

Adding a 3D-Printed Dark-Field Illuminator to Your Stereomicroscope

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In recently published articles in the Micscape magazine [1,2], we have reported two examples of using 3D printing FDM technology to restore or add functionality to old priceless microscopes. This new article will show how to 3D print a simple accessory that can add dark field illumination to ordinary stereomicroscopes (SM). This paper will give a general description of this darkfield illuminator, more detailed information for the construction can be found on our Instructable page [4].

The Dark Field Illumination

The principle of the darkfield illumination technique for a standard microscope is illustrated in Figure 1. The light from the source is blocked by a collector, allowing only light from the cone's border to pass through. In an ordinary microscope, the condenser then focuses the transmitted light through the microscope table's opening at an angle that does not directly hit the objective aperture, creating a dark field of view. However, when the light hits the specimen on the slide, some rays are reflected or refracted (due to the contents inside the cellular organism) straight to the objective, illuminating the specimen. The bright objects moving on a dark background enhance the clarity of the specimen, making observations easier. Stereomicroscopes are typically used for magnification observation and usually lack an optical system to shape and focus light from the source. However, darkfield microscopy requires a shaped filter to maximize the oblique transmission of the residual transmitted light through the slide with the sample.

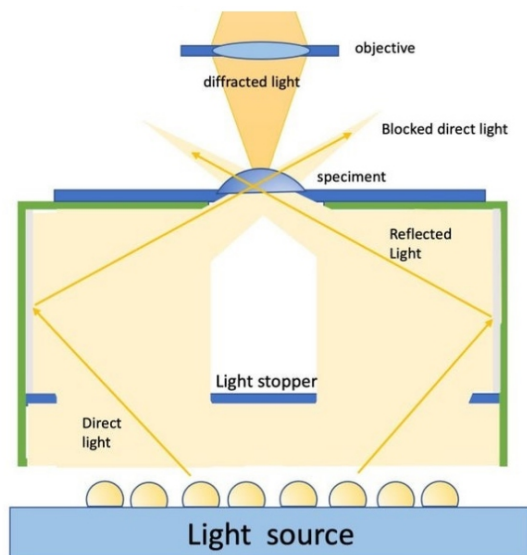


Figure 1: diagram of the basic theory of Dark Field

If your SM has a transmitted light source, you can easily build a darkfield accessory using simple materials. You need a cylindrical box with an opaque light-stopper, reflective coating, and a collector opening, its size calculated to fit your SM model [3]. Additionally, the availability of 3D printing technology allows for the creation of customizable versions of this device, enabling surface modeling to optimize illumination. In our case, the model was designed to fit precisely inside the base of our stereomicroscope [2]. However, we have made openSCAD files available, allowing you to easily modify the parameters shown in Figure 2 to fit the dimensions of the 3D-printed components to different stereomicroscope models.

To do this, check the size of the opening on your stereomicroscope's stage and the stage's depth. Note that we use LEDs as our light source instead of the original halogen light [2]. If you are using a halogen light source, be careful to avoid melting the device if it is in contact with or too close to the bulb. Once you modify the parameters for your microscope in the openSCAD script, you can 3D print the body. Next, add a strip of aluminum foil between the two internal rings as shown in Figure 3. For the top lid, check the size and the center of the aperture and adjust it if needed. Measure the diameter of the aperture by placing a ruler on the microscope table and measuring the diameter of the view size, as shown in Figure 4. Use half of this value for the aperture radius to create the hole. Before 3D printing, I suggest making a lid from cardboard to ensure the aperture aligns perfectly with the objective. Once you print the top, cover the internal part with aluminum foil, as shown in Figure 4.

Another essential part of the device is the "light stopper." Its size and position are as crucial as the lid aperture, requiring

accurate measurements. To adjust the optimal size and position for the light stopper circle on your device, we recommend building it with inexpensive materials that you can modify easily. This allows you to find the best darkfield effects without wasting 3D printing time and material. You can cut a round piece of black tape, approximately twice the size of the lid aperture, and place it on a round transparent plastic acetate sheet with a diameter equal to the device's internal diameter. Plug it into the bottom of the device (to hold it in place, you can either 3D print the part attached or make a ring out of cardboard, as shown in the figures). Insert the device into your stereomicroscope and ensure no direct light is coming from the LED. You can vary the diameter and radius of the black stopper circle to find the best effect. Once you are satisfied with the result, you can modify the openSCAD script to generate the model for 3D printing. Then, cover the stopper surface facing the light source with black tape.

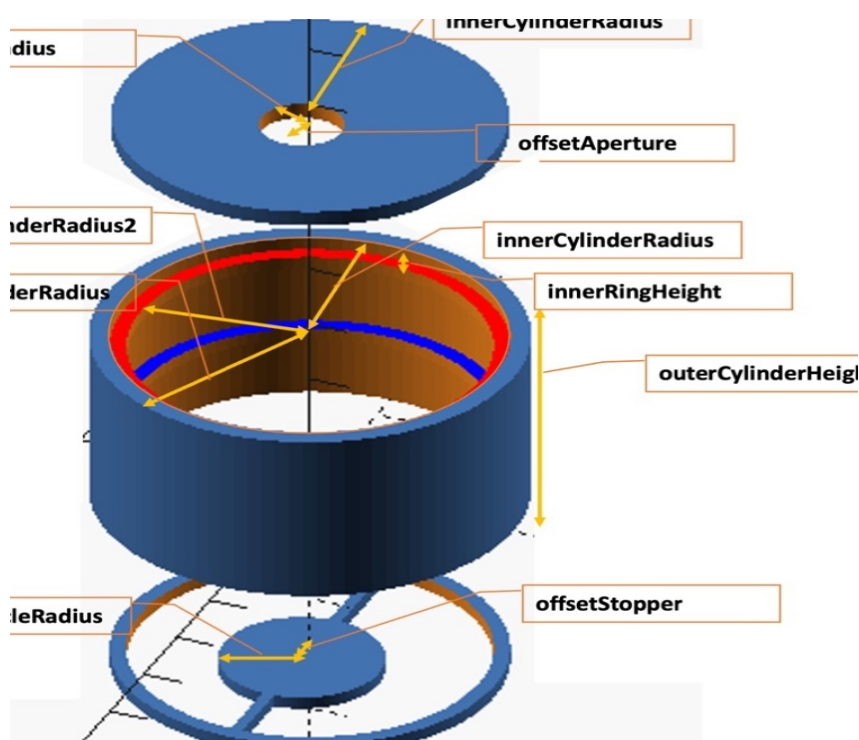


Figure 2: Exploded view diagram showing the 3D printed parts of the device. The labels indicate the name of the adjustable parameters used to create the model. These parameters are in the openSCAD program publicly available from the Instructable site of the project [4].

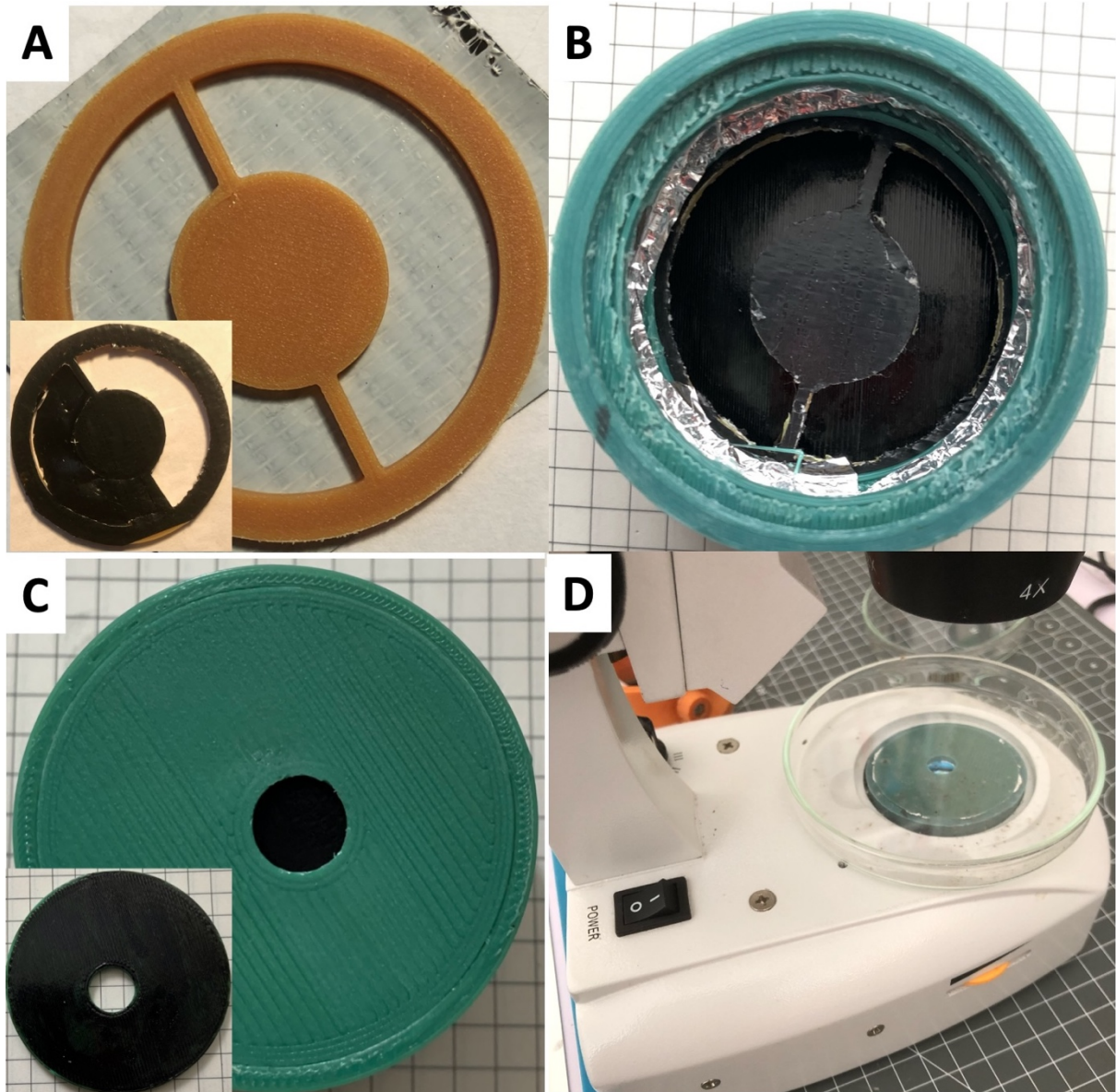


Figure 3: A. Light stopper: The inset shows the use of dark tape to darken one side of the stopper. B. Main cylinder with an aluminum strip. C. Top lid with opening: The inset shows the side that has been darkened using an oil-based marker. D. Darkfield illuminator inserted in our stereomicroscope (SM).

Conclusion and Outlook

In Figures 4 and 5, some examples of specimens viewed in dark field are shown. Our device is very useful for observing tiny organisms at relatively high magnifications. Figure 4 shows mold growing on organic residue left in a petri dish, viewed in both direct and dark field illumination. In this case, the white color of the mycelium contrasts very well with the dark background.

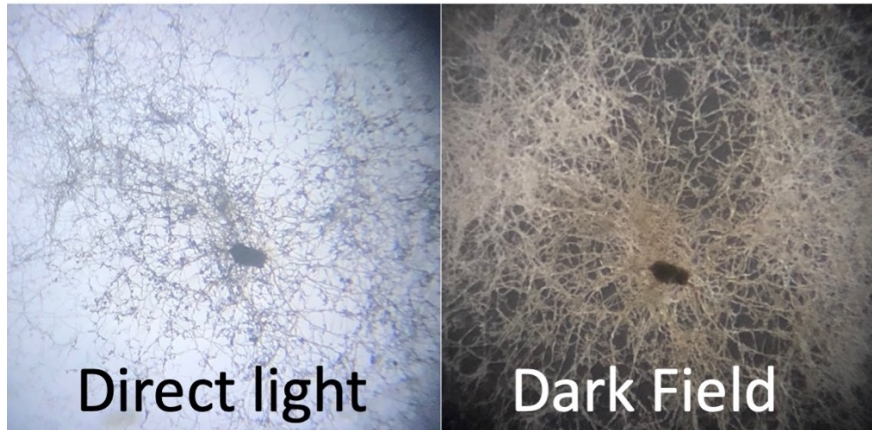


Figure 4: Comparison with direct illumination: The dark field produced by our device offers two examples of dark field illumination of specimens. The observed mycelium developed in the petri dish is shown in Figure 3D.

Figure 5 presents various examples of observations using the darkfield illuminator on an SM. The top

row includes, on the left, a prepared slide showing the muscle in the rear leg of a locust; in the center, a trachea taken from the same insect; and on the right, a detailed view of a ganglion from the central nervous system of the same animal. In the middle row, you can see, on the left and center, two examples of aphid insects, and on the right, salicylamide crystals. The bottom row features, on the left, the wing of a housefly; in the center, the scales of a large white butterfly's wing; and on the right, a mouse tooth.

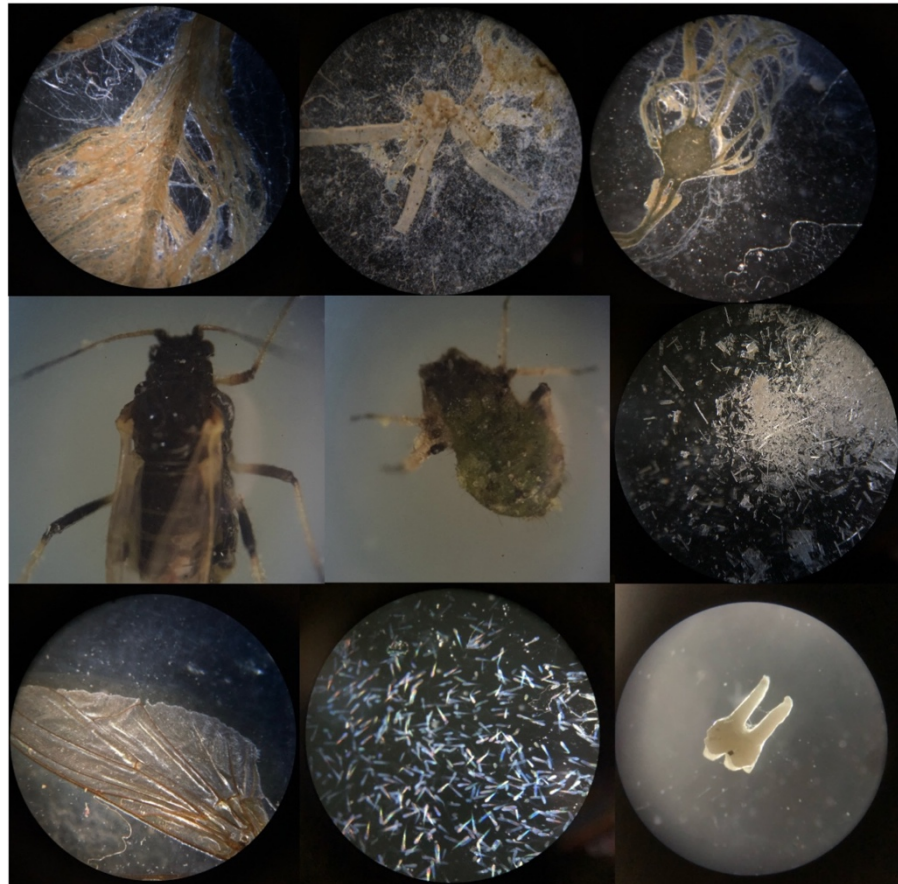


Figure 5: More examples of observations using the darkfield illuminator on an SM. **TOP:** Left: Prepared slide showing the muscle in the rear leg of a locust. Center: Trachea taken from the same insect. Right: Detail of a ganglion from the central nervous system of the same animal. **MIDDLE:** Left: A fly (*Drosophila melanogaster*?). Center: Aphid. Right: Salicylamide crystals. **BOTTOM:** Left: Wing of a housefly. Center: Large white butterfly wing scales. Right: Mouse tooth.

The device can be further improved to maximize the oblique light and reduce the leakage of direct sunlight. We would be delighted to hear from you if you have made any improvements. The next step is to enhance the geometry of the internal reflecting surface by modeling it in a parabolic or toroidal shape, similar to a professional illuminator.

We hope this article helps you to improve your SM by adding dark Field illumination capabilities. Have fun with your observations!

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