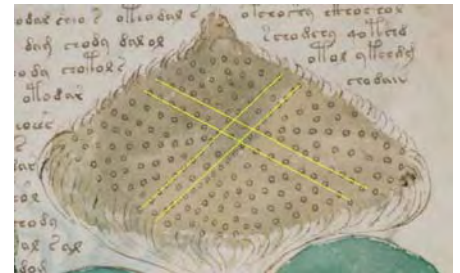


# The Biological Section of the Voynich Manuscript: A Textbook of Medieval Plant Physiology?

Lincoln Taiz and Sandra Lee Taiz

The Voynich manuscript, written in a mysterious cipher and illustrated in a herbal-like form with stylized paintings of bizarre, unidentifiable plants, remains to this day one of the most enduring enigmas of the medieval period (Kennedy and Churchill, 2004). Discovered in 1912 by the antiquarian book dealer Wilfred M. Voynich, the vellum codex has since attracted legions of cryptoanalysts and history sleuths (but unfortunately few professional botanists) dedicated to unlocking its secrets. Voynich apparently happened upon the codex during a book-hunting expedition in Frascati, Italy, near Rome at the Villa Mondragone, then a Jesuit college. The Villa had been built in 1573 by a wealthy Cardinal and used as a summer residence for Pope Gregory XIII. Voynich later found a letter written in Latin inside the book, signed by Joannes Marcus Marci of Cronland, Prague, and dated August 19, 1665. According to Marci, the book had once belonged to the Holy Roman Emperor Rudolph II (1552-1612), who believed it to be the work of the 13th century English cleric, Roger Bacon. Although the codex's authenticity has often been questioned (e.g. D'Imperio, 1978; Schinner, 2007), its medieval origin has recently been confirmed by carbon-14 analysis (Greg Hodgins, pers. commun.). The parchment dates to the early fifteenth century, between 1404 and 1438. In addition, the ink used in the manuscript is consistent with a medieval origin, although there is no way of telling when it was applied to the vellum (Rene Zandbergen, pers. commun.). These findings rule out the 13th century scholar Roger Bacon as the author, an idea favored by Voynich himself (Kennedy and Churchill, 2004).



**Figure 2.** Close up of seed head of the “sunflower” in f.93r showing two pairs of parallel lines (indicated in yellow) traversing the seed head, forming the outline of a cross.

The Voynich codex is currently housed at the Beinecke Rare Book Library at Yale University, which maintains a gallery of digitized images of the 246 pages of the manuscript on its website ([http://beinecke.library.yale.edu/dl\\_cross-collex/SearchExecXC.asp](http://beinecke.library.yale.edu/dl_cross-collex/SearchExecXC.asp)). The first part of the codex (folios 1r-66v), often referred to as the “Botanical” or “Herbal” section, contains

crudely executed paintings of stylized plants, sketched in ink and filled in with washes of green, brown, yellow, blue, and red (D'Imperio, 1978). Few, if any, of the plants are identifiable, although resemblances to actual plants can be found by the determined observer. For example, the plant in Fig. 1A is stylized beyond recognition, although the plants in Fig. 1B and C bear

some resemblance to sunflowers. However, sunflowers only appeared in Europe after 1492, decades after the supposed age of the manuscript according to the carbon-14 dating results. A closer inspection of the “sunflower” in Fig. 1C reveals a cross outlined in seeds (Fig. 2). This suggests that the artist considered the religious or philosophical significance of the drawings in the Herbal section at least as important as naturalistic representation, if not more so.

The remainder of the codex has been divided into five different categories depending on

**Figure 1.** Three pages from the Herbal section of the Voynich manuscript: (A) unidentifiable decorative plant, f.16v; (B) sunflower-like plant with lobed leaves and strange “galls” on the roots, f.33v; (C) another sunflower-like plant, f.93r.



**Figure 3. Illustration from the Biological section of the Voynich Manuscript showing nude female figures dancing or bathing in two vats of green liquid (f.78r).**



have labored longest on the problem generally agree that the cipher cannot be based on a simple substitution method (Bennett, 1976; Zandbergen, 2011).

There is also a third possibility: the Voynich text could be written in a private language. This was the final assessment of William F. Friedman, and some cryptoanalysts have come to the same dismal conclusion (D’Imperio, 1978). Dismal, because a cipher written in a private language would be the most difficult to unravel without the benefit of a key, like the Rosetta Stone. While this has not stopped avid aficionados from pursuing the meaning of the text, there is a growing fear that the cipher may never be cracked. If not, the illustrations may provide the only clues we will ever have to the significance of what has been called “The most mysterious manuscript in the world” (Manly, 1921).

Arguably, the most intriguing and delightful illustrations of the Voynich manuscript are contained in the so-called Biological section, which features cartoon-like drawings of nude female figures busily engaged in various activities, either in groups or individually. Some seem to be dancing while holding hands in vats of green liquid, which are connected to each other

by sections of pipes comprising a plumbing system (Fig. 3). Some are interacting with flexible tubes through which liquid seems to be flowing (Fig. 4). What could these drawings possibly mean?

## INTERPRETATIONS

According to one hypothesis, the drawings with the nude females comprise a health manual for women. The liquid-filled vats represent therapeutic hot spring baths; hence the alternative moniker “balneological.” According to a second hypothesis, the various tubes and bath-like structures represent the uterus and other organs of the female reproductive system. According to this theory the Biological section might be a medieval manual of gynecology. Yet, apart from the spa-like baths, it is difficult to identify anything that might be construed as gynecological among the many drawings of women (Kennedy and Churchill, 2004). Moreover, the dominant color of the liquid is green, consistent with a botanical interpretation. A botanical interpretation would tie the Biological section more closely to the main Herbal section of the manuscript.

the types of illustrations: the “Astrological” or “Astronomical” section (folios 67r-73v), the “Biological” or “Balneological” section (folios 75r-84v), the “Rosette” or “Medallion” section (85r-86v), the “Pharmaceutical” section (folios 87r-102v), and the “Continuous Text” section (folios 103r-117v). The Pharmaceutical section also includes some herbal illustrations as well (folios 90r-96v). Although some of the drawings are reminiscent of the astrological or alchemical herbals of the Middle Ages (Toresella, 1995), taken as a whole the illustration program of the Voynich manuscript is unlike that of any other extant medieval herbal.

The script used in the text of the Voynich manuscript is also unique (see Fig. 2). Despite the best efforts of some of the world’s top code-breakers, including William Frederick Friedman, America’s chief cryptanalyst during World War II, who cracked Japan’s notorious “Purple Cipher,” the text of the Voynich manuscript remains as opaque today as the day it was discovered. Some of the characters resemble alchemical symbols and others resemble Arabic numerals (D’Imperio, 1978). Assuming the cipher represents a known language, such as medieval Latin, the words could have been encrypted either by *transposition* or *substitution*. Transposition involves rearranging the letters of words – in effect, turning them into anagrams. In contrast, substitution retains the order of the “letters,” but substitutes other letters or symbols in their place. Although no generally accepted interpretation has emerged from the plethora of theories regarding the nature of the cipher, those cryptoanalysts who

**Figure 4. Selected illustrations from the Biological section of the Voynich Manuscript showing nude female figures carrying out various tasks: (A) f.79r; (B) f.77r ; (C) f.82r; (D) f.83v.**



*De Plantis* by Nicolaus of Damascus (c. 63 BCE – 14 CE) could well have been the source of the botanical ideas presented in the Voynich manuscript. Roger Bacon (ca. 1214-1294) had based his university lectures on plants, summarized in *Questiones supra de Plantis* (ca. 1245), on *De Plantis*, and Albertus Magnus (ca. 1206-1280) in his *De Vegetabilibus* (ca. 1260) provided additional commentary on the questions posed in *De Plantis* (Reeds, 1980). We therefore propose that the Biological section addresses at least four of the questions discussed in *De Plantis*:

1. What is the origin of the green color of stems and leaves?
2. How is water and nutriment from the soil digested, translocated, and assimilated in plants?
3. How are leaves, flowers, and fruits produced?
4. What is the nature of the plant soul?

These were all questions that had been discussed in *De Plantis* in terms of the four elements and the Galenic humors theory.

Consider the illustration shown in Fig. 3. In the upper left and right corners we see two stylized objects that could be plant reproductive structures – flowers, fruits or cones. The upright twig-like structures at the tops resemble the styles and stigmas of pistils. Flowing either into or out of the bases of these two structures are streams of liquid passing through a series of short pipes connected to two vats containing a green liquid in which nude females are dancing or bathing.

Setting aside the significance of the nude females for the time being, let us focus on the two other striking elements of the drawing: the green liquid and the short pipes. It is reasonable to assume that the green color that dominates the Biological section of the manuscript represents the green pigment of leaves and stems: chlorophyll. In *De Plantis*, Nicolaus discusses the green color in the bark of trees:

The whole tree ought to be of a green color, and that is because the food is attracted and the wood of the tree rarefied, so that owing to the heat a small quantity of concocted food percolates, and the moisture remains with it. In consequence, it appears on the outside, and then the green color will be [seen]. This is also the case with leaves, but there is more concoction in them. That is the difference in power between leaves and bark.

– From *De Plantis*, based on Arabic translation II 8.216-221; Drossaart Lulofs and Poortman, 1989, p.202.

This passage suggests that the green color is the result of the “percolation” of “concocted” (digested) food from the wood to the bark. The

idea of “concoction” in plants was based on the theories of Aristotle and Galen on the digestion of food in animals. The Greeks envisioned digestion as a two stage process: the first stage was concoction of the food in the stomach by heat to form the “chyme”; the second stage was the concoction of chyme in the liver to form “nutrient blood”; the last stage was the transformation of nutrient blood into bone, flesh, and tendon (Powell, 2003).

According to Nicolaus, leaves, unlike roots and the woody trunks of trees, are able to concoct their own food, hence they are green throughout. Regarding the locations where concoction takes place, the Arabic version of *De Plantis* has this to say:

The first concoction takes place in the lower part of the plant within the earth, and the second in the marrow outside the earth which is in the middle of the plant; thereupon the nutritive materials make their appearance in order to be distributed.

– From *De Plantis*, based on Arabic translation II 8.222-227; Drossaart Lulofs and Poortman, 1989, p.204.

In other words, concoction of the soil in plants is similar to the digestion of grass in ruminants – it takes place in stages at various locations. The root first absorbs nutriment from the soil and carries out the first stage of digestion. The partially digested material is then transported upwards through the “marrow,” or pith of the stem, which, Nicolaus tells us, some call the “womb”, while others call the “vitals” or the “heart” of the tree. About halfway up the tree, the concoction is further digested, although not completely, before being passed on to the leaves, where the final digestion takes place. As discussed by Karen Reeds (1980), Albertus Magnus, writing in *De Vegetabilibus* around 1260 CE, described the process of leaf production as the extrusion of partially digested food from the pores of the stem:

[Albertus] first established that in general leaves were formed from an ill-digested mixture of a watery vapor and a dry earthy excrement which was exuded or exhaled from pores in the stem, propelled by a certain generative, formative power within the plant.

– From Reeds, 1980, p.352.

Returning now to the Voynich manuscript, we postulate that the green liquid in the vats in Fig. 3 represents a fermenting (digesting and concocting) mixture of earth and water. The lower vat represents the first concoction in the root, because it is the lowermost part of the system. The upper vat might represent either the second concoction in the “marrow” of the stem or the third concoction in the leaf. In this model, the

green liquid is moving upwards to the aerial portions of the plant. In *De Plantis*, the upward movement of digested food from the root to the shoot is likened to steam rising from a bath, consistent with our hypothesis. According to Nicolaus, upon reaching the extremities of the plant, the steam condenses back to a liquid and flows back down to the root, forming a bidirectional circulatory system similar to that of animals (anticipating Harvey’s theory of the circulation of the blood):

It is not in the nature of water to rise upwards, but the heat draws the moisture into the extremities of the plant, so that the food will get to all its parts, while that which is superfluous is secreted. Just as in a bath, the heat attracts the moisture and then turns it into vapor which rises, and when it abounds in the place, it returns in drops. Similarly, the superfluities in animals and plants return from the upper to the lower part and rise in their actions from the lower to the upper.

– From *De Plantis*, based on Arabic translation II 1-2.145-151; Drossaart Lulofs and Poortman, 1989, p.176.

## A MODERN EXPLANATION

Although the details of the mechanism are incorrect, a modern plant physiologist can recognize several key concepts involved in the movement of sap that are still valid today. For example, heat is involved in driving the evaporation of water (“transpiration”) from the pores (stomates) of leaves, which generates the attractive force that pulls water up the stem through the tube-like nonliving water conducting cells, the xylem elements. The idea of a water circulatory system in plants is also valid, as some of the water that arrives in the leaves via the xylem can be returned to the root via the phloem, the system of living tube-like cells involved in transporting sugars throughout the plant. Xylem and phloem comprise the vascular tissue of plants.

The porosity of woody tissue was observed by Greek natural philosophers, even without the aid of microscopes, and this no doubt gave rise to the idea of “ducts” for the transport of water and food. In *The Parts of Animals*, Aristotle had compared both animal “blood vessels” and plant “vessels” to garden irrigation systems:

The water-courses in gardens are so constructed as to distribute water from one single source or fount into numerous channels, which divide and subdivide so as to convey it to all parts ... Now just after the same fashion has nature laid down channels for the conveyance of the blood throughout the whole body, because this blood is the material out of which the whole fabric is made. This becomes very

**Figure 5. Decorative floral motif.**  
Enlargement of the floral motif in  
Figure 4C.



evident in bodies that have undergone great emaciation. For in such there is nothing to be seen but the blood-vessels; *just as when fig-leaves or vine-leaves or the like have dried up, there is nothing left of them but their vessels* [italics added].

– Aristotle, *The Parts of Animals* Book III, Part 5. Translated by William Ogle (1882) London.

Albertus Magnus had also pulled apart a leaf of plantain and observed the fibrous strands of the vascular tissue (Reeds, 1980). By the same argument, Fig. 4A could also be interpreted as a vascular strand transporting concocted food from the root to the shoot and back again. The small basins at different heights in which the nude females are standing could correspond to leaf nodes, where vascular tissue diverges from the stem to the leaf. According to *De Plantis*, the diameters of the ducts can regulate growth in different directions, causing the plant to grow either up, down, or horizontally. This is reminiscent of the topic of “nutrient allocation” in modern plant physiology, whereby nutrients are preferentially translocated to specific organs, such as growing fruits, at different times of development.

Fig. 4C could represent the process of seed production. A nude female pushes liquid through a T-shaped tube, which gushes toward a flower-shaped object to the right. A line extending from the “flower” bends and terminates in a small star, which hovers over a sleeping female cradled in a bed-like structure. An enlargement of the “flower” is shown in Fig. 5. This appears to be a purely decorative floral motif, similar to those found in the margins of illuminated manuscripts (for example on the lower border of the frontispiece to the *Antidotarium Nicolai*, Egerton Ms. 747, fol. 112).

We interpret the enigmatic “flower-seed” sequence in Fig. 4C as follows: The material pushed through the tubes towards the flower represents the generative liquid or vapor, derived from the pith or marrow of the stem, which gives rise to the seed, represented by the sleeping female in her capsule-like “bed.” It is stated in *De Plantis* that each plant germinates

and grows according to its “star.” The star-on-a-string motif, which appears elsewhere in the cosmological diagrams of the manuscript, could represent the psyche or soul of the plant, which is governed by the heavens.

Fig. 4D could represent either two leaves being extruded from the pores of the stem, or two fruits growing in response to the translocation of concocted food brought to them via the vascular system. According to *De Plantis*, the lightest vapors arrive in the vascular system first to form the flower, followed by the heavier, earthier material, which forms the fruit. The green color and shapes of the “fruits” suggest that they could be gourds. Gourds symbolize the resurrection in Christian art (Ferguson, 1961). They were also used by pilgrims as flasks to carry water, consistent with their role as the ultimate destinations of the green liquid that nourishes the plant.

Finally, what can we say about the significance of the nude females? If we adopt the view that their function in the manuscript is to delight, entertain, and instruct the reader, the nude females may serve as metaphors for the vital force, or vegetative souls, of the plant, which, according to Aristotle, directs the growth, development, and reproduction of each plant species. Women had been strongly identified with plants throughout antiquity, and this association strengthened during the Middle Ages and Renaissance.

If we accept the idea that the female figures represent vegetative souls, why are there multiple “souls” within a single plant? How many souls does an individual plant have? In his treatise *On the Soul* (Book I, Part 4), Aristotle expressed the belief that the higher animals must possess a single soul, because cutting them in half invariably kills them. In contrast, plants can be divided up into many segments, and each segment can potentially survive and regenerate another plant. Aristotle inferred from this ability to propagate plants from cuttings that plant souls can multiply and spread throughout the plant, endowing each part with regenerative powers.

If our hypothesis is correct, what are the female vegetative souls actually *doing* in the large green vats? An analogy can be made between the process of decoction discussed by Aristotle and the process of crushing and fermenting grapes to make wine. Indeed, the two objects in the upper corners of the drawing, from which or to which the liquid is flowing, could represent stylized bunches of grapes. We propose that the artist may have depicted a scene resembling grape crushing as a humorous (and no doubt familiar) metaphor for the concoction of earth and water, which, according to Aristotle/Nicolaus, produces the green substance of plants. The use of women to carry out this joyful process is a time-honored tradition, still practiced today at various wine festivals, and is yet another association of women and agriculture.

**Figure 6. Christian symbols in the Biological section: Christian cross and possible rosary, f.79v.**



However, lest we misinterpret the Biological section as an exercise in pagan philosophy, the artist has inserted a few Christian symbols. As shown in Fig. 6, the nude female figure in the uppermost structure holds a cross, symbolizing Christ, while the figure below her holds a ring-shaped object with an ornament at one end. Although there are no visible beads, the ring-like structure could represent a schematic rosary, symbolizing the Virgin Mary. We have found several female figures holding such rosary-like objects, but only one cross, consistent with the overall feminine theme of the Biological section. Much more could be speculated about the marvelous illustrations of the Voynich manuscript, but we have probably exceeded our quota already. One aspect of the illustrations seems indisputable, however, and that is that images of plants and women predominate. If our interpretation is correct, what makes this medieval codex unique is that the artist does not depict secular scenes of courtly love with maidens in enclosed gardens, or religious scenes of the Virgin Mary surrounded by her roses. Rather, the author depicts a philosophical scene in which women represent vegetative souls located within the very marrow of the plant, driving the processes that make plants grow and reproduce.

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THE WORLD OF HORTICULTURE

# The Pear Industry in China

Yuanwen Teng

In China, 13 *Pyrus* species have been described and more than 3000 cultivars have been recorded. Recent results using DNA markers have revealed the genetic phylogeny and diversity of *Pyrus* species and the evolution and development of cultivars. Cultivars are mainly originated from *P. ussuriensis*, *P. pyrifolia*, and *P. sinkiangensis*. Pears are grown in nearly every province or region of the country with different predominated species and cultivars. Although traditional cultivars still account for over 50% of total pear production, recently released cultivars are becoming leading cultivars in some regions. China is also the world leading country in pear production, with an annual output of more than 14.39 million tonnes (t) and 1.26 million hectares (ha), which account for 65.7% of world production and 72.3% of world growing area, respectively. Pear industry ranks third in fruit industry after oranges and apple in China. The vast area of pear growing contributes to greatly different systems of orchard management. Generally speaking, pear trees growing in North China are trained as a central axis or leader form, but in South China, especially in newly planted orchards, open-center tree form is usually used. Recently, the trellis pergola training system prevailing in Japan has been introduced into some areas of China. Due to lack of dwarf rootstocks, most old orchards were established with low planting density. However, newly planted pears with vigorous rootstocks and high planting density tend to be managed with intensive systems, resulting in poor yield and quality as the orchards age due to poor light penetration. Artificial pollination and fruit bagging have become regular practices and related research has been carried out to obtain the best pollinators and most efficient fruit bags. To meet the increased requirements for consumer safety, integrated pest management (IPM) has become more and more popular, including the use of pheromone mating disruption, yellow sticky traps, and insect trapping lamps. However, chemical sprays are still regularly used to control serious diseases.

## PYRUS GERMLASM RESOURCES IN CHINA

China is a large continental country with diverse climates that contains the most plentiful *Pyrus* germplasm resources in the world. Based on an extensive investigation, 13 species have been described by taxonomists (Table 1). Among these *Pyrus* species, only a few species have been cultivated for commercial production. The commercial pear cultivars native to China are composed of four main groups: Ussurian pear (*P. ussuriensis*), Chinese white pear (*P. pyrifolia*), Chinese white pear group, formerly also assigned to *P. x**bre**tschneideri*), Chinese sand pear (*P. pyrifolia*) and Xinjiang pear (*P. x**si**nkangensis*). Besides the major cultivars, the minor cultivars originated from *P. x**phae**ocarpa*, *P. pashia* and unidentified hybrids are also grown in some areas of China (Teng and Tanabe, 2004). Chinese white pear cultivars are the most widely cultivated in Northern China and have been long assigned to *P. x**bre**tschneideri*. Recent studies with different DNA mark-