

The Microscope of Linnaeus and His Blind Spot¹

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KEYWORDS

Linnaeus, Carl von Linné, aquatic microscope, simple microscope, botanical microscope, microscopy, Uppsala, Sweden, lens, magnification, resolution

ABSTRACT

Carl von Linné (Linnaeus) was the pioneering taxonomist of the 18th century. His microscope survives along with the collections at his former residence in Sweden, though little has been known about it. The instrument is here described and its performance is demonstrated. Curiously, Linnaeus showed little interest in, or knowledge of, microscopic organisms. Very few of his drawings portrayed minute structures and examples of those that survive are described. We also review Linnaeus's little known booklet on microorganisms.

LINNAEUS AND CLASSIFICATION

The world knows of Linnaeus as the taxonomist who bequeathed to science the Latin names for species that we know today. This is not a correct view. First, the names are as often Greek as Latin. Second, many of the names — such as *Musca* the housefly and *Gryllus* the cricket — had been in use for centuries before. Third, his original intention was to become a physician and his interest in natural history was initially a spare-time interest. And last, the great Swedish naturalist is known everywhere as Linnaeus — except in



Carl von Linné

his homeland of Sweden, where he is usually referred to by the name of Carl von Linné. He had acquired the “von” when ennobled in 1761.

The role of Linnaeus in systematizing the world of living organisms was both crucial and timely. Al-

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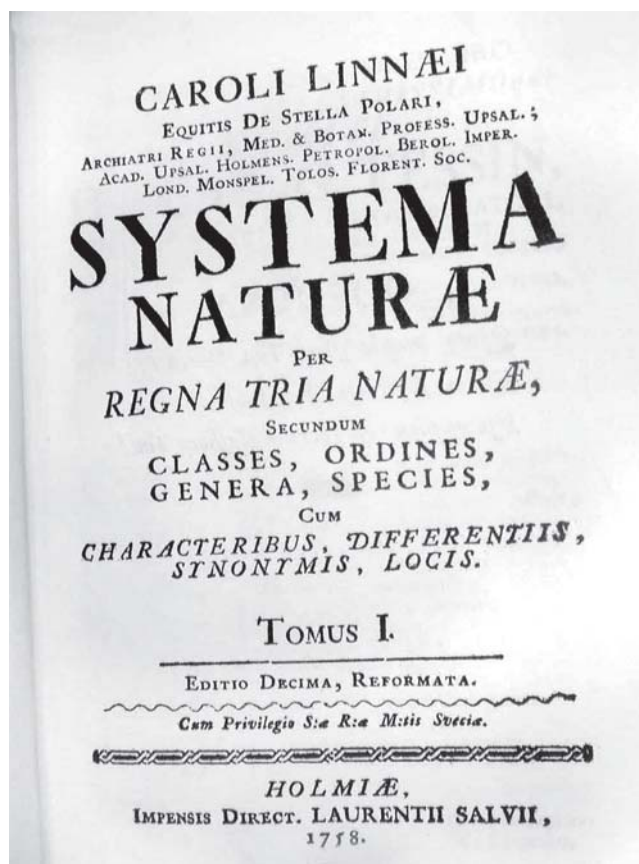


Figure 1. *Systema Naturae* was the title of Linnaeus's great work on taxonomy. This is the grand title page of the 10th edition of the folio volume from the Linnean Society Library, Burlington House, London.

though it is often overlooked, Linnaeus recognised the importance of the sexual organs of flowering plants as the diagnostic criterion of their taxonomic relationships. This gave him a unifying principle by which he could categorize and rearrange the plants with which he was familiar. It also allowed him to simplify and rationalize their scientific names. Linnaeus's most familiar legacy was in simplifying nomenclature to just two terms — the genus and the species. The earlier Latin descriptions of herbs had become complex beyond imagination.

Let us take, as an example, the tomato. The name comes from *tomatl*, the term by which the plant is known in the ancient Aztec language still spoken in central Mexico, where the plant is native and where it was first collected by European explorers in the first half of the 16th century. The plant was initially believed by European horticulturists to bear poisonous fruit; not surprisingly, since the family Solanaceae in-

Afterias.	<i>Corpus radiatum</i> , corio tectum, scabrum.	<i>Stella marina</i> . <i>Stella oligantis</i> . <i>St. pentactinoides</i> . <i>St. polyactinoid</i> .
Medusa.	<i>Corpus orbiculatum</i> , gelatinosum, sub- tus filamentosum.	<i>Urtica marina</i> . <i>Urt. vermiformis</i> . <i>Urt. crinita</i> . <i>Urt. atrophyta</i> .
Sepia.	<i>Corpus oblongum</i> , interne ossium, an- terius octo artubus donatum.	<i>Sepia</i> . <i>Loligo</i> .
Microcosmus.	<i>Corpus variis heterogeneis tectum</i> .	<i>Microcosm. marin.</i>

Figure 2. An indication of the blind spot of Linnaeus can be gleaned from his description of the "microscosmos" in the *Systema Naturae*, which is how he designated planktonic marine microorganisms. They were inelegantly grouped together as a varied and heterogeneous group of bodies.

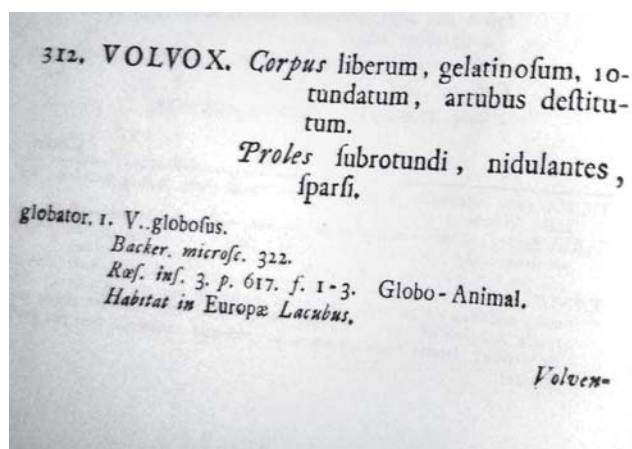


Figure 3. The colonial chlorophyte alga *Volvox* (then dubbed *V globosus* by Linnaeus, and now known as *V globator*) is well described. Allusions to the mode of reproduction, described in the text, suggest that Linnaeus may have observed it with a microscope.

cludes a host of potentially poisonous plants, including tobacco and deadly nightshade. When specimens were brought to Europe by the early explorers, it was originally cultivated purely for decorative purposes.

Its first description in the European literature was published by the Italian physician and botanist Pietro Andrea Mathioli (1501-1577), who included it in his 1554 book, *Comentarii* (1) as *pomi d'oro* (the golden apple). Rumors subsequently spread that it had aphrodisiac properties, and in English it became known as the

“love-apple” and in French as *pomme d’amour*. This was far too simple for the herbalists, who were ever mindful of the need to restrict their unique insights to the cognoscenti by inventing terms that the unschooled public could not understand. They gave it formal polynomial Latin name: *Solanum caule inermi herbaceo, foliis pinnatis incis, racemis simplicibus*. Such lengthy Latin descriptions were narrative descriptions. This one translates as: “the herbaceous nightshade with a smooth stem which has incised pinnate leaves and a simple raceme.”

Linnaeus recognised that the plant was allied to others in what he called the Solanaceae, and simplified this lengthy description to just two words, *Solanum esculentum*. We can perceive the origin of both terms, since *solanum* is the Latin for nightshade, while *esculentum* means edible, and comes from *esca* (the Latin for food). The generic epithet has changed since then. The head gardener at the Chelsea Physic Garden in London, a Scot named Philip Miller (1691–1771), renamed it *Lycopersicon esculentum*, the term we use today. Miller’s generic name “*lycopersicon*” comes from the Greek *lycos* (wolf) and *persicon* (peach) and refers to the fact that these fruits are widely eaten by wild dogs in Central America. With such intricate and complex histories behind “Latin names,” it is easy to see why Linnaeus became determined to rationalise them — and easy to grasp why he found the subject so absorbing.

Linnaeus is widely celebrated for his life-long project: to classify the world of “plants and animals” (2). It is to the world of “animals and plants” that he exerted the greatest influence “in the world” (3). Linnaeus is said to have possessed a belief that God had “ordained him to bring order to nature” and to bring his unified system of classification to “all living things” (4). Although this is universally claimed, it is not entirely correct. The one area for which Linnaeus had a blind spot was the universe of microscopic organisms. He was not ignorant of them; the work of Leeuwenhoek on microscopic organisms had been known to biologists for a century, and the experiments of Abraham Trembley had popularized *Hydra* and led to the widespread purchase of microscopes (5).

Linnaeus also wrote on the microbe world, but in such a perfunctory manner that it beggars belief that he could dismiss such a varied category in so few words. His best known microscopical coinage was for the amoeba, which he named *Chaos chaos*. It is tempting to assume that this was a common amoeba, but *Chaos sp.* is in fact an unusual giant amoeba that Linnaeus would have found easy to observe. The relative characteristics of similar species were examined



Photo by Jan Ford

Figure 4. Professor Gunnar Broberg (right) with the author at the house of Linnaeus that is preserved in Uppsala, Sweden. The Cuff microscope owned by Linnaeus is standing on the table, with the Olympus OM2n 35 mm camera on a stand for micrography.

by George Warren at Temple University (6). It is clear that the *Chaos chaos* of Linnaeus was not the familiar *Amoeba proteus* of the present day.

MICROORGANISMS AND THE SYSTEMA NATURAE

The great work in which Linnaeus published his extraordinary taxonomic lists is the *Systema Naturae* (7). It is truly an inspiring body of work (Figure 1). Many of his proposed terms are with us today — *Homo sapiens*, for example, is a typical Linnaean coinage. Yet look at the page in which he mentions marine microorganisms — plankton. The Latin description simply says, *Microcosmus* — *Corpus variis heterogeneis tectum* (Figure 2). The term “heterogeneis” means a form of reproduction in which the young are a different form of life from the adult (and “tectum” means roof, or lid). In the margin appear the words “Microcosm. Marin” — the ocean’s microcosm. It is very far from a comprehensive survey.

One of the rare organisms he did study, and authoritatively described, is *Volvox globator*. Linnaeus sets this down clearly, as a gelatinous spherical organism. The original text shows that he originally named it *V globosus* (Figure 3). This alga is conspicuous, and easy to observe with the naked eye. *Volvox* is up to 2



Figure 5. The Cuff microscope owned by Linnaeus is screwed into a brass boss in the lid of the microscope case. The case of these botanical microscopes performs two functions: as a base when in use and also as a storage facility.

mm in diameter, and is hardly a diminutive organism to record. Linnaeus's description (7) suggests that he had observed it with a microscope: *corpus liberum gelatinosum rotundatum artubus destitutum, proles subrotundi nidulantes sparsi*. This describes the organism as a "free gelatinous rotund body devoid of limbs, nesting within are small rotund offspring that scatter." Observing *Volvox* with the naked eye is feasible, but his description of the release of small daughter-colonies that had been "nesting" within the parent suggests the use of a microscope.

THE LINNAEUS MICROSCOPE

The original microscope is preserved in Linnaeus's house in Uppsala, Sweden. It was shown to me by Professor Gunnar Broberg (Figure 4), and I was able then to both examine and photograph it (Figure 5), but also to use it to generate photomicrographs. These investigations have not been previously undertaken; indeed a Google image search for the phrase "Linnaeus microscope" produces no hits. The background to this

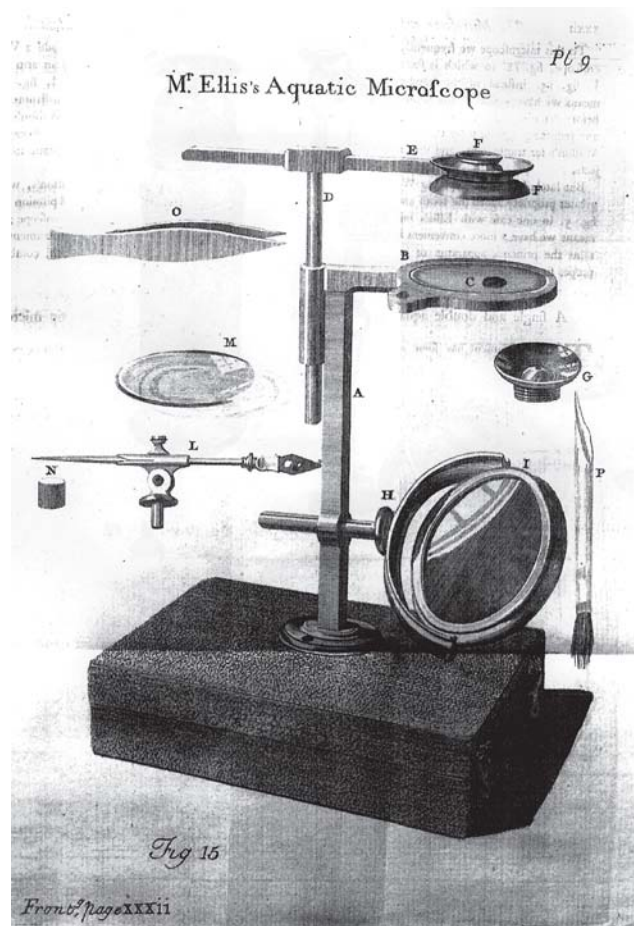


Figure 6. Around 1750, John Ellis of London conceived of the popular type of botanical (or aquatic) microscope used by Linnaeus. The instrument was manufactured by John Cuff, who engraved his name on the microscope. Accessories included a brush, brass tweezers and a watch-glass.

work is outlined in *Single Lens* (5), though the construction of the microscope and the micrographic results were not investigated at that time.

Linnaeus's microscope is a botanical (or aquatic) instrument made in London by John Cuff around 1750. It was based on a design by John Ellis (Figure 6), and these instruments are variously known as Cuff (or Ellis) microscopes. The maker's name is engraved on the main pillar: "CUFF, London." The microscope is fitted within a sharkskin-covered case (Figure 7) and possesses a circular stage with a glass insert, a double-sided substage mirror, and a transverse lens arm that permits the microscopist to observe a given area of the selected specimen.

There are two lens-holders, each fitted with a silvered Lieberkühn reflector that was used to direct light

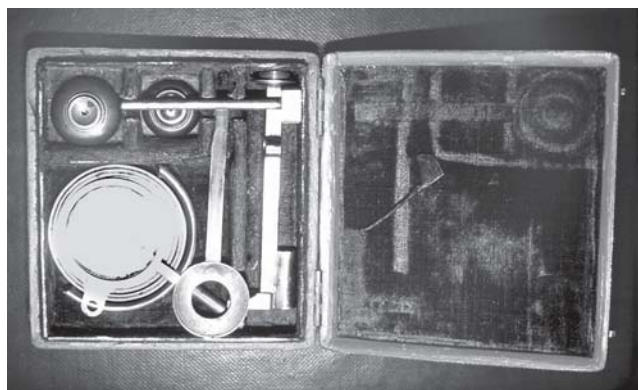


Figure 7. Transportation of these simple microscopes was an easy matter. The components were easily disassembled and stored away within the case, each fitting into a custom-built section within the velvet-lined box.

downwards onto the upper surface of a solid specimen. The equipment immediately reveals that the likely purpose of the microscope was to examine the minute details of floral structures. These instruments, when used as aquatic microscopes, were fitted with a concave watch-glass so that aquatic organisms could be studied. Furthermore, aquatic specimens were observed by transmitted light, reflected upwards from the substage mirror. Only an investigator of structures like the floral components of angiosperms would require illumination from above, hence the Lieberkühns.

We can disassemble the instrument (Figure 8) and can easily identify the lens arm and holders, the Lieberkühn reflectors and the substage mirror. The main pillar is solid square in cross section, and is fitted with a circular support for the rod that supports the lens bracket. A cutting blade that Linnaeus used — to dissect floral structures, no doubt — also survives. It is made of wrought iron, with a cutting surface that extends across a quadrant of a circle (Figure 9).

There are also two lens holders, though only one still retains its lens. This is a low-power soda glass biconcave lens of 6 mm diameter with a nominal magnification of 28x. It is in poor condition, and shows signs of opacity possibly due to crystallization. The other, missing lens would have been of far higher magnification (say 150x) and we may deduce this from the surviving stops that were used to hold the lens in place, and also to restrict its aperture. The smaller of the two is less than 1 mm in diameter, and lenses of this diminutive size typically had a magnification ranging between 150x and 200x. It is unfortunate that this lens is missing. The image quality generated by the



Figure 8. When fully disassembled, the mirror (left), body pillar (below) and lens bracket (right) can be seen. The crudely hand-cut disc of glass and the circular stage into which it fitted indicate that this was an instrument used for botanical, rather than aquatic, specimens.



Figure 9. The single surviving lens (right) is of poor quality. The metal stops that acted as lens holders (center) show that a smaller, high-power lens was originally present. Note the wrought iron cutting blade (left) used for dissection.

low-magnification lens that survives is extremely disappointing, with an observed resolution no better than 20 μ m (Figures 10 and 11).

MICROSCOPY PERFORMED BY LINNAEUS

It is clear that Linnaeus was possessed of a great love of living organisms, though it is curious that he served the smallest of these so badly. We have observed that he dealt discursively with microscopic organisms

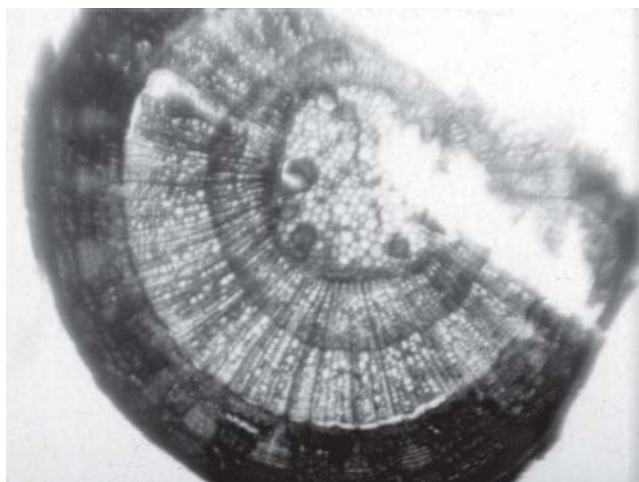


Figure 10. A hand-cut section of a two-year stem of the linden tree *Tilia europaea* imaged with Linnaeus's surviving microscope lens. The resolution and clarity are very poor; only the largest vessels can be clearly resolved.

in his great work *Sytema Naturae*. In 1768, at the age of 61, he published a small book in Latin under the title *Mundum Invisibilem* (Figure 12) which was devoted to his ideas on microscopy (8). It is a short book, running to no more than 23 pages, and includes his ideas on a rust fungus on the cereal *Triticum* (the name it bears to this day, as is true of most of Linnaeus's coinages).

In 1766, he read with interest the words of Baron Otto von Münchhausen, whose technical abilities left much to be desired. "Fungi, when they become old," wrote the exuberant Baron, "scatter a blackish dust...I have kept such dust in water and at a moderate temperature, when the spheres swelled up and change into animal-like balls. These little animals...move about in the water..." and so on.

The timing was crucial, for Linnaeus had recently given the topic of "Mundus invisibilis" to a student as the topic for a thesis, and he paid great attention to the Baron's writings. Linnaeus was still in contact with John Ellis, the designer of his microscope, and wrote to say: "You may pick up, in most barns or stacks of corn, spikes of wheat or barley, full of black powder, which we call *ustilago* or smut. Shake out some of this powder, and put it into tepid water, about the warmth of a pond in summer, for three or four days. This water, though pellucid, when examined in a concave glass under your own microscope, will be observed to contain thousands of little worms."

Hearing nothing on the subject from Ellis, he wrote again: "Before I venture to put forth such an opinion, I beg of you to lend me your lynx-like eyes...having once

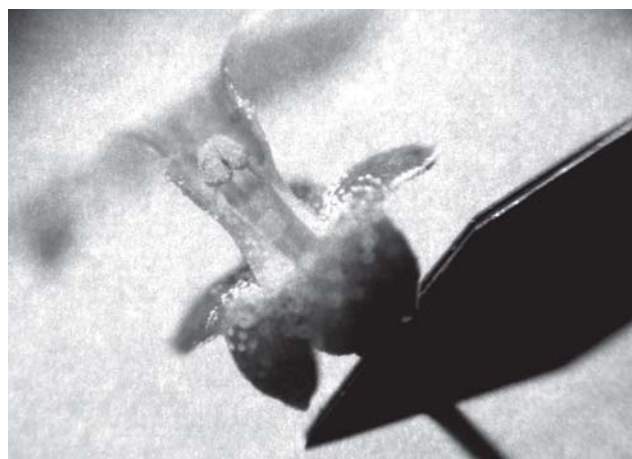


Figure 11. *Primula* is shown through the comparable lens of a botanical microscope owned by George Bentham. The floral structures can be studied with this lens, magnifying 19.6x, and it can be inferred that the Linnaeus lens once gave a similarly clear image.

discovered the little worms in *Ustilago*, by the help of the microscope, I can now see them with my naked eyes."

But John Ellis was having none of it. Rightly, he recognised that Münchhausen and Linnaeus himself were observing contaminant organisms, rather than the transmutation of fungi into little creatures. Wrote Ellis: "By your letter, you seem to think that the seeds of the *Fungi* are animated, or have animal life, and move about; my experiments convince me of the contrary. I must first let you know, that I am convinced that in almost all standing, or even river, water there are the eggs, and often the perfect animals, of those you call animalcula infusoria. As soon as these reach their proper *pubulum*, they grow and increase in numbers." (9)

The Secretary of the Royal Society, Dr. Matthew Maty, published a warning about these "ridiculous absurdities." How curious that Linnaeus, given to such accurate and painstaking observations throughout the realm of plants and animals, seemed so easily led astray by his microscopic observations. He even named some of the rust fungi *Chaos*, the genus we now associate with amoebae, and for a time the wheat rust was known as *Chaos ustilago*. There are no illustrations in *Mundum Invisibilem*.

In a review of the surviving papers, there are few drawings that reveal minute detail. Here I cite two: one botanical, the other zoological. They are taken from a page of his journal for 1732, and show fine detail — though nothing that could not be made out with the naked eye. The first figure shows the common cord

moss, *Funaria hygrometrica*, of which the leaflets can be clearly discerned (Figure 13). This is a good study of a macroscopic (rather than microscopic) specimen. The anatomical details, even if a microscope would help to make them easier to perceive, are not those that a microscope reveals. The same species was portrayed by Robert Hooke in the 1660s (10), and in his meticulous engraving the cellular structure of this diminutive plant is vividly conveyed.

The second study is of the crane fly *Pedicia rivosa* (originally named by Linnaeus as *Tipula rivosa*) in which the venation of the wings is meticulously portrayed. The figure shows an adult insect (Figure 14), and the clarity of the drawing — with the appendages and mouthparts finely recorded — confirms Linnaeus's abilities both as observer and recorder of the natural world. Was a microscope involved in making these studies? Here is a revealing extract from Linnaeus's own journal written at the time. He records setting out to travel from his home in Uppsala to Lapland on May 12, 1743, and carrying with him "an ink-horn, pencease, microscope and spying-glass." Clearly, he regarded a microscope as an important aid, and this fact alone reminds us how remarkable it is that Linnaeus used it to so little effect.

CONCLUSIONS

Linnaeus set out to classify every known species of plant and animal life — but only if it was visible with the naked eye. Surprisingly, for such a diligent investigator and systematist, his infrequent references to microscopic organisms were fleeting and ill-informed. Early accounts of Linnaeus's work tended to disregard any idea that he used a microscope. In 1905, the noted microscopist Sir Frank Crisp wrote in the *Journal of the Royal Microscopical Society* that he "never heard that Linnaeus did" use a microscope.

We can counter that by quoting Linnaeus's own journal, in which we can see that he was clearly accustomed to carrying a microscope on his voyages of discovery. The existence of a microscope that he owned, in Uppsala, further substantiates the connection between the man and the world of microscopy.

Yet we have to face the undeniable fact that Linnaeus did very little in the field of microscopical research. Microorganisms were his blind spot. A century after Leeuwenhoek was revealing the wondrous world of microbes to the gaze of science, the world's greatest pioneering taxonomist ignored them almost entirely. He may have had a microscope, but had a blind spot in how to put it to good use.

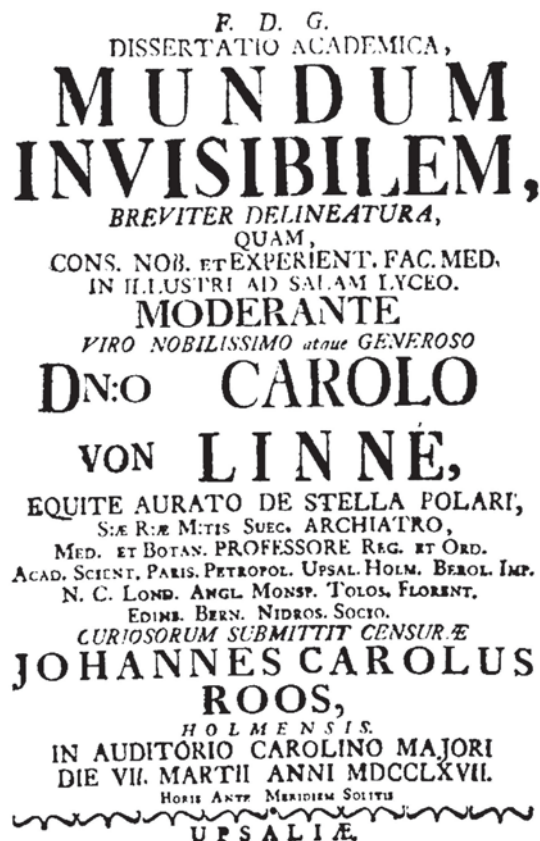


Figure 12. The title page of Linnaeus's only publication on microorganisms, *Mundum Invisibilem* (invisible world). This text-only book of only 28 pages was published in Sweden in 1767.

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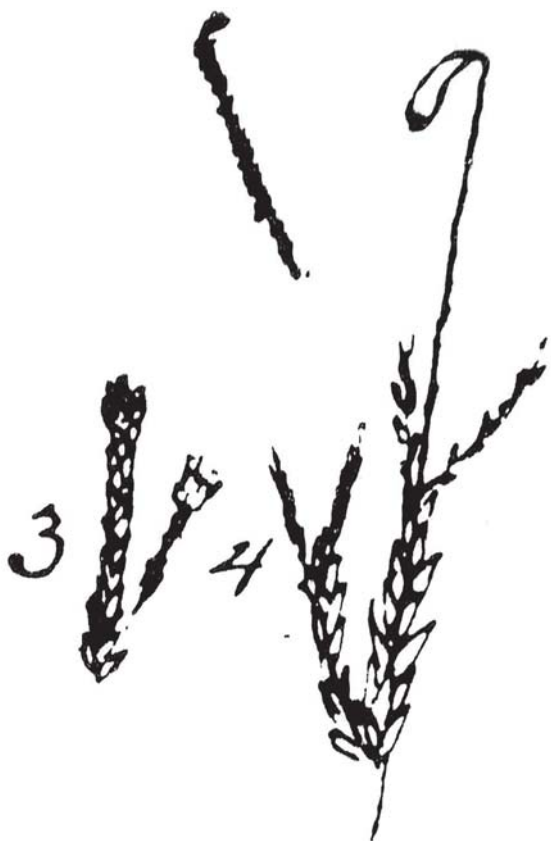


Figure 13. *Funaria hygrometrica* was portrayed by Linnaeus during his excursion to Lapland, which began on May 12, 1732. The drawing gives an excellent impression of the morphology of the common cord moss. However, it does not include anything that requires the use of a microscope.

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Figure 14. In his drawing of an adult crane-fly, *Pedicia rivosa*, Linnaeus vividly illustrates his capacity to faithfully record the morphology of the specimens he studied; even the wing venation is expertly portrayed. A microscope, however, is not necessary for studies at life size.

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