

# Smartphone Microscope

July 28, 2014

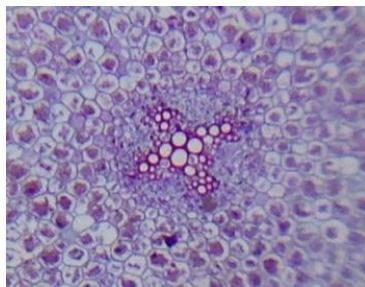
Constructed by Joseph Miles and Srikant Iyer, Payne Lab, School of Chemistry and Biochemistry,  
Georgia Tech, Atlanta, GA

Initial Design: \$10 Smartphone to digital microscope conversion!. *Instructables.com*.

<http://www.instructables.com/id/10-Smartphone-to-digital-microscope-conversion/>

## Purpose:

Build an inexpensive microscope using a smartphone as a detector. With the use of this tool, images such as the following may be obtained.



Typical dicot root cross-section

## Background:

Microscopes work by utilizing one or more lenses to enhance the ability to see very small objects of interest, much like a telescope allows the user to see at great distance. The first microscope was invented in the 1590's by Zacharias Jansen and his father, both of whom were eyeglass makers. Having knowledge of focal lenses, they created a microscope that could magnify up to 10 times what is possible with the human eye alone. As with many inventions, numerous modifications have been made over time to optimize the potential of microscopes. At the time of this writing, the most powerful microscope in the world, the *Scanning Transmission Electron Holography Microscope* (STEHM), gives the ability to see at 30 million times magnification.

The cost for a modern microscope sufficient for an educational setting begins at \$227 (according to [microscopesamerica.com](http://microscopesamerica.com) for the Accuscope 3080) and most classrooms or labs will require considerably more than one microscope. Creating this smartphone microscope serves several purposes: (1) provide a cost efficient educational tool, (2) enhance mechanical skills, and (3) create a spark of excitement and interest for science. We envision high school students building this microscope as a combined physics, biology, and shop project. It can be completed in approximately 1 – 1.5 hours by a skilled student.

## Materials:

- ¾ inch plywood
- (3) 4 ½ inch x ¼ inch carriage bolts
- (11) ¼ inch washers
- (9) ¼ inch nuts
- (2) ¼ inch wingnuts
- 1/8 inch plexiglass
- Laser pointer (Grreat Choice brand, not a typo)
- Flat bottomed flash light

## Tools:

- Drill
- ¼ inch and 5/16 inch drill bit
- ¾ inch spade drill bit
- Power saw
- Tape measure/ruler
- Level
- Pencil or pen and permanent marker
- 11mm wrench (size appropriate to nuts)
- Vice or glove
- Hack saw or small hand saw

**Procedure:**

1. A 7"x7" piece of plywood was cut to serve as the microscope base and plexiglass was cut to serve as the phone stage. The wood and plexiglass were drilled using 5/16" bit for all holes except the lens hole (designated in blue) which was drilled using  $\frac{1}{4}$ " bit, at measurements shown in Figures 1A and 1B, these holes should align except for the lens hole in the plexiglass. The lens hole is explained in Step 4.

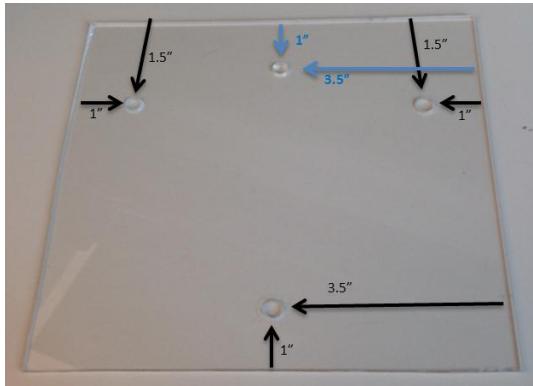


Figure 1A

Plexiglass and wood with measurements showing where holes should be drilled

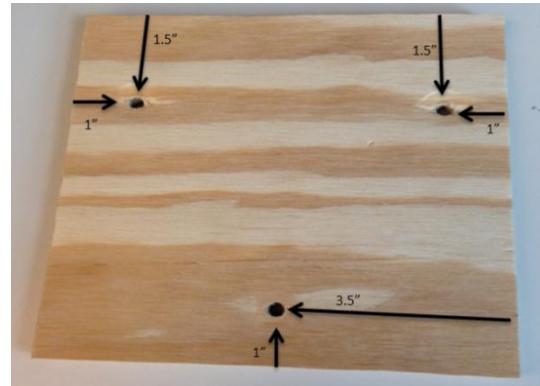


Figure 1B

Plexiglass and wood with measurements showing where holes should be drilled

2. A 7"x3" piece of plexiglass was cut to serve as a stage for the sample of interest. The 7"x3" piece of plexiglass was marked and drilled (1) 1.5" from the top and 1" from the left side, and (2) 1.5" from the top and 1" from the right side (Figure 2A).

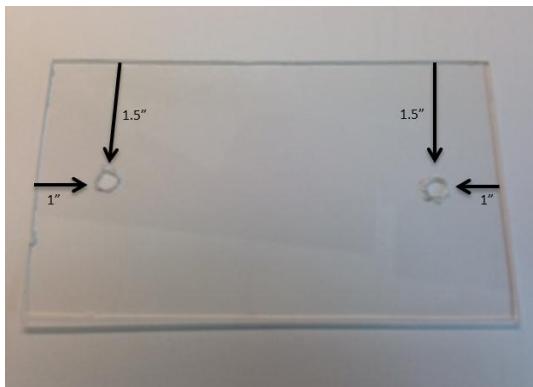


Figure 2A

Small piece of plexiglass with measurements showing where  $\frac{1}{4}$ " holes should be drilled

3. To obtain the focusing lens, a laser pointer must be disassembled. Various brands may be able to be taken apart differently. For the Grreat Choice brand laser pointer (Figure 3A), the external casing must be cut to remove the internal components. A vice is preferable to hold the pointer, but it can be held stable by hand using a glove for protection from the hand saw. Carefully hold the pointer secure on a stable surface, such as a

table, and slowly cut length wise until the blade cuts through the case. Remove the internal components of the pointer and obtain the focusing lens (Figure 3B) which will be at the front of the pointer.



Figure 3A  
Laser pointer packaging



Figure 3B  
Focusing lens

4. To ensure the lens would be held in place without the use of glue, the lens hole was drilled using  $\frac{1}{4}$ " drill bit.

The hole was slowly and carefully made larger by moving the drill bit in a circular motion in the hole, and then repeatedly fitment was checked until the lens would be tightly pressed in.

5. Using the spade bit, countersink holes were created in the bottom of the plywood so that the bolt heads did not stick out (Figures 5A and 5B). The carriage bolts were secured in the plywood with washers and nuts (Figure 5C on page 4).



Figure 5A  
Bottom of board showing depth of countersink hole

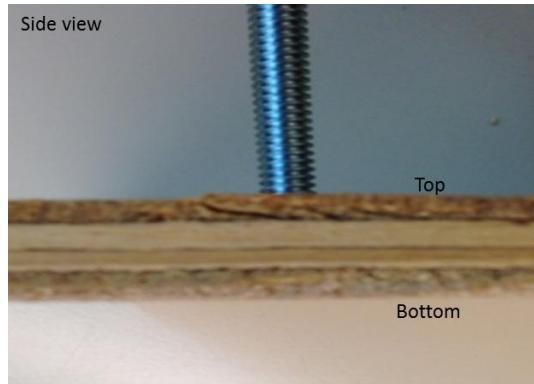


Figure 5B  
Side view showing that the bolt head does not protrude past the bottom of the board



Figure 5C  
Bolts secured onto board

6. Wing nuts were placed approximately half way down on the 2 forward most carriage bolts with the wings facing down and a washer on top for the 7"x3" plexiglass to rest on (Figure 6A). Next a nut and washer was placed on each carriage bolt and lowered approximately  $\frac{1}{2}$ " and the 7"x7" plexiglass was lowered onto the carriage bolts and secured with washers and nuts (Figure 6B).



Figure 6A  
Small plexiglass resting on washers and wingnuts



Figure 6B  
Large plexiglass resting on and secured by washers and nuts

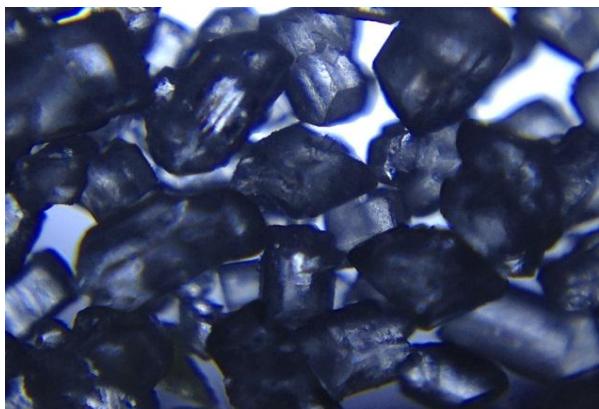
7. A flashlight was placed under lens as needed to backlight and wingnuts were used to adjust focus on the sample of interest.

For questions about this project, please feel free to contact Joseph Miles at [Jcwmiles@gmail.com](mailto:Jcwmiles@gmail.com).

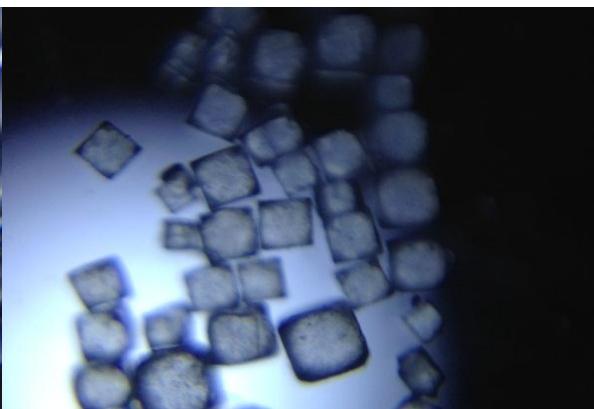
Images obtained with the smartphone microscope



Leaves



Sugar



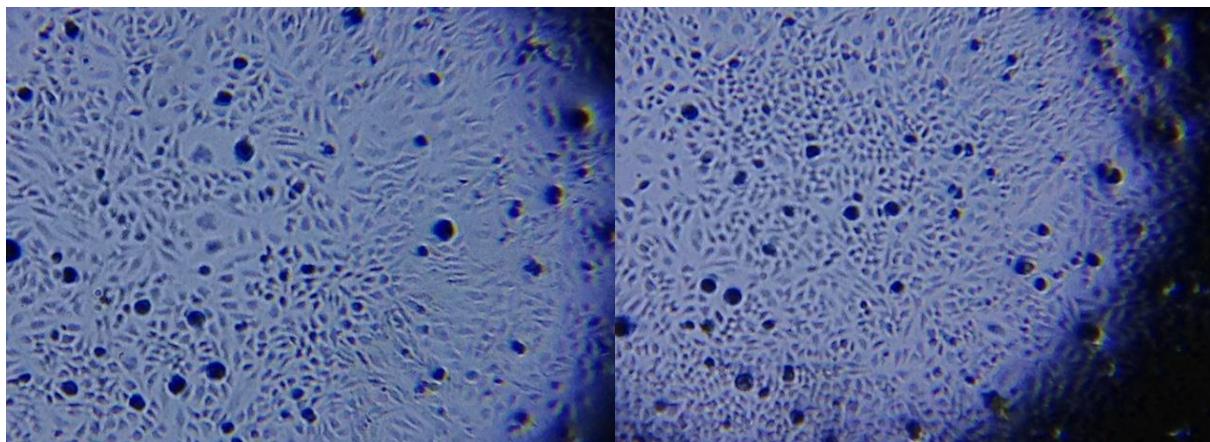
Salt



Paper towel



Lychee Skin



HeLa cells (derived from cervical cancer)

**References:**

\$10 Smartphone to digital microscope conversion!. (n.d.). *Instructables.com*. Retrieved July 25, 2014, from <http://www.instructables.com/id/10-Smartphone-to-digital-microscope-conversion/>

Grreat Choice® Laser Pet Toy. (n.d.). *Pet Supplies, Pet Accessories and Many Pet Products*. Retrieved July 25, 2014, from [http://www.petsmart.com/supplies-training/toys/grreat-choice-laser-pet-toy-zid36-11452/cat-36-catid-200099?var\\_id=36-11452&\\_t=pfm%3Dsearch](http://www.petsmart.com/supplies-training/toys/grreat-choice-laser-pet-toy-zid36-11452/cat-36-catid-200099?var_id=36-11452&_t=pfm%3Dsearch)