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Cheaper, Simpler "Make-It-Yourself" Microscope: Creating Lens from Polymer and the *Foldscope*

Research Question:

Can microscopes used in scientific learning be improved by the addition of an easy-to-make step-by-step procedure of curing the polymer, polydimethylsiloxane (PDMS), as well as have better optical focus and resolution while still being low-cost and portable?

Hypothesis:

Commonly used light-microscopes can be innovated by the addition of a simple, descriptive guide to curing PDMS lenses targeted for the general audience. Also, experimenting and identifying the optimal conditions and factors will create more efficient PDMS-based lenses with low cost, light weight, portability, assembly simplicity, and better optical focus and resolution.

Background:

Microscopes have been often used in a diverse array of places. They are found in schools, hospitals, scientific research centers, homes, and various other locations for a multitude of purposes. Microscopes also come in different types, such as light microscopes, electron microscopes, scanning tunnel microscopes, and atomic force microscopes just to name a few. For forms of microscopes other than the light microscope, preparations for the sample to be mounted on a slide often lead to the death of a cell or cells. Also, these microscopes tend to be more specific, with higher magnification power and better resolution, as well as more expensive. Thus, light microscopes are used in this experiment. Also, in light microscopes, a form of optical lens is required to magnify the a clear image of the sample to the human eye. In this project, PDMS (polydimethylsiloxane)-based lens will be cured in various base:curing agent ratios into droplet-like shapes at various environmental setups in order to find the most optimal conditions required for the best optical performance of PDMS. The optical performance will then be measured via the focal length, the distance between the PDMS lens and the focal point of the image of the sample, or where the image appears to be located, and where light rays passed through the lens converge to create a point. A greater focal length indicates more magnification power and a smaller field of view. The other way to measure optical performance is by the resolution of the microscope, or its ability to distinguish points of the sample that are found close to each other, or in another definition, clarity. Throughout the years, there have been innovations to the microscope, making them high-powered yet simple and cheap, and most importantly, widely accessible to a larger audience of people. Through this research project and experiment I am trying to create the best PDMS-lens which can be implemented in a cheap, widely accessible microscope such as the *Foldscope*, a portable, small paper-origami microscope invented by Professor Manu Prakash of Stanford University in attempts to simply make an easily-assembled high-powered microscope at the cost of a few cents to a few dollars for the use by people who then would have not had access to commonly-used microscopes.

Rationale:

Improving the efficiency of light microscopes via more innovative lens is important and vital to the community since learning about the microscopic world is just as vital as expanding human knowledge on the macroscopic world and extremely large universe surrounding us. Without microscopes, bacteria and viruses—causes for diseases and ailments to humans—would have never been discovered, so specific cures and treatments would, likewise, been unknown to man, and medicine today would not be as advanced as it currently is. Also, humans would know nothing of small atoms, small cells, and small molecules, so the various scientific fields would remain archaic and undeveloped, and perhaps chemistry and biochemistry would cease to exist. Thus, the invention of the microscope and its various innovations are crucial to the world, impacting not only medical and scientific fields but also in education, criminology, and various other areas of study. I also believe evolution of the microscope resembles that of a computer. The computer has evolved into so many other essential tools we have today, such as the laptop, calculator, smart-phone, smart television, other smart devices, robots, and so many other machines. There are also additions to the computer itself, such as the world-wide internet, social networking, digital media and files, apps, games, and so forth. The innovation rate is astounding, and for instance, laptops are becoming more portable and lightweight with lower cost, faster processing speed, larger data storage, and most importantly, more accessible to all people. Likewise, I would like to create a better microscope by creating a more efficient PDMS-based lens. Also, I want to ensure that the microscope lens can be easily accessible by all people—all ages, all education levels, all scientific interests, all economic classes—from local communities to throughout the world. Another feature I wish to add helps to expand knowledge on the functioning of a microscope and makes scientific learning more enjoyable and personalized—by creating an easy-to-make guide on the process of curing a simple, efficient PDMS-based ball-lens from raw materials.

<u>Basis of Hypothesis:</u>

I specifically focused my hypothesis to improve the various parameters of the PDMS-based ball lens while still keeping simplicity to integrate my interest in chemistry research and my ideas for innovation with the need to make scientific tools, like the microscope and its lens, more accessible, understandable, and enjoyable, by compiling an easy-to-make step-by-step manual on creating PDMS lens that an average person could follow. Also, from my prior experiences, knowledge, and research, I believe that this innovation of a cheaper, fully functional, higher-resolution, more portable microscope lens is possible. Like I said in my rationale, computers are a great example of how a crude invention could end up being so refined, accessible, and highly efficient today. Also, Professor Manu Prakash of Stanford University has invented the *Foldscope*, a pocket-sized, cheap, highly functional and durable paper-origami microscope. Dr. Prakash has also termed his motivation “frugal science,” which seeks to distribute powerful yet inexpensive scientific tools to the world—specifically to underdeveloped areas like third-world nations. Likewise, innovating microscope lens which could easily be accessible and creatable by average students is very realistically plausible.

Operational Definitions:

- Easy-to-make step-by-step procedure: In terms of authoring as simple how-to-assemble-microscope lens guides, as stated in my research question and hypothesis, I am referring to creating videos or print manuals which explain the process of creating PDMS-based lens through a curing process, with all environmental factors and controls explained—such as temperature, humidity, curing agent:base ratios, materials used, and so forth—that a general science student in a middle or high school could comprehend and follow easily.
- Low cost: I would define low-cost as less than $2.00, and perhaps as low as to a couple of cents required to create operational, efficient spherical ball-lenses from curing PDMS. I would like the cost to be a couple of cents, so that added to a cheap efficient light-microscope—like the *Foldscope*—the cost would still remain low, yet remain fully functional and high-tech.
- Portability: I would define portability in terms of a lens with small mass, ideally to fit a small, portable microscope—like the *Foldscope*. Specifically, I would aim for a low mass of a few grams.

- Optical focus and resolution: I would calculate the optical focus and resolution from physics equations using various measurements from the lens, when attached to a microscope, and given constants and numbers. By using better equipment and measurement devices, I will try to be as precise as possible in measurement of various dimensions, as the entire microscope system would be small, and precision would be harder to obtain as well as more significant to a smaller system. Also, I would try to use the best numerical equations to model/approximate the optical focus and resolution—equations that are not too simple that the approximated value would greatly deviate from the "actual" value, and equations not too complicated that the chance of making a calculation error is significant.

<u>Descriptors Used for Literature Search:</u>

- (Light) Microscopy
- Optics
- Frugal Science/Making Science and Scientific Tools and Equipment More Accessible by a Larger Target Consumer Audience
- PDMS and its Physical and Chemical Properties
- Polymer Lens/PDMS Lens
- Curing Polydimethylsiloxane (PDMS)
- *Foldscope*
- Hanging Droplet Lens
- Cheap, Portable, Lightweight, Clear, High-Powered Microscopes