What percent of Americans believe American students score at the bottom of the world list for science education & literacy?

A. 7%

B. 19%

C. 35%

D. 44%

E. 83%

44%!!!

Believe it or not, Pew Research Center states K-12 students in America rank in the *middle*, not the bottom of the world rank for science literacy & knowledge (Public's knowledge of science and technology, 2013)

Integrating Polymer Chemistry and Optics: Creating Cheap, Portable, High-Powered Do-It-Yourself Microscopes

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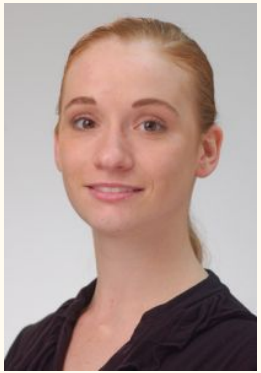
Mount Hebron High School
Dr. Minjoung Kyoung
UMBC Department of Chemistry & Biochemistry
3 May 2017

Intern/Mentor

- UMBC Department of Chemistry & Biochemistry
- Kyoung Research Lab Group
  - Dr. Minjoung Kyoung
  - Noah Robinson
  - Erin Kennedy

Credit: UMBC

Credit: UMBC



Credit: UMBC

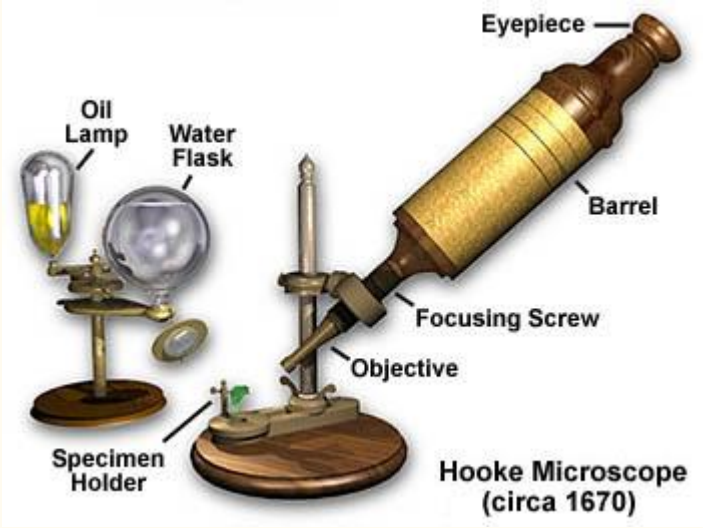
Goals of Project

- Introduction
  - Microscopy & optics
  - Polymer chemistry/polydimethylsiloxane (PDMS)
  - Frugal science
- Synthesizing PDMS hanging droplet lens for use in cheap, portable, high-powered microscopes

Why this Research? What for?

- First planned to participate in intern/mentor program two years ago
- Originally intended to investigate effect of chemistry on sound
- Interest in chemistry & interdisciplinary sciences
  - Chemistry AP
  - Chemistry GT/AP tutoring
  - Aspire to eventually become chemistry professor
- Met my mentor, Dr. Minjoung Kyoung
  - Introduced to microscopy & PDMS hanging droplet lens research
  - Dr. Kyoung shared her plan for me to make a cost-efficient, lightweight, high-powered microscope by the end of my internship

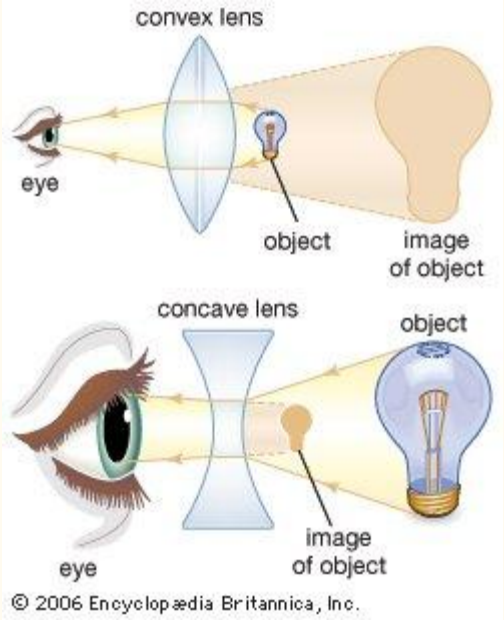
What is Microscopy?



Credit: micro.magnet.fsu.edu

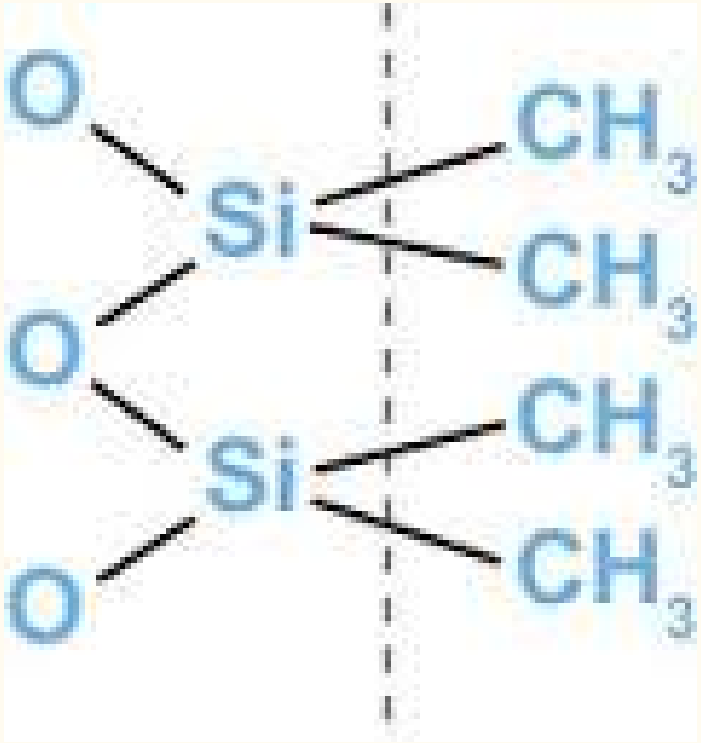
- Study & use of microscopes in scientific research and related fields
- 1267- First recorded use of lens for magnification purposes (Vandervoort, 2014)
- 1595- Zacharias & Hans Jansen created first 2-lens light compound (LM) microscope (Vandervoort, 2014)
- Robert Hooke added eye-piece to Jansen's microscope & credited as inventor of LM microscope (Vandervoort, 2014)

What is Optics?



- Study of light & behavior of light (Halliday, 2005)
- Concave lens diverge light while convex lens converge light
- All lenses in a microscope exhibit optical properties
  - Refractive Index: Intensive property of material of lens; determines angle at which light is bent when refracted, through a lens
  - Magnification: depends on material & amount of curvature of concave lens has; additive with many lens
  - Resolution: amount of clarity limiting the magnification of lenses

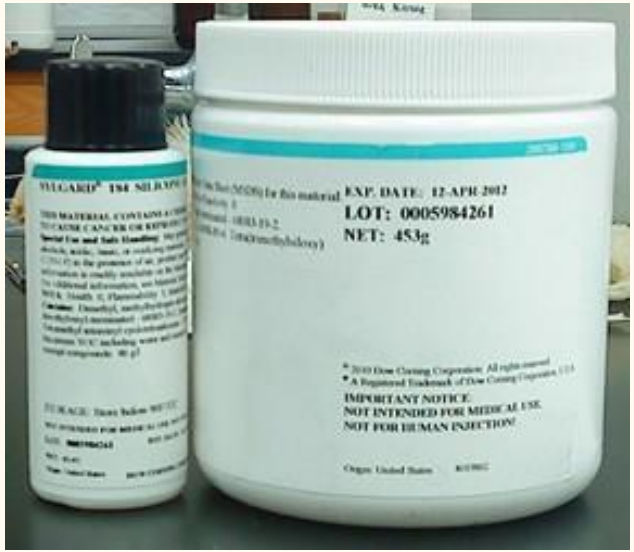
What is PDMS?



Credit: Dow Corning

- PDMS (polydimethylsiloxane)
- Cheap, commonly-used clear, flexible polymer used in microfluidics and packaging (European Centre for Ecotoxicology and Toxicology of Chemicals).
- Relatively nontoxic, making it safe both biologically and ecologically (European Centre for Ecotoxicology and Toxicology of Chemicals, 2011; Kuo, 1999).
- Commonly found in industrial applications, sometimes in food, drugs, moisturizers, contact lenses

Curing Process of PDMS



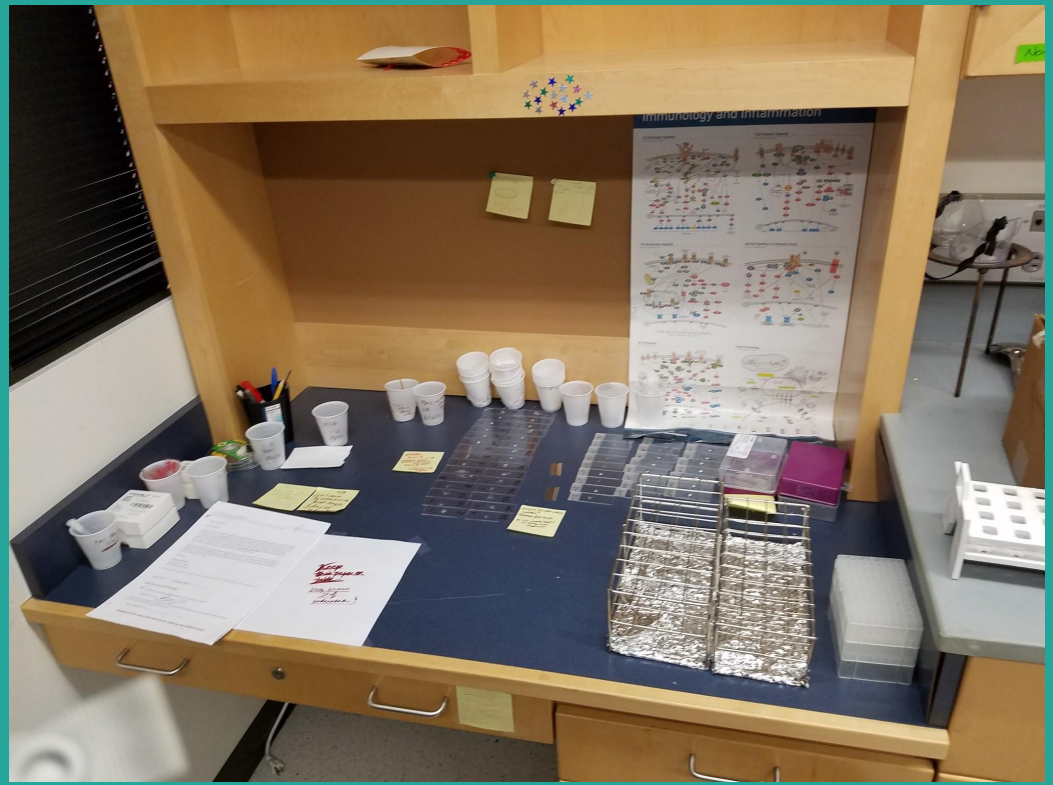
Credit: Draiput.com

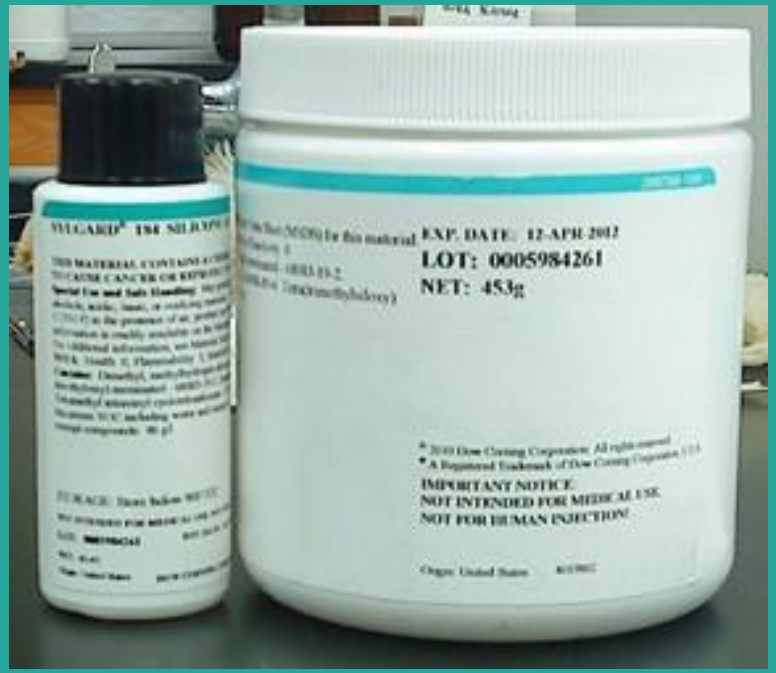
- Materials:
  - Dow Corning Sylgard 184 Curing Agent & Silicone Elastomer Base
  - 20-200 µL micropipette
  - 20-200 µL micropipette tips
  - Digital Mass Scale
  - Vacuum Desiccator
  - Plastic Cup
  - Microscope Slides
  - Razor
- Safety Equipment:
  - Oven Mitts
  - Disposable Gloves
  - Fume Hood

Curing Process of PDMS

- Protocol:
  - Set Oven to Desired Temperature (>100 Degrees Celsius)
  - Weigh Out 1:10 Mass Ratio (CA:B)
  - Stir for 1 Minute with Pipette Tip
  - Place in Desiccator and Degas Until All Air Bubble Released
  - Cut Off Small Parts of Pipette Tips with Razor
  - Pipette Desired Amount On Glass Microscope Slide
  - Hang Slides Upside Down Off Metal Rack
  - Place Rack in Oven Until Hanging-Droplet Lenses are Fully Cured
  - Remove & Cool Samples on Rack

Typical Day in Lab

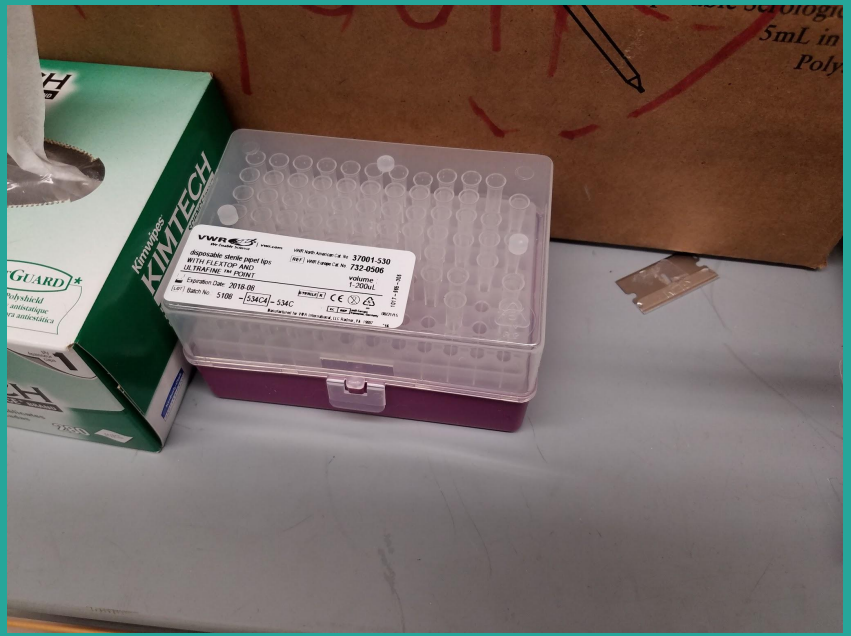


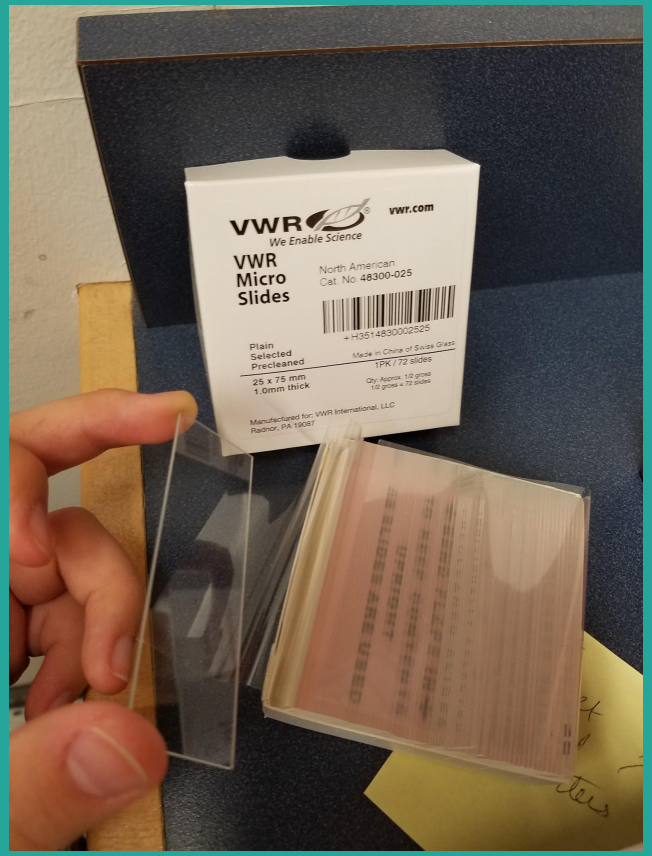

EXP. DATE: 12-APR-2012
LOT: 0005984261
NET: 453g
IMPORTANT NOTICE
NOT INTENDED FOR MEDICAL USE
NOT FOR HUMAN INJECTION!

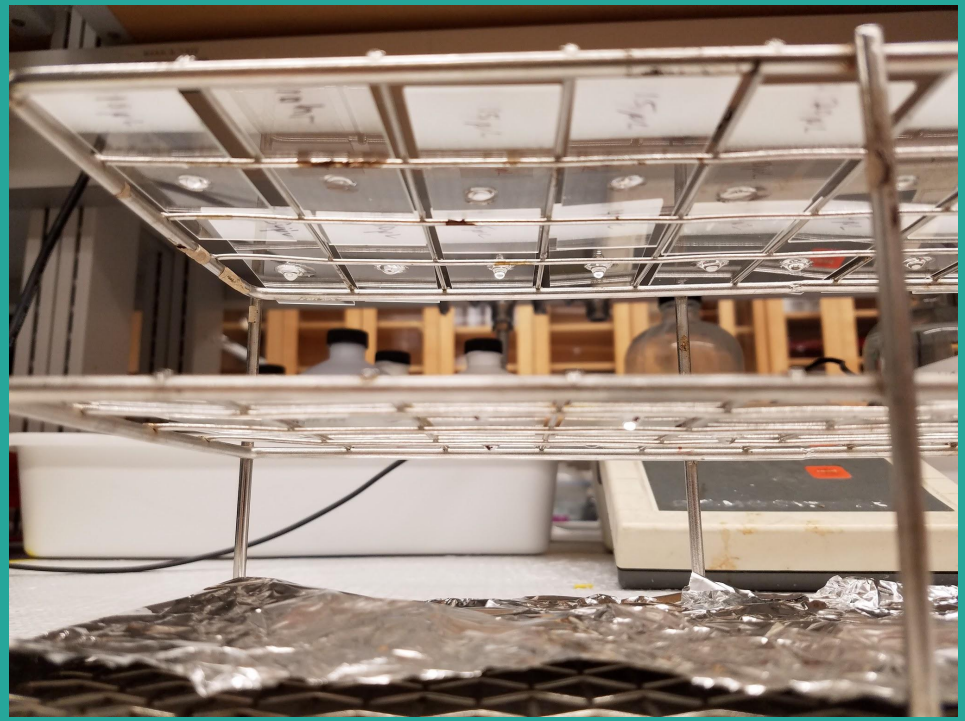

Voyager
OHAUS


GAS
VAC
18" OPERATING SASH HEIGHT
UMBC WASTE ACCUMULATION CONTAINER
BUILDING Meyr ROOM # 444
CONTACT Kyoung EXT
CHEMICAL NAME PERCENT
1X PBS Buffer % 2
DI / Pure Water % 96
DATE HANDLE WITH CARE
2 kg
BP9726-2
Tryptone
Granulated
Yeast Extract
HEPES, FREE ACID


Fisherbrand Elite


KIMTECH
Kimwipes
VWR
disposable sterile pipet tips
WITH FLEXTOP AND
ULTRAFINE™ POINT
37001-530
732-0506
volume
1-200uL
Expiration Date 2016-08
Batch No. 5108 -53MCA- 53MC

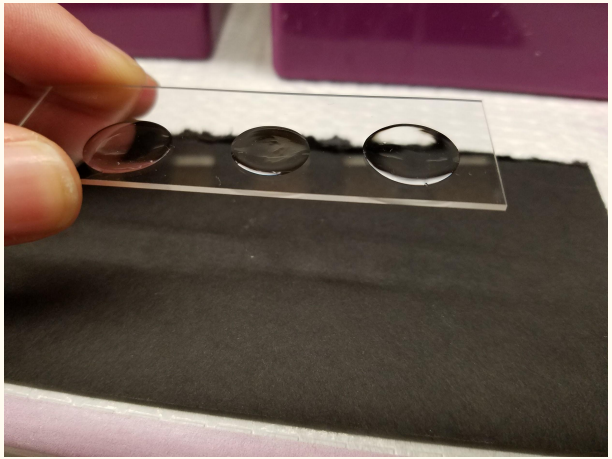

VWR
We Enable Science
vwr.com
VWR
Micro
Slides
North American
Cat. No. 48300-025
+H3514830002525
Plain
Selected
Precleaned
Made in China of Swiss Glass
1PK/72 slides
25 x 75 mm
1.0mm thick
Qty. Approx. 1/2 gross
1/2 gross = 72 slides
Manufactured for: VWR International, LLC
Radnor, PA 19087



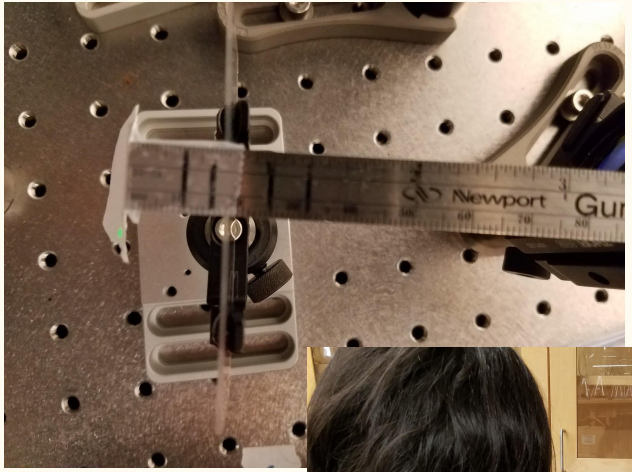

BLUE M

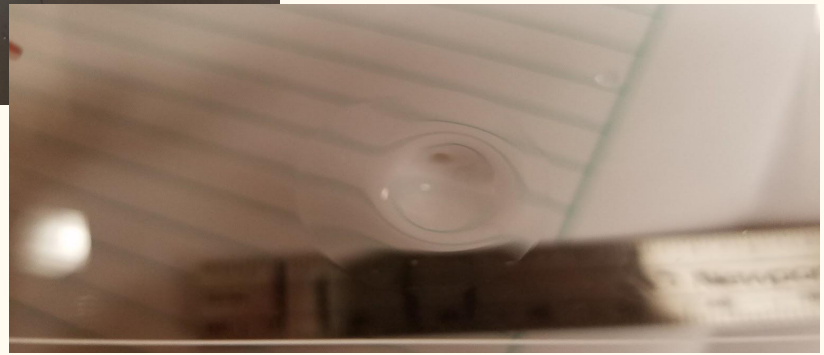

Single-Wall TRANSITE OVEN

Original Research



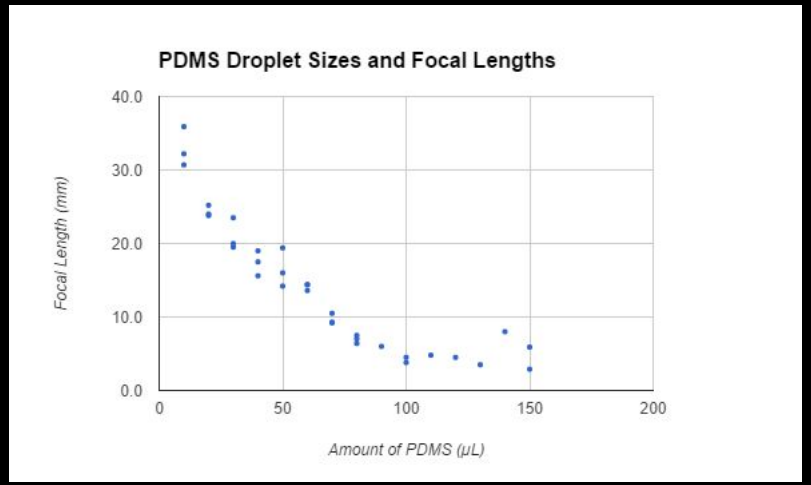
Analysis

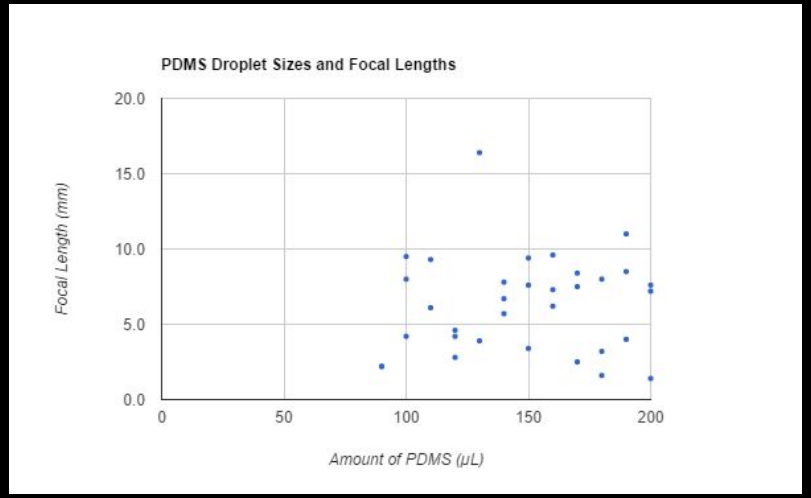




Data Analysis

(10 μL to 150 μL on top right)
(90 μL to 200 μL on bottom right)

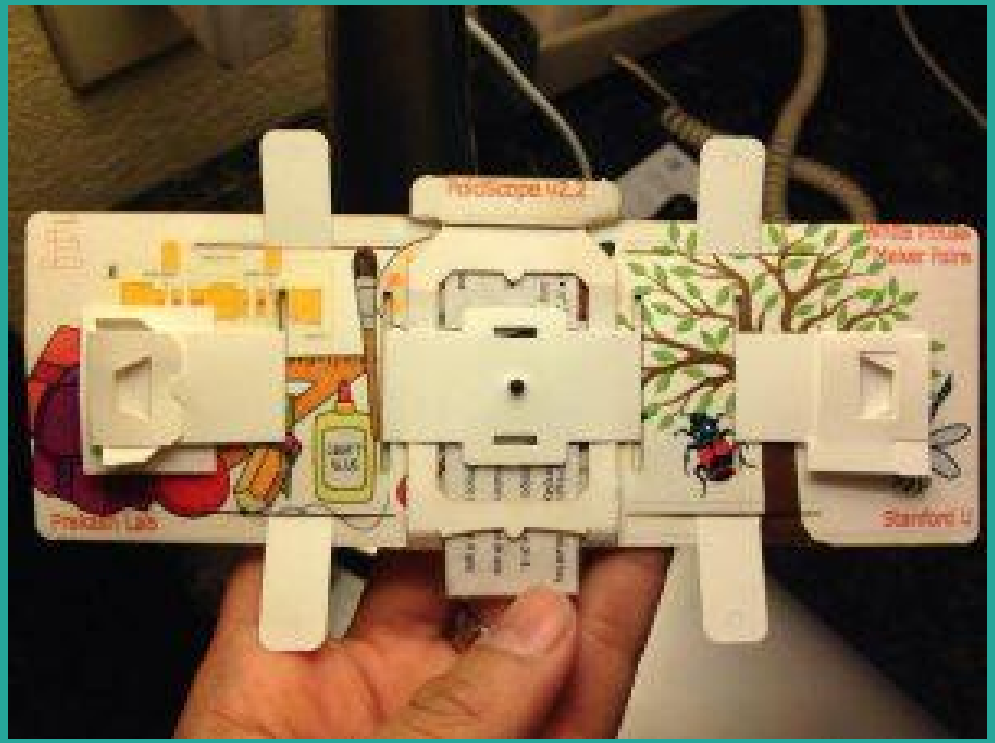




Research

- Originally followed PDMS curing protocol
- Experimented with variations of PDMS curing
  - Varying surface from which PDMS droplets cured (ie aluminum foil, parafilm, pipette tips, glass slides)
  - Varying curing agent: base ratios on absorbance values
  - Varying mixing times
  - Varying droplet amounts on focal length & magnification
  - Varying curing temperature & times
- Microscope design

Foldscope



Credit: Stanford University

What is Frugal Science?

Credit: PATH Blog

- Termed by biological engineering Professor Manu Prakash of Stanford University (Cybulski, 2014)
- Idea of making high-powered scientific tools cheaper and accessible to all (Cybulski, 2014)

Final Product

- To create cheap, portable, high-powered microscopes
- Oral presentation/guide directed to regular-level science high school science classes (Or Elementary/Middle-school level classes)
- To aspire to captivate interest in science for audiences less scientifically inclined, advanced, or affluent

Conclusion

- Frugal science
  - High-powered, cheap, portable microscopes accessible by all
  - Make microscopes more efficient and easy-to-use
- Advance scientific knowledge and interest, especially in less affluent and scientifically inclined areas
  - Do-it-yourself, cheap, easy-to-follow microscope kit & guide
  - Conceptual understanding of science behind working of microscope & curing polymer lenses

Questions?