber, were the *Latin Herbarius* (1484) and the *German Herbarius* (1485), which in contrast to *Das puch der natur* contained illustrations of a higher level of detail, boasting a distinctly ornate style. Complete with fleurs-de-lis and filigreed leaves, these images exemplify how detail and artistic skill are not always congruent to effectiveness. These flourishes of detail, while initially causing the illustrations to look more advanced than those previous, obscure and render the drawings more untrue to nature than an un-stylized version might have. This artistic liberty becomes even more pronounced in the infamously illustrated *Ortus Sanitus*, published in 1491 as a highly modified Latin translation of the *German Herbarius.* While many of *Ortus Sanitus'*s pictures are merely reduced and poorly copied versions of those in the *German Herbarius*, many have been blatantly augmented by myth. For example, its illustration of *Narcissis*, owed to the Greek myth, has been drawn with humanoid figures in place of each flower, and the mandrake root, which has been steadily accumulating its own myths over time, has been rendered as a fully formed woman with

[9] Arber (1970)

leaves sprouting from her head. These fantastical illustrations, along with their accompanied mythical texts, truly display the final "deterioration" of botanical illustration.

2.3 Return to Natural Observation (1500-1600)

Leaving behind the degraded illustrations of the manuscript era, our analysis continues onward to the woodcut illustrations of the 16th century herbal, in which we explore the role of illustrations in the overall dismissal of past convention and subsequent return to natural observation. While naturalism as an art form was first developed by artists of the Renaissance, the initiation of the return to nature within botanical science is largely credited to the sequential efforts of two men, Hans Weiditz, the illustrator of Brunfel's *Herbarum vivae eicones* (1530) and Leonhart Fuchs, botanist and author of *De historia stirpium* (1542). Weiditz, a notably talented draftsman, drew directly from plant material with unprecedented accuracy, and Fuchs, recognizing the utility of these images, went to great lengths to have his own herbal properly illustrated and, in the process, redefined what constituted a proper illustration. With the development of naturalism, botanical illustration was largely able to begin shedding the myth, malpractice, mistrust that it collected during the manuscript era and become a practice of positive significance for the development of descriptive botany. While still limited to the medical and superficial properties of plants, this dedication to correct pictorial representation of plant forms was an essential step towards the scientific examination of native flora, forming the foundation upon which botanical science then developed.

2.3.1 Development of Naturalism

Before we can discuss the work of Weiditz and Fuchs, it is important to first understand the artistic developments of naturalistic techniques upon which they drew. At the turn of the 16th century, as science began reorienting itself away from philosophy and towards direct observation, naturalism began to develop as a distinct art form, independent of the illustrations included in herbals. Naturalism, as it relates to the visual arts, aims to represent the appearance of nature with least possible discrepancies. Traditionally in naturalism, the subject which was being represented was not as important as the technique used to render it, but nevertheless, because this art was based in natural observation, truth inevitably seeped in and conferred to these artworks a scientific value. Thus, the convention of direct observation in naturalistic art initially developed without a strong

scientific influence, and only after the artistic practices were in place did botanical texts begin containing naturalistic illustrations.

Of the naturalistic artists who represented plants in their works, particular attention should be called to both Leonardo da Vinci and Albrecht Durer. Though neither was a botanical illustrator by trade nor even depicted plants with any great frequency, da Vinci and Durer sketched and painted plants as they directly saw them, capturing details that had been previously ignored. A splendid example of this can be seen in Durer's famous *Das Grosse Rasenstuck*, painted 1503. This work is a large, remarkably realistic watercolor of a simple patch of turf, including plants no less common than a dandelion, yet is rendered more realistically than perhaps any botanical illustration prior; however, it is not clear whether Durer captured this level of detail with the intent of scientific study or by incident of his astute observation of nature.[10] Nevertheless, Durer is thought to have especially influenced the work and techniques of Hans Weiditz. In contrast to Durer, Da Vinci composed a series of botanical chalk sketches that, while thought to have been used primarily to inform the foliage in his later painting of *Leda,* were clearly also evidence of botanical study in their own right. On a particular sketch of marsh plants, da Vinci wrote a series of observations alongside, exemplifying his equally scientific and artistic curiosity:

> "This is the flower of the fourth kind of rush, which is the tallest of them, growing three to four *braccia* [1.5-2 metres] high, and near the ground one finger thick. It is of a clean and simple roundness and beautifully green; and its flowers are somewhat fawn-coloured. Such a rush grows in marshes etc., and the small flowers which hang out of its seeds are yellow."[11]

Ultimately, these works by Durer and Da Vinci are considered to be the first of modern botanical art, and although they were not used alongside botanical texts, they were significant to the development of botanical illustration because they laid an important foundation for the artistic techniques required to attain naturalism.

2.3.2 Woodblock Printing

Along with the development of new artistic techniques, there was a concurrent technological advancement in the development of woodblock printing, which brought with it many benefits to the practice of illustration. Essentially, woodcuts functioned as stamps that could be

[10] Blunt & Stearn (1994)
[11] Taken from Clayton (2007), pg 54, a translation of da Vinci's note dated to 1510

printed in books alongside the moveable type utilized by the printing press, conferring some level of consistency to the reproduction of illustrations. While woodcuts alleviated some human error associated with the hand-copying process of manuscripts, they came with their own particular limitations as well. Primarily, rather than the one individual required to draw directly into a manuscript, the creation of a woodcut by traditional method involved three separate artists, all working at different pay grades.[12] First, a draftsman, the lowest paid of the three, would sketch a particular plant onto paper, same as might occur with a manuscript. Next, the copier would transfer this sketch onto a woodblock, and a sculptor, at the top of the pay grade, would carve the negative space around the lines out of the wood to form the stamp, which could then be rolled with ink and printed until the block's design was dulled, warped, or rotted. This commission gradient and distribution of work is important to recognize because it alludes to an inherent issue in the process. Of these three men, only the lowest paid and thus least incentivized artist would be directly working from plant material. The sculptor, paid as much as 1.5 to 5 times the commission of the draftsman,[13] would produce a final product for publication after two degrees of separation from the original observation, often allowing for details to be lost, obscured, or exaggerated in the process, reflecting still the concerns presented by Pliny in 45 A.D., although to a much lesser degree than that of the manuscript.

2.3.3 Hans Weiditz & Leonhart Fuchs

While there are a few small occurrences of naturalistic plant renderings in botanical texts prior to 1530, none are near comparable in accuracy or impact to those drafted by Hans Weiditz in Otto Brunfel's *Herbarum vivae eicones,* (*Living portraits of plants*). While the herbal's text displays little botanical novelty, the illustrations contained in its pages mark a significant transition in the development of botanical illustration. Rather than having been copied from past images, Weiditz is known for having drawn from real plant specimens and with an exactness that had never been achieved or even strived for in prior herbals. Rendering each plant specimen as it existed before him in nature, Weiditz captured details from the slightest curl in a flower's petals to the smallest tangle in its roots. According to Sachs:

[12, 13] numbers reported by Kusukawa (2012)

> Woodcuts were added to supply any defects in the description, and to give a clear idea of the plant intended by the name; and these figures, which always give the whole plant and were drawn immediately from nature by the hands of practiced artists, are so true to nature that a botanist's eye at once recognizes in every case the object meant to be represented. These figures and descriptions… rendered a great service to science."[14]

Well recognized for his accuracy, Weiditz was also reasonably criticized for his perhaps overzealous adherence to direct observation, as he included along with his fine details many other specimen-specific peculiarities, such as torn leaves, clods of dirt, and discoloration. These details, while true to the plant being drawn from, were not true to the nature of the species being represented. Furthermore, as Weiditz largely concerned himself with rendering the plant in its full habit, many of the important morphological structures are not discernible or even oriented towards the viewing plane, although there is no reason to believe that these details would have been recognized as significant to the herbalists and physicians of time. Nevertheless, these drawings took on a measure of utility as visual aids that strongly contrasted the trivial position held by images in herbals prior. In this position of utility and novelty, Weiditz's drawings resounded on a large, communicable scale within the botanical community and, in effect, initiated a reorientation of botanical attention back to nature.

In 1542, Leonhart Fuchs, one of the founding fathers of botany, encouraged and developed upon the now naturalistic practice of botanical illustration, most notably with the publishing of his herbal, *De historia stirpium commentarii insignes* (Remarkable commentaries on the history of plants).[15] This text, while of much greater botanical novelty than Brunfel's, was also rich in carefully considered illustrations, a matter in which Fuchs openly prided himself in, writing in the preface:

> "To the description of each plant we have added pictures. These are lifelike and modeled after nature and rendered more skillfully, if I may say so, than ever before. This we have done for no other reason than that a picture expresses things more surely and fixes them more deeply in the mind than the bare words of the text."[16]

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[14] Sachs (1906), pg. 14-15

[15] The full title of this work is: *Remarkable commentaries on the history of plants belabored with great expense and vigilance with more than five hundred live images of plants attached*

[16, 17] Taken from Kusukawa (2012)

Thus, while Fuchs had not a hand for drawing like Weiditz, he believed strongly in the power of illustrations as teaching tools rather than as superficial renderings, and he professed as much in his works. While Weiditz used illustrations as if they were mirrors to reflect nature, Fuchs saw them as opportunities to present ideas, to show 'types' that would be true to the nature of plants but were not bound by natural circumstance such as superficial imperfections, specimen-specific abnormalities, or even normal artistic lighting and color. To this, Fuchs wrote:

> "With industry and attention, we have taken care lest with shadows and other less necessary things with which painters often bring about the glory of their art, the natural form [*native forma*] of herbs be blotted out, and lest we suffer these masters to follow their whims so that the picture would then correspond less to the truth [*veritati*]."[17]

For the first time, botanical knowledge that encompassed more than singular observation was being directly incorporated into illustrations, ultimately expanding the limits of what these images could communicate and how they could be used. This was a fine line to tread, for to deviate even slightly from direct observation allowed much room for error. To ensure accuracy, Fuchs is known to have worked very closely with his artists – Albrecht Meyer the draftsman, Heinrich Fullmaurer the copier, and Veit Rudolt Specklin the sculptor, to instruct them on the forms that they were representing, and the collective result of this cooperation was a graceful and unprecedented combination of scientific information and artistic utility.

2.3.4 Botanical Developments: Illustration & Description

Ultimately, the return to natural observation in illustration triggered a response in the botanical community that then expanded wildly on its own. Inspired by the naturalistic display and perhaps equally awoken by contrast to the degraded quality of the most recent herbals, 16th century botanists such as Hieronymus Bock, Rembret Dodoens, Charles de l'Ecluse, and Matthias de l'Obel began attempting to revive botanical knowledge from the physicians of antiquity, although going only so far as to accept that which they could observe themselves. In hopes to identify the plants described by Dioscorides, Theophrastus, Pliny and Galen, this generation of German botanists began carefully examining, comparing and documenting their regional floras, and although there was not yet an expressed concept of species, by 1623, botanist Kaspar Bauhin estimated that the known number of plants counted up to 6000, a substantial increase from the 500

plants that were described by Fuchs in 1542.[18] Unfortunately, although the wealth of botanical knowledge expanded, during these years of progress, the illustrations of Weiditz and Fuchs remained unrivaled. According to Sachs:

> The artistic and scientific value of the drawings, which were appended to the descriptions and in later herbals were reckoned by thousands, did not keep equal pace with their number; Fuchs' splendid figures remained unapproached, and gradually, as the distance from Durer's time increased, the woodcuts grew smaller and poorer, and sometimes even quite indistinct. The art of describing on the contrary continually improved.[19]

Thus, instead of new drawings being made for the new plants, old ones were merely copied throughout various herbals over the years, becoming poorer and poorer representations as their degrees of separation lengthened and copier's errors slipped in, much reflecting the degradation of *De materia medica*, and as a result, botanical illustration would again slip from a brief position of significance.

2.4 Aesthetics Vs. Utility (1600-1800)

While the practice of botanical illustration remained mostly unimproved upon throughout the rest of the 16th century, it saw drastic changes in the 17th and 18th centuries, influenced particularly by the transition of woodblock printing to copper engraving (1600) and by Linnaeus's sexual system of classification (1753). Both of these changes greatly affected the degree of aesthetics, utility, and actual use of illustration for plant identification and documentation. Copper engraving, for instance, allowed for much finer details in printing than woodcuts, but as it was a highly laborious and expensive process, it catered mainly to financially-endowed productions, causing a notable shift in the style and use of botanical illustrations away from utility and towards aesthetics. Linnaeus's classification system, on the other hand, partially retrieved the practice from decorative frivolity by conferring to it a greater scientific utility, because his system relied on the delineation of visually-discernible characters that could be well represented with illustrations. Unfortunately, these advancements would be restricted in use to the more lavish botanical subscriptions until the invention of lithography in the late 18th century, which with its markedly reduced expenses, allowed for illustrations to be available for inclusion within the more technical

[18, 19] Sachs (1906), pg. 38 & pg. 19

botanical identification and classification texts of which we are primarily concerned.

2.4.1 Copperplate Engraving

At the turn of the 17th century, the popular printing process for illustrations began shifting from the older woodblock method to copperplate engraving, which has important effects on the production and accessibility of botanical illustrations. As opposed to the woodcut, in which the negative space around the drawing had to be carved away, copper engravings are made through a positive relief process: the lines of the drawing are cut directly into the metal, which then act as shallow ink wells to transfer the image when damp paper is pressed on top. Copper, a relatively soft metal, has a smooth and malleable surface that retains fine detail more readily than the grained surface of wood, thus enhancing the resolution of detail that was possible in these prints[20]. Copperplates also allowed for the creation of tone through stippling, which lends to the softer and less "lined" appearance of 17th and 18th century botanical prints. While the products of these copper engravings were significantly more detailed than the woodcuts of previous practice, the expense and intensity of the production would reflect poorly upon the accessibility of quality botanical illustrations. The copperplate itself was costly and wore down after one hundred or so prints,[21] and as the time required to engrave these plates was greatly magnified, the labor costs increased as well, although it should be acknowledged that this increase in time and effort was a largely result of increased expectation for detailed works. Nevertheless, with enhanced detail comes inflated expenses, and the new printing process subsequently becomes highly susceptible to the demands of the commissioning market.

2.4.2 The Commissioning Market

As plants become increasingly *fashionable* in the western world, beginning with the Age of Exploration in the 1600's and escalating through the Wardian Era of the 1800's, a commissioning market developed for botanical prints that prioritized aesthetics over utility, which is most evident in the production of florilegia. Similar to herbals, florilegia were specifically composed to record plants but, unlike herbals, had no ethnobotanical emphasis and very little text,

[20] Note: the details behind the creation of a copper engraving are much more complex than described here. For a more complete explanation of the process, see Nickelson (2006).
[21] Numbers reported by Nickelson (2006)

although the want of text was more a result of the limitations of copper engraving than by active exclusion. Regardless, florilegia were notably lavish in nature and were mostly commissioned to visually document the flora of university and private estate gardens, such as Bessler's famous *Hortus Eystettensis*, financed by bishop-prince Johann Konrad von Gemmingen to record the splendor of his gardens in Eichstaett, Bavaria (1613).[22] In a combined pursuit of aesthetics and documentation, much care was taken in the creation of these prints to show the plants in their horticultural prime, although the expectation still remained for these works to be drawn from direct observation. As a result, the artworks were often richly colored and highly detailed, establishing a particular style of plant portraiture that is continued in many botanical artworks today. Note that the use of the term 'artwork' here rather than 'illustration' is intentional, as the degree of *scientific* intent in these garden florilegia is debatable. This distinction becomes even more muddled, however, as the aesthetic conventions are carried over into the later florilegia published to document specific scientific expeditions, such as the *Bank's Florilegia,* which exhibits copperplate engravings derived from Sydney Parkinson's sketches from Sir Joseph Bank's voyage on the *HMS Endeavour* (1768-1771) and the *Flora Graeca,* compiled in a series of ten volumes from John Sibthorp's comprehensive survey of flora of Greece with the renowned artist Ferdinand Bauer (1786-1787).

2.4.3 Linnaeus' Sexual System of Classification

Of the botanical artworks and illustrations that were produced prior to 1753, the majority were realistic and more highly detailed than ever before, but as mentioned previously, the amount of information given in their details was lacking, largely because botanical science was without a focused means of identifying or classifying plants. According to an essay by Reveal and Pringle in volume 1 of the *Flora North America* (1993),

> At the time, the classification, identification, and naming of plants were, at best, nationalistic and personal, at worst, chaotic. Classification schemes were designed only to retrieve information, not to express relationships; identifications were based on regional features, not diagnostic characters; and nomenclature was a personal expression of opinion as to position, location, and features as compared to similar plants." (pg. 161)

[22] Information regarding the names and dates of specific florilegia has been derived from reports by the American Society of Botanical Artists

Other organizational systems were also often tied to ethnobotanical properties or even arranged alphabetically by common name, as was with Fuch's *De historia stirpium,* and the content of these illustrations was highly reflective of this, depicting the plant's habit from flowers to roots as it might have been plucked from the ground, because these were the characteristics delineated by the botanical descriptions.[23] While earlier illustrations made it easier to visualize the written plant descriptions or even lack thereof, their usefulness in conveying information was limited without a proper identification scheme to guide and filter which descriptions were important to the species.

A change occurs when the Swedish botanist Carl von Linnae, better known as Linnaeus, published three monumental books, *Systema naturae, Genera Plantarum,* and *Species Plantarum,* in which he delineated a classification and naming system for plant species based on characteristics of their sexual organs. Linnaeus's system, while still of an artificial nature, provided much-needed direction and consistency in botanical nomenclature and classification. The "sexual system," as it was termed, used characteristics of a plant's stamens and pistils as a mode of classification; Linnaeus explained that of his recognized sexual characters, "there are four dimensions from which to take these differences: *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."[24]

Linnaeus's inclusion of illustration as a bona fide source of botanical information, worthy enough to be considered in the development of a new system, exemplifies the position they were to hold as evidence for the classification of plant species. By defining specific, visual characteristics that could be easily included in illustrations, Linnaeus' system substantially increased the usefulness of illustration to botanical science. Many florilegia began to exhibit dissections of the flower's sexual anatomy, such as Pierre-Joseph Redoute's famous *Les Liliacees,*[25] and as the sexual system caught on across Europe, almost all botanical illustrations, where utilized, began to be drawn with dissected and magnified flowers, showing the number, shape, position, and proportion of the stamens and pistils. While it may seem intuitive and possibly even an insignificant development to add minor details such as these to the already well-developed conventions of botanical illustration, by increasing their potential usefulness, the new system also

[23] See Arber (2012)
[24] Linnaeus (1751), taken from Nickelson (2006)
[25] accessed from Botanicus Digital Library; reported in Howard (2009), pg. 19

created a niche for illustrators that required artistic skill. This new niche was distinctly scientific in nature, retrieving the practice back from its gravitation towards aristocratic decoration. As Goethe is said to have remarked, "A great flower-painter is not now to be expected: we have attained too high a degree of scientific truth, and the botanist counts the stamens after the painter and has no eye for the picturesque grouping and lighting."[26] For the first time since Fuchs, these illustrations gained the potential to be more than stand-in representations; they could now carry scientific ideas and explanations, could become models that had the capacity to teach the reader rather than just show them what they might readily see with a specimen in hand.

2.4.4 A Collaborative Approach

In comparison to a woodcut from the 16th and 17th centuries, the new illustrations being produced by the end of the 18th century were especially grand and informative: copperplate printing methods increased the level of detail, as well as production expenses; florilegia popularized and financed the practice and, in doing so, set unnecessary expectations of opulence; and finally, Linnaeus's system helped retrieve botanical illustration from the borderlines of decoration by giving them new potential for containing botanical substance. These new conventions meant several things. Primarily, with the printing of illustrations being such an expensive and laborious task, for illustrations to be included in a publication, they had to be effective enough to be considered worthwhile by the botanist and the publisher directing them. To be effective, illustrators now had to be trained in the particulars of botanical science, for example in stamen and ovary morphology, in order for their drawings to include scientifically accurate information, and additionally, because the creation of botanical illustrations naturally became a highly collaborative effort, it was also to the benefit of the botanist to understand some aspects of the drafting process to properly instruct their illustrators.[27] Thus, strong partnerships developed between botanists and illustrators of the 18th century, such as between Sir. Joseph Banks and Franz Bauer, Joseph Pitton de Tournefort and Claude Aubriet, and between Linnaeus and George Dionysis Erhet. The resulting illustrations, while still informed by the aesthetic instincts of the illustrator, were actively controlled for so that accuracy was not compromised in the desire for beauty.

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[26] Quote taken from Carr (1983) pg. 15
[27] See Nickelson (2006) for thorough depiction of this relationship

The effort that was put into the creation of these illustrations speaks volumes for the importance they originally held to botanical scientists; and there are many written accounts stating such; Sir Joseph Banks, for instance, wrote in the preface of his *Delineation of Exotic Plants* (1803) that "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."[28] Ultimately, upon the conclusion of the 18th century and carrying onward into the 19th, botanical illustrations were held in high regard within the scientific community, a fact which stands in strong contrast to the mostly disinterested attitude towards illustrations in botanical science today.

2.5 Illustration in Technical Botanical Texts (1700 - 2000)

Thus far in this analysis, we have made for a general discussion of illustration to descriptive botany, but it must be admitted that our account has thus far been attuned to the more popular depictions of the history of botanical illustration; that is, to the more exciting points where the practice has succeeded and failed. A history on the evolving utility of botanical illustration to descriptive botany, however, would be remiss in failing to acknowledge that the use of illustration actually became quite divided upon the development of more technical plant identification guides. While illustrations were used frequently and lavishly for monotypic species descriptions and documentation of flora, as can be seen in the works of Franz (1758-1840) and Ferdinand Bauer (1760-1826)[29], the more-technical treatises that attempted to devise methods for species classification and identification initially made little use of pictures.[30] These texts, from which our modern-day plant identification schemes and guides are formed, only take up the use of imagery upon the appropriate advances in printing technology, and when they do, they do so in a relatively inconsistent manner under the influence of persistent bias and past convention, and ultimately decline in use upon the conclusion of the 20th century.

2.5.1 Development of the Tripartite Format

In a paper exploring the development of plant identification guides, Sara Scharf (2009)

[28] quote taken from Nickelson (2006), pg. 1
[29] For a more complete discussion of the works of Franz and Ferdinand Bauer, notable as two of the most influential illustrators of their time, see Lack (1998).
[30] Sachs (1906) pg. 39-41

argues that printing and monetary constraints placed against the use of illustrations in the 18th century, in combination with increasing pressure to handle the mounting numbers of known plant species, ultimately influenced the way botanists began to organize their classification and identification schemes. According to Scharf, without the aid of illustrations, botanists took to developing complexly structured guidebooks that included standardized technical vocabularies, regularly adhered-to layouts, indexes, and cross-references between different components of the books[31]. These conventions were later formally established in the early 19th century as the "Tripartite Format" as a means to combine both natural classification and artificial schemes into a single text through the inclusion of three components: a character-based identification key, a section of species descriptions grouped by natural affiliation, and an index.[32] Since the original establishment, many texts began also including introductions and glossaries, and upon technological advancements in the 19th century, these texts began to use illustrations to support their variable components.

2.5.2 Technological escalation & stagnated conventions

At the turn of the 19th century, the invention of lithography, which allowed for more affordable reproductions of images alongside text, made illustrations accessible for use within technical plant identification guides[33]. The response, however, was not a clean or full transition from unillustrated to illustrated texts, due largely to the influence of persistent biases generated out of past artistic conventions, causing illustrations to be perceived as misleading and frivolous or as limited to the presentation of elementary concepts for the botanical enthusiast and not as professional tools for making technical distinctions. In texts that began to utilize visual references, there was no real reassessment of the way in which illustrations could be manipulated to best benefit the function of the guides; rather, these authors and the artists under their direction seem to have defaulted to the conventions of illustration that had been previously established, resulting in the initial inclusion of non-technical or overly-ornate images, such as can be seen in John Lindley's *Collectanae Botanica* (1821). The position of illustration in botanical science was further complicated by the invention of photography in 1839, and tensions immediately arose

[31] These claims are also supported by Voss (1952)
[32] Scharf (2009) pg. 101
[33] Flannery (1995) pg. 119

regarding the continued utility of illustration. William Talbot, inventor of the calotype, expressed his opinion on this subject quite clearly:

> "The powers of the pencil fail to express these minutiae of nature in their innumerable details. What artist could have the skill or patience enough to copy them? Or granting that he could do so, must it not be at the expense of much valuable time, which might be more usefully employed? .... The object which would take the most skillful artist days or weeks of labour to trace or copy, is effected by the boundless powers of natural chemistry in the space of a few seconds." (1839)[34]

While Talbot was convinced on the superior utility of photography, other accounts of the day expressed more thought towards the continued use of illustrations, such as the news report released by *La Gazette de France* that, upon detailing the invention of the daguerreotype[35] in 1839, expressed: "Let not the draftsman and painter despair; M. Daguerre's results are something else from their work, and in many cases, cannot replace it."[36]

Despite these inconsistencies and biases, it is evident that many botanists of the day still considered illustrations to be of utility, well-represented in a statement made by Britton and Brown in the preface of their *Illustrated Flora of the Northern United States, Canada, and British Possessions,* which states:

> "a complete illustrated manual is of the greatest service; always useful, often indispensable. The doubts and difficulties that are apt to attend the best written descriptions will often be instantly solved by figures addressed to the eye… By these facilities [illustration], not only is the study of our native plants stimulated and widened among all classes, but the enjoyment, the knowledge and scientific progress derivable from these studies are proportionately increased."

After professing this opinion, however, Britton and Brown make an additional observation that their attempt to utilize illustration in such a manner seems to be somewhat singular in the Americas, and that this reason can be mostly attributed to the fact that there is a "lack of any apparent demand for such a work sufficient to warrant the expense of the enterprise," a statement that reveals the slowly receding position of botanical illustration within botanical science.

2.5.3 A Lack of demand in the 20th century

Up until this point in the discussed history, the effort involved in drafting and printing of

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[34] Talbot (1839)
[35] The daguerreotype was a contemporary form of early photography to that of Talbot's calotype
[36] Taken from translation by Beaumont Newhall, reprinted from *La Gazette de France* (Paris), January 6th, 1839; included in Newhall (1980) pg. 17-18.

botanical illustrations has been contingent upon technological advancement, and each time a change was made to the process, there was a subsequent change in the manner in which illustrations were used and their resulting effectiveness, for better or worse. These changes, however, were relatively slow up until the last century, which experienced a renaissance of new printing and image-related technology, beginning with the most basic precursors of photographs in the 1840's and progressing exponentially to the hi-tech drafting tablets and digital illustration software. Modern technologies, while mostly enhancing the ease of drafting and accessibility of botanical illustrations, have not resulted in a commensurate academic response in the use of illustrations within botanical texts. Despite the continual lowering of associated expenses through successive technological advancements, the 20th century experiences a declining demand for the generation of botanical illustrations.

One of the more prominently noted reasons for this declining demand is the advancement of photography. Successive developments that improved the quality and accessibility of photographs over the past century have logically increased their prominence and use. As a non-specialist and relatively inexpensive means of image capture, photography steadily begins to replace illustration for the presentation of botanical imagery, especially once the appropriate printing technologies were established in the mid-20th century.[37] Many of the same advances that made photography convenient, however, also increased accessibility of illustrations, and even Talbot, in all his distaste for drawing, initially noted the potential that photography presented for making efficient and accurate copies of artworks.[38] Unfortunately, the resulting advancement of each was incongruent. As imaging technology has progressed toward the digital age, photography, in its increasing ease of use and ubiquity, has seemingly brought about a perception that photographs in turn nullify the utility of illustrations, evident in the fact that many plant guides began and continue to be chiefly "illustrated" by photographs,[39] as can be observed in Oleg Polunin's *Wildflowers of Europe* (1969), Frank C. Seymour's Flora of New England (1982), and readily evident in many of the Peterson's Field Guides.

Concurrent with the advancement of photography, and equally bound to developing technology, is the professionalization of botanical science. Along with most other natural sciences,

[37] See Simpson (2008) for a more thorough review of this history
[38] Talbot (1839)
[39] Brown (1907)

20th century botany experienced a notable shift away from field-based, descriptive, and organismal science and into the labs.[40] Thus, the descriptive aspects of botanical science, including the drafting of field guides, have become substantially overshadowed by new-age genomics and phylogenetics, generating a disparity in resources available for alpha-taxonomy[41]. Because of a combination of academic and monetary resource depletion, this atmospheric shift has, in line with pervasive biases and past conventions, seemingly resulted in a general disinterest among academics within the botanical community in the continued utility of illustration to botanical texts.

CHAPTER 3: Format & Function of Illustrations in Modern Guides

3.1 The Pragmatic Flora & Technical Guide

Complementary to the historical analysis, the second integral component of this research involves the reassessment of botanical illustration within modern botanical identification guides, taking into consideration past convention, current need, and practicality for overall effectiveness. In order to accomplish this reassessment, it is necessary to delineate the type of guide we are addressing and briefly explain the logic and conventions behind their use of illustrations. In many ways, it is difficult to make concise statements regarding plant identification keys: the "kinds" are too various, the exceptions within these kinds too abundant, and information nested within each are always subject to revision. Entire treatises have been written to delineate and suggest forms of plant identification and classification texts, and it is not within the scope of this paper to elaborate on these nuances, but instead to grasp at the prevalent, applicable trends. According to Shelter (1971) in regard to the Flora North America project, an identification guide can be considered, at its most basic level, as a "time-honoured information retrieval system… a physical repository of descriptive data about plants which are organized and formatted, usually in book form so as to answer a time-tested series of prescribed questions."[42] Within this definition, guides fall across a vast spectrum of forms, distinguishable for differences in floral scope, organization of included species, and the means by which a user would navigate this organization. Furthermore, the intended user has a great influence on the type of information included and the way in which it is presented, resulting in a range of guides that, as Hawthorn (2007) describes, are spread about a

[40] Heywood (2001)
[41] Cullen (1984)
[42] Quote taken from Heywood & Moore (1984)

scale between marketability and technicality, which seems to be commonly equated with degree of professional experience of the intended user, spanning from laminated fold-out cards and glossy picture guides (e.g. *Wildflowers of the Smokies*, White et. Al, 2003) to highly technical, text-based floral inventories (e.g. *Flora of West Tropical Africa*, Hepper and Keay, 1954-1972).

Within this spectrum, we will be focusing on what Hawthorn (2007) defines as 'pragmatic floras' and 'technical guides,' intended for use by students and professionals alike, although without an appeal to a non-scientific audience. These types are derived from the previously discussed tripartite guides of the 19th century, including still the three components of a character-based identification key (most often dichotomously arranged), a section of species descriptions grouped by taxonomic relation, an index, and in more modern versions also an introduction and some form of glossary.[43] In modern modifications of the tripartite format, the delineation between natural and artificial components relies more on functionality than on position within text, and thus arrangement is variably employed, such that the character keys and descriptions are often patterned within each plant family. Nevertheless, because each component functions differently, the placement of illustrations within this system can in turn indicate how they are intended to function and allow us to postulate on how they may be arranged to function more effectively.

3.2 The Use of Illustration in Pragmatic Floras

By and large, the use of illustrations in modern pragmatic floras is restricted to the species description and glossary components, but is rarely accounted for within the artificial character keys. Illustrations included within the glossary are mostly situated as independently functioning spreads, which provide easy visualization and comparison of commonly used terms, such as between different leaf shapes, fruit types, trichome morphologies, etc. The characters are often simple to draw, require little space, and provide a good deal of information to new users, and thus have become fairly commonly used within modern guides. Illustrations within the descriptive sections are much more complex of an endeavor and thus are not as frequently used; however, guides that do utilize them tend to do so quite liberally, as noted by Leggett & Kirchoff (2011) and as can be observed in A. S. Hitchcock's *Manual of the Grasses of the Unites States* (1950) and Joseph E. Harned's *Wildflowers of the Alleghanies* (1936). In this use, individual species are often separately illustrated, depicting the plants in full habit with enlarged and dissected sexual parts,

[43] Leggett & Kirchoff (2011)

similar to the composition to late 18th century engravings but with a lined appearance more reminiscent of the woodcut. While mostly drafted with accuracy, these full-habit illustrations have to be much reduced in size to fit within the given space and, as a result, often lose much of their capacity for communicating important details for identification, such as leaf surface structures and ovary morphology, such as has occurred with the seventh edition of *Gray's New Manual of Botany* (1908), instead giving a more general impression of the species rather than a directed account. By being arranged in such a way, the function of the illustrations is limited to a passive role within the guide, since to reach the species description, the user must have already progressed through the character-based sections of the guide and only upon turning to the page of the species description be presented with a visual representation, acting as confirmation for what information was already gathered.

When confronted with competition from advancing technology, the justification of the page space and effort involved in the creation of these illustrations becomes precarious, because internet inquiries now provide fast and easy access to a spread of digitized herbarium specimens, *in situ* photographs and even other digitized illustrations, which can all act to different degrees for visual confirmation of species identification. Even justification of the less-intensively illustrated glossaries becomes questionable, because many of the common terms that they depict are also easily found through a quick image search on smartphone or laptop. The results of these searches are obviously limited by internet access, which is not always available in the field, and by reliability, whereas in-text illustrations have been confirmed by the author as veritable representations. Nevertheless, it shows how the accessibility of digital imagery creates tenuous conditions for the usefulness of illustrations within keys, especially considering the efforts that go into producing them in comparison to how the user may be inclined to regard or disregard them.

3.3 Suggestions for Increased Utility

Ultimately, upon reevaluating the retained benefits of botanical illustration in light of changing imaging technology, we suggest two central conditions for a more efficient inclusion of illustration in modern plant identification guides:

Primarily, rather than expending efforts in illustrating individual species, a more effective use of resources for pragmatic identification guides may be the prioritization of drafting and including illustrations to function as visual aids for characteristics situated within the artificial

keys. The basis of this suggestion relies on the fact that an effective key must be one that is effective in communicating: the user must be able to understand the information being presented within each couplet in order to progress through the key to the correct species. Verbal descriptions, while essential to the function of these keys, are particularly restrictive in the description of shapes, often resulting in excessive use of botanical jargon. For example, a key may prompt, "perigynia subulate to narrowly lanceoloid, evenly tapered to beak; or perigynia narrowly to broadly ovoid, ellipsoid, obovoid, or globose, abruptly and concavely contracted to the beak?" which in its verbosity sacrifices clarity. Furthermore, the extensive vocabulary that has been devised to manage the description of many of these shapes requires the subtlest distinctions between terms, such as between obovate and obovoid, and often results in inconsistent use and interpretation (Hawthorn 2006). Visual references placed directly within the key can help clarify jargon and reduce verbosity, bypassing cluttered verbal translations by directly expressing information through the conversion of visual data to visual prompting rather than visual data to verbal prompting, or as Britton and Brown claimed as being "addressed to the eye," ultimately aiding in more succinct identification.

Secondly, for this application of illustrations alongside the key, it is essential that they be drafted to fit properly in the space and properly to the information presented. Textual layout is essential to the functioning of pragmatic keys, and the spaces in the margins created by indentation create prime, but limited, real-estate for the inclusion of illustrations. Therefore, characteristics to be illustrated should be chosen on a basis of priority, perhaps those that are considered verbose, confusing, or in general need of visual explanation. Furthermore, to be effective within the limited spaces, the illustrations should be drafted with reduction in mind: clean, decisive shapes can present information with greater clarity than do illustrations with excessive shading and non-essential textures. Thus, in an ideal situation, each illustration should be drafted specifically for the intended couplet, so as to as to best control the manner in which this information is presented by minimizing extraneous detail without losing context. In order to accomplish this precision of presentation, the illustrator must be well-versed in the ideas and characteristics that are being communicated by the intended couplets to avoid misinterpretation and inaccuracy, especially since these concepts should be selected for illustration on the basis of needing further clarification, necessitating a dynamic collaboration between the botanical author(s) and artist, inherently continuing a time-tested partnership for the advancement of descriptive botanical science.

CHAPTER 4: Illustration of the *Guide to the Vascular Plants of Tennessee*

4.1 Introduction

The final component of this research, and also the seed from which it originally grew, is the drafting of illustrations for the second edition of the *Guide to the Vascular Plants of Tennessee,* compiled by the Tennessee Flora Committee in 2015. In many ways, the *Guide* presents a perfect example of the themes evident in the previously discussed modern plant identification guides. The *Guide* is formatted in a tripartite-derived arrangement, including a glossary, character-based dichotomous keys, and species descriptions grouped by genus. Like many pragmatic plant identification keys, the *Guide to the Vascular Plants of Tennessee* is sparsely illustrated, utilizing images only in the initial glossary to present visuals for basic terminologies, such as for corolla shapes and inflorescent types. Of the few illustrations included, they are relatively simple line drawings, having been reused with permission from Eugene Wofford's *Guide to the Vascular Plants of the Blue Ridge* but in reproduction having lost much of their resolution and specificity to the key in which they are contained. Therefore, our guide, a comprehensive 813-page identification guide of all the vascular plants within the state of Tennessee, thus contains only 9 pages of non-specific illustrations. For these reasons, members of the Tennessee Flora Committee recognize that the *Guide to the Vascular Plants of Tennessee* can stand to be much improved by the addition of illustrations, and our efforts have thus been directed towards the creation of these.

4.2 Materials & Methods

4.2.1 Three Approaches for Improvement of the Guide by Illustration

Drawing upon our historical research and survey of botanical illustration in modern keys, and in respect to our own limitations of space, time, and available resources, we ultimately decided upon three different ways in which to improve upon the *Guide to the Vascular Plants of Tennessee* through illustration. Primarily, for the already illustrated glossary, we reassessed which terms should be included as well as the way in which this information can be best presented. While we decided that many of the terms merely needed to be redrawn, to both enhance the level of detail and retain an artistic consistency, we also decided to include a few new terms that do not translate well in the written glossary, such as the spurred corolla of *Aquilegia* and the papilionaceous corolla characteristic of some Fabaceae. Additionally, we also reduced the illustrations depicting inflorescent types from more-detailed drawings to skeletal figures, in order to not distract from the

depicted branching pattern with the inclusion of species-specific details. Second to revamping the initial glossary, we also created illustrated spreads for the depiction of the general structures in selected plant families, to be included as full to half-page satellite glossaries prefacing the descriptions of the family keys. Due to the time involved in drafting these spreads and due to the amount of space they require, we decided that this addition was only necessary for higher taxa, such as for the Pteridophytes and Gymnosperms, and as well for the notably challenging families, such as for Cyperaceae, Poaceae, and Asteraceae. The third way in which we used illustration to enhance the guide was the generation of couplet-specific figures to clarify the more cryptic and confusing characteristics which determine progression through the key. Couplets identified as such were chosen based on observation of the experiences of students who use the *Guide* as a primary botanical source for identification in the Plant Taxonomy course at the University of Tennessee at Chattanooga. Those couplets that often lead students astray, or those which we have ourselves consider in a position to benefit from the inclusion of a visual, have been rendered as illustrations, to be printed within the indented margins of the key, proximal to the specific couplet depicted. Ultimately, these three manners of including illustrations are designed to confer the greatest increase in clarity and usability to the *Guide* while remaining reasonably within the parameters of available resources.

4.2.3 Methods of Drafting

The effectiveness of these three approaches is contingent upon methods used for the drafting of these illustrations. As we have readily seen through the history of botanical illustration, inaccuracy can be disastrous to proper plant identification. Therefore, in the drafting of the illustrations for the *Guide to the Vascular Plants of Tennessee*, care was taken to work directly from fresh material and herbarium specimens to avoid the pitfalls associated with copying from indirect sources. Secondary sources, however, such as photographic references and other illustrations, were still often beneficial as supplements to direct observation. During the initial observation and sketching stage, drawings were first rendered in graphite to facilitate modifications made through collaboration. This collaboration was especially essential for the creation of couplet-specific figures, since they were chosen for their being a source of confusion, and often many drafts had to be created of a single characteristic in order to work out how to present the feature with the most clarity and accuracy (Figure 1). Once a figure was agreed upon,

illustrations were rendered in ink, digitized with an Epson high-resolution scanner, and processed through Adobe Photoshop CC to remove smudging and extraneous lines, as well as to enhance the overall image quality for eventual inclusion into the *Guide to the Vascular Plants of Tennessee*.

Figure 1. The above images show two stages in the process of drafting illustrations for the guide. The image on the left is a scan of a graphite sketch made during the planning of a family spread for Cyperaceae, in which collaboration between artist and botanist is evident. The image on the right shows the ink-rendered product of the graphite sketch. The final product is presented in Figure 7 in the Results section of this paper.

4.3 Results

The results of this exercise were: the generation of a revised general glossary, represented by Figure 2, the creation of 18 family spreads (Figures 3 – 7), and the drafting of 20 new couplet-specific illustrations (Figures 8 & 9) for inclusion into the planned second edition of the *Guide to the Vascular Plants of Tennessee.*

Figure 2.a Corolla shapes and symmetry for the illustrated glossary

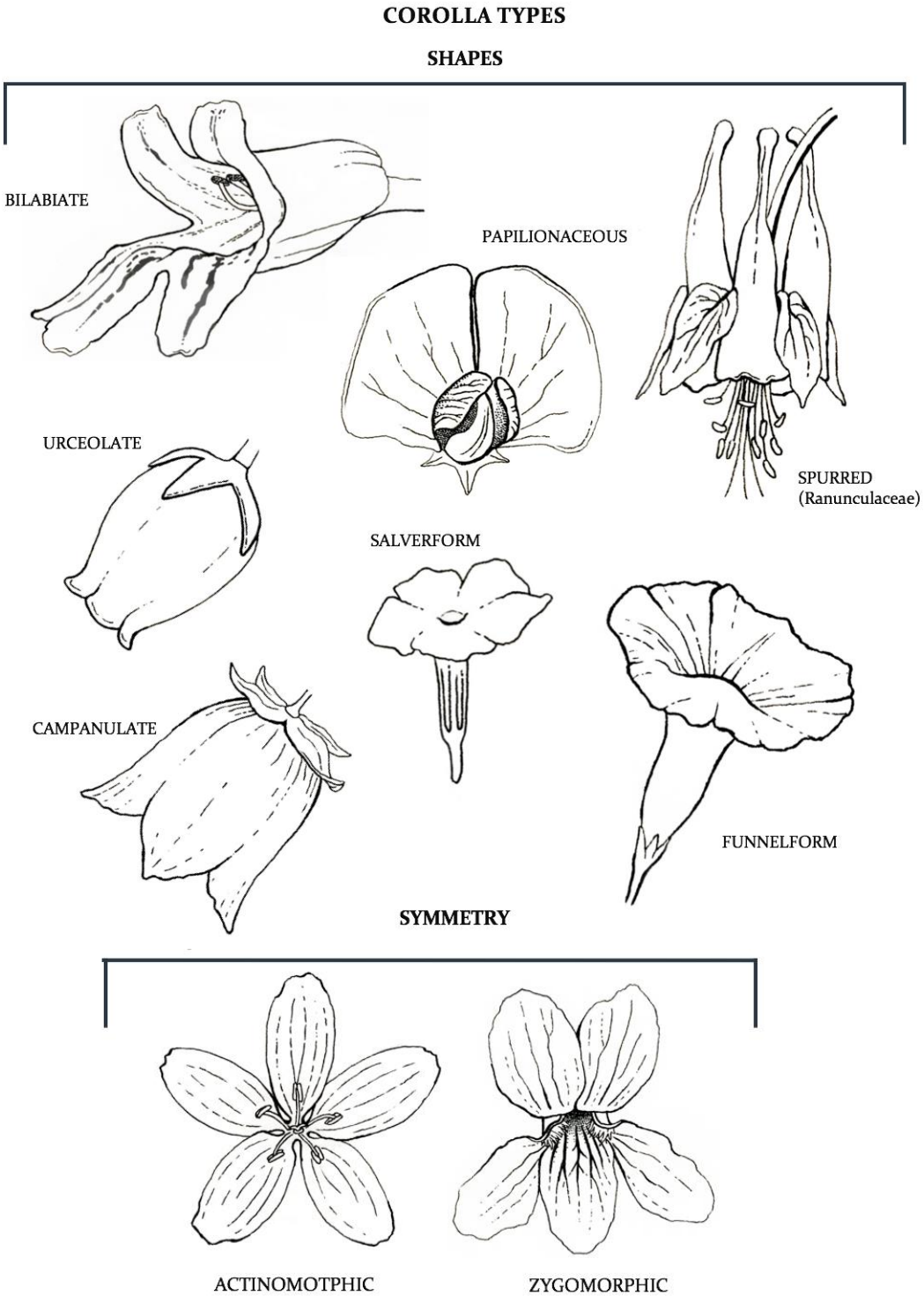


Figure 2.b Fruit types for Illustrated Glossary

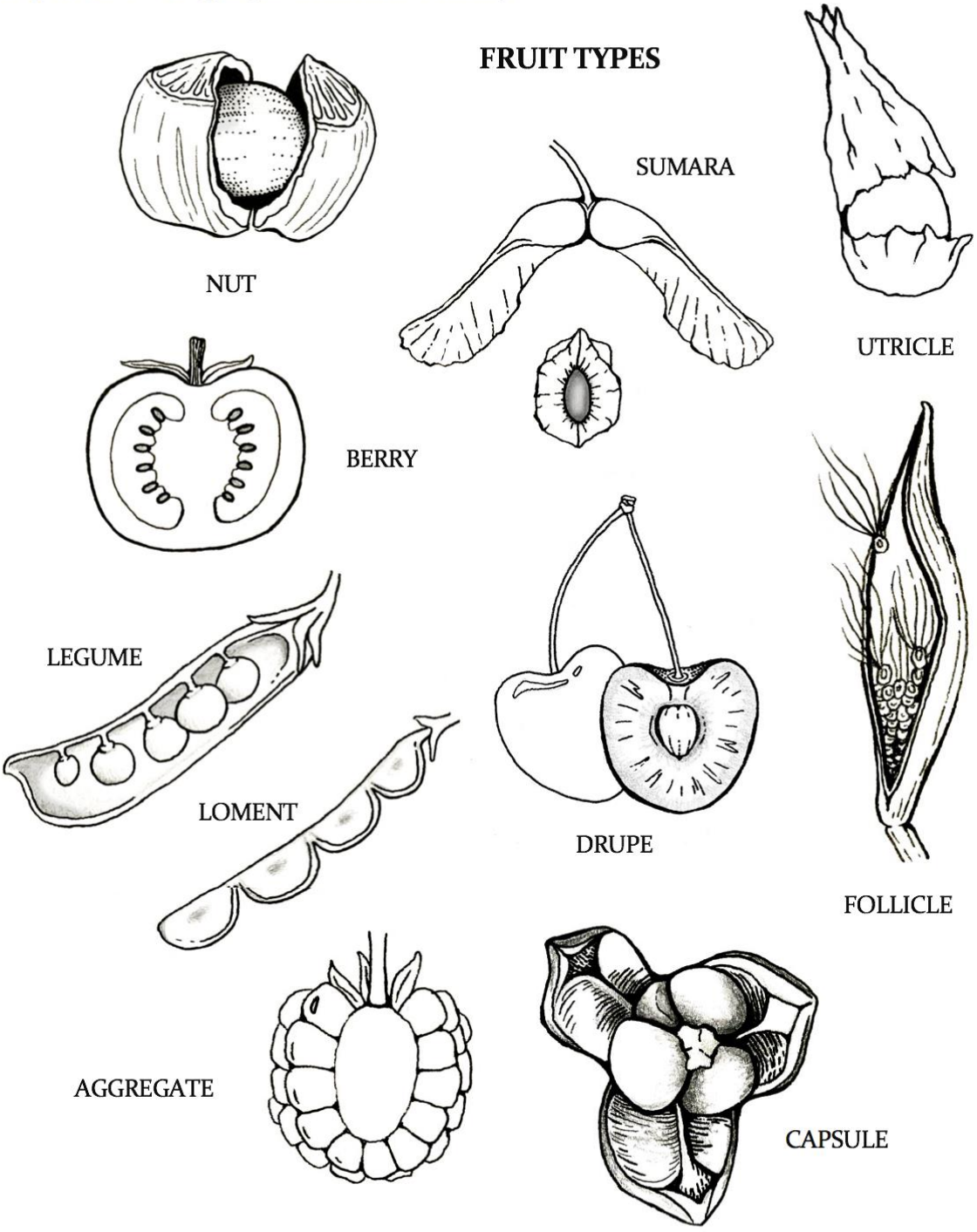


Figure 4 Gymnosperm glossary, depicting families Pinaceae, Cupressaceae, and Taxaceae

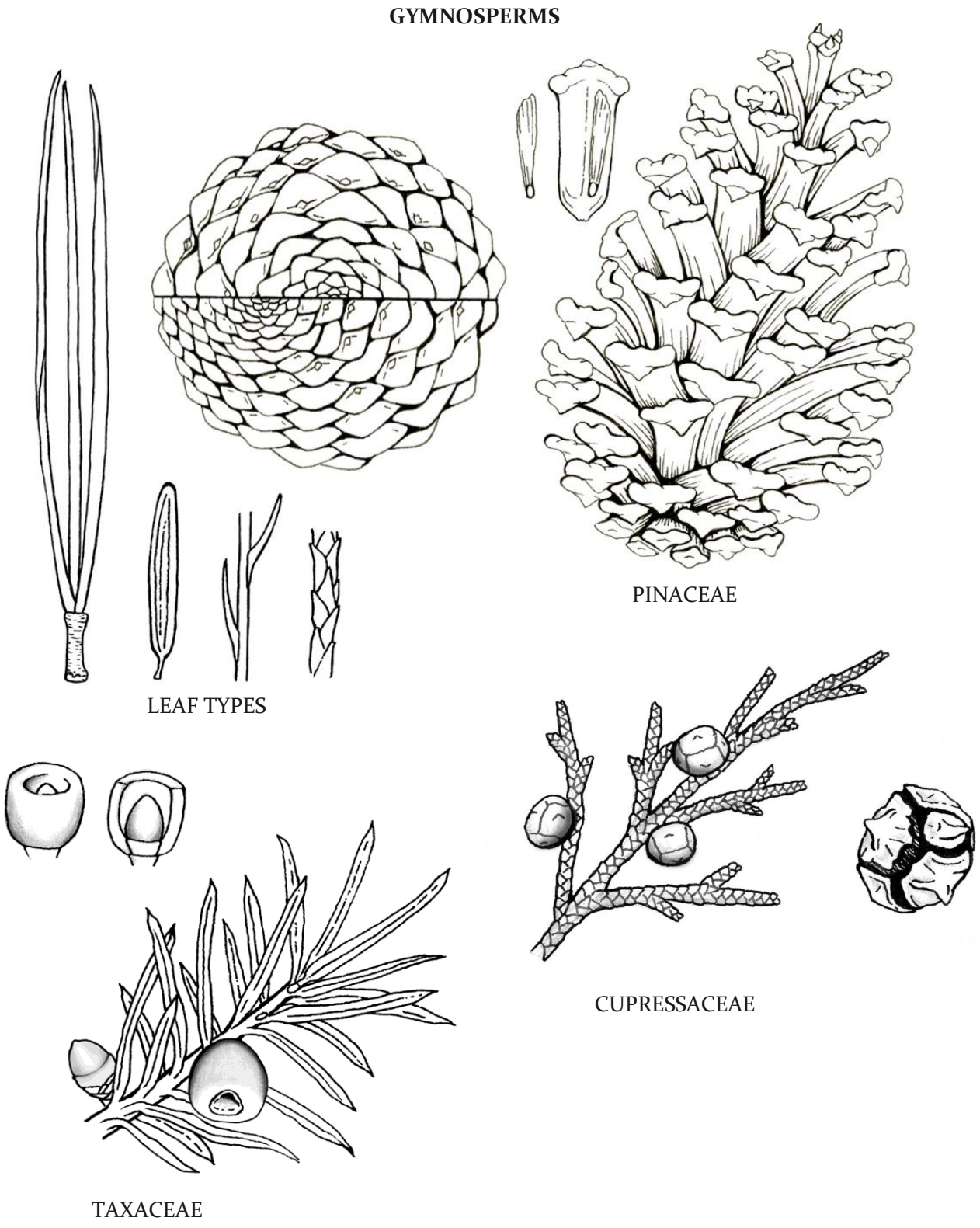
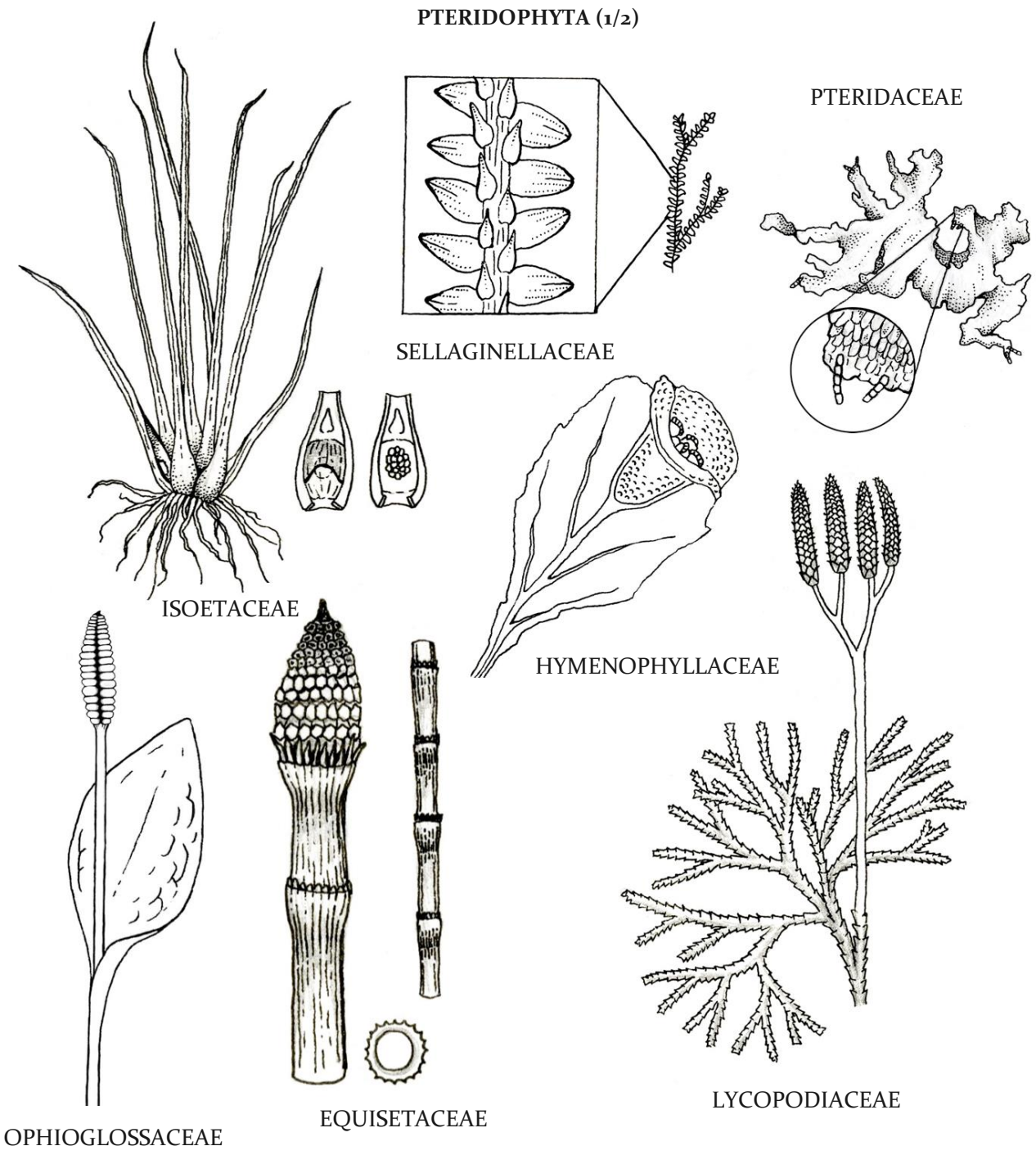


Figure 5 Pteridophyte glossary, illustrating the major families and their characteristic features



PTERIDOPHYTA (2/2)

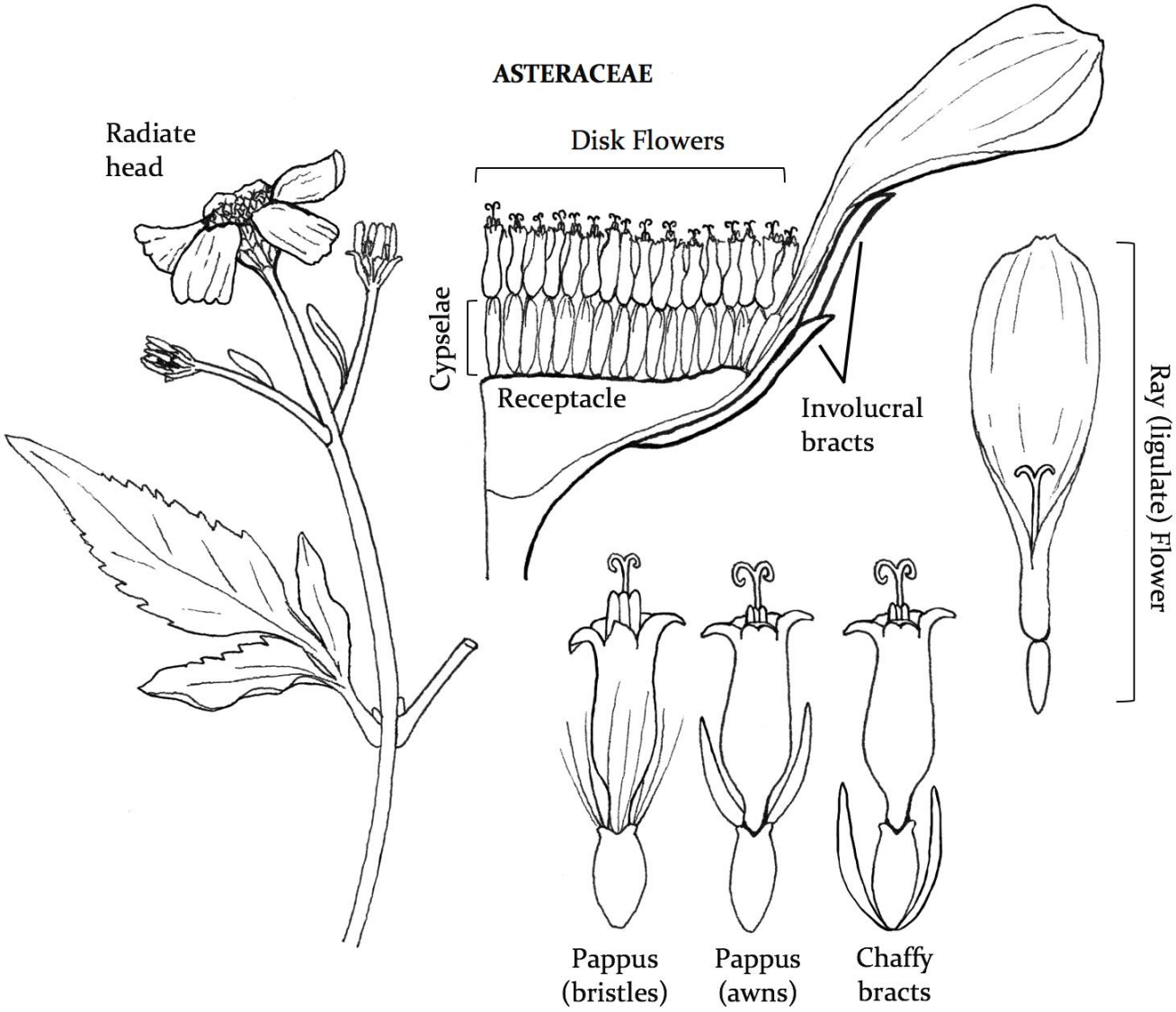


Figure 6.a Asteraceae, depicting necessary terms for identification of subgroup and key

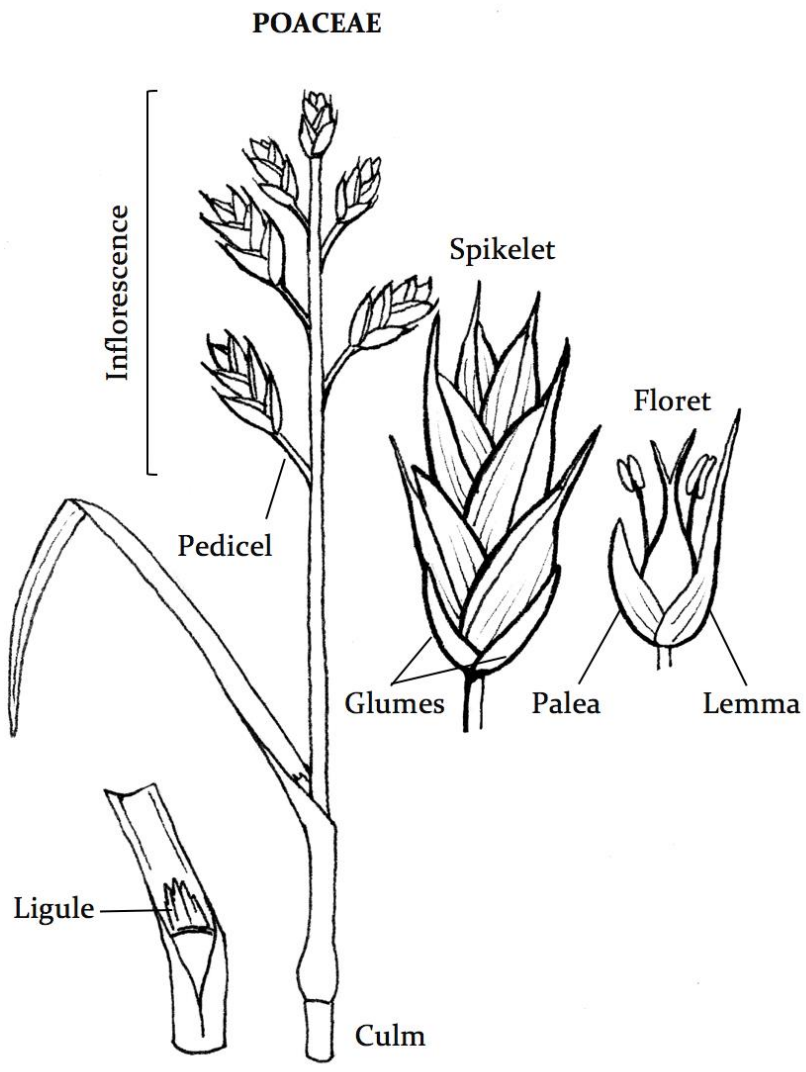


Figure 6.b Poaceae, depicting necessary terms for identification of subgroup and key

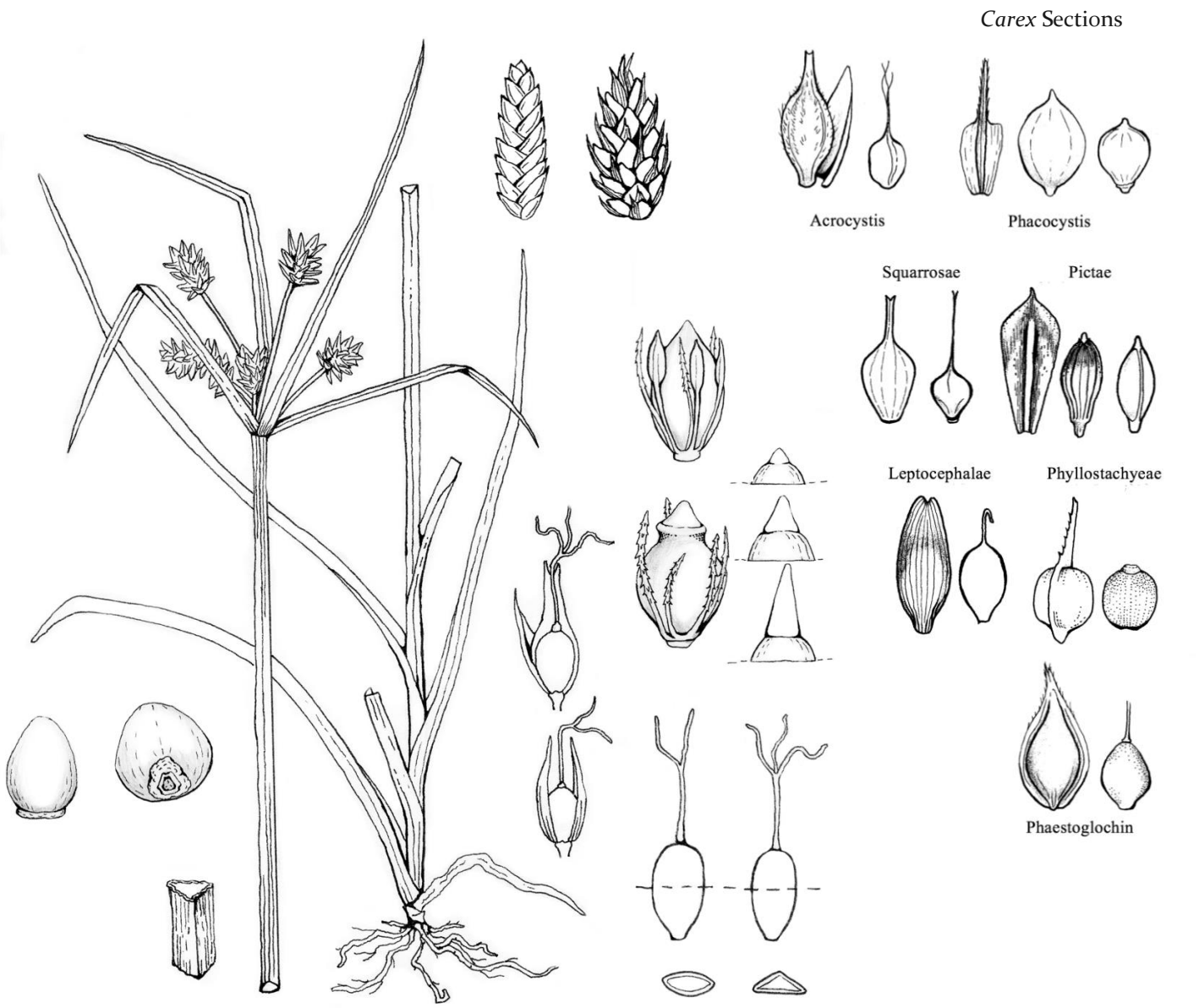


Figure 7 The above figure shows part of the work that is to be included in the Cyperaceae family treatment. Addition, for the genus Carex*, which is notoriously difficult in identification, we have taken extra care to illustrate a spread of the different perigynia and achene types that define the different Sections of* Carex*. Shown here are Acrocystis, Phacocystis, Squarrosae, Pictae, Leptocephalae, Phyllostachyeae, and Phaestoglochin.*

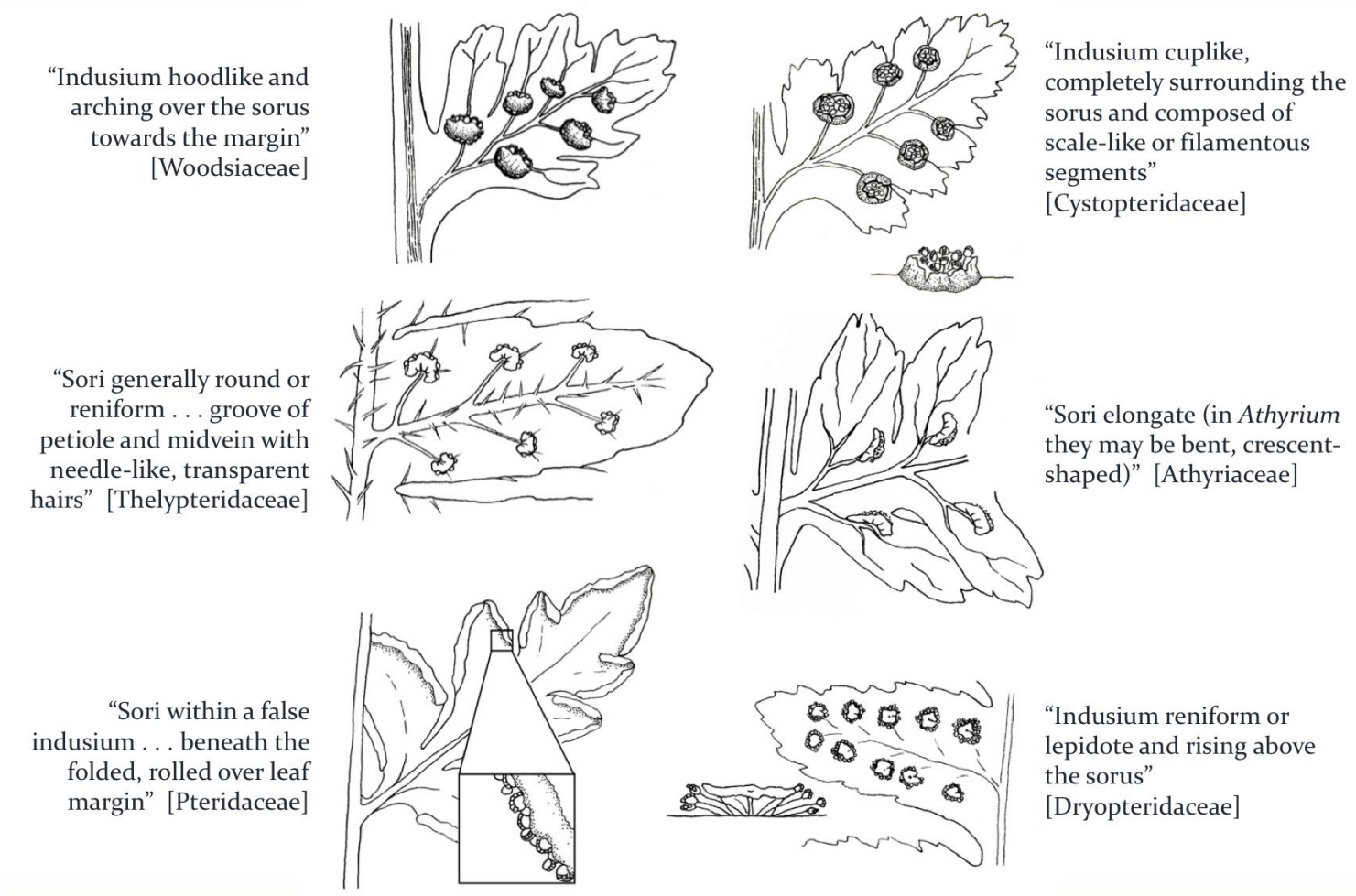
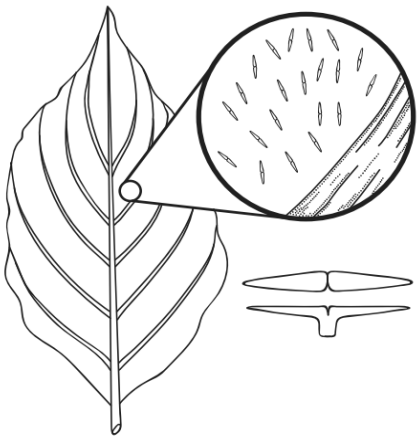


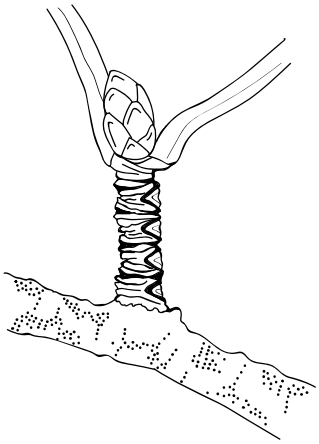
Figure 8 The above figure shows various forms of pteridophyte reproductive morphology, presenting the written description used within the Guide *that routes to different fern families, and the illustration which has been drafted to augment these couplet descriptions.*

Figure 9 The below images each represent illustrations for different characteristics throughout the keys which have been defined as difficult or confusing. Below each is the description that is used within the Guide of the Vascular Plants of Tennessee, *and above is our depiction of which.*

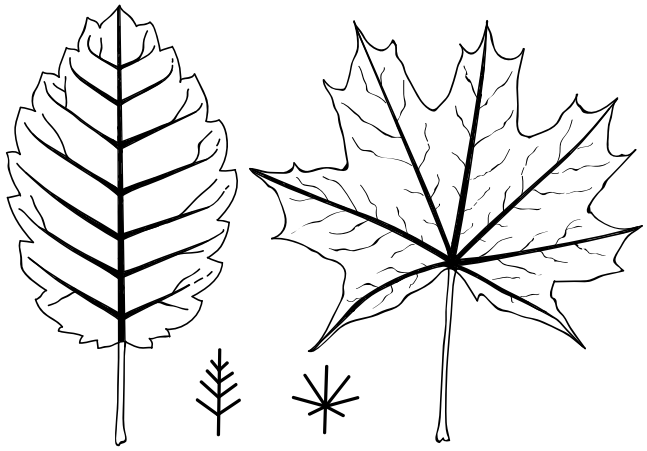
"Perianth modified into a floral tube." [Thymelaeaceae]



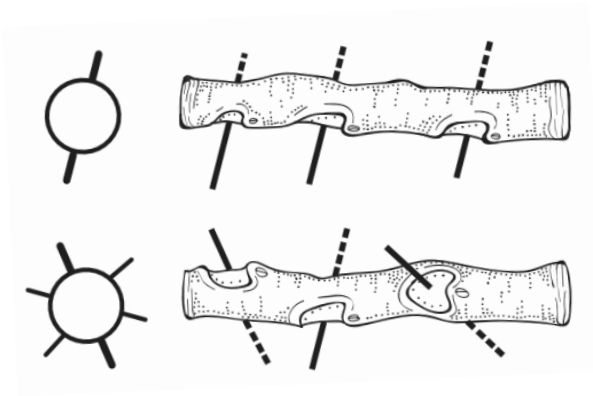
"Lateral veins arching strongly upwards, becoming parallel or nearly so with the midrib; at least some hairs forked and closely appressed to the lower leaf surface." [*Cornus*]



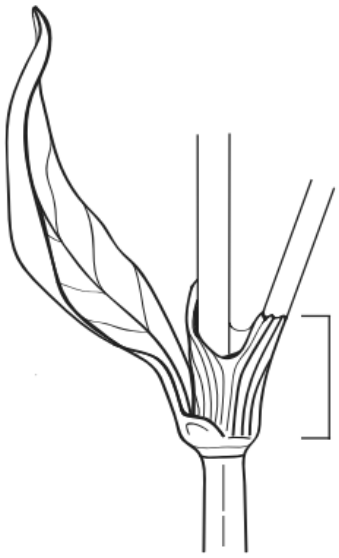
Spur branch



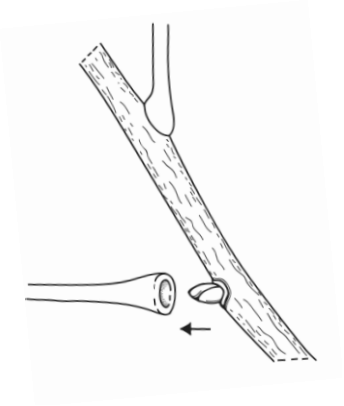
Pinnate or palmate venation



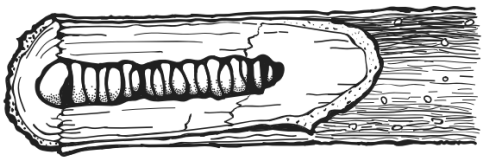
"Leaves arranged in 2 distinct rows on opposing sides of the stem." or "Leaves spirally or randomly arranges, not in distinct rows."



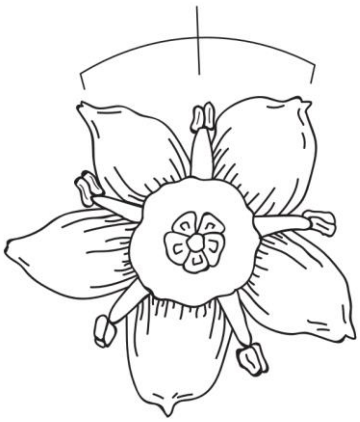
"Ocrea (a tubular sheath derived from fused stipules) present." [Polygonaceae]

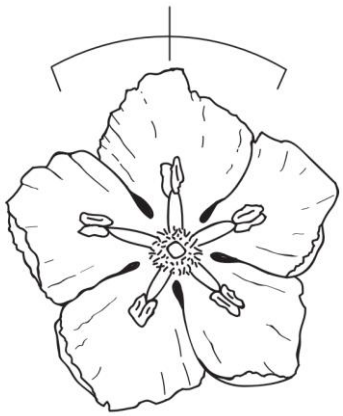


"Axillary bud enclosed by the leaf petiole." [Platanaceae]

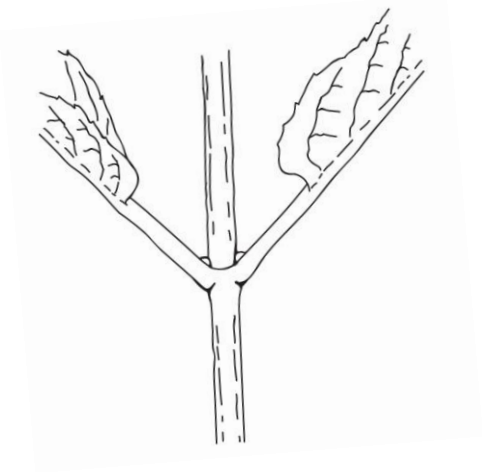


"Pith chambered, sometimes faintly." [*Itea*]

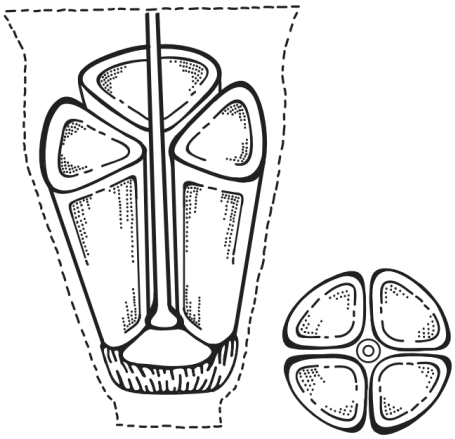




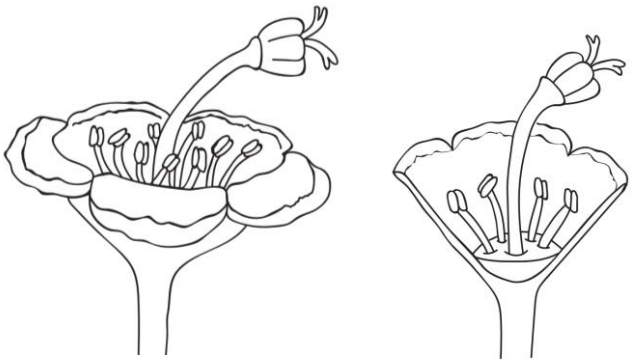
"Stamens alternating with sepals" or "Stamens opposite the sepals."



"Petiole bases meeting or joined by a transverse line." [Caprifoliaceae]



"Ovary slightly or deeply 2- or 4- lobed, appearing as 2 or 4 separate ovaries at maturity. Style attached basally or terminally"



"Flowers greatly reduced and contained within a cup-shaped, calyx-like involucre" [Euphorbiaceae]

4.4 Conclusion

In conclusion, while the initial purpose of this project was to draft illustrations for the eventual second edition of the *Guide to the Vascular Plants of Tennessee,* the endeavor developed into a multifaceted exploration of the conventions and effectiveness of botanical illustration throughout its historical and current applications. We have shown through this investigation the strong ties which bind illustration to shifting technologies, drafting habits, and ideologies and the results this can have on the degree to which illustrations benefit or hinder descriptive botanical science. In observing the use of illustration in modern botanical keys, we have determined that much of it is governed by residual convention, which becomes partially antiquated in light of advancing technologies, and that there is a need for the reassessment of this utilization. Findings from these investigations helped guide us in the drafting of illustrations for the second edition of the *Guide to the Vascular Plants of Tennessee,* inspiring our relatively novel approach of including illustrations within the character-based keys of the guide. Ultimately, we believe that this approach, when paired with our revision of the general glossary and drafting of family-specific figures, will greatly benefit the second edition of the guide, increasing its academic accessibility through a practical, modern application of a time-tested practice.

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