Revisiting Antony van Leeuwenhoek
Using a Student-Constructed Simple Microscope To Stimulate Interest in Microscopy

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. . . I am writing to tell you that a certain most ingenious person here, named Leeuwenhoek, has devised microscopes which far surpass those which we have hitherto seen. . . (He) . . . describes certain things which he has observed more accurately than previous authors . . . if it pleases you, and you would test the skill of this most diligent man . . . give him encouragement, then pray send him a letter containing your suggestions, and proposing to him more difficult problems of the same kind.

—Reinier de Graaf (28 April 1673)[1] (Gravé 1991)

In 1673, Antony van Leeuwenhoek, a Dutch draper and haberdasher with little or no formal scientific training, wrote a most extraordinary letter to the Royal Society of London. In fascinating detail, van Leeuwenhoek described the ". . . observations on a mold; on the stinger, mouthparts, and eyes of the bee; and on the louse. . ." he made using the simple microscopes he designed and crafted by hand (Gravé 1991). In the 109 additional letters to the Society that followed over the next half century, van Leeuwenhoek reported ". . . numerous wonders by the aid of the microscope. . .," ranging from the first descriptions of bacteria and protista ("zeer kleine dierkens" or little "animalcules") to the circulation of blood in the capillaries of an eel (Stein 1931). In 1679, to honor "His work . . . in little things, but not little in glory," van Leeuwenhoek was elected a member of the Royal Society, a distinction rarely awarded to a person who is not a citizen of Great Britain (Stein 1931).

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Today, many biology teachers begin their laboratory instruction on the compound optical microscope with a discussion of van Leeuwenhoek's life, the simple microscopes he crafted, the techniques he invented, and the microscopic world that so fascinated him. Some instructors have even constructed or purchased replicas of a van Leeuwenhoek microscope to demonstrate how van Leeuwenhoek used them (Walter & Via 1968).

This paper describes how we expanded a traditional discussion of van Leeuwenhoek's accomplishments into a hands-on laboratory activity in which each student builds his or her own van Leeuwenhoek-like microscope and uses it to study some of the ". . . most aesthetically pleasing images science can offer. . ." (Ford 1985). Once familiar with visual sense enhancement by use of the microscope, and with some experience observing the "microscopic world," we find these students more receptive, and often eager, to develop the techniques needed to use a modern compound optical microscope.

Construction of van Leeuwenhoek-like Microscope

As van Leeuwenhoek was aware, the most important component of a simple microscope is the lens; and he apparently devoted much time perfecting his lens grinding skills. However, lens grinding is well beyond the range of activities described in this laboratory experience. Fortunately, this is not an unsurmountable problem. Many craft stores and plastic supply houses sell inexpensive plastic "cabochons" or decorative "Round See-Thru Stones" which are actually excellent convex lenses ideally suited for our purpose.

Given simple instructions, either verbally or in writing, and supplied with the following readily available materials, students should be able to complete construction of a van Leeuwenhoek-like microscope (Figure 1) in about 45 minutes:

1. Photocopy of microscope "body" template
2. 15 × 15-cm piece of cardboard
3. Scissors
4. Rubber cement
5. 11-mm plastic cabochon (or "Round See-Thru Stone")
6. 1-inch "corner brace"
7. Premixed tube of wallpaper paste or other water-based adhesive
8. 8/32 × 1-inch round head machine screw and nut
9. #10 brass washer
10. Two 8-cm lengths of heavy duty self-adhesive waterproof foam insulation tape (½-inch thick and ¾-inch wide)
11. Two double pointed ½-inch staples
12. Plasticene "clay"

To begin the microscope assembly process, each student should cut out and then glue the microscope body template (Figure 2) to the cardboard backing using rubber cement. When the cement is dry, the student can cut out the microscope "body" template with its cardboard support. The two lengths of self-adhesive foam insulation are then secured onto the microscope body-cardboard support over areas marked "A." These foam strips will serve as the microscope "stage" and as a guide when focusing the optical system. To construct the optical

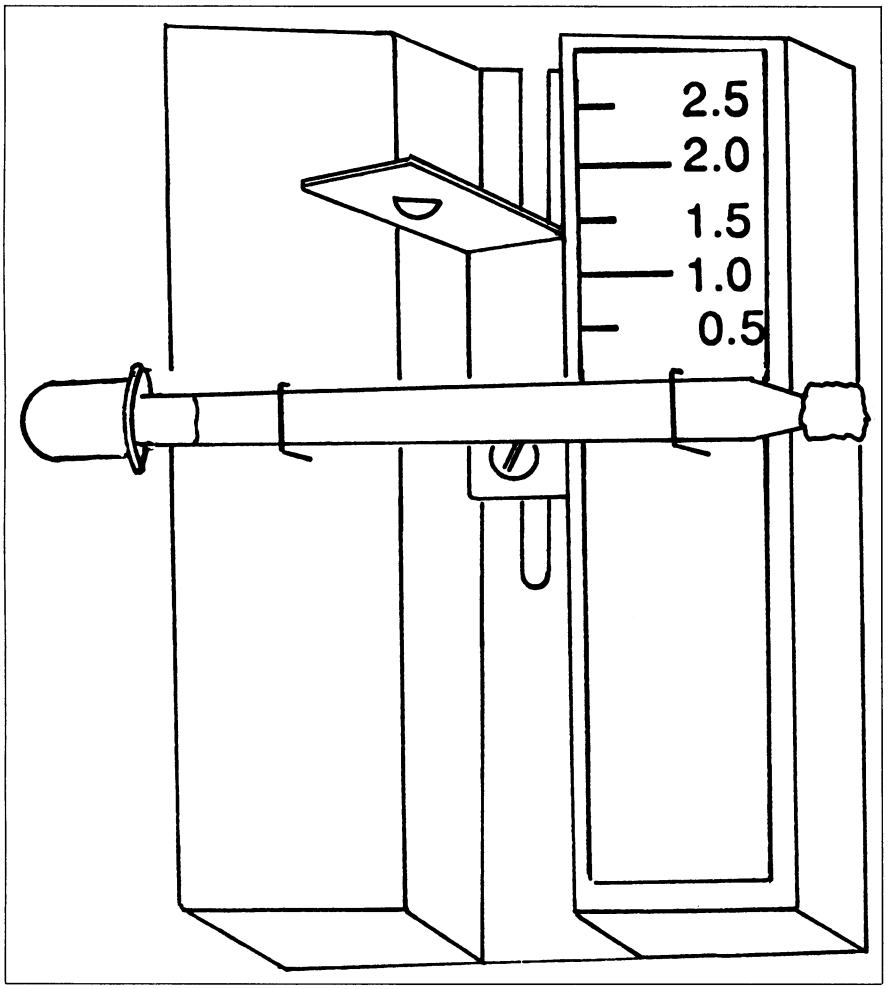

Figure 1. Completed van Leeuwenhoek microscope (not to scale).

system of the microscope, the student should apply a very small quantity of wallpaper paste or adhesive around one of the two screw holes in the corner brace and use this adhesive to attach the cabochon (flat surface toward the screw hole) over the hole. If excess paste gets onto the center (viewing portion) of the lens, the lens can be easily removed from the brace, washed with water, dried, and then reglued. The corner-brace optical system is secured to the microscope body using the machine screw, washer and nut as shown in Figure 1. The metric ruler strip that will be used to calculate the magnification of the microscope is cut from the photocopy and glued to one of the two foam insulation strips again using rubber cement. Finally, to complete the assembly of the microscope, two staples that will serve as microscope "stage clips" are inserted into the foam insulation strips as shown.

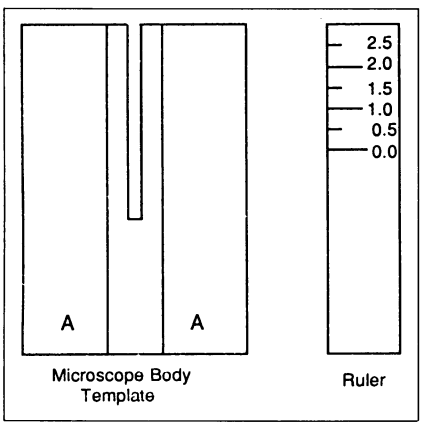

Figure 2. Microscope and ruler templates that can be photocopied and used by students to construct their microscopes.

Observation of Vinegar Eels

It is most appropriate that the student first turn his or her newly constructed van Leeuwenhoek-like microscope to an observation of the same vinegar eels (*Anguillula aceti*) that van Leeuwenhoek so vividly described in his letter to the Royal Society in 1676 (Dobell 1932). The student can fill a common eyedropper with liquid from an apple cider vinegar culture of vinegar eels (Morholt, Brandwein & Joseph 1958), seal the open end with plasticene "clay," and then secure the dropper onto the insulation tape "microscope stage" by sliding it under the two "stage clip" staples. Holding the microscope close to one eye, and pointing it toward a distant source of light (if skylight is used, caution the student not to point the microscope toward the sun!), the student can use the screw stem extending from the bottom of the microscope to move the brace-mounted lens back and forth until the eels are clearly in focus. With adequate illumination and proper focusing, the student should have very little trouble observing the rather large corkscrew-shaped eels swimming rapidly through the culture medium.

Figure 3. The completed microscope is held close to the eye using one hand and focused by sliding the screw stem back and forth using the other hand.

Once the student has made and recorded his or her observations, it can be most informative to estimate the magnification of the microscope system used to observe the vinegar eels. This can be accomplished using the metric ruler attached to the microscope. The student can determine the distance from the front of the convex lens to the middle of the eye dropper when the eels are in focus and use this

distance measurement to calculate the magnification using the formula:

Magnification of the microscope
= 25 cm/distance from the lens to specimen when the eels are clearly in focus

Depending on the diameter of the cabochon used, magnifications between 25X and 45X are obtainable.

Familiar with the use of his or her microscope, the student can now be encouraged to embark on his or her own microscopic investigations using cultures of other large microorganisms made available to them. We have found that *Paramecium, Vorticella* and rotifers make fascinating subjects for follow-up microscopic studies. In addition, if two slits are cut in the foam insulation, temporary wet mounts and permanent slide preparations can be mounted and observed. We have also used this activity to introduce a study of cell structure. Students prepare temporary mounts of slivers of cork and then compare their observations with Robert Hooke's classic description of cork "cells" in his *Micrographia*, published in 1665.

Several lines of evidence strongly suggest that students are indeed still as ". . . interested in viewing the very small as was Antony van Leeuwenhoek (1632–1723) more than three centuries ago" (Walter & Via 1968). Even though students are told that they need not take their microscopes with them when they leave class, few are ever found left behind. Moreover, many students come to the next class meeting with descriptions of observations they have made on their own, using the microscopes they built in class. There have even been students who returned to class proudly displaying more substantial and modified instruments they constructed from wood, plastic, and even sheet metal. Finally, there is general agreement among instructors that students who have participated in this introductory laboratory activity perform at a higher level of achievement in subsequent laboratory activities where the compound optical microscope is used.

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