# Teacher-to-Teacher

## Eyeglasses and the Discovery of the Microscope

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The phenomenon of magnification that causes objects to appear larger than their actual size was known during antiquity. Neither the date of the discovery nor the name of the person who first observed or recorded the phenomenon is known. It is speculated that the discovery resulted from a fortuitous observation that small objects appear enlarged when seen through a spherical glass vessel filled with water. This explanation stems from Roman writings on the subject.

In the second century AD, Ptolemy (Claudius Ptolemaeus), an astronomer, geographer, and mathematician, wrote a treatise on optical phenomena known at that time. In this treatise, entitled *Optica*, he discussed magnification by glass spheres filled with water and also by pieces of glass of certain shapes. Despite this knowledge, more than a thousand years passed before glass lenses came into use.

Progress in the sciences virtually came to a standstill after the second century AD and remained so until the sixteenth century. There is still no satisfactory explanation for the lack of scientific inquiry and advancement of knowledge over such a long period. Furthermore, much of the scientific knowledge of antiquity would have been lost to Western civilization had it not been for Arab scholars, who translated the ancient scientific writings into Arabic and studied them over the centuries.

The Crusades of the eleventh to thirteenth centuries made it apparent to Europeans that in many respects Muslim culture was more advanced than their own. Europeans translated scientific works written in Arabic; and through this process, scientific accomplishments of the ancient Greek and Roman civilizations reappeared in the West.

The rediscovered teachings of the ancient scholars were read with awe, but instead of being an incentive for renewed investigation, they were accepted as being authoritative. Several more centuries were to pass before the scientific teachings of antiquity were seriously challenged.

During the Dark Ages in Europe, Alhazen, an Arabian scholar (ca. 965-1040), made significant contributions to optics by his studies of refracted light and magnification due to refraction. However, he saw no practical application for his observations.

The precursor of both the microscope and the telescope were lenses for aiding vision and correcting defects in vision. Roger Bacon, an English scholar of the thirteenth century, experimented with lenses and concluded that they would be useful for aiding vision. In his *Opus maius* written in 1267 he stated, "if a man (sic) looks at letters and other minute objects through the medium of a crystal or of a glass or of some other transparent body placed upon the letters, and this is the smaller part of a sphere whose convexity is towards the eye, and the eye is in the air, he (*sic*) will see the letters much better and they will appear larger ...and therefore this instrument is useful for the aged and for those with weak eyes." Unfortunately, Bacon's scientific and other scholarly endeavors brought him into conflict with the Christian religion. Bacon, who was educated at the University of Oxford, and later became a Franciscan monk, ardently pursued knowledge. He wrote on astronomy, mathematics, and physics, especially optics. He was also well versed in philosophy and theology and wrote on those subjects, too. Because some of his scientific and other writings disagreed with the teachings of the Church, Bacon was condemned to imprisonment in 1278 by the superiors of the Franciscan establishment in Paris, where he was then living. Knowledge of his activities thereafter is scanty, but it is believed that he died around 1292. He did send a copy of his *Opus maius* to the Pope in Rome, and fortunately this work has survived.

About 1300 the first eyeglasses were produced by an unknown inventor. The invention is often attributed to either Alessandro della Spina or Salvino degli Armati, but no evidence supports such claims. The earliest unequivocal evidence of eyeglasses is not a written record, but a fresco painted in 1352 by the Italian painter Tommaso da Modena.

FIGURE 1. Portrait of Ugo di Provenza, a Dominican monk, writing with the aid of eyeglasses. It is part of a fresco painted in 1352 by Tommaso da Modena on the wall of the chapter house of St. Nicola Monastery, Treviso, Italy.

The fresco in the chapter house of St. Nicola Monastery, Treviso, Italy depicts thirty-seven Dominican monks, each of whom is seated at a desk in his own cell. The artist portrayed each monk somewhat differently. For example, one is sharpening a quill pen, and another is reading. The painting of Ugo di Provenza shows him wearing eyeglasses as he is writing (fig. 1).

It is interesting that Alessandro della Spina, like Ugo di Provenza, was a Dominican monk. This fact suggests that the Dominicans had a role in either inventing eyeglasses, or at least in promoting the use of the newly invented aids to vision.

Written records of eyeglasses dating from the latter part of the fourteenth century exist, and the first reference to eyeglasses in literature appeared at that time. Chaucer, in the "Wife of Bath's Tale," wrote of seeing friends through an eyeglass, "spectacle...through which he may his verray freendes see."

Some individuals opposed eyeglasses and considered it sacrilegious to improve on the powers of vision bestowed by the Almighty. Nevertheless, by the early sixteenth century it is known that the pope had no objection to such devices. This is evident from a work of art, a portrait of Pope Leo X painted by Raphael in 1517. In the portrait which now hangs in the Uffizi Gallery, Florence, Pope Leo is seated at a table on which there is a manuscript, and he holds a magnifying glass in his hand (fig. 2).

The original magnifying devices, made from crystal or glass, were double convex in shape. The word "lens" is the Latin for lentil, and as the original magnifying devices were doubly convex like the common lentil, they were given the name lens. The quality of the crystal or glass available during the early history of eyeglasses was often imperfect, as were the techniques for making lenses. Though the lens magnified the object, the image was frequently distorted. Spectacle makers' guilds appeared in the fifteenth century, and thereafter the quality of lenses improved. During the early sixteenth century, concave as well as convex lenses were made. Concave lenses correct defects in the ability to see distant objects; convex lenses correct problems in seeing close objects.

The invention of the telescope and the microscope are interwoven. Both of these instruments came into existence during the early part of the seventeenth century. The alignment of two lenses, one behind the other so as to give greater magnification than that observed with only a single lens, is believed to have been a fortuitous discovery. Credit for the discovery is often given to either Hans Janssen or his son Zacharias, or Hans Lippershey. All three were Dutch spectacle makers. The evidence that any of these three invented the microscope is inconclu-

sive. Contrary to popular belief, Galileo did not invent the telescope. Galileo constructed his first telescope in 1609, after hearing of a telescope made by Lippershey. The Galilean telescope can be used as a microscope by increasing the distance between the lenses. It is believed that Galileo knew this and made microscopic observations. However, because of the distance between the object and the observer's eye due to the length of the instrument, the Galilean type microscope is awkward to use and has never been popular.

Vision is the most precious of all the senses, and the benefits of eyeglasses on human welfare over the centuries are incalculable. The impact of the microscope on science, particularly in the advancement of biological knowledge, is also incalculable. Considering these facts, it is remarkable that neither the inventor of eyeglasses nor the inventor of the microscope is known.

In the period immediately after its invention, microscopes were either commercially made by spectacle makers or actually constructed by individuals who wished to use them. By the middle of the seventeenth century, microscopes and telescopes were made professionally. Unlike the long period between the discovery of magnification and the invention of eyeglasses, development of the microscope was relatively rapid. In 1668 Divini, a professional microscope and telescope maker, constructed a microscope that could be adjusted to give four different powers of magnification; in addition, he improved his instrument by eliminating some of the distortion by the magnifying lenses. A report published by the Royal Society, London, stated:

> Eustachio Divini hath made a Microscope of a new Invention, wherein instead of an Eye-glass convex on both sides, there are two plano-convex Glasses, which are so placed, as to touch one another in the middle of their convex surface. This Instrument hath this peculiar, that it shews the Objects flat and not crooked, and although it takes in much, yet nevertheless magnifieth extraordinarily. It is almost 16 1/2 inches high, and adjusted at 4 different lengths. In the *first*, which is the least, it shews lines 41 times bigger than they appear to the naked Eye: In the *second*, 90 times In the *third*, 111 times: and in the *fourth* 143 times. Whence one may easily calculate how much it augments surfaces and solidities.

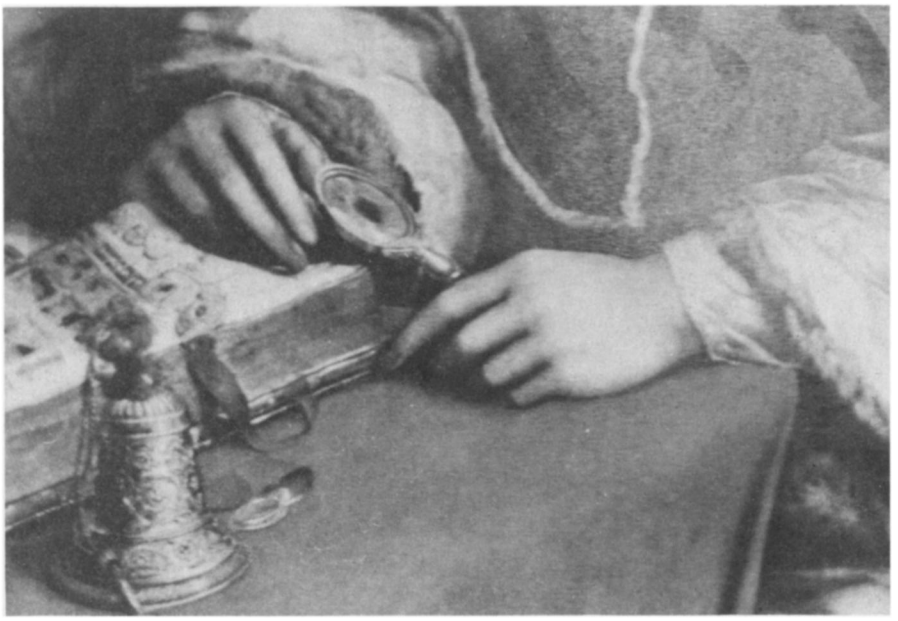

FIGURE 2. A magnifying glass held by Pope Leo X. From a portrait painted in 1517 by Raphael, and now in the Offizi Gallery, Florence, Italy.

Another professional microscope and telescope maker, Campani, made microscopes with coarse and fine adjustments for focusing. Campani also gave his attention to chromatic aberration. He made lenses by cutting and shaping glass, instead of using molten glass and molds. Lenses made from molten glass often contained air bubbles and other imperfections. The Royal Society reported that he had:

> found a way to work great Optick Glasses with a Turne-tool, without any Mould: And whereas hitherto it hath been found by Experience, that small Glasses are in proportion better to see with, upon the Earth, than the great ones; that Author affirms, that his are equally good for the Earth, and for making Observations in the Heavens . . . .without finding any Iris, or such Rain-bow colours, as do usually appear in ordinary Glasses, and prove an impediment to Observations.

Campani's claims notwithstanding, chromatic aberration remained a problem until the nineteenth century.

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## References

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