THE MICROSCOPE IN THE DUTCH REPUBLIC

The Shaping of Discovery

EDWARD G. RUESTOW
University of Colorado – Boulder

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Introduction

The character of European science changed profoundly during the course of the seventeenth century. Aggressive experimentation established its place in scientific practice, and a new mathematical mechanics embracing both the terrestrial and celestial realms overthrew a divided Aristotelian cosmos and its qualitative, teleological physics. To prove no less distinctive of modern science, however, new scientific instruments created or discovered new phenomena and began, for the first time, to extend the reach of the human senses.[1]

The identification of science with discovery was accentuated, although it was discovery that assumed many forms. Architects of the new mechanics grasped new truths by exploring avenues of opportunity in the dematerialized realm of mathematics,[2] while anatomists cast about for previously unseen structures concealed in the gore of dissected bodies. A single, subtly designed pendulum experiment nudged the gradual unfolding of a deeper generality in an evolving system of ideas, and the air pump inspired a broad program of experimentation that explored the phenomena encountered in a vacuum.[3] But two other new instruments, the telescope and microscope, emerged as perhaps the most widely recognized and evocative new symbols of scientific discovery.

The beginnings of telescopic discovery dramatically impressed the age. In 1610 the English ambassador in Venice described Galileo's newly printed *Sidereus nuncius* as "the strangest piece of news (as I may justly call it) that he hath ever yet received from any part of the world." In it, Galileo recounted the discovery of mountains and craters on the Moon, new planets revolving around Jupiter, and the multitude of previously unrecognized stars that composed the Milky Way. In distant Wales, Sir William Lower, who himself had already observed the Moon through the telescope, exclaimed admiringly nonetheless that "my diligent Galileus hath done more in his three fold discoverie than Magellane in opening the streightes to the South sea or the dutch men that weare eaten by beares in Nova Zembla."[4]

Galileo soon published his account of the phases of Venus as well and reported several odd and inexplicably varying images of Saturn that Christiaan Huy-

1 Van Helden (1983a).
2 Yoder (1988), 26, 50, 59–63, 84–5, 95; see also I. B. Cohen (1980), 52–68.
3 Westfall (1971), 463; M. B. Hall (1965), 94–109.
4 Nicolson (1956), 33, 35, 37.

gens in the Netherlands finally, in 1656, grasped as manifestations of a planetary ring.[5] Huygens had also sighted the first satellite of Saturn the year before, and prompted by this young Dutchman's abilities, Henry Oldenburg, the future first secretary of the Royal Society of London, evoked again the older exemplar of discovery and the emerging expectation of more to come: With yet more perfect telescopes, he wrote, "we may by their means make navigations as well into ye Heavens and discover new Countries there" as Columbus had done in America.[6]

But discovery with the telescope proved halting. Huygens's discovery of the satellite of Saturn in 1655 was in fact the first major discovery in several decades, and after the sighting of the fourth and fifth satellites of Saturn in 1684, planetary discoveries ceased for nearly a century.[7] Shortly before his death in 1694, Huygens himself confided to his countryman Antoni van Leeuwenhoek that he believed astronomical observation had reached its limits, and that little more was to be seen.[8]

Delayed in its beginnings, the career of meaningful microscopic discovery also threatened to be a fleeting one. The pace of a quarter-century of successive discoveries in the late seventeenth century was not to be equaled until the nineteenth century, and by the early 1690s Robert Hooke was lamenting the waning ardor in the use of both the microscope and telescope. Most of those who had pursued these inquiries had now "gone off the Stage," he noted, and the opinion now prevailed "that the Subjects to be enquired into are exhausted, and no more is to be done."[9] Although the preeminent remaining microscopist, the Dutchman Leeuwenhoek, had over thirty years of persisting microscopic researches still ahead of him, the tempo of microscopic discovery had already slackened.

The telescope and microscope had made an enduring impact on the European imagination nonetheless and, together, left their distinctive impress on the new image of the world the seventeenth century had forged. The sweep from the astronomical imagery of the telescope to the newly discovered realm of the microscopic became a standard literary trope, embracing a symmetry of dimensions that stretched away endlessly in both directions.[10] The early English devotee of the microscope Henry Power proposed in 1661 "that the least Bodies we are able to see with our naked eyes, are but middle proportionals (as it were) 'twixt the greatest and smallest Bodies in nature, which two Extremes

5 On the struggle over the interpretation of Saturn's ring, see Van Helden (1974a,b).

6 Oldenburg (1965–), 1:277. Albert Van Helden points out that the expectation of a continuing improvement in scientific instruments emerged only during the course of the century (Van Helden 1983a, 49, 54–5, 65–6, 68–9).

7 Van Helden (1980), 147–9, 154; idem (1985), 129ff., esp. 154–5, 161, 163; idem (1983b), 137–8.

8 AvL to RS, 26 Feb. 1703, AvL Letters, fol. 240v. Huygens, however, had fallen well behind the cutting edge of telescopic observation and had made no new telescopic discoveries himself since the 1650s (Van Helden 1974a,167). Not everyone looked upon the progress of astronomy so pessimistically; see Basnage (1687–1709) 23:155, 159.

9 Hooke (1726), 261.

10 Hill (1752a), 105, 288–9; Schatzberg (1973), 69, 99, 258–9, 281; Jones (1966), 24–5, 128, 215–16; Saine (1976), 63–4.

lye equally beyond the reach of humane sensation." It was a prospect, however, whose testimony to the march of science was not without its ambiguity. Reflecting on Power's passage a century later, the German microscopist Wilhelm Friedrich von Gleichen-Russworm concluded that we could not but be shaken by the narrowness of our understanding; everything our dull senses perceive around us is pure mystery, he wrote, and still only the smallest part of God's boundless Creation. In less exalted tones, the Jesuit Athanasius Kircher had already remarked in 1646 that the microscope and telescope revealed that everything we see is very different from what it seems.[11]

Notable differences distinguished the usual contexts of microscopic and telescopic observation, however, and hence the nature of the discoveries to which they led. Despite the suggestion of limitless space, the revolutionary impact of telescopic discovery lay more in the recognition of what was familiar than in the encounter with what was not. The most consequential of Galileo's discoveries revealed that the Moon had mountains and valleys like those on Earth, that Jupiter had satellites like the Moon, and that Venus had phases like those of the Moon. Although Henry Oldenburg remarked that "ye vulgar opinion of ye unity of ye world" had now been "exploded," the new heavens in fact differed most fundamentally from the old in the new affinity of Earth and the other planets.[12] Apart from the vast distances and the surprise and uniqueness of Saturn's ring,[13] the telescope discovered little for which precedents and analogies did not readily come to mind. Not so in the realm of the microscope. Although many of its revelations echoed the familiar world as well, the microscope proved an increasing source of images and phenomena whose gripping impact lay rather in their strangeness.

Telescopic discoveries in the seventeenth century were also quickly incorporated into well-developed systems of astronomy. These discoveries helped overthrow a comfortable, traditional cosmos, to be sure, but they were most highly prized in scientifically progressive circles precisely because they simultaneously seemed to argue for a new alternative. They had confirmed the true system of the heavens, said Huygens, who perceived an argument for Copernican theory even in Saturn's ring.[14] In the case of notable microscopic discoveries, however, the immediate challenge was to make sense of them, and the conceptual resources at hand were usually crude, ill-fitting, or simply unpersuasive.

Adapted to one astronomical theory or another (Copernican, that is, or Tychonic), telescopic discoveries were immediately set within a framework of precise and measured order. In their slow progress along unchanging paths, the celestial motions had long been the epitome of regularity, while, even through the telescope, the appearance of the celestial bodies themselves conformed to an austere simplicity. Through better instruments, the stars still appeared as shin-

11 Power (1664), preface pp. [5]–[6]; Gleichen-Russworm (1764), [2]; Kircher (1646), 834–5.

12 Oldenburg (1965–) 1: 277; Van Helden (1974c): 57.

13 Nothing had so surprised the astronomers of the century as had Saturn's ring, noted Huygens's countryman Nicolaas Hartsoeker (1694, 186); see also Van Helden (1974a), 158.

14 *OCCH* 13: 434–5, 438–41, 740; see also ibid., 586; Van Helden (1974a), 163.

ing points, and the planets, apart from Saturn's anomalous ring, as starkly illuminated spheres. The backdrop of space was unrelieved blackness, against which even the colors of the planets appeared muted and pale. The microscopic observer, on the other hand, was confronted with the rich visual complexity of diverse and unusual textures, bizarre forms, and unexpected hues and light effects.[15] Dramatically accentuated by the lens,[16] the motion encountered through the microscope was often relentlessly irregular, frantic, and, as it was also remarked, inexpressible.[17]

Telescopic and microscopic observations in the seventeenth century tended to cater indeed to two contrasting aesthetics in modern science. Historically and emphatically a mathematical science, astronomy embraced the ideals of simplicity and demonstrable necessity in its conceptual construction. Most often applied to the realm of living things, on the other hand, the microscope accentuated rather the endless and often inexplicable diversity of natural forms and what seemed at times their superfluous and irrepressible abundance. By the end of the century, astronomy and the telescopic discoveries had been incorporated virtually in toto into a Newtonian "system of the world" derived from three universal laws and a framework of "mathematical principles"; but the microscope testified to an evermore intricate complexity in nature and a pervasive and continuing unexpectedness.

The difference between telescopic and microscopic discovery was not absolute. Huygens alluded to the novelty also encountered through the telescope,[18] and Saturn's ring in particular remained a unique and baffling phenomenon. The discovery of blood capillaries, on the other hand, was conceived from the start in terms of a broad, well-articulated theory, that of the circulation of the blood, and lent itself to the prospect, at least, of a mathematical rendering.[19] Microscopic researches into organic generation searched as well for a deeper order and unity underlying the diversity of life. Nonetheless, whereas the characteristic telescopic discoveries were quickly assimilated to a theoretical system and a simplifying mathematical order, early microscopic observations underscored nature's capacity for endless surprises and for images that challenged the limits of the imagination.

The microscope made the experience of discovery more widely accessible as well. Potential astronomical discoveries in the seventeenth century were narrowly limited in number, and, apart from the surfaces of the Moon and Sun,

15 One twentieth-century amateur naturalist – hence perhaps closer in spirit to the characteristic seventeenth- and eighteenth-century observer – with a reflective and lyrical bent describes the realm of microscopic life in particular as a "color-charged, glistening world" (Dillard 1974, 126). A contemporary microbiologist vividly conveys that sense as well in writing of the symbiotic relationship between *Paramecium bursaria* and the alga *Chlorella:* L. L. Larison Cudmore describes the paramecium as "golden, transparent and candescent, its body covered with thousands of hairlike cilia, beating in sensuous waves," and as having within that body "hundreds of tiny glowing roses, emerald green shining with refracted light" (Cudmore 1978, 43).

16 Lumsden (1980), 1:132–3.

17 Müller (1786), xviii–xix.

18 *OCCH* 13:586.

19 See Chapter 7, n. 42.

they presumed a technical knowledge of astronomy sufficient, at a minimum, for finding one's way through the night sky. Potential microscopic discovery, on the other hand, lay immediately at hand and all about, and everything was new. Moreover, microscopes of exceptional optical qualities (for the time, of course) could be made with minimal technical expertise; even a dexterous youngster toying with a bit of glass around a candle flame might contrive a simple but powerful instrument.[20]

For the first half-century, nonetheless, the opportunities for microscopic discovery were only hesitantly explored. To be sure, early microscopes were burdened with technical shortcomings, and those that in time proved optically the best – and simplest – proved the more troublesome to use. Nature's microscopic structures were difficult to manipulate, and to display them before an instrument could pose the greatest technical challenge of all. There were obstacles that pertained to the imagination as well. An indifference and perhaps blindness to the prospect of microscopic discovery were sustained in varied and subtle ways. So obstructive were such barriers that in the Netherlands, where Leeuwenhoek and Jan Swammerdam emerged among the principal pioneers of early microscopic discovery, the beginnings of that discovery required the stimulus of acute personal reactions to goading social circumstances. Early microscopic discovery unfolded hence as an intricate interplay of cultural traditions, social relations, and personal sensibilities. How that interplay forged the experience of discovery is indeed the subject of this book.

First, however, there had to be the instrument, and, though the source of so much that was unexpected, the microscope itself had required a preceding jolt to the imagination. That jolt was provided by the invention of the telescope.

20 See Chapter 1 regarding n. 90.