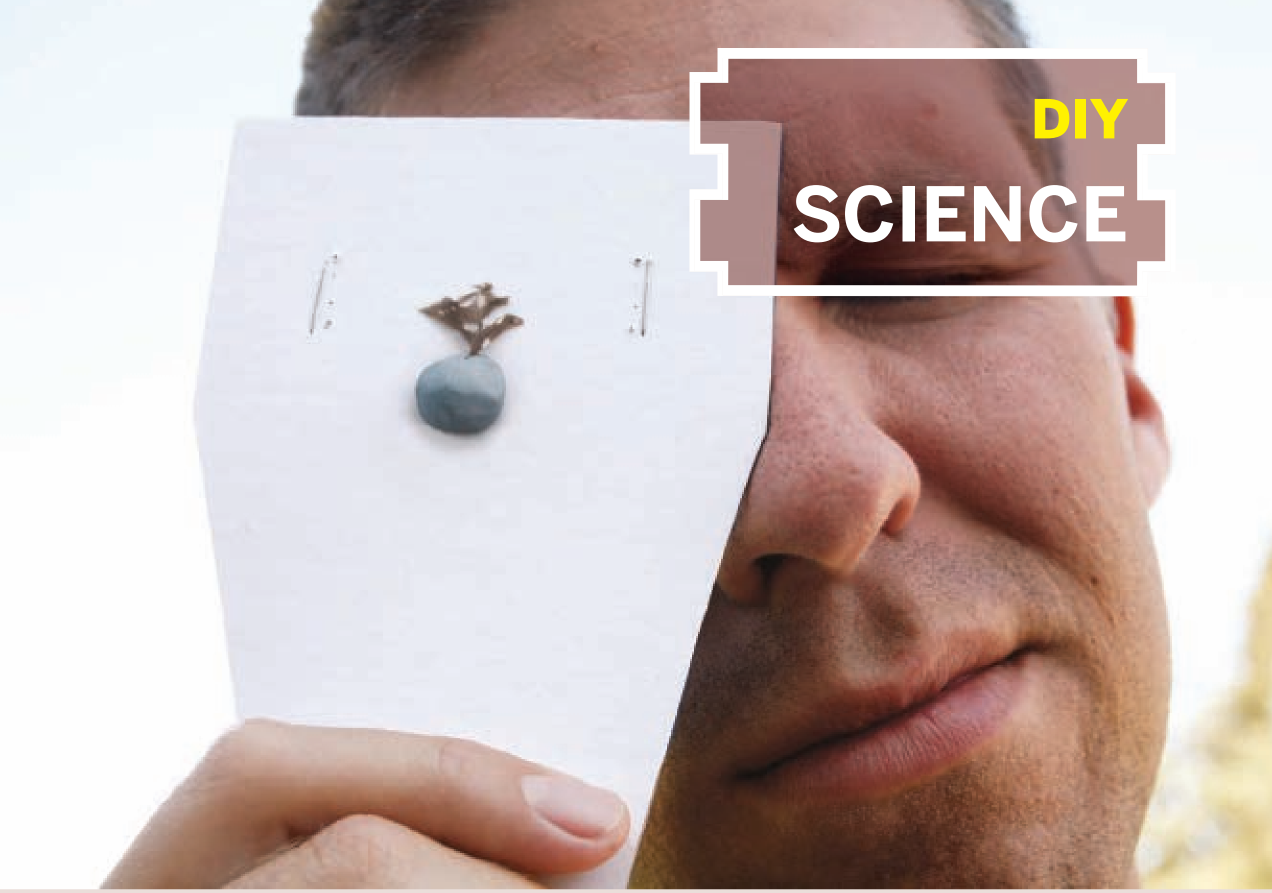
DIY SCIENCE



A 1673 VIEW OF THE MICROSCOPIC UNIVERSE

Make your own van Leeuwenhoek microscope. By Patrick Keeling

Photograph by Sam Murphy

Antonie van Leeuwenhoek (1632–1723) was a wealthy cloth merchant who lived in the city of Delft, in the Netherlands. He is best known for his pioneering work on microscopy: from 1673 onward he created as many as 500 microscopes, and from these made numerous significant discoveries. It was he who first discovered the existence of single-celled organisms, a discovery that ironically brought his scientific credibility into question for some time.

The success of his microscopes can be attributed to many things, but a number of technical matters stand out. First, his microscopes relied on a single lens. Compound microscopes (those with more than one lens in the light path) theoretically provide better resolution, but they're also much more technically challenging to fabricate. As well, van Leeuwenhoek devised a method for producing lenses that apparently reduced the need for precise grinding, a laborious and technically difficult process.

The few remaining examples of van Leeuwenhoek's microscopes are elegant creations of brass or silver with many working parts. However, the basic functional aspects of his design and his glass-sphere lenses can be replicated in a few minutes, using simple materials. Following the steps here, you can make a working van Leeuwenhoek microscope capable of 100x to 200x magnification.

It's amazing to consider how we often take microscopy for granted in this day and age. When you use the microscope you've built, imagine what

MATERIALS AND TOOLS

Glass Pasteur pipette or capillary tube or whatever glass source is handy
1mm poster board, 5cm×10cm for the thick side
Cardstock, 5cm×10cm for the thin side
Dab (about 1ml) of tacky poster putty such as Elmer's Tack Adhesive Putty, the kind used to stick posters on a wall. In a pinch, you could use chewing gum.
Drill and bits: 1/16" and 7/32" (optional)
Stapler, razor blade, safety goggles
Flame A portable plumbing torch or Bunsen burner works best, but a disposable lighter or even a candle also works if your glass is thin (e.g., a capillary tube).

Fig. A: Brass replica of a van Leeuwenhoek microscope (front and back views). You can build one from simpler materials, with the same optics and operating principles.

it must have been like to peer through one of these creations and discover a completely unknown realm of life — because your instrument will reproduce the microbial world just as it would have looked using the technology of the 17th century.

1. Cut the microscope plates.

Cut out 2 roughly equal-sized pieces of poster board and cardstock. They can be any size and shape, but if you want to pay homage to van Leeuwenhoek's microscopes they should be about 6cm×3cm, with a slight taper at one end.

2. Drill the light path.

2a. Drill a 1mm (1/16") hole in the poster board and cardstock (Figure B). It's best to drill both at once, and to drill into something like wood or additional poster board to give a clean hole. The hole should be 1.5cm from the sides and the top, and about 4.5cm from the bottom.

2b. Make a lens pocket (optional).
If you want to make a little pocket between the poster board and cardstock for your lens, you can drill a shallow depression on the inside face of the poster board using a 7/32" bit. This isn't necessary, since the cardstock will bend around the lens, but it makes a cleaner finished product.

Alternatively, you can use 2 pieces of poster board, in which case you'll need to drill this pocket or the lens will be too far from the surface to be used (the lens has a short working distance). It's also helpful to carefully shave off any protruding paper around the holes with a sharp razor blade, as loose paper fibers can be magnified along with your specimen.

3. Create the lens.

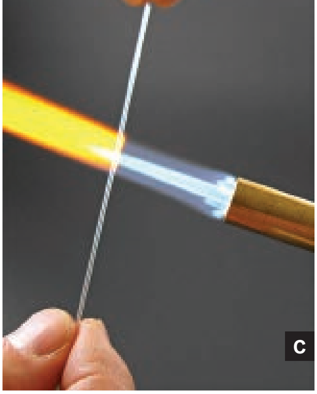
The lens will be a glass sphere whose diameter dictates the magnification. Aim for a lens about 2mm in diameter since this is big enough to work with and gives a decent magnification.

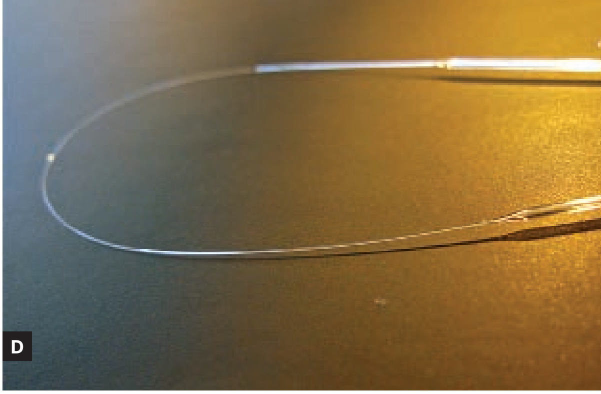
⚠ CAUTION: Wear eye protection when melting glass.

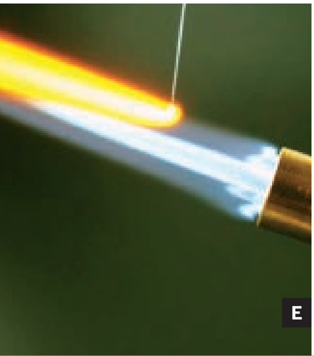
First, stretch the glass. Holding the pipette/tube at both ends, place the center in the flame and hold it there until the glass melts and wobbles freely between your hands. Roll it in the flame to equally expose all sides of the heated area (Figure C). When the glass is soft, remove it from the flame and immediately pull the 2 ends apart to stretch it very thin (Figure D). You're aiming for a glass tube of <0.5mm. Too thick and your lens will be a teardrop rather than a sphere; too thin and you'll have to feed a tedious length of glass into the flame or the lens can break off.

Now form the lens. Once the stretched glass has cooled sufficiently to handle, break it somewhere in the middle. Position the flame horizontally, and slowly feed the stretched glass into the flame from above. Watch carefully. A small, white-hot glass sphere will grow at the tip of the tube as you feed it into the flame. It's critical to keep this sphere in the flame and not to let it cool before it's done — if you pull it out and reintroduce it, bubbles will form. Keep feeding until the sphere is about 2mm in size (Figure E).

Photography by Patrick Keeling







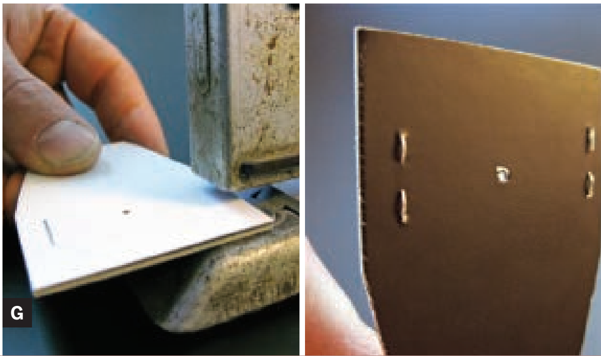


Fig. B: Drill cardstock and poster board at the same time. Figs. C and D: Heat the glass evenly until soft and wobbly, then immediately stretch it into a thin filament or tube. Fig. E: Break the stretched glass in the center, then feed it into a horizontal flame. A small sphere will form. Fig. F: Place the lens in the hole on the inside of the poster board. Fig. G: Staple the 2 layers together with the lens in between.

TIP: A nice trick to help keep this motion constant and the sphere in the flame is to feed the stretched glass though the loop of a pair of scissors so that about 5cm of glass extends from the loop. Then hold the scissors by the blade and twist slightly so there is mild tension on the glass. This will hold the end of the glass steady as you feed it into the flame.

Once the sphere is the size you want, remove it from the flame, let it cool completely, and break the tube off about 0.5cm from the sphere. This gives you a short handle, like a lollipop stick, so you can avoid touching the lens during construction. This also ensures the light path will be perpendicular to the "wound" caused by breaking the lens from the tube.

You can make several lenses from one stretched segment of glass: when one sphere is done, snap it off and start another. They're easy to make, so make several and choose the best sphere with no visible imperfections (such as bubbles).

NOTE: Your lens should be a sphere, not a teardrop. If you get a teardrop shape, your glass was likely not stretched thin enough, so go back to Step 3 and stretch a new one to be thinner.

If you want to work with a smaller lens, you may need to drill holes smaller than 1⁄16". The hole must be smaller than the lens, to keep the lens from falling out, and to limit the visibility of your light source background and ensure proper contrast.

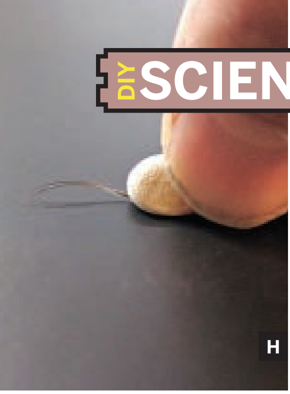
If you're going to measure the diameter of your lens for use in calculating its power (see botany.ubc.ca/keeling/resomicr3.html), do it now, before you assemble the microscope.

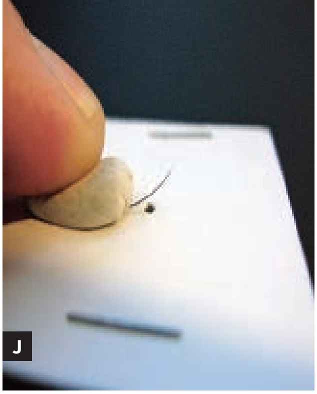
NOTE: These lenses have very short working distances, so your sample has to be very close to the lens. That's why you use the thinner cardstock on one side. It also means your microscope works in one direction: you look through the poster board side and place your sample on the cardstock side.

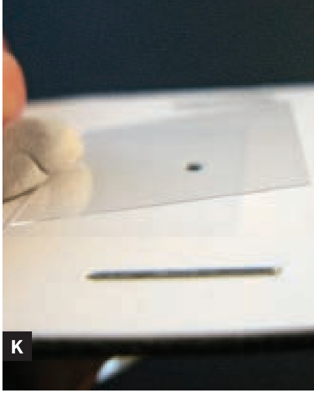
4. Assemble the microscope.

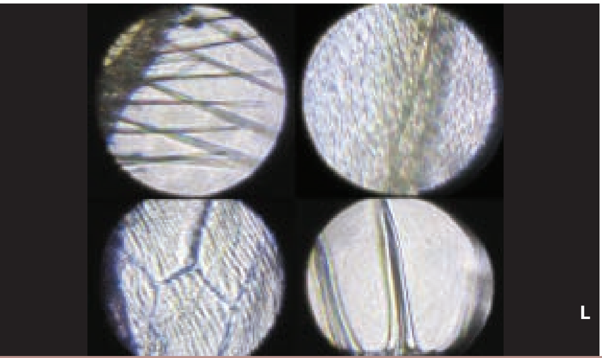
Holding your sphere by its handle, place it over the hole you drilled in the poster board (in the pocket if you made one), with the handle lying flat on the inside surface of the poster board (Figure F).

Set the cardstock on top so the lens and handle are sandwiched between the 2 layers. Hold the 2 layers firmly together with the holes and lens lined up,









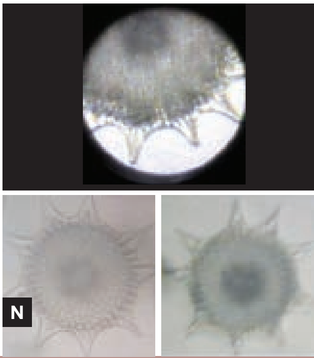


Fig. H: Press tacky putty onto the specimen. Fig. I: Put putty on the microscope. Fig. J: Push or pull putty to pivot your sample closer or farther from the lens. Fig. K: Mount a glass cover slip and drop liquid samples onto it. Fig. L: Insect wing, onionskin, and radiolarian skeleton. Fig. M: Live cells in liquid. Fig. N: Radiolarian skeleton images from a commercial field microscope (left), and 2 homemade microscopes (right and top).

and staple it about 0.5cm on each side of the hole. Staple with the cardstock side up, so the staple is less likely to get in the way of the sample (Figure G).

5. Make your focus mechanism.

The biggest challenge to making a microscope from paper is how to focus your specimen. The solution is to take advantage of the simultaneously elastic and sticky properties of tacky poster putty to both mount the specimen and pivot it in relation to the lens. (Recently used chewing gum works as well if you can't find putty.)

To illustrate how this works, we'll mount the barb of a feather as an example. To start, put your feather barb on a flat surface. Take a dab of putty about the size of a pea, press it over one edge of the barb (Figure H), and pick it up. The barb will stick to the putty and project from it. Now stick the putty below the hole on the cardstock side of the microscope, so the barb is right over the lens (Figure I). Don't get putty on your lens. This will serve as your stage, focusing device, and movement controls.

6. Explore the microscopic world.

To view your specimen, hold the microscope sideways, as close to your eye as is comfortable, looking from the poster board side into a light source, such as a light bulb or a bright sky (don't look directly at the sun). To focus, place your thumb on the putty. Push the putty up toward the top of the microscope to pivot the sample closer to the lens, and pull down to pivot away from the lens (Figure J).

The same principle is used to mount other kinds of samples. Mount any dry, solid specimen as described; to easily see the microscope in action, I like feather barbs, insect wings, or onionskin. To mount a wet specimen, mount a glass cover slip as described (Figure K), then drop your sample onto the cover slip and hold the microscope horizontally with the cover slip facing up (so your sample doesn't drip) and look from the bottom.

Wet samples can also be mounted between 2 cover slips, although this takes a bit of practice. For this I suggest diatoms since they're big and regularly shaped. Forams and radiolaria are also good, but not as easy to find in nature.

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