Supplementary material:

Constructing a "Leeuwenhoek-like" microscope

The microscope described here is made with Plexiglass and is painted with bronze paint to reproduce aspects of Leeuwenhoek's apparatus.

Materials used:

Two pieces of acrylic glass (Plexiglass), one 3 mm thick (15 x15 cm)
and the other 10 mm thick (3 x 10 cm);
Key chain laser pointer (or a broken CD drive);
Chloroform;
Two screws and nuts (≈ 3,5mm x 7 cm);
Epoxy putty, instant glue or glue gun;
Hacksaw (or thin-tooth circular saw); electric drill;
Sandpaper;
Hypodermic needle;
Wood screw (7 mm);
Bronze paint;

Assembling the microscope:

1) *Preparing the pieces:*

With a hacksaw or a thin-tooth circular saw, cut the acrylic pieces represented in Figure 1.

The pieces necessary to construct the microscope are the following: A = one piece; B = one piece; C= two piece; D= two pieces; E= one piece; F= four pieces; G= one piece. After the pieces are cut, they finished with sandpaper.

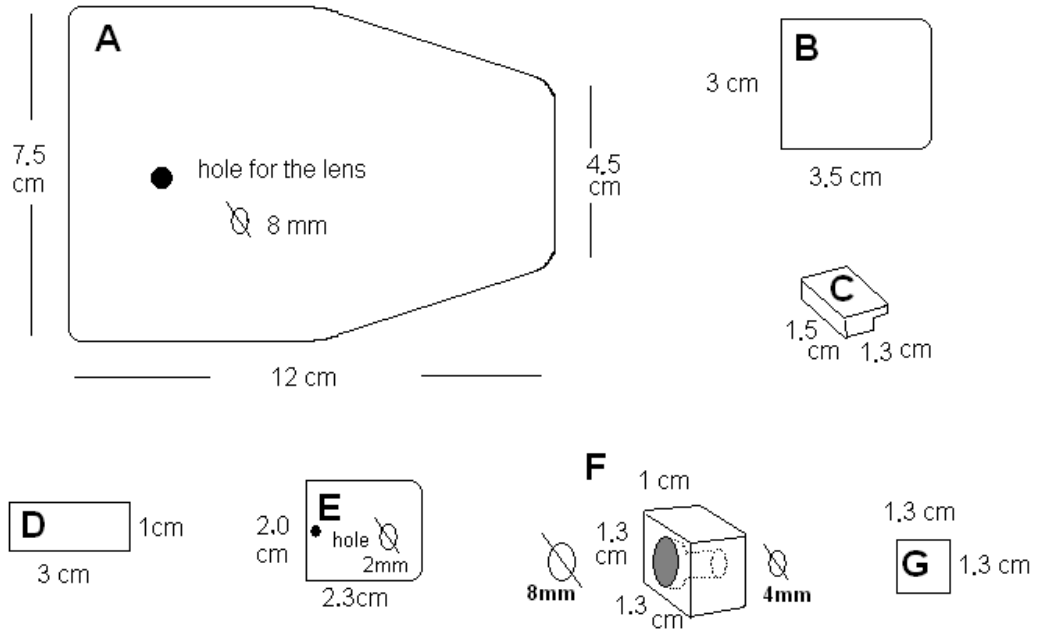

Figure 1. Dimensions of acrylic pieces needed to build the microscope. The pieces A, B, D, E and G are made with 3 mm thick acrylic, and the pieces C and F are made with 10 mm thick acrylic.

2) The first assembly step is the focus system:

- With an electric drill, make a hole 4 mm in diameter in the F pieces. The hole crosses the piece. Using an 8 mm drill bit, enlarge the hole until it occupies almost the middle of the piece. This enlarged portion is made to hold the screw head or the nut.
- Put the screw into the hole of the two F pieces. In one, the screw head is placed in the 8mm hole and in the other, the 8mm hole is positioned to the end of the screw into that is put into the nut (Figure 2A).
- One D piece is glued with chloroform to the F piece that contains the screw head. Take caution not to allow the chloroform to touch the other F piece (with the nut). This piece needs to stay free to move (Figure 2B).
- The other D piece is glued the same way as before (Figure 2C). The F piece with the nut is not fixed.
- The E piece is positioned with the 2 mm hole over the F piece with the screw head. The E piece is glued with chloroform to the F piece that contains the nut (Figure 2D).
- With epoxy putty, fix the nut in the F piece, taking care not to allow the resin

to contact the screw. After the epoxy polymerizes, the E piece will move forward or backward when the screw is moved to the right or left. This part will be the microscope focus system.

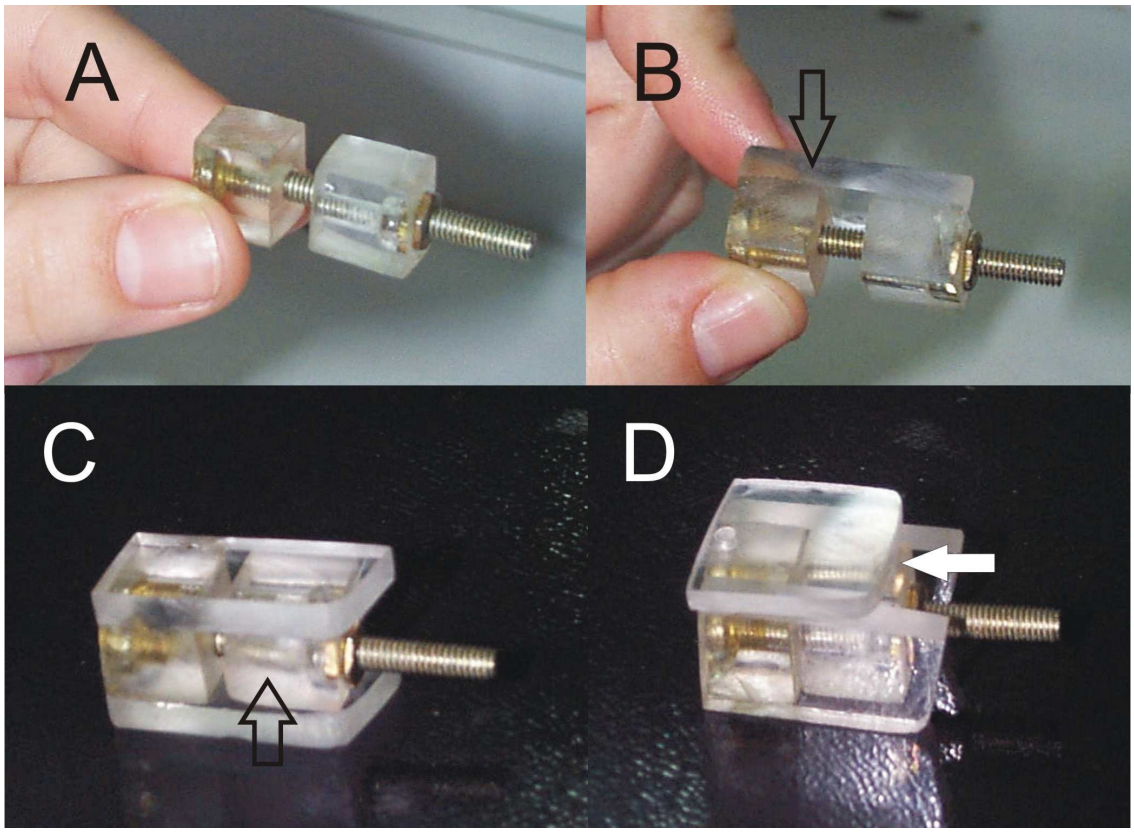

Figure 2. Assembly of the focus system. See text for details.
In B, the arrow shows the parts that have been glued; in C, the arrow shows the part that isn't glued (moves freely); in D, the arrow shows the part that is glued (pieces D and E).

3) Assembling the "control stage" system:

- Glue with chloroform one F piece to the rounded margin of the B piece, taking care that the 4mm hole is kept out. After this step, put the screw into the hole of the F piece (Figure 3A), and glue the G piece in the F surface that has the screw head. Now the screw can rotate, but it doesn't leave the system.
- Put the pieces that are together from the previous step on top of the A piece. Put the other F piece in the small edge of the A piece. Pass the screw through this F piece and glue it with chloroform. With epoxy putty, fix the nut in this F piece (fixed in the A piece border), taking care not to allow the resin to contact the screw.

- Observe in Figure 1 that the C pieces have a groove. It corresponds to the space in which the C pieces overlap the B piece (Figure 3C, Arrow). The C pieces are glued only in the A piece in both sides of the B piece, but not glued in this one. Now, when the screw is turned, the B piece moves up and down.

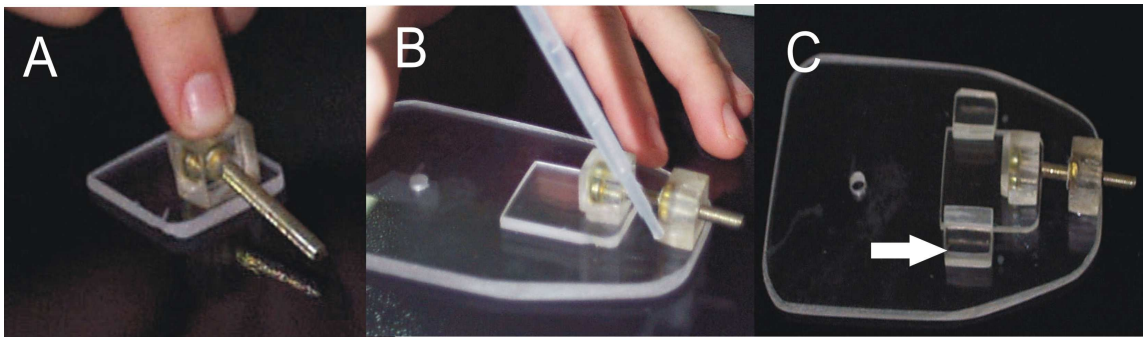

Figure 3. Assembly of the control stage system (see text for details).
The arrow in the C figure shows the C piece that is glued only to the A piece.

4) Joining the focus and "control stage" systems:

- Look in the focus system for the F piece that contains the screw head. Glue this face of the F piece to the B piece of the "control stage". Take care to maintain the 2 mm hole of the E piece in line with the lens hole in the A piece. (Figure 4A).
- Using epoxy putty, fix the plastic part of a hypodermic needle (remove the metallic needle), over the 2 mm hole in the E piece. This part of the hypodermic needle will be used to support the samples that will be visualized in the microscope (sample holder).
- To finish the structure of the microscope, make knobs with which to focus and to position screws with epoxy putty (arrows in Figure 4 B).
- Paint the microscope with bronze paint to give the apparatus a resemblance to the Leeuwenhoek microscope.

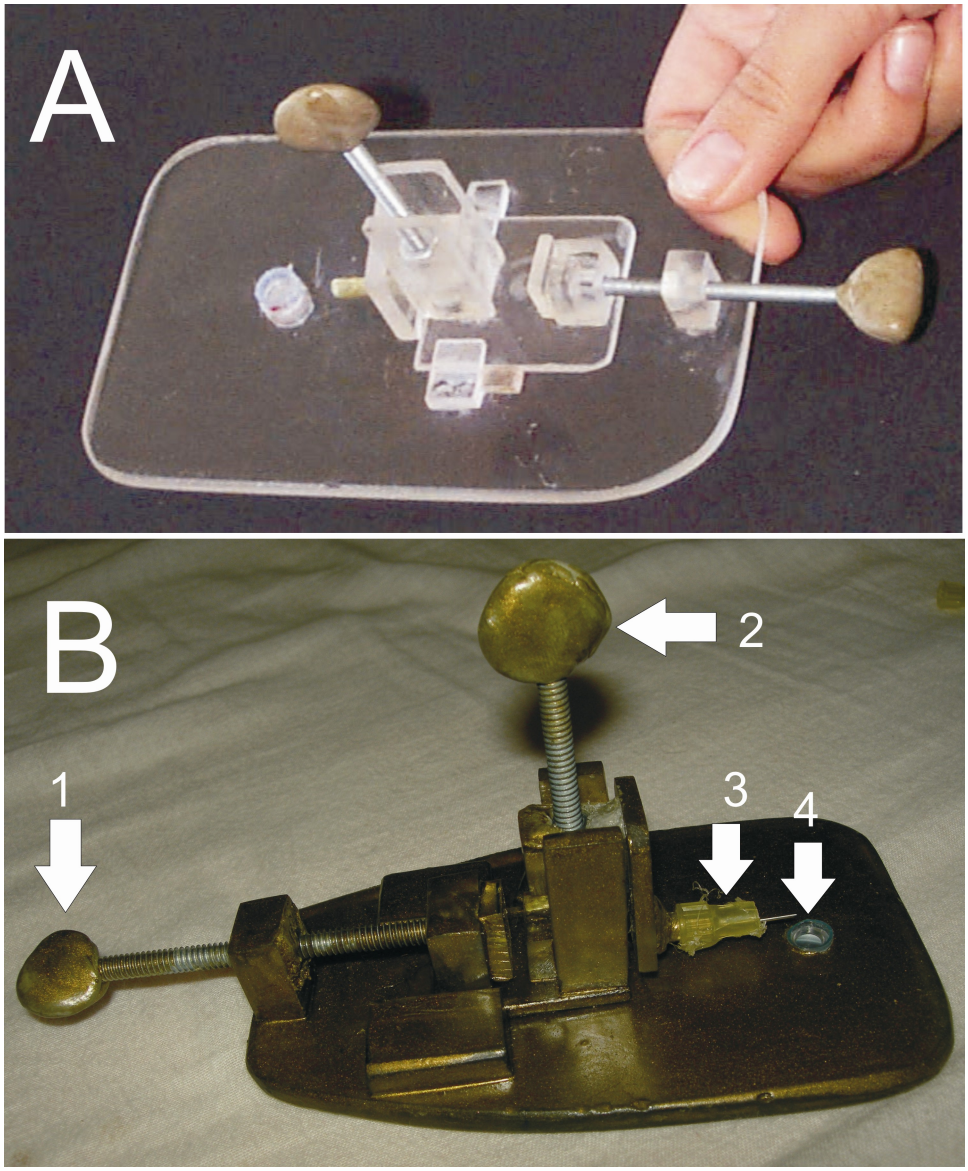

Figure 4. General view of the microscope before (A) and after painting (B).
The arrow 1 point to the control stage knob made using epoxy putty; 2- focus system knob; 3- support the samples, in this case a syringe needle to fix insects and other material, 4- lens.

5) Adding the lens:

-The lens is obtained from a key chain laser pointer and can be found in the top of the key chain. Using a knife, break the plastic part of the key chain and remove the lens (Figure 5). Another possible source for the lens is a broken CD driver, from a computer or CD player. This lens shows a bigger amplification power than the one obtained from key chain laser.

- The lens should not be glued because it can be damaged by the glue chemistry. We normally fix the lens into a 1 ml micropipette TIP. The TIP is conical, and the lens is fixed only by pressure. The TIP is cut 1 cm around the

lens and is fixed into the hole in the A piece.

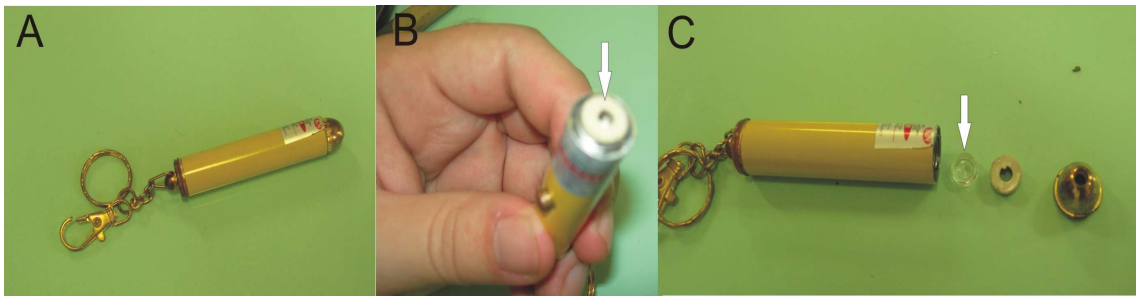

Figure 5. A) key chain laser pointer; B) The plastic piece that needs to be broken to get the lens; C) The lens is shown by the arrow.

6) Using the microscope (preparing the samples):

Three different supports are used to hold the samples.

A) Small animals and part of plants:

Materials that are normally observed in a stereomicroscope are small insects or parts of animals or plants that can be fixed in the top of a hypodermic needle and placed in the focus system. In order to visualize the sample, it is important that the light source reflects in the sample.

Put the sample in front of the lens, turning the control stage knob and focus by turning the focus knob.

B) Thin material such as plants tissues:

Thin materials that can normally seen in temporary preparation, like the cells of onion skin and other vegetable tissues, can be put between two glass coverslips and attached to the plastic protection that covers the hypodermic needle. To fix the coverslips in the plastic protection, make a little slit in the top of the plastic protection and glue it with instant glue (or a glue gun). Standard staining procedures can be used for these preparations, such as methylene blue and eosin.

The light in this case needs to pass though the preparation. We can, for example, look directly at a fluorescent light.

C) Water microorganisms:

To observe water microorganisms such as rotifers, *Paramecium* and others, it is necessary to build a micro-aquarium. For that, we used a hot glue gun and two coverslip pieces. We glue in a "V" shape on one coverslip and pressed another coverslip over the glue, leaving a space between the two coverslips (about 0.5 mm). Alternatively, a thin plastic card can be cut into a "V" shape and glued onto the two coverslips. Next, these coverlips are glued onto the plastic protection of a hypodermic needle. A little slit is made on the top of the plastic protection, and the coverslips are put onto this slit and glued with instant glue or a glue gun (Figure 6).

Using a pipette, water with microorganisms is put into the space between the coverslips and is observed with the microscope.

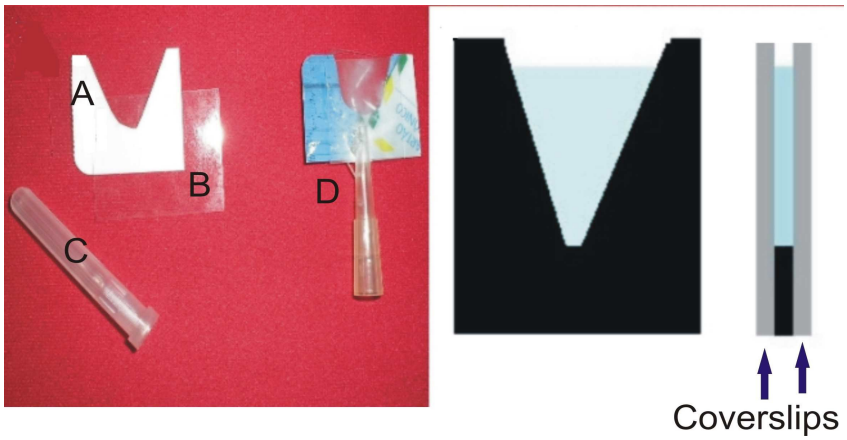

Figure 6. Construction of the micro-aquarium. A) a plastic card with a V cut; B) coverslip; C) Hypodermic needle plastic protection; D) assembled micro-aquarium. From the side, a schematic view of the micro-aquarium with the position of coverslips and the space for water (samples).

Making a microscope with a laser pointer, PET bottle and other recyclable materials

This microscope version is easer to construct than the "Leeuwenhoek-like" microscope described previously, but it works as well as that one. However, in using this "simpler version", the impact that the student experiences when he manipulates a microscope that looks like Leeuwenhoek's is missing,

and the “historical interest” may also be diminished. The instructions for constructing this microscope have been previously published, and it was shown that this simple apparatus can motivate children to discover the “microscopic world” (Wallau et al., 2008).

Materials used:

Key chain laser pointer

PET bottle

Cork (from wine bottle)

Piece of hard plastic (This plastic can be obtained from a freezing box, for example).

One iron nail and one screw (≈ 2 cm)

Epoxy putty and instant glue

Rubber bands

A hypodermic needle.

Assembling the microscope:

1 - With a saw, a knife or a knife heated in fire, cut the PET bottleneck just below the screw in the top of the bottle (Figure 7A).

2 - In the screw region, make a transversal cut in the top of bottle until almost the edge of the thread. This cut should be roughly 3 mm wide (Figure 7B).

3 - Cut a cork so that it is 1.3 cm in length. The cork diameter should be slightly smaller than the internal bottleneck diameter because the cork requires easy movement inside the PET bottleneck.

4 - Using a knife or a hot nail, make a hole of roughly 2 mm in the center of the CAP. Put the cork inside of the bottleneck, and fix the cork in the bottle CAP with a wood screw (the screw passes by the hole in the CAP) (Figure 7C).

5 - In the transverse cut in the bottleneck, fix a nail in the cork, leaving 2 cm of the nail sticking out of the cork, passing by the cut. Now, you can see that when the bottle CAP is moved to the right or left, the nail moves forward or backward. It will be the microscope focus system, and it will later be attached to the body of the microscope (Figure 7D).

7 - Using a piece of plastic that is roughly 2 mm thick, cut one 12 cm x 10 cm rectangle and another that is 10 cm x 7 cm. This plastic can be obtained from a freezing box, for example. These pieces will constitute the body of the

microscope. In the bigger plastic part, the lens will be fixed the lens, and in the smaller plastic part, the focus system will be fixed.

8 - In the center of smaller plastic part, fix the focus system (the bottleneck, cork and CAP) constructed in steps 1 to 6 (Figure 7E) using the epoxy putty.

9 - With epoxy putty, fix the plastic part of a hypodermic needle (remove the metallic needle) to the nail that was fixed to the cork of the focus system. This part will be used to support the samples that will be visualized in the microscope. Once the epoxy putty has completely polymerized, this microscope part is finished.

10 - It is now time to add the lens to the microscope. The lens is obtained from a key chain (see details in the description of the Leeuwenhoek microscope).

11- In the bigger plastic part, it is necessary to make a hole with a diameter of about 0.8 mm to fix the lens. This hole is placed with one border of 10 cm in size, more or less at 1 cm from the edge. The lens should not be fixed with glue, because the lens can be damaged by the glue. We normally fix the lens into a 1 ml micropipette TIP. The TIP is conical, and the lens is fixed only by pressure. The TIP is cut to fit 1 cm around the lens and is fixed into the hole in the bigger plastic part.

12 - Assemble the two parts together by fixing both with a rubber band. The microscope is finished, and now we need to prepare the samples.

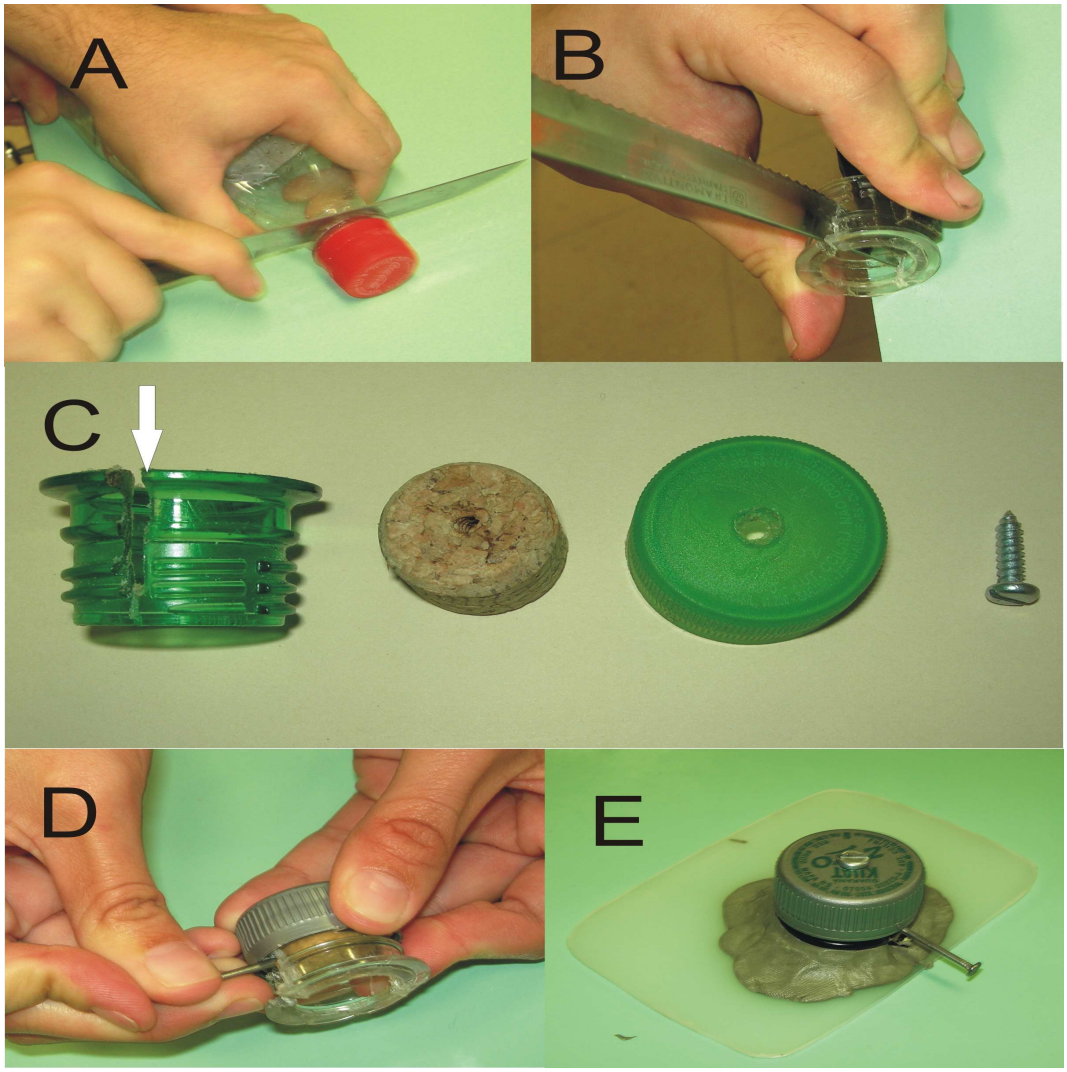

Figure 7. A) Cutting a PET bottleneck; B) transversal cut in the top of the bottle; C) details of the transversal cut, the cork, the CAP with the hole and the screw; D) nail which has been fixed in the cork (make sure that the nail has a slight angle forward in the cut region of the PET bottleneck; E) the focus system fixed with epoxy putty to the smaller plastic piece.

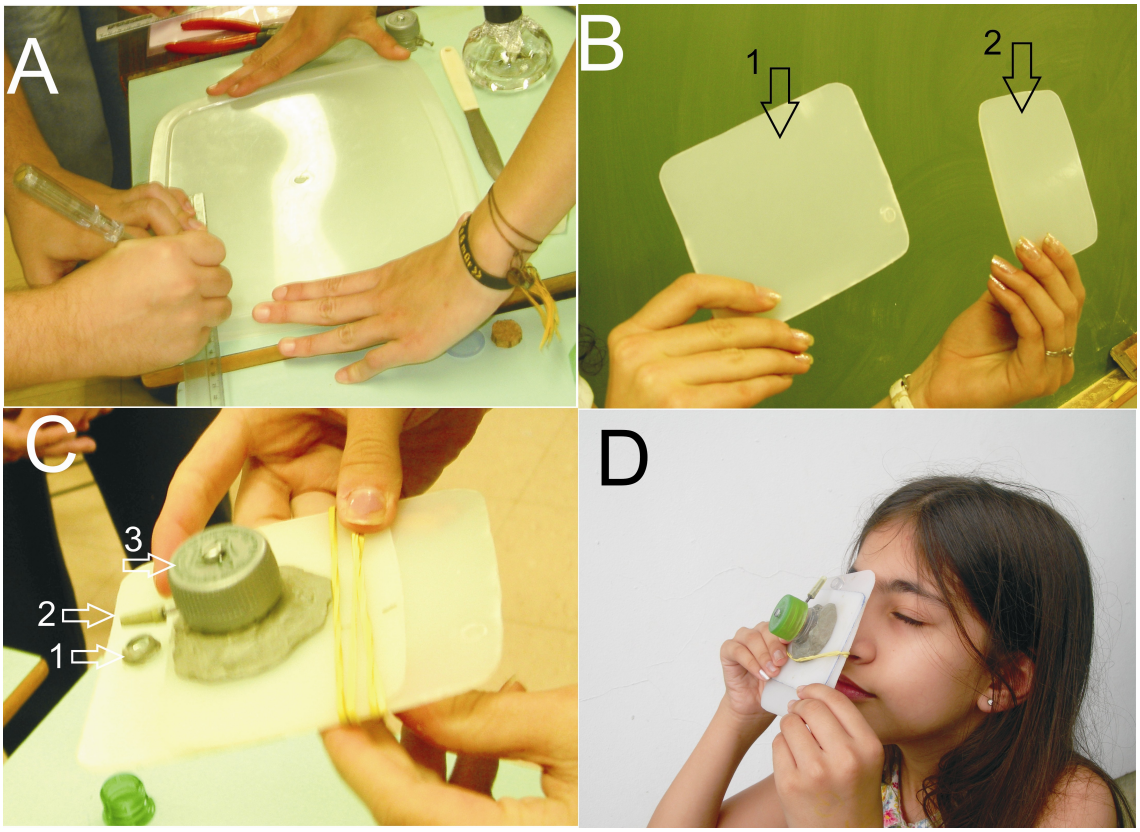

Figure 8. A) A freezing box cap is used to cut the plastic body parts of this microscope; B) 1- the large and 2 -small plastic parts; C) the complete microscope is shown with the rubber bands that hold together the large and small parts of microscope; 1- lens, 2- support the samples that will be visualized, 3- focus system; D) one observing with the microscope.

Using the microscope:

For details about sample preparations and instructions for which sample holders to use in the microscope, see the previous description in the Leeuwenhoek's microscope section.

For visualization with this microscope, put the sample in front of the lens, and move the small plastic part. Using the focus system, turn the CAP for right or left movement and look close to the lens to find the focus.

Wallau GL, Ortiz MF, Rubin PM,. Loreto ELS, Sepel LMN. Construindo um microscópio, de baixo custo, que permite observações semelhantes às dos primeiros microscopistas. *Genética na Escola*,3(2):8-12. 2008.
http://www.sbg.org.br/GeneticaEscola2/web/Vol3Num2.htm