3D viewing and recording with non-stereo binocular microscope

I present some tricks for getting full 3D view of microscopic subjects and a means of making anaglyph photos and videos using cheap and easily constructed filters.

First the easy trick you may already know: Especially in darkfield view, with the Abbe condenser at its highest position, if you move your head side to side you can see the background shift relative to the foreground. If you move the eyepieces just a little closer together than usual you get the full 3D effect. Images from the slight angular difference from one side of the objective lens to the other are sent to the left and right eyes respectively giving the sense of depth. Good results are seen with 4X, 10X and 20X objectives. You can move the eyepieces closer together to increase the sense of depth, however too close and it can be uncomfortable. A limitation of this 3D view is its narrow depth of field. Objects above and below the plane of focus blur rapidly, making the depth perception here somewhat unsatisfactory.

To get better 3D in brightfield on a single-objective binocular or trinocular microscope you can use filters to “encode” the left and right sides of the illuminator light and filters on the eyepieces to “decode”. I have used both polarizing filters and red/cyan filters cut from cardboard 3D glasses to do this. With this method the eyepieces can be at their most comfortable distance. Polarizing film, and red/cyan filters (in the form of cardboard 3D anaglyph glasses) are available at the cost of a couple boxes of slides.

For direct viewing through the eyepieces the better method is that using polarizing filters. An assembly consisting of a pair of polarizing filters with the left and right sides at perpendicular polarization alignment is placed on the illuminator. Each of the eyepieces is covered with a polarization filter that can be rotated freely. The eyepiece filters are aligned by rotating to give maximal light blockage while the illuminator is covered by the left, then the right side of the assembly. Then the illuminator is covered by the assembly pair, centered so that light from the left and right sides have perpendicular polarization. Viewing through the eyepieces now gives a very strong 3D effect for 10X, 20X, 40X and 60X objectives. Note that best results are seen with the abbe condenser at its lowest position, or absent entirely.

While the polarization method is best for direct viewing on the microscope, if you want to make photos or videos or present 3D images on a monitor in real time then red/cyan filters are the better choice. With a camera on an eyepiece or trinocular port simply replace the polarization assembly on the illuminator with a similarly constructed red/cyan filter assembly. The anaglyph image is then viewed on the monitor or camera screen with red/cyan 3D glasses.

It may be desirable to make 3D photos without the red/cyan color encoding. To do this you can take separate photos of the same subject covering the left and right half of the illuminator. The photos can then be arranged side-by-side for either cross-eye or parallel viewing.

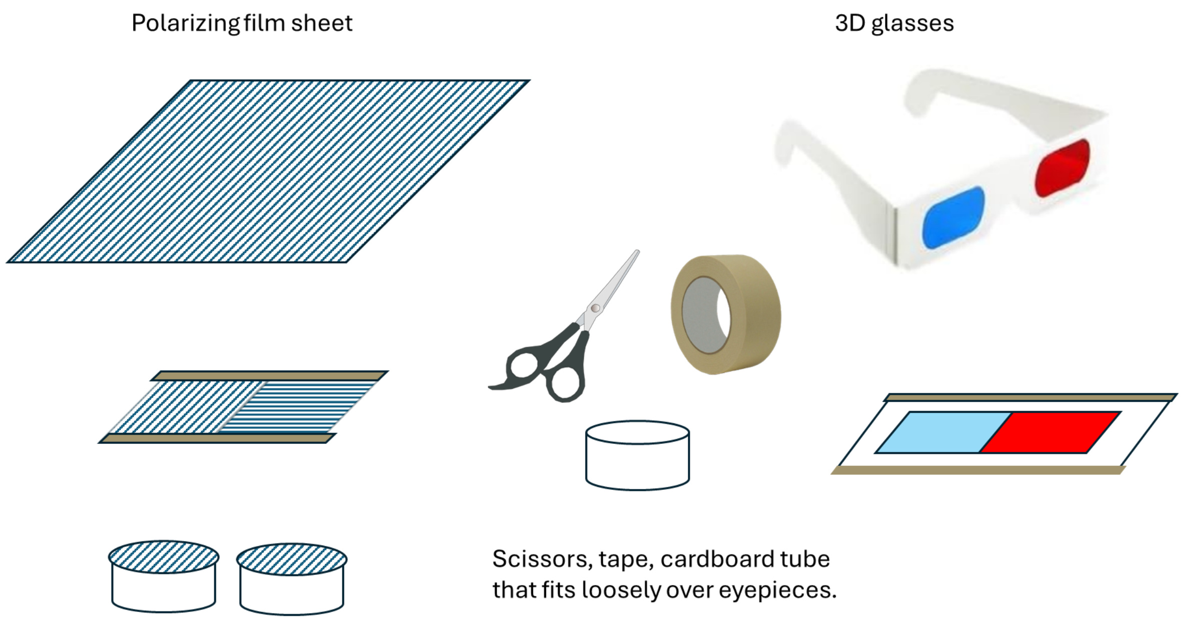
Construction of filters:

Polarizing illumination assembly: The polarizing film comes with protective backing on both sides – remove this after cutting to desired shapes (squares that cover the microscope illuminator and circles to cover the eyepieces). Fasten the squares together with perpendicular alignment using tape on the outer edges.

Polarizing eyepieces: Ideally you would find a cardboard tube that fits over the eyepieces and allows for easy rotation. You may have to make it yourself with paper and tape. Glue circles of polarizing film to these.

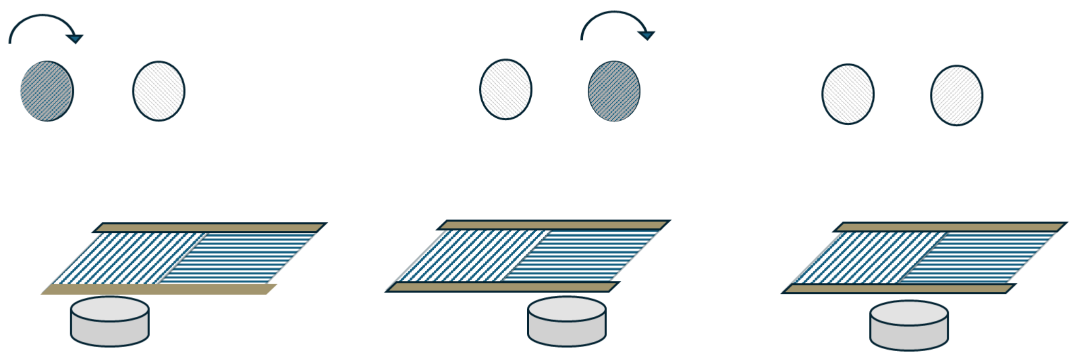
Anaglyph illumination assembly: Cut the cardboard 3D glasses such that the red and cyan filters can be joined as shown and tape together around the edges.

Anaglyph eyepieces: Don't bother. You'll want to view the anaglyph images that your camera sends to the monitor. (Anaglyph eyepieces work ok, but you lose a lot of image intensity. Seriously – use the polarization system for direct viewing!)



Alignment of polarization filters:

It is important that the abbe condenser be in its lowest position for alignment and viewing.



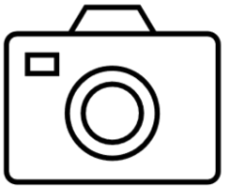
With illuminator covered by vertical polarizer rotate left eyepiece polarizer to darkest

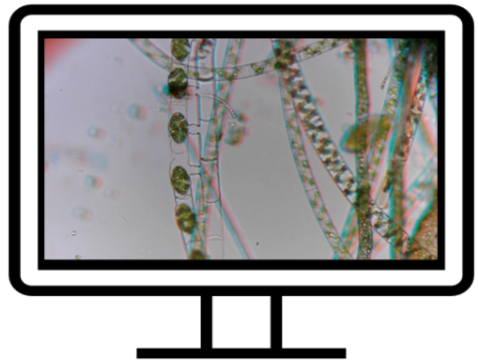
With illuminator covered by horizontal polarizer rotate right eyepiece polarizer to darkest

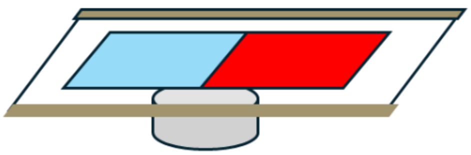
Center polarization assembly on illuminator and view 3D

Alternatively, the abbe condenser can be removed entirely, but this reverses the direction of the illuminating light on the subject so the alignment procedure must be done for each eye with illumination filter assembly in the reversed position.

The polarization method is great for direct viewing through the eyepieces, but for photography and sharing the 3D view on a monitor you will want to use the red/cyan filter to encode the view as anaglyph. When you find a view that you want to record, simply replace the polarization assembly with the red/cyan assembly (cyan left, red right) – the focus will remain the same. Initially the monitor or camera screen may show too much red or blue in the background. You will need to shift the assembly side to side to get the desired neutral gray. This may involve very fine movements.





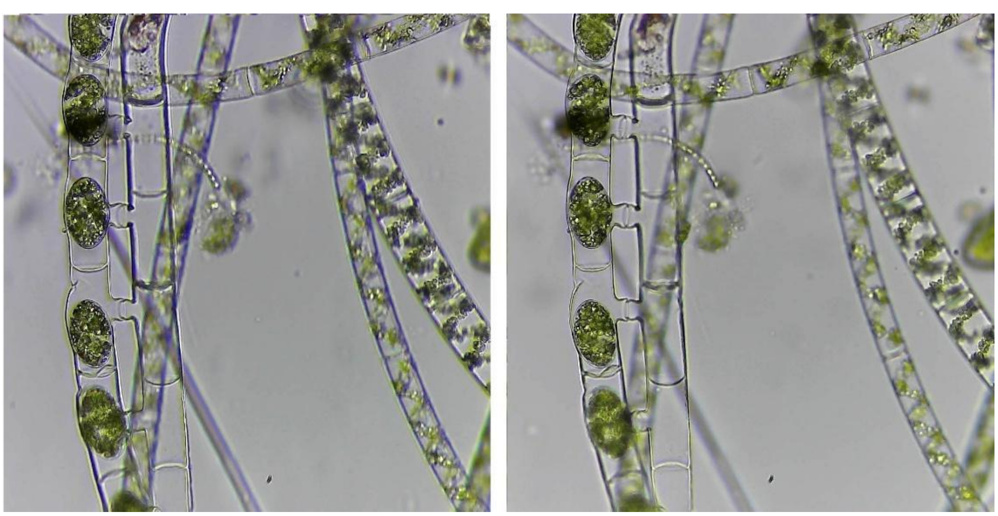


Center cyan/red assembly on illuminator and use camera on eyepiece or trinocular port to capture 3D anaglyph image or video

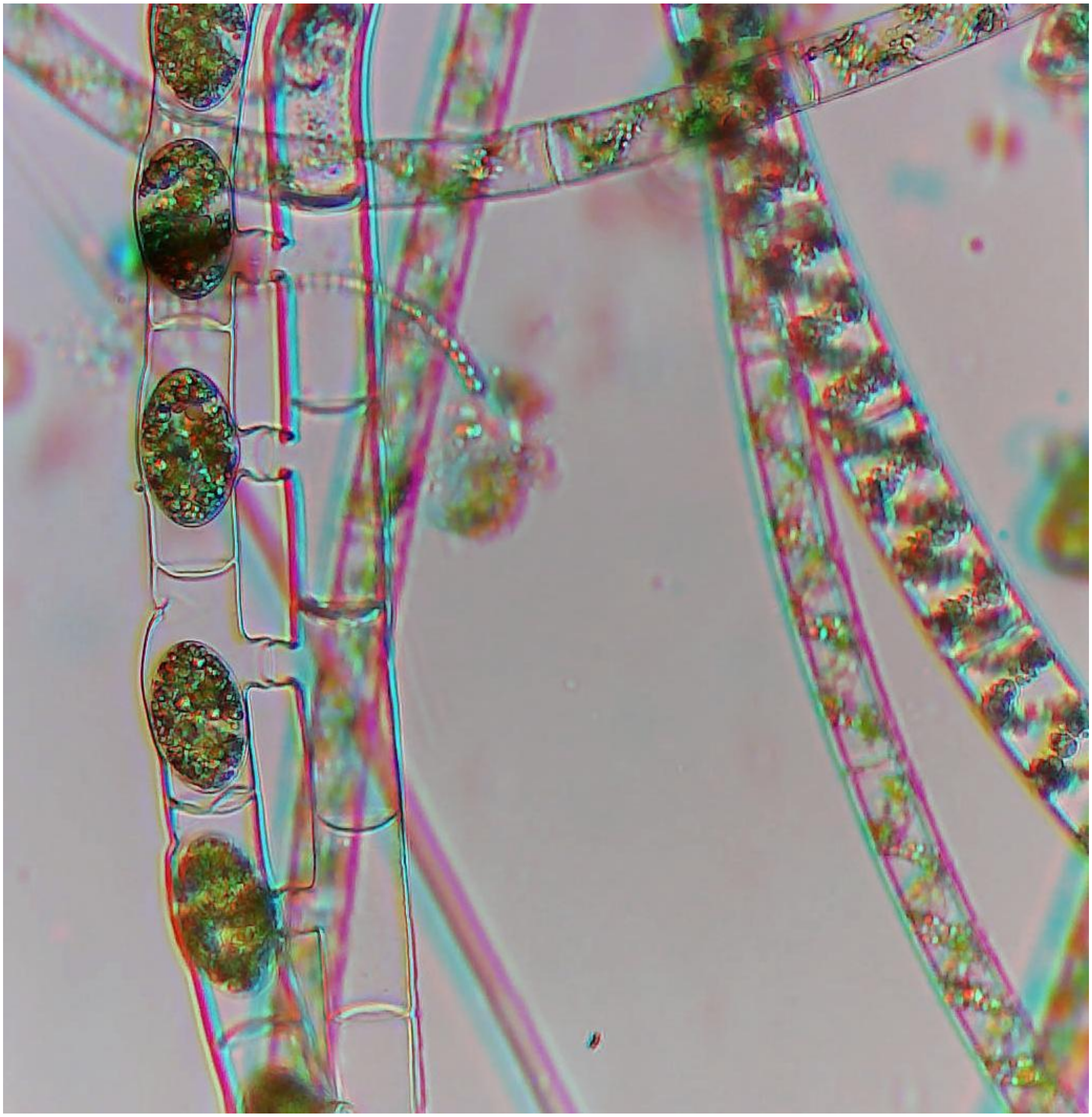
View on monitor with 3D glasses

The red/cyan anaglyph encoding causes some degradation of the subject's original color. To avoid this you can remove the filter and simply take two photos blocking the left and right half of the illuminator respectively. In this case you sacrifice the motion in favor of original color.

Cross-eye stereo view of algae 20X objective



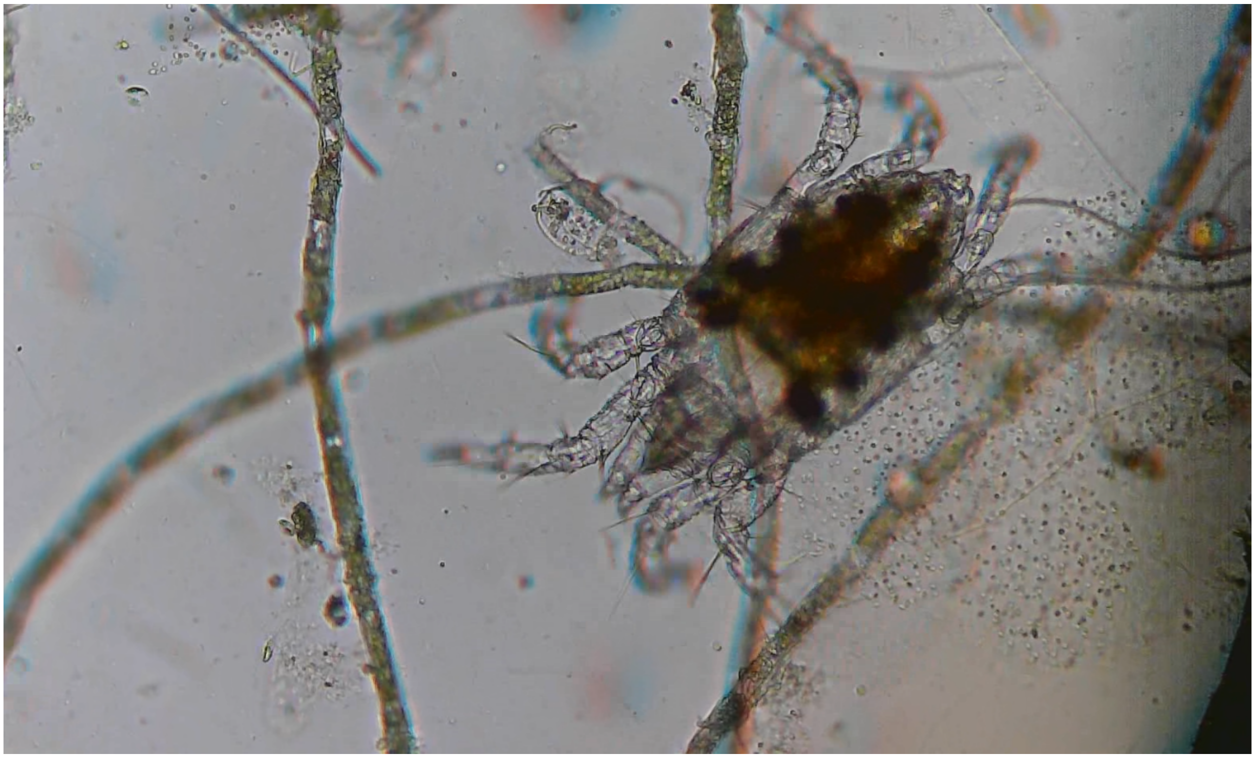
Anaglyph image of same view



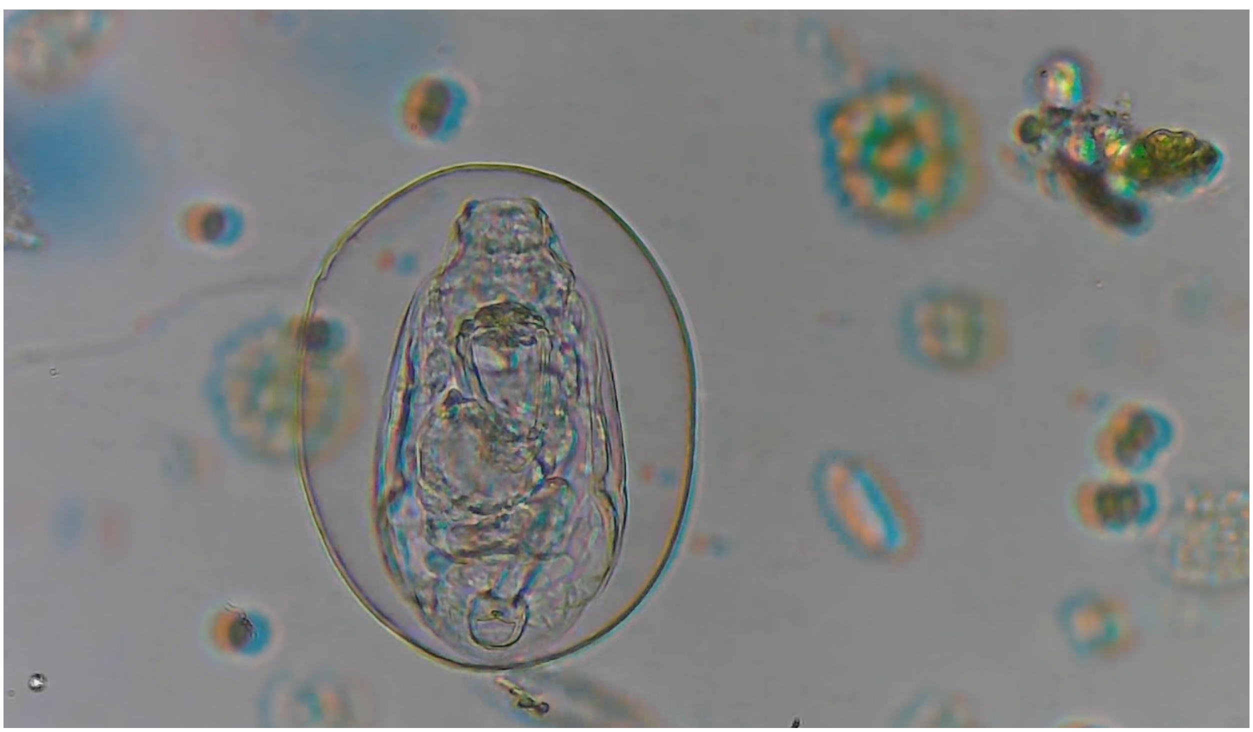
Below are a few anaglyph photos I've made using the cyan/red assembly. Actually, they are frames grabbed from anaglyph videos using the technique – it's much easier to find the right image in a video you've already made.

Vorticella 40X objective

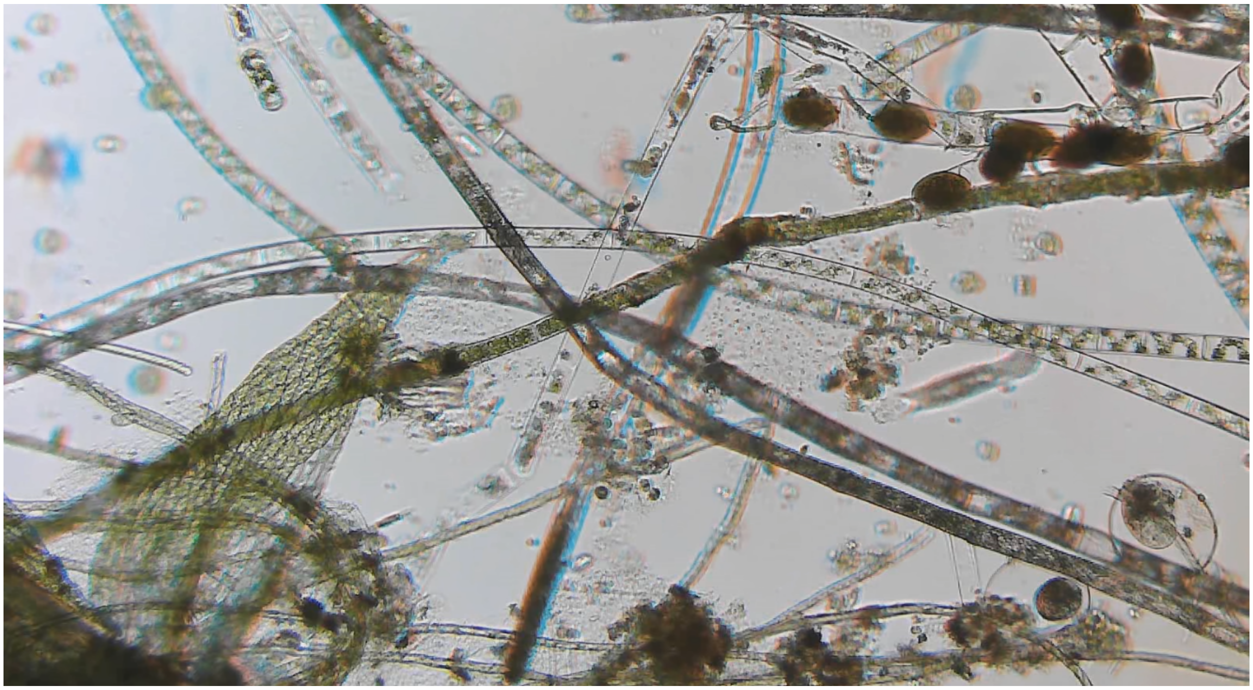
Diatom and amoeba 60X objective



Water mite 20X objective



Rotifer hatching 40X objective



Algae field 10X objective

Possible limitations of the technique:

I developed and have tested these filters on an AmScope T490 and an iScope 1153EPC using a cheap webcam on the trinocular port and an iPhone 12 on an eyepiece. Both of these microscopes have a rack-and-pinion abbe condenser which can be set to very low position, or removed if desired. The abbe condensers of some bi/trinocular microscopes are adjusted by a helical screw system, and it may not be possible to set them low enough for best results.

Below are some resources that I found valuable in developing and understanding 3D microscopy techniques.

reddit discussion "Stereo/3D vision with a binocular compound microscope"

https://www.reddit.com/r/microscopy/comments/w54il4/stereo3d_vision_with_a_binocular_compound/

from Diet Tom's YouTube channel "ShinyaVision - Experience The Microcosmos in 3D with this Simple Microscope Mod"

https://www.youtube.com/watch?v=z6TUnvAD-Pg

from Microbehunter Microscopy YouTube channel "How to get a 3D effect with your microscope"

https://www.youtube.com/watch?v=9btIpf5mjyA

3D videos of a variety of microbes can be found on my YouTube channel: "darwexter" https://www.youtube.com/@darwexter

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