Applications of Light Microscopy Principles in Building a Smartphone Microscope

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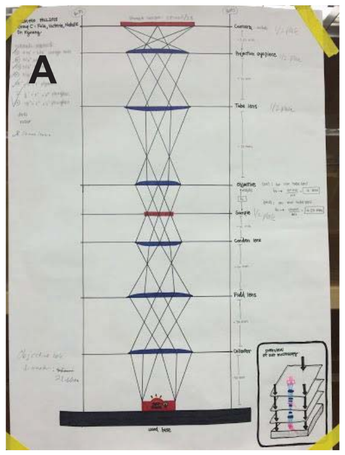
Introduction

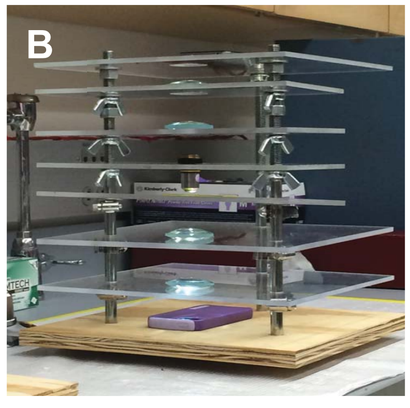
Compound light microscopy has been widely used in scientific and medical research to gain a better understanding of certain organisms, cells, or tissues. Because of this, there is interest in developing an affordable imaging solution.

Objective

Our goal was to build a simple but powerful compound light microscope with the ability to view/image items from everyday life with:

- adjustable & portable function
- interchangeable objectives
- maximum light collection





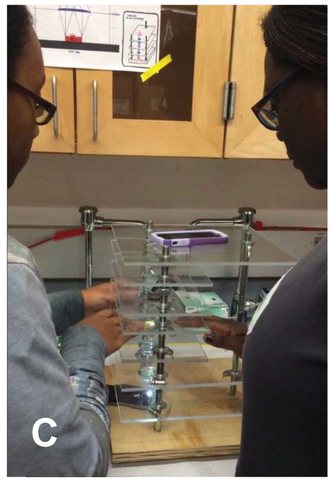


Figure 1
(A) The initial microscope design.
(B) Finished microscope.
(C) Adjusting microscope focus.

Materials Used

- Four 50mm focal length/diameter Ajax Scientific Lenses
- One iPhone 4 camera
- Three 13” long, ½” diameter partially threaded carriage bolts
- Three 11” X 11”X ¼” acrylic sheets
- Four 11” X 5 ½”X ¼” acrylic sheets
- Six ½” diameter wingnuts
- Eight 7/16” - 29/32” Diameter Adjustable Clamps
- One 12” X 12” X ¾” plywood plank
- Light Source: iPhone 5 flashlight

Results

We developed a portable and adjustable cellphone microscope with interchangeable objective lenses and a large diameter condenser lens (50 mm) to collect and transfer light efficiently for less than $200. Particularly, the mobile platform of the objective lens can be adjusted so that it can meet the optimal focal length for each lens and sample image.

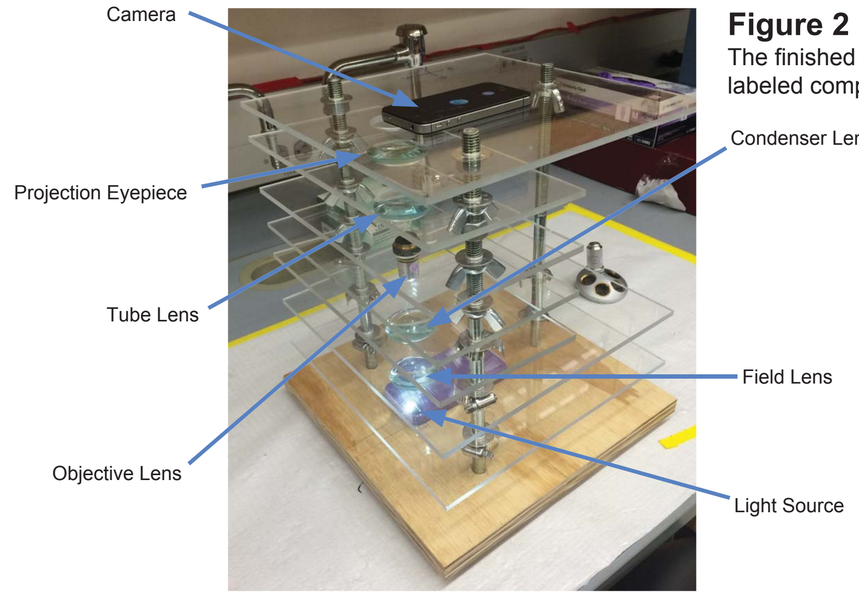
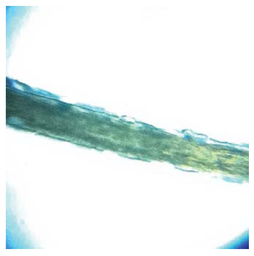
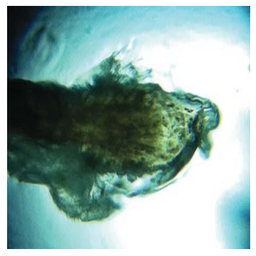
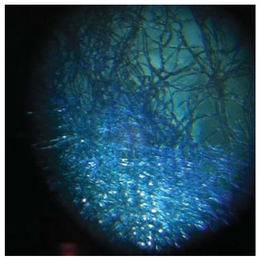


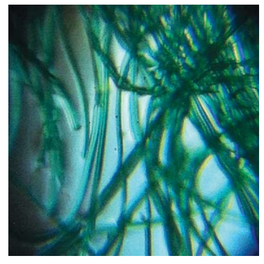
Figure 2
The finished microscope with labeled components

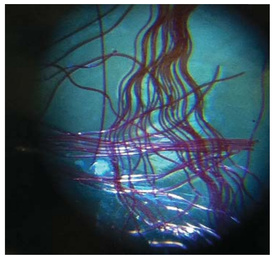
Figure 3
The images of samples viewed through the microscope.


40x hair shaft


40X hair root


10x cotton


40x silk


10x nylon

Magnification calculations for 10x objective lens
10x objective lens made for tube lens : 160 mm
Fo = F1/M = 160 mm / 10
Fo(10x) = 16 mm

M1 = F1/Fo — Fo = camera: 3.85 mm iPhone camera lens
M1 = 50 mm / 3.85 mm — F1 = Projection eyepiece distance: 50 mm
M1 = 13.0 x magnification

M2 = Ftube lens /Fo (10x) — F tube lens = tube lens distance: 50 mm
M2 = 50 mm / 16 mm — F2 = 10 x objective focal length: 16 mm
M2 = 3.13 x magnification

Total Magnification = M1M2 = (13.0x)(3.13x) = 40.7x magnification

Magnification calculations for 40x objective lens
40x objective lens made for tube lens: 170 mm
Fo = F1/M = 170 mm / 40
Fo(40x) = 4.25 mm

M1 = F1/Fo — Fo = camera: 3.85 mm iPhone camera lens
M1 = 50 mm / 3.85 mm — F1 = Projection eyepiece distance: 50 mm
M1 = 13.0 x magnification

M2 = Ftube lens /Fo (40x) — F tube lens = tube lens distance: 50 mm
M2 = 50 mm / 4.25 mm — F2 = 40 x objective focal length: 4.25 mm
M2 = 11.8 x magnification

Total Magnification = M1M2 = (13.0x)(11.8x) = 153x magnification

Conclusion

The combinations of objective lenses and several convex lenses enabled us to image various samples, such as cotton, silk, nylon, and human hair with 40.7x and 153x magnification through 10x and 40x objective lens respectively.

This project allowed us to explore the basic principles behind the compound light microscope, including Köhler illumination, through building our own stable and affordable microscope which achieves a magnification comparable to the other expensive professional microscopes. The project can be carried further with some mechanical and physical improvements.

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