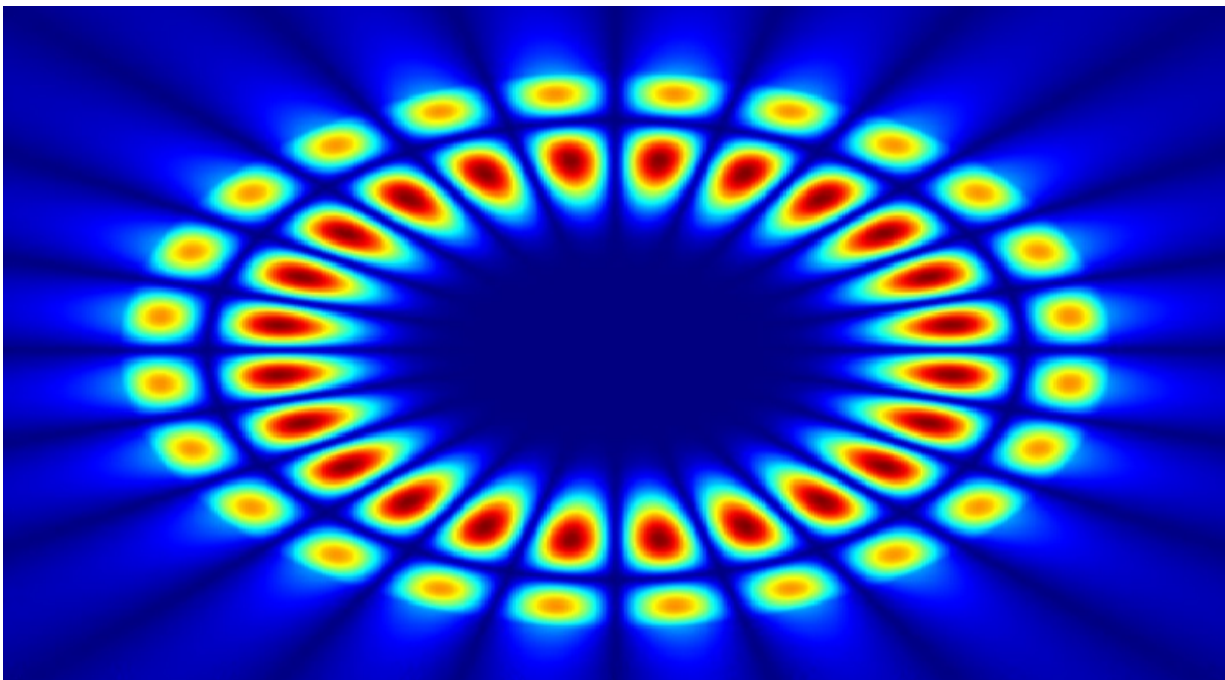


# Future biosensors could be woven into clothes

June 23 2015, by Sarah Bates

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Researchers funded by the National Science Foundation are creating a new biosensor that uses laser light, engineered viruses and advanced manufacturing techniques to more accurately detect the smallest amounts possible of biological molecules--in our food, in our water and even in our own blood. Shown here is a cross-sectional view of a circular optical cavity or resonator showing whispering gallery modes total internally reflected along the surface of a fiber. Credit: Joe Cheeney, University of California-Riverside

Commonly used health tests, such as pregnancy and blood sugar tests, involve putting a drop of fluid on a test strip, which is infused with a

substance designed to detect a specific molecule.

The strip acts as a simple biosensor, a device that detects chemicals with the help of [biological molecules](#) such as proteins or enzymes.

These devices work, but are limited in scope and can be imprecise. As anyone who has experienced a false sense of security knows.

Other health tests require time-consuming chemical reactions or bacterial culture.

Researchers funded by the National Science Foundation (NSF) are creating a new biosensor that uses laser light, engineered viruses and advanced manufacturing techniques to more accurately detect the smallest amounts possible of biological molecules—in our food, in our water and even in our own blood.

Detecting trace amounts of contaminants or medical biomarkers sooner could help safeguard against harm.

Thanks to these technologies, biosensors of the future may no longer be in cardboard boxes, but in fibers woven into clothes.

## **Whispering galleries of light**

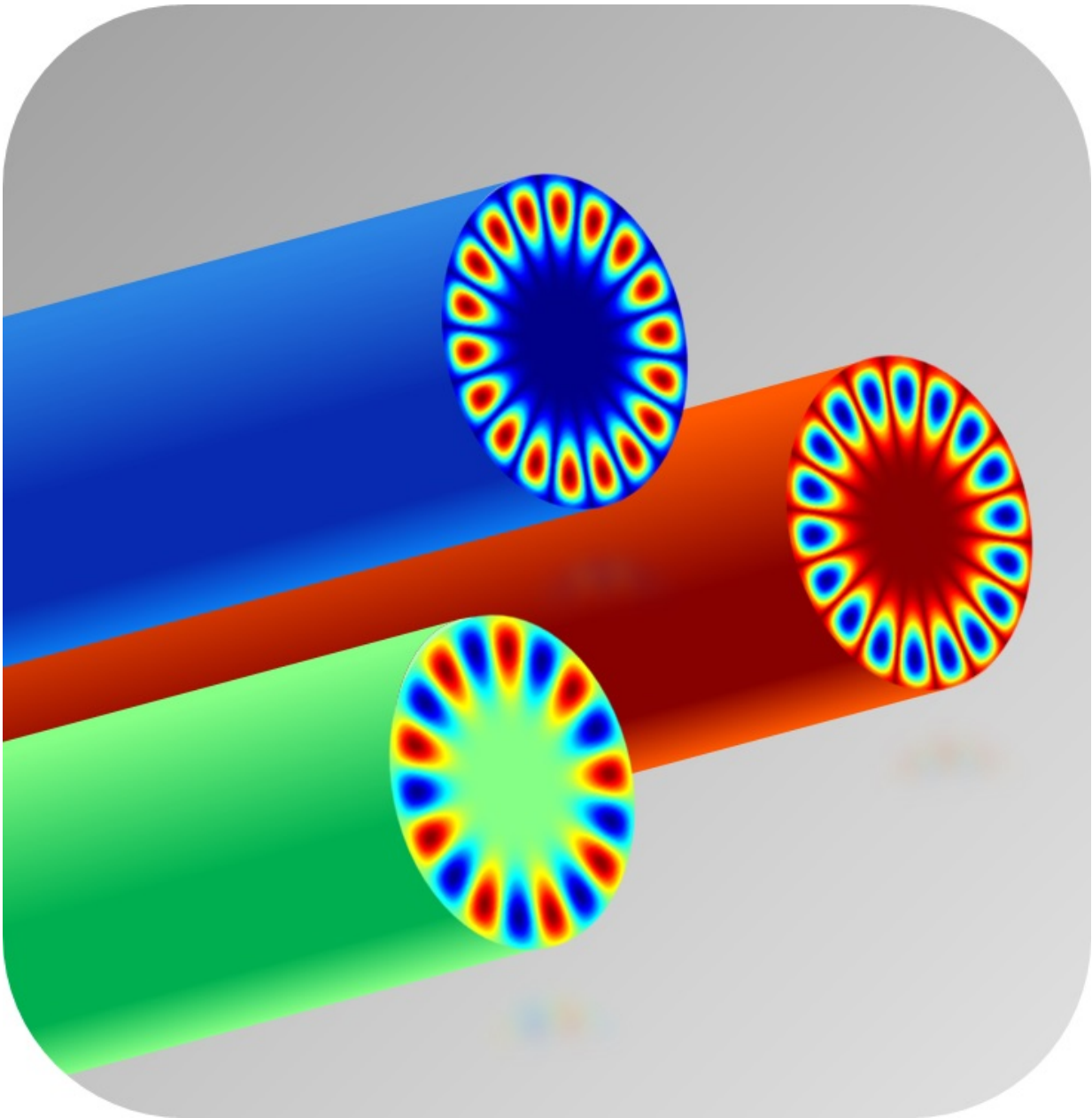
The basic mechanism behind these sensors is based on an old phenomenon.

Engineers Elaine Haberer and Nosang Myung at the University of California, Riverside, use [laser light](#) to amplify the detection of single particles, a technique known as whispering gallery mode resonators.

Whispering galleries that involve sound have been around for a while.

Famous examples include Grand Central Terminal and St. Paul's Cathedral in London, where the domed geometry of the rooms amplifies the faintest whisper to listeners well outside of earshot.

Whispering galleries of light work much the same way, with waves of photons traveling within a circular space, or cavity. Any particles within these cavities encounter the waves thousands to millions of times, changing the light in subtle ways that researchers can detect.



One technique, known as electrospinning, creates long, hair-like fibers made of plastic, metal or ceramics. This fiber-making process is like making cotton candy, says Engineer Nosang Myung at the University of California, Riverside, who has worked with nano-sized, bio-manufactured structures for more than a decade. "You have a drop of liquid. Spin it. Out comes a long fiber. It's just like a cotton candy machine, except you apply electrical fields to spin it up," he says. The light or electromagnetic field profile of whispering gallery modes are shown propagating along the periphery of three fiber resonators. Credit: Joe Cheeney,

The modern-day twist is in the shape and makeup of the cavity.

For the Riverside team, the cavity is actually a long, thin fiber that has specially engineered viruses embedded in it. The laser is directed perpendicular to the length of the fiber, activating the sensor.

"So long as the cavity is circular and smooth, you can achieve a whispering gallery—you can even create one in a water droplet," Haberer says. "The challenge is to create smooth, durable cavities simply, so they can be used for different purposes."

## **Electrified cotton candy**

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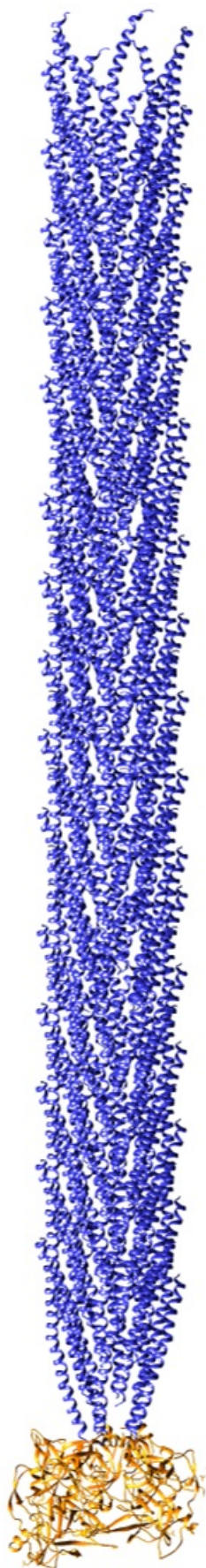
This fiber-making process is like making cotton candy, says Myung, who has worked with nano-sized, bio-manufactured structures for more than a decade.

"You have a drop of liquid. Spin it. Out comes a long fiber. It's just like a cotton candy machine, except you apply electrical fields to spin it up," he says.

This process sounds straightforward, but it's the result of recent advances in manufacturing that allow these fibers to be made quickly and cheaply.

The challenge is to make them perfectly smooth and to insert the viruses that interact with the biological molecules the engineers want to detect.

Myung and his graduate students can integrate different types of viruses during the spinning that will enable the sensors to detect different kinds of molecules. For example, one fiber might detect glucose while another senses cholesterol.



Using viruses is another new approach for biosensor technology. Not only are few--if any--biosensors created by electrospinning, most use enzymes. But enzymes are fragile and don't last long at room temperature, according to Engineers Elaine Haberer at the University of California, Riverside. Viruses have more staying power. Shown here is a schematic of the filamentous M13 bacteriophage or virus, which is used to organize the biorecognition elements of the biosensor. Credit: Steven Garcia, University of California-Riverside

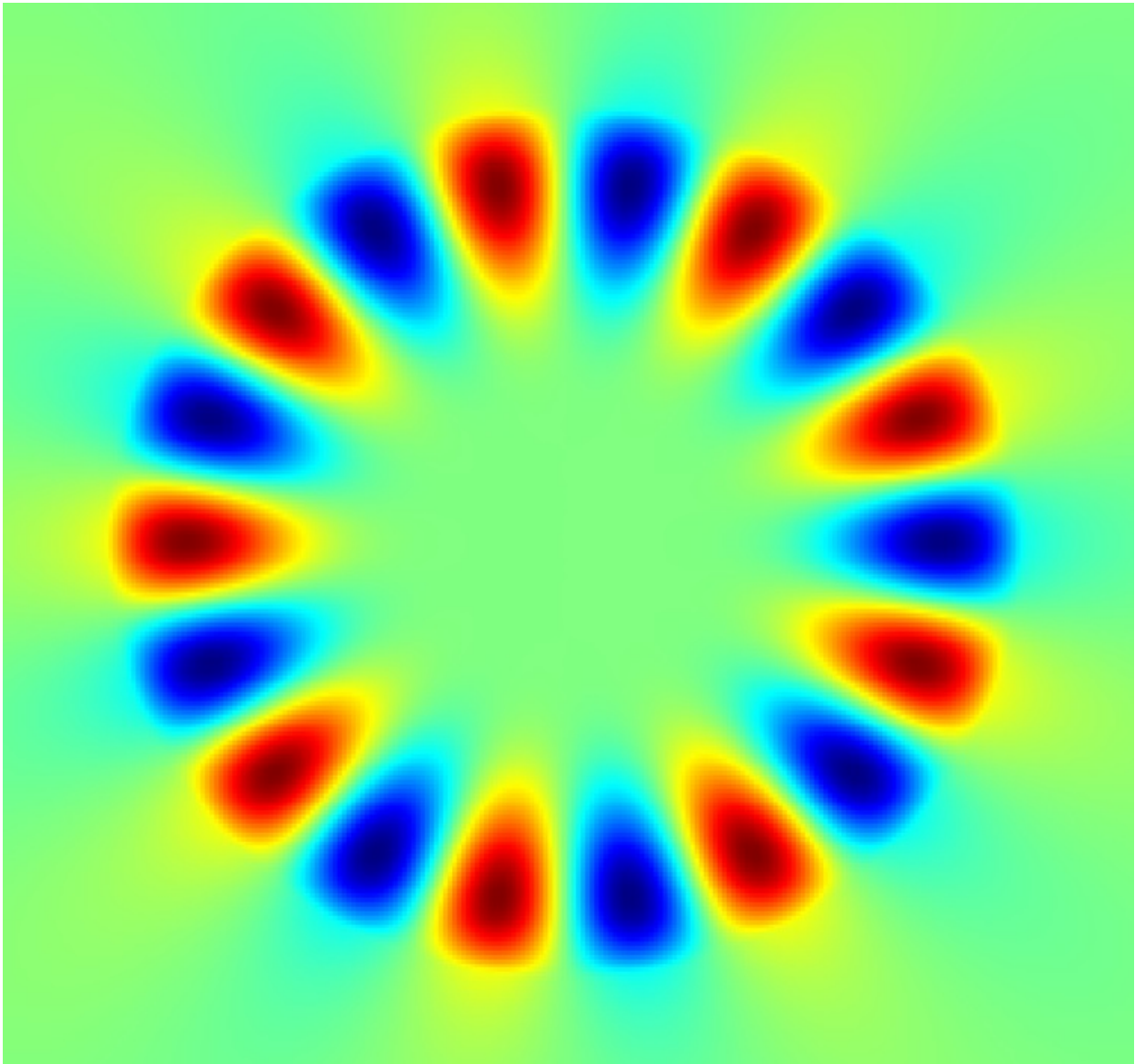
"It's like making cotton candy that's a different color," Myung says.

Using viruses is another new approach for biosensor technology. Not only are few—if any—biosensors created by electrospinning, most use enzymes. But enzymes are fragile and don't last long at room temperature, according to Haberer. Viruses have more staying power.

"Viruses are just protein surrounding genetic materials, so they are more stable than enzymes or antibodies, and we can pack more bio-sensing molecules on them," Haberer says.

Preliminary tests show the [viruses](#) hold up pretty well to the electrospinning process, but there is some loss. The researchers continue to refine the process.





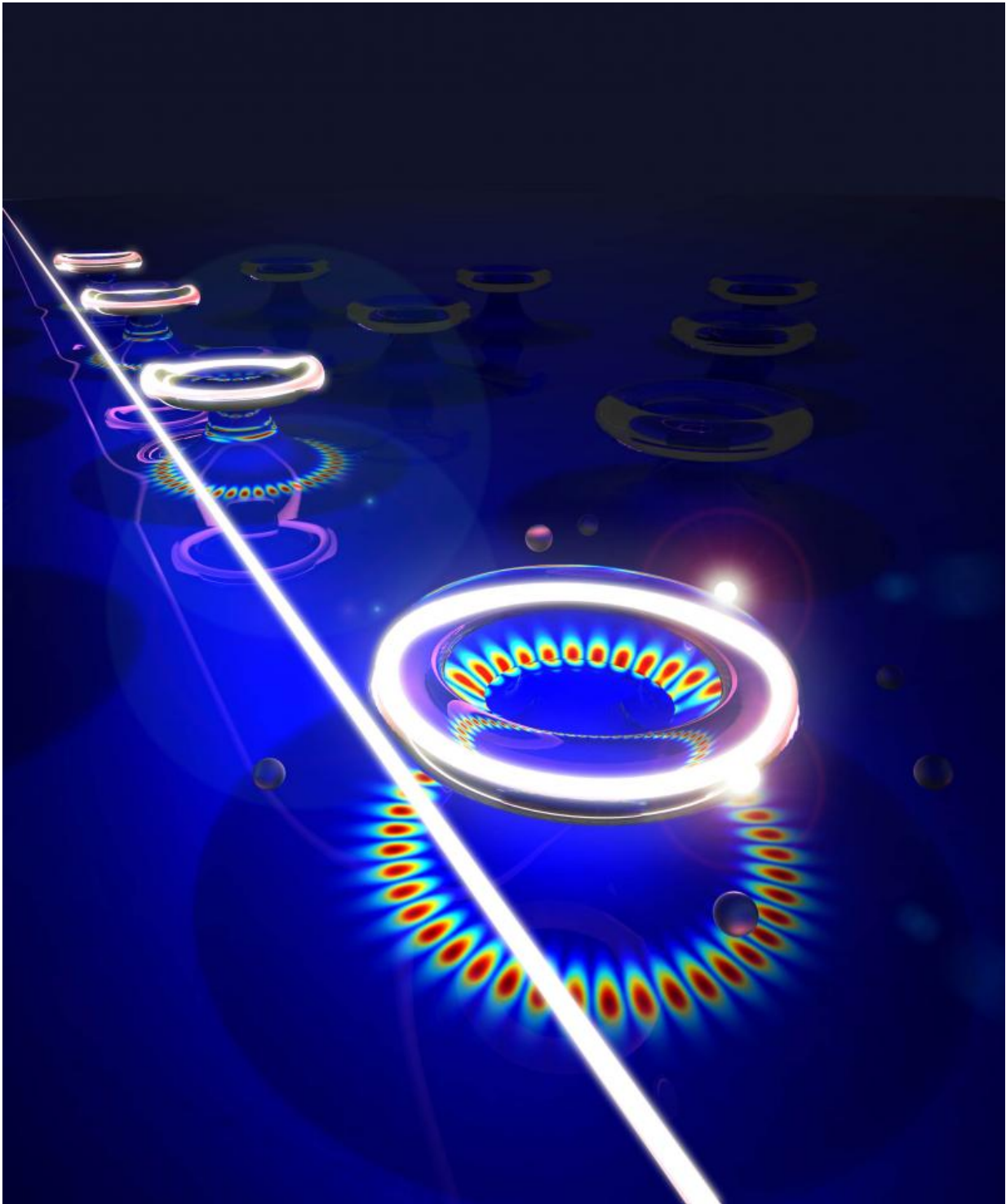
Engineers Elaine Haberer and Nosang Myung at the University of California, Riverside, use laser light to amplify the detection of single particles, a technique known as whispering gallery mode resonators. Whispering galleries that involve sound have been around for a while. Famous examples include Grand Central Terminal and St. Paul's Cathedral in London, where the domed geometry of the rooms amplifies the faintest whisper to listeners well outside of earshot. The modern-day twist is in the shape and makeup of the cavity--which amplify light instead of sound. Shown here is a cross-sectional view of a circular optical cavity or resonator showing whispering gallery modes total internally reflected along the surface. Credit: Joe Cheeney, University of California-Riverside

## **(Laser) cavity dwellers**

The eventual goal is to densely bundle these fibers together to sense many molecules at once, and to do so more quickly with less bodily fluid. That same, single drop of blood could provide all the biological material that you or your doctor would want to analyze.

"Rapid, on-site detection of biomolecules is critical for healthcare, environmental monitoring, food safety and quality," says Usha Varshney, program director in the NSF Division of Electrical, Communications and Cyber Systems, who funds the research. "There is a great demand for novel, high-performance sensor technologies, able to detect many target biomolecules within small sample volume at a reduced cost."

The project is part of a larger trend in research being done at the intersection of disciplines, with significant progress coming from unexpected places.



Other National Science Foundation-funded engineers can use whispering gallery modes to detect airborne viruses. Any particles, including viruses and biomolecules, within the gallery will scatter the light, and a small device registers

the presence and characteristics of the particle. Learn more about optical whispering galleries: [nationalsciencefoundation.tumblr.com](https://nationalsciencefoundation.tumblr.com). Credit: Lan Yang, Nano/Micro Photonics Laboratory, Electrical and Systems Engineering Department, Washington University

"These cavity materials are novel; no one has done this before," Haberer says. "With these fibers, you can imagine different types of sensors in the future, on different types of surfaces, like in clothing."

For the short term, the cavities are still fragile and best-suited for more lab research. Consumers will have to wait a long while for laser-powered, bio-sensing suits.

Provided by National Science Foundation

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