

Detecting anthrax in the palm of your hand: applications of a smartphone microscope

Bacillus anthracis is a bacterial pathogen that causes the disease anthrax. In 2001, *B. anthracis* was used in a bioterrorism attack in the United States that resulted in 22 individuals becoming infected, 5 of whom died as a result of this attack. A great deal of attention has been dedicated to responding to bioterrorism events to reduce the potential loss of lives. One such area of research has focused on the development of new technologies to detect and respond to the intentional release of bacterial pathogens such as *B. anthracis*.



Fig. 1. 3D Smartphone microscope for iPhone 5 or 5s.

Advances in smartphone cameras and computational power have resulted in the use and deployment of mobile imaging and detection platforms for targeting bacterial pathogens that can cause disease. Compact and mobile, these designs promise field-ready technologies that will advance responses to biothreat events, patient point-of-care diagnostics, and animal disease screening. Recently, we have reported the development and use of a 3D printed smartphone microscope in combination with a small bacterial growth chamber for the detection of *Bacillus anthracis* spores in three to five hours, a 50% reduction in detection time compared to current methods. The smartphone microscope design is unique because it uses a 3D printed housing that holds an inexpensive glass bead against the smartphone camera. Other portable microscopes use a glass lens that can cost up to \$15, but the microscope cost is reduced to less than \$1 by using a glass bead. Different size glass beads allow the magnification to be changed. A 3 mm glass bead will magnify objects 100 \times whereas a 1 mm glass bead magnifies 350 \times , allowing one to visualization of objects 1/50th the diameter of a human hair.

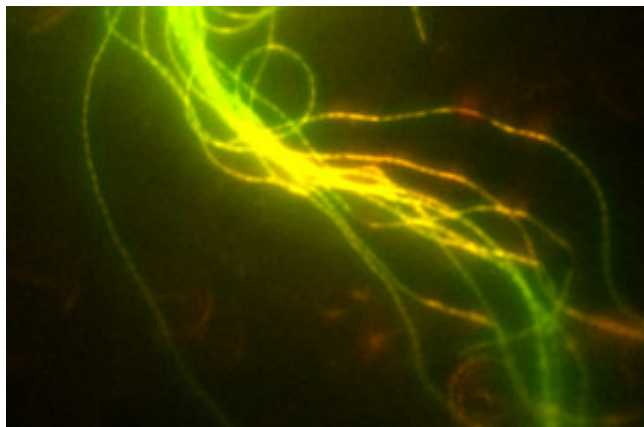


Fig. 2. Image of live and dead anthrax cells taken with a fluorescent smartphone microscope.

While the ability to view anthrax cells using a smartphone microscope is a great first step, ideally more information about the bacteria could be acquired from the images. For example, if anthrax cells were detected, determining whether the cells were alive or dead would be very important. If the anthrax is dead, it poses no threat to public health. To gain more information from smartphone microscopy images, we have modified the current smartphone microscope for fluorescence detection. Fluorescence occurs when an object is hit with a specific type of light, but reflects a different wavelength back. The fluorescent smartphone microscope design uses the same lens holder and glass bead as described above with one modification: a thin piece of colored plastic is placed over the smartphone camera flash to allow the type of light illuminating the sample to be controlled. Treating the anthrax with a simple chemical mixture will result in live cells appearing green and dead cells appearing red in the light. A picture can then be taken using the fluorescent smartphone microscope that helps scientist determine if the anthrax cells are alive and capable of causing illness and potentially death.

The entire microscope system, including the specific color filters for the flash, contains supplies costing less than \$1, making this device extremely affordable to deploy. Furthermore, the ability to generate fluorescence with the smartphone opens up possibilities in other biological detection areas. The advancement of low-cost fluorescent detection opens up enormous opportunities for field chemical and biological detection.

For more information about the microscope, please visit: <http://1.usa.gov/1VO4mtx>

Rebecca L. Erikson¹ and Janine R. Hutchison²

¹*Electronics and Measurement Systems,*

²*Chemical Biological Signatures Science,*

National Security Directorate, Pacific Northwest National Laboratory,

Richland, Washington

Publication

[Reagent-free and portable detection of *Bacillus anthracis* spores using a microfluidic incubator and smartphone microscope.](#)

Hutchison JR, Erikson RL, Sheen AM, Ozanich RM, Kelly RT

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