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The Art of Observing the Small: On the Borders of the *subvisibilia* (from Hooke to Brockes)

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Introduction[1]

With the invention of the microscope and its adoption as a scientific instrument since the second half of the seventeenth century, the techniques and the concept of observation became the object of renewed interest and scrutiny. One can even say that it is above all the technical extension of sight that puts "observation" at the center of new discussions. Robert Hooke, author of *Micrographia: Or some Physiological Descriptions of Minute Bodies Made by Magnifying Glasses with Observations and Inquiries thereupon* (1665), concludes from the newly disclosed world of the previously invisible that the naked eye can only see nature as distorted. Only the new "artificial instruments"—like the telescope and the microscope—are able to make up for the "mischiefs, and imperfection, mankind has drawn upon itself" (n.pag.).[2] Above all, with the help of the microscope, man can now learn the art of precise observation.[3] If he applies himself diligently to that which he sees through the new lenses and literally makes do with "little," then—and, strictly speaking, only then—he can arrive at a knowledge of the "true nature of the things themselves."[4]

While both the microscope and the telescope occasion new theories and techniques of *pure* observation, microscopic observations in particular lead to far-reaching meditations on the nature of matter, the infinite smallness of the microcosm, and that which, in spite of the microscope's powers of magnification, is *not* able to be observed. Hooke's ideal of limiting observation entirely to what is visible is exceeded precisely with regard to the new, microscopically delimited world. For seeing through the microscope does not only demonstrate what the technically equipped eye can *see*; rather in the same stroke it also demonstrates what it can*not* see—even with the aid of the microscope.[5]

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In other words, and to be more precise: with this new vision through the magnifying glasses, the line of demarcation in the dichotomy between the visible and invisible, the knowable and the unknowable is displaced. While for Hooke it is still the case that the realm of seeing is coextensive with that of matter and knowledge, relegating the realm of the invisible to that of the immaterial and speculative, in other authors a more complex process of border-negotiations results in a possible, though not always realized incorporation of the invisible into the realm of the visible. With the discovery that what was once invisible to the eye can be made visible with the help of the microscope, the invisible has become the *potentially* visible; thus it too can move into the realm of knowledge. The *subvisibilia*, the worlds visible only through the microscope, thereby become an arena for a new kind of science of the invisible just starting to gain contour.

These negotiations on and over the borders of the visible will be considered in the following pages, primarily through the works of Hooke, Leibniz, and Brockes. It will be shown that Hooke's ethos of observation, which involves a clear demarcation of the realm of the visible and the knowable, leads to a re-description of the visible by various philosophers from Fénelon to Gottsched. Leibniz and Brockes ultimately introduce the invisible once again into the sphere of knowledge in order to deify at the same time the world of the observable.

Visible Knowledge

Scarcely a natural philosopher from the second half of the seventeenth century was so convinced that the new magnifying glasses would revolutionize observation as the Royal Society's notorious curator of experiments, Robert Hooke. Hooke thus belongs to those first natural philosophers who, with their microscopic investigations, also demonstrated how the new technique of observation should be carried out.

The decisive virtue of "proper" seeing is here, in a very literal sense, *modesty*: the true natural philosopher recognizes and remains within his limits. He is content with what his senses supply. The result is that there is in fact "not so much requir'd" to carry out observation correctly. All the true philosopher needs is "a sincere Hand, and a faithful Eye, to examine, and to record, the things themselves as they appear" (Preface n.pag.). His only care must be that "of imploying his Senses aright." Along these lines—in accordance with the topoi of the new empirical method—observation should supersede reflection and imagination.

> The truth is, the Science of Nature has been already too long made only a work of the Brain and of Fancy: It is now high time that it should return to the plainness and soundness of Observations on material and obvious things.

Nothing could be more simple and reliable than the true art of observation—and at the same time, nothing could demand more self-control. For the true art of observation needs to reign itself in, and hold itself back, in order to concentrate completely on what is evident and perceptible. Hooke repeatedly expresses this new discipline of seeing in formulas of modesty that exploit the virtue of "contenting oneself" on a rhetorical plane as well:

> If therefore the Reader expects from me any infallible Deductions, or certainty of Axioms, I am to say for my self, that those stronger Works of Wit and Imagination are above my weak Abilities; or if they had not been so, I would not have made use of them in this present Subject before me: Whenever he finds that I have ventur'd at any small Conjectures, at the causes of the things that I have observed, I beseech him to look, upon them only as doubtful Problems, and uncertain ghesses, and not as unquestionable Conclusions, or matters of unconfutable Science; I have produced nothing here, with intent to bind his understanding to an implicit consent; I am so far from that, that I desire him, not absolutely to rely upon these Observations of my eyes, if he finds them contradicted by the future Ocular Experiments of other and impartial Discoverers. (Preface, n. pag.)

Only a head with more "Wit and Imagination"—Hooke's half-ironic message implies—would be in the position of constructing "infallible Deductions." He, on the other hand, with his "weak Abilities," must content himself with his "Ocular Experiments." And where he doesn't, then the reader may adhere to better future experiments, insofar as they are more impartial.

With this cleverly inserted rhetoric of *humilitas* (which derives from "lowness" or "smallness" in Latin), Hooke establishes a new area of knowledge: that of the small that has now been made visible. At the same time, limits are imposed: this area reaches only as far as the technically enlarged field of vision. The limit of the visible begins where the eye is technically improved, but it extends only to the point where the strength of the glasses ends. Thus the "ocular" observation which produces knowledge can on the one hand only take place where the new instruments of seeing extend the gaze by a given factor (up to 280 times in the case of Hooke), and on the other hand the technical extension of the gaze leads to a new but all the more strict delimiting of knowledge. Should the philosopher transgress these limits with "Wit and Imagination," then he is doing nothing more than "wandring far away into invisible Notions"—and the philosophy of nature has then "quite destroy'd it self." As the miscroscope demonstates, what is seen with the naked eye can deceive; on the other hand, every speculation beyond the limits of enlargement can only lead to presumptuous speculation. There is therefore only one true vision which falls prey neither to deception nor to speculation, and that is the one that is technically extended.

The limit defined with this definition of the observable divides the "visible" of the material and the concrete from the "invisible" of abstract concepts

which no longer describe something which is really present. In the "new visible World" there is nothing invisible. This distinction of visible and invisible, concrete and abstract, modest and presumptuous, is then ultimately placed in tandem to that of "small" and "large." The upshot: any claim to include what is not visible in the realm of knowledge is associated with arrogance, whereas a preoccupation with the visible—and above all with the small—is associated with the *modestas* evoked multiple times in Hooke's *Preface*.

The result is curious in several regards. Hooke casts doubt upon "naked" vision, but not upon the new kind of seeing through the microscope. That the limits set through the new lenses are arbitrary does not seem to occur to him, nor that the unreliability of "naked" vision that the microscope had proven might and indeed must characterize "enhanced" vision as well. The ungraspable chaos which one sees at first glance through the microscope is scarcely described. The excessive demand made on the eye does not seem worthy of mention for Hooke. Instead he parades his "minute bodies" as if they had appeared to him immediately under the lens. Despite some metaphoric designations of "infinite numbers" and the description of diffuse images, in general Hooke conveys the impression of a world which is certainly tremendously small, but in no sense overwhelming. On the contrary, Hooke's world of the small seems quite readily comprehensible. The result is a seemingly clear boundary between the world of (new) visibility and the material, i.e., the realm of knowledge, on the one hand, and the world of the ungraspable, invisible and speculative on the other hand.

Invisible Worlds

While Hooke's *Micrographia* celebrates the new vision above all as the perfection of observation, other philosophers and investigators of nature are more skeptical. Thus the gaze through the microscope leads time and again to experiences of excessive demand which, along with the new vision, produce a new uncertainty and ultimately a new invisibility. Microscopic observation, these authors stress, is anything but a self-evident process. For example, the zoologist and microscopist Leeuwenhoek writes:

> No Body must Publish or bring to light, new Discoveries, and judge by one sight, but he must see the same over and over several times, for it doth happen often to me, that People looking through a Magnifying-glass, do say now I see this, and then that, and when I give them better Instructions, they saw themselves mistaken in their opinion, and what is more, even he that is very well used to looking through Magnifying-glasses may be misled by giving too sudden a Judgment, of what he doth see. (306)

As a consequence, observation through the microscope is for Leeuwenhoek, as for others among his contemporaries, anything but a simple and immediate

vision. Repetition and more precise instruction are required so that what is seen can become an object of observation. The distinction between observation and opinion proves more difficult than Hooke had implied; it must be drawn anew, and for that one needs, as Bacon already emphasized in his *New Organon*, patience and practice. Even with the help of a microscope, one should in no event put one's faith on what one sees at first glance.

In subsequent years, well into the eighteenth century, microscopists all note that the look through the microscope initially overwhelms all faculty of comprehension. George Adams remarks how difficult it is to observe "animalcula," precisely because they are so "exceeding numerous**"** (44), and Henry Baker points to how "innumerable" the "minute plants" are and makes clear how "tedious" it would be "to enumerate" (255) all the beautiful and particular forms which are revealed under the magnifying lens.

These ever recurring experiences describing such excessive "microscopic" demands go hand in hand with reflections on the nature of matter: a matter which has revealed itself to the new gaze as an inconceivable swarm of living mini-creatures which are always teaming on the threshold of invisibility. Calculations and comparisons are carried out time and again that not only describe the tremendous smallness of the new microcosm, but also make clear that visibility and invisibility are *not* simple opposites. On the contrary, from the microscopic observations one can conclude that "visibility" is nothing other than a multiplication of "invisibilities." The invisible can become visible and vice versa. Commenting on the microscopic investigations of his contemporaries, Gottsched remarks in his *Erste Gründe der Gesamten Weltweisheit*: "Since the division of bodies can transform visible things into invisible ones, it is therefore no wonder that from the composition of many invisible particles, visible ones can emerge" (326).

One sees here how on the one hand a new "invisibility" emerges which is not related to anything supernatural, but rather to matter itself, while on the other hand this new invisibility moves into the visible sphere: the visible is comprised of the non-visible. The invisible is therefore no longer beyond the material world, but rather a part of it.

This new form of distinguishing between visibility and invisibility which draws the invisible into the world of the empirical ultimately leads to far-reaching reflections on the infinite. If the invisible conceals itself behind the visible, so that everything potentially visible either is visible or becomes so when sufficiently amassed, then no one can say with certainty where and whether a stable boundary can be drawn between the two. Following this train of thought, François de La Mothe-Fénelon, in his *Demonstration de l'Existence de Dieu* from 1712, comes to the following conclusion:

> The microscope discovers for us, in every body, almost a thousand things that have escaped our knowledge. How many other objects are there in each object seen under the microscope which the microscope itself cannot reveal? What

> would we not see if we could continually refine the instruments that come to the aid of our weak and crude vision? But let us supplement by means of imagination what our vision lacks, and let our imagination itself become a kind of microscope that shows us in each atom a thousand new and invisible worlds: even then it would not be able to show us in the little bodies new discoveries without limit: it too would exhaust itself and be forced to stop, to succumb, and to allow a thousand wonders to remain unknown in the smallest of bodies (40–41).

Fénelon's emphasis is not on that which appears through the act of magnification, but rather on that which remains hidden. The new microscopic boundary of the visible is recognized as arbitrary, which begs the question of what more would be seen if the lenses could be perfected even further. Here, the imagination comes into play and leads the gaze beyond the limits of even the best microscope. But even imagination has a limit. The suggestion is that nature is to a far greater degree—in fact, infinitely—smaller than can ever be imagined, much less seen. Thus before the eyes of the microscopist and the inner eye of the imagination there emerges an inconceivably large invisible world, which is however still part of nature and matter.

Leibnizian Infinities

Leibniz, who develops his own new kind of optical lens in his *Notitia opticae promotae*, belongs to the few philosophers from the end of the seventeenth century who were convinced that "telescopes are far from being as useful and from revealing the beauty and varieties of nature which microscopes reveal" ("Reflections" 566). Microscopic lenses are, according to Leibniz, what have granted observation a radically new kind of knowledge: that the world of the living does not end where the human eye can no longer see. The observations of "Lords Swammerdam, Malpighi, and Leuwenhoek," the great microscopists of the seventeenth century, have "facilitated the assumption" that "the living being and every other organic substance does not begin when we think" ("Neues" 25).[6] Thus magnification lenses have made empirically evident to what an enormous degree the micro-world beneath the visible is comprised of the tiniest living and reproducing beings. "Our experience is in favor of this great number of living things; we find that there is a prodigious quantity of them in a drop of water," Leibniz writes in a letter from 1687 to Antoine Arnauld (*Sämtliche* 2.2: 189).

The new experience of an overwhelming quantity of the smallest living organisms in a fluid which seems transparent to the naked eye leads Leibniz inexorably to the conclusion that the true nature of things must *per se* elude observation. What the naked eye observes as the color green is composed, as one can see under a microscope, of yellow and blue particles. What appears smooth to the eye looks under the microscope to be rough and non-uniform.

What to the naked eye appears to be a single self-contained object reveals itself under the microscope to be composed of a million parts.[7] One is thus forced to assume that even that which appears under the microscope as uniform is in truth comprised of an infinite number of the smallest particles. For Leibniz, the divisibility of matter is just as endless as the possible infinitesimal divisibility of a mathematical quantity. In 1671, Leibniz notes in his *De Materia Prima*: "Matter [. . .] is divided into infinite parts. There are infinite creatures in any given body" (*Sämtliche* 6.2: 280). He thus arrives at his philosophy of "mundi in mundis in infinitum" (241), which endlessly miniaturizes the microscopically observable cosmos in a *mise-en-abyme*: "Every piece of nature can be comprehended as a garden full of plants and a pond full of fish. But every twig of the plant, every member of the animal, every drop of his juices is in turn such a garden and such a pond" (*Monadologie* 29). Were the microscopist to content himself with that which he can observe in the new lenses, he would merely become another victim of an arbitrarily posed limit of sight. Every act of seeing naturally has a limit. Once it is proven, however, that limits of seeing are not also limits of nature, empirical observation must lead to a new, speculative hypothesis. Visibility only demonstrates what must remain eternally closed to the eye, despite all technical perfection: the extension through to the infinite.

The impossibility of ever seeing this extension through to the infinite leads Leibniz not to a new distinction of the visible from the invisible, and thus from empirical to speculative knowledge, but on the contrary to the assumption that the new technically extended observation must lead virtually seamlessly to metaphysics. For the observation that the limits of matter do not conform to the limits of seeing leads inevitably to the conclusion that "invisibility" gives no information whatsoever about the being of things. The fact that a drop of water, seemingly transparent under the microscope, reveals an incomprehensible quantity of the smallest living beings thus testifies for Leibniz to the continuity of all being.[8] Where the understanding, misled by mere seeing, posits "leaps," smooth transitions are to be seen under the microscope. What seems transparent to the naked eye is, in reality, filled with the smallest living beings. The universe is a continuous whole with no unfilled regions—and thus no delimitable or excludable space of the invisible or the metaphysical.

Hence, for Leibniz, it is not possible to trace a border that would separate the divine-invisible (and unknowable) from the earthly-visible (and knowable) realm. Visibility and invisibility are—as the microscope had shown—relative terms; they tell us nothing about the nature of things. Indeed, what Leibniz learns from the microscope is that all that is invisible is potentially visible; and that all that is visible (regardless of how much it is magnified) can completely change its aspect. In other words, the demonstration that the limits of the visible are *movable*, and thus arbitrary, leads Leibniz—in a manner that

is, of course, precisely the opposite of Hooke's—to the conclusion that these limits tell us nothing about matter or substance at all; and that the understanding—Hooke's speculation—is in any event involved when it comes to detailing the nature of things. Hence, Leibniz rejects the way the natural philosophers draw a border between the visible and the invisible and sees the limitation of knowledge to the visible as an arbitrary and groundless limitation.

At the same time, however, it would be wrong to conclude that Leibniz simply expands the realm of the knowable beyond all limits. If Leibniz rejects the significance of the distinction between the visible and the invisible, he does not for that reason give up the distinction between the finite and the infinite. It is this limit that defines the 'humility' of Leibniz's philosophy: human knowledge cannot comprehend the infinity that is the universe, and that only God can know. While human knowledge on the basis of observation can expand indefinitely, and while reason, by means of such inventions as probability and the calculus, can find a sure footing within nature's infinity, this infinity remains contingent for humans; in its necessity, it is only known to God. Human knowledge is thus always too small by an infinity. What divine knowledge can think and know is in this sense beyond human understanding. What constitutes Leibniz's humility is this recognition of the infinitely large discrepancy between the smallness of human and the greatness of divine understanding.

Infinite Views: Brockes

Nowhere in the early German Enlightenment does microscopic observation become an object of more poetic interest than in the poetry of Barthold Heinrich Brockes (1680–1747).[9] Brockes's poems therefore play a particularly important role in the understanding of the history of the art of observing the small and of the relationship between the visible and the invisible. As has often been pointed out, Brockes proceeds with "the care of a natural scientist" in the domain of poetry, to quote as early a reader as Breitinger (432). And indeed, Brockes's poetics of observation can be seen in several of the poems in his multi-volume *Irdisches Vergnügen in Gott, bestehend in Physicalisch- und Moralischen Gedichten* (1721–1748).

In his much-quoted poem "Das Grosse und das Kleine," we find the following stanza about an observer of nature:

> Er setzte sich darauf ins Gras,
> Die grosse Kleinheit zu betrachten,
> Nahm sein Vergröss'rungs-Glas,
> Das unserm Augen-Strahl
> Jedweden Vorwurf funfzig mal
> Vergrössert zeiget,

Und fand, daß dieser Wurm so klein,
Daß er auch, durch des Glases Schein,
Die Grösse kaum vom Sand-Korn übersteiget (vol 1: 146–7).

He sat himself down on the grass,
To consider the great smallness,
Took his magnifying glass,
Which to the beam of our eye,
Every object shows
Fifty times enlarged,
And found this worm to be so small,
That it too, as it appeared through the glass,
Scarcely surpassed the size of a grain of sand.

In a nature transformed into a kind of laboratory, the poet directs his whole attention to the small. He looks through his magnifying glass and sees a worm so tiny that it would have been imperceptible to the naked eye. The description clearly follows the *dispositio* of experimental reports that had been established by Robert Boyle and others and that Hooke, too, had followed (cf. e.g. Shapin and Schaffer). Step by step, the poet shows us first the position of the observer, then the instrument that is being used in its technical features, and finally the object of observation. No speculation leads the attention astray. Everything seems to be reduced to mere description. Observing the small is cast as an empirical practice that a) dedicates itself entirely to the world of the newly visible and b) has the modesty to deal with things as small as a grain of sand.

But Brockes does not limit his poetic observations to the experience of the senses alone. Even in a stanza that is focused entirely on the newly visible, the limit of observation is crossed, even if implicitly, in the little word "fand" (found, V. 7). *Fand* can be understood in the sense of experimental philosophy as "coming across" something ("vorfinden") that is thereby given as an object of knowledge; but it can also mean to "determine" or "judge" something ("befinden")—meaning that it would involve an act of interpretation.[10] Even if the stanza does not conclude with a generalizing statement but with a single observation—the appearance of the worm in the microscope has scarcely the size of a grain of sand—the reader is clearly meant to feel wonder at the image of such a minuscule living body.[11] The microscopic observation is more than the isolated fact of the sort presented by Hooke; the empirical "find" is at once an object of awe and an occasion to admire how God's care for his creation extends even to the smallest of his creatures.[12]

The "great smallness" in this stanza also alludes to the theme of the endless nesting of the small within the small. In even the smallest drop there is a world of invisible living things. This *topos* is developed in more detail in Brockes's poem "Neu-Jahrs-Gedicht" (1730):

Ein jedes Blat, ein jedes Tröpfchen Naß,
So in der Thiere Cörpern stecket,
Wenn man dieselbige mit Fleiß und Ernst bemerckt,
Zeigt uns viel lebende Geschöpfe. Man entdecket
Sie Scharen-weis', und fast bey Millionen.
Ja äusserlich auf vieler Thiere Haut
Wird ihrer eine Zahl, die sonder Zahl, geschaut (vol 4: 400–1).

Each leaf, each droplet of fluid
That is hidden in the body of the animals,
If one steadily and earnestly observes them,
Shows us many living creatures. One discovers
Them in multitudes and almost by the millions.
Indeed, on the surface of many animals' skin
can be seen a number without number of them.

Very clearly, this poem concerns the idea of "worlds within worlds *ad infinitum*." A closer and more attentive—and technically enhanced—look at a leaf or a drop of water reveals an immense number of minute bodies. The expression "Zahl, die sonder Zahl" (a number without number) identifies this immensity as infinite and thus uncountable. The observer finds himself confronted with an overwhelming 'too-muchness'. The microscopic world enfolds itself as a world without end.

At the same time, however, Brockes concludes the stanza with the verb "geschaut" (seen or observed). This verb suggests that this number without number can be apprehended. The new 'invisibility' of the infinite worlds is here—poetically—transformed into a new 'visibility'. The mere abstraction or imagination of an endless continuation of the visible becomes—through the lens of poetry, as it were—vivid. The 'infinite' is thus made to appear as something almost within reach of the senses. "Bemerken," "entdecken," "finden," "schauen," "betrachten," "zeigen" are the verbs employed by Brockes to describe the different encounters with nature. Verbs that deal more with reflection or speculation do make their appearance in Brockes's poems on the small, but the emphasis is on ocular verbs. It is very clear that for Brockes, what leads to an understanding of God is the visible world. This is symptomatic of many of Brockes's poems: here as elsewhere, they are less concerned with the incommensurability of the infinite than with an effort to demonstrate the actual *presence* of the infinite within the material world.

Brockes's poems within the development we have been tracing here are for this reason ambivalent. On the one hand, Brockes pursues very much the strategy of a natural philosopher in the sense of Hooke. What counts is the world of the visible; and what is described is what is observed. The "modest" observer contents himself with the limits of the visible and with what is within reach of the (technically enhanced) eye. Any observation be-

yond this would be presumptuous. At the same time, however, this "visible" is more than what Hooke had envisioned; it now includes, for example, the infinity of worlds within worlds that Leibniz had posited on the basis, in part, of microscopic observations. But while the influence of Leibniz on Brockes is more than evident, the result is anything but Leibnizian. Whereas Leibniz insists on the distance separating the finite from the infinite, which from the human perspective can only be approximated, never actually comprehended, Brockes—and not only in the stanzas quoted here—seems to provide a "presentation" (*Veranschaulichung*) of the infinite. For Leibniz, a number "without number" can be fathomed and even used very effectively in calculations, but never *made visible*. In Brockes, it can be "seen."

In this use of the verb "see," the meaning of the word has come full circle. In the metaphysical tradition, it meant to observe with the eye, but also to understand intelligible objects—to observe with the mind's eye. For the natural philosophers of the 17th century, it meant only to observe with the eye—which now included, however, the technically enhanced eye. With Brockes, finally, under the guise of natural philosophy's limitation of seeing to its literal sense, the observation of the visible, the intelligible realm that had been ruled out of bounds has been recovered; the infinite is now not just an object of understanding, but of ocular observation, as it were. In Brockes, the very limits of observation that the microscope had made evident have now been turned into the tools of its expansion into realms that otherwise were reserved for God and the mind alone.

[1] I would like to thank Jocelyn Holland for translating the major part of this article.

[2] The most insightful history of the microscope in the Early Modern period remains Wilson.

[3] The expression the "art of observation" or "l'art d'observer" first appears *expressis verbis* only during the 18th century (e.g. in Jean Senebier or Charles Bonnet), and the main reference is Bacon's *Novum Organum*. Hooke nonetheless plays an important role in the history of the art of observation.—On the historical dimensions of the art of observation, see Daston.

[4] Hooke does not at first distinguish in this manner between the microscope and the telescope—but it becomes clear in the course of his treatise that for Hooke, the epitome of true observation is microscopic and not telescopic.

[5] The art historian and media theorist Peter Bexte argues compellingly that a history of seeing is unthinkable without a history of not-seeing.

[6] Leibniz is talking here in terms of history and the historical origin of all beings; but the same idea also applies to the origin of knowledge.

[7] Leibniz comments on this at various points in his writings. Cf. for example *Nouveaux Essais sur l'entendement humain*, II, 23, § 12–14. See Fontenelle for a similar idea: "Many bodies that appear solid are nothing but a mass of these imperceptible animals, who find enough freedom of movement there as is necessary for them. A tree leaf is a little world inhabited by invisible worms, and it seems to them a vast expanse where they learn of mountains and abysses . . ." (Fontenelle, *Conversations*; cited by Wilson 208).

[8] See e.g. Beeley on the continuity of being in Leibniz.

[9] While English poets had discovered a fascination for the microscope by the end of the 17th century, German poets were more reticent. The microscope makes an appearance in the

writings of authors such as Harsdörffer, Schottelius, and Grimmelshausen, but it is treated superficially and skeptically. Cf. among others Arno Schmidt; Richter; Gunnar Schmidt.

[10] Cf. Grimm 3: 1641–49.

[11] On the grain of sand in Brockes, see Binczek.

[12] Of course, almost all of Brockes's poems culminate in a proof of God's existence and a praise of his greatness.

Works Cited

Adams, George. *Micrographia Illustrata, Or, the Knowledge of the Microscope Explain'd: Together with an Account of a New Invented Universal, Single or Double, Microscope* [. . .]. 4th ed. London, 1771.

Baker, Henry. *The microscope made easy: or, I. The nature, uses and magnifying powers of the best kinds of microscopes* [. . .]. 3rd ed. London, 1744.

Beeley, Philip. "Unendlichkeit, Fülle und Kontinuität als Prinzipien der Natur (§§ 61 f., 65)." *Gottfried Wilhelm Leibniz: Monadologie*. Ed. Hubertus Busche. Berlin: Akademie Verlag, 2009. 161–174.

Bexte, Peter. *Blinde Seher: Wahrnehmung von Wahrnehmung in der Kunst des 17. Jahrhunderts*. Amsterdam and Dresden: Verlag der Kunst, 1999.

Binczek, Natalie. "Die Ordnung der Sandkörner. Zu Christian Wolff und Barthold Heinrich Brockes." *Paradoxien der Entscheidung. Wahl/Selektion in Kunst, Literatur und Medien*. Eds. Friedrich Balke et al. Bielefeld: transcript, 2004. 57–86.

Breitinger, Johann Jacob. *Critische Abhandlung von der Natur, den Absichten und dem Gebrauche der Gleichnisse*. Zürich, 1740. Stuttgart: Metzler, 1967.

Brockes, Barthold Heinrich. *Irdisches Vergnügen in Gott, bestehend in Physicalisch- und Moralischen Gedichten*. 9 vols. Hamburg: Herald, 1721–1748.

Daston, Lorraine. "The Empire of Observation, 1600–1800." *Histories of Scientific Observatio*n. Ed. Lorraine Daston and Elizabeth Lunbeck. Chicago: U of Chicago P, 2011. 81–114.

Gottsched, Johann Christoph. *Erste Gründe der Gesamten Weltweisheit, Darinn alle Philosophische Wissenschaften in ihrer natürlichen Verknüpfung abgehandelt werden*. 1733. Kassel, 1969.

Grimm, Jacob and Wilhelm Grimm. *Deutsches Wörterbuch von Jacob Grimm und Wilhelm Grimm*. 1852–1971. 33 vols. München: dtv, 1984.

Hooke, Robert. *Micrographia: Or some Physiological Descriptions of Minute Bodies Made by Magnifying Glasses with Observations and Inquiries thereupon*. London: Martyn and Allestry, 1665.

Leeuvenhoek, Antoni van. "Part of a Letter from Mr. Leuvenhook, Dated June 9th, 1699, Concerning the Animalcula in Semine Humano, &c." *Philosophical Transactions* 21 (1699). 301–308.

La Mothe-Fénelon, François de Salignac de. *Oeuvres Philosophiques ou Demonstration de l'Existence de Dieu*. 1712. Amsterdam: Châtelain, 1731.

Leibniz, Gottfried Wilhelm. *Gottfried Wilhelm Leibniz: Sämtliche Schriften und Briefe*. Edited by the German Academy of Science. 8 series. Darmstadt and Berlin: Berlin Academy, 1923–.

———. *Monadologie*. 1714. Trans. Hermann Glockner. Stuttgart: Reclam, 1994.

———. "Neues System der Natur." *Fünf Schriften zur Logik und Metaphysik*. Ed. Herbert Herring. Stuttgart: Reclam, 1966. 21–34.

———. "Reflections on the Common Concept of Justice (1702?)." *Leibniz: Philosophical Papers and Letters*. Ed. Loemker. Dordrecht: Klumer, 1989. 561–573.

Richter, Karl. "Mikroskop und Teleskop in Brockes' Irdischem Vergnügen in Gott." *Prägnanter Moment. Studien zur deutschen Literatur der Aufklärung und Klassik*. Ed. Peter-André Alt et al. Würzburg: Königshausen & Neumann, 2002. 3–17.

Schmidt, Arno. "Barthold Heinrich Brockes, oder Nichts ist mir zu klein." *Nachrichten von Büchern und Menschen. 1: Zur Literatur des 18. Jahrhunderts*. Frankfurt/Main: Fischer, 1971. 7–27.

Schmidt, Gunnar. "Von Tropfen und Spiegeln. Medienlogik und Wissen im 17. und frühen 18. Jahrhundert." *KulturPoetik* 2 (2002) 1: 1–23.

Shapin, Steven and Simon Schaffer. *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*, Princeton, NJ: Princeton UP, 1985.
Wilson, Catherine. *The Invisible World: Early Modern Philosophy and the Invention of the Microscope*. Princeton, NJ: Princeton UP, 1995.

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