The New York Times https://www.nytimes.com/2026/06/19/science/indoor-air-viruses-bacteria.html

Buildings May Soon Have ‘Immune Systems’ That Fight Airborne Disease

Following the pandemic, the federal government is spending $150 million on new technology to ensure clean indoor air. Here’s what scientists are pursuing.

Listen · 9:43 min

By Carl Zimmer **Photographs by Caroline Gutman**

Carl Zimmer started reporting on the airborne spread of disease during the Covid pandemic. He is the author of “Air-Borne: The Hidden History of the Life We Breathe.”

June 19, 2026, 5:00 a.m. ET

Linsey Marr, an environmental engineer, stood next to a pair of clear plastic boxes packed with tubes, nozzles and electronics, an odd-looking prototype that one day might serve to protect children in day care from airborne pathogens.

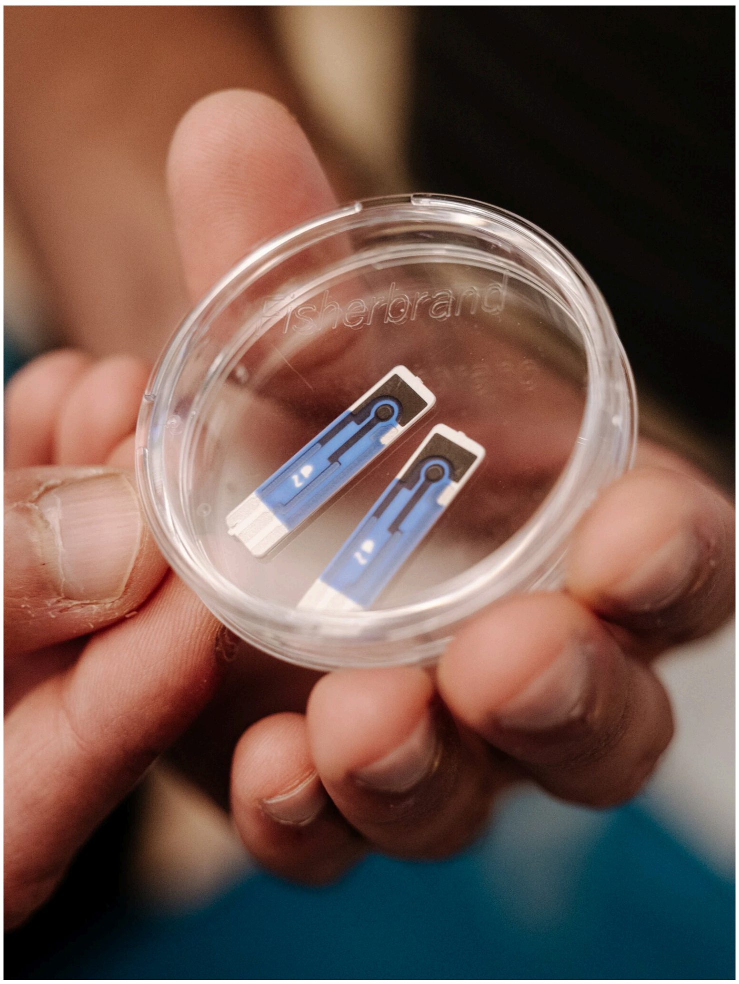
A nozzle filled the right-hand box with a faint silvery mist. A pump pulled some of that air into the left-hand box, where a sampler trapped floating particles and droplets. Soon, a digital screen bolted to the box turned red: “Detected! Dust mite allergen Der f 1.”

A protein shed by dust mites, Der f 1 can trigger asthma attacks when inhaled. Dr. Marr’s device had detected 843 picograms of Der f 1 per cubic meter. A single grain of salt is about 10 million times as heavy.

"Before this instrument, it would have taken us two days to figure out how much was in the air," Dr. Marr said. "Now we're doing it almost in real time."

Dust mite allergens are not the only threats that Dr. Marr's team aims to fish from the air. The technology, still evolving, can already sniff out influenza, the coronavirus and E. coli.

"We have 10 different things that we're able to detect, and by the end of the program, there will be 25 different things," she said.



Clockwise from top left: Experimental sensors that can grab proteins from pathogens and allergens and produce a signal indicating what they have detected; a game-like simulation on the risk of airborne infection in a day care center; a mist of dust mite allergens; tubes directing air through the day care diorama.

Dr. Marr was shouting over the din on the fifth floor of a Washington office building where over 200 people milled about, getting a first look at a rapidly evolving frontier in science: technology designed to keep indoor air safe in day care centers, schools, hospitals — anywhere people gather.

This grown-up science fair was hosted by the Advanced Research Projects Agency for Health — ARPA-H, for short — which is spending $150 million to create what it calls “an immune system for every building.”

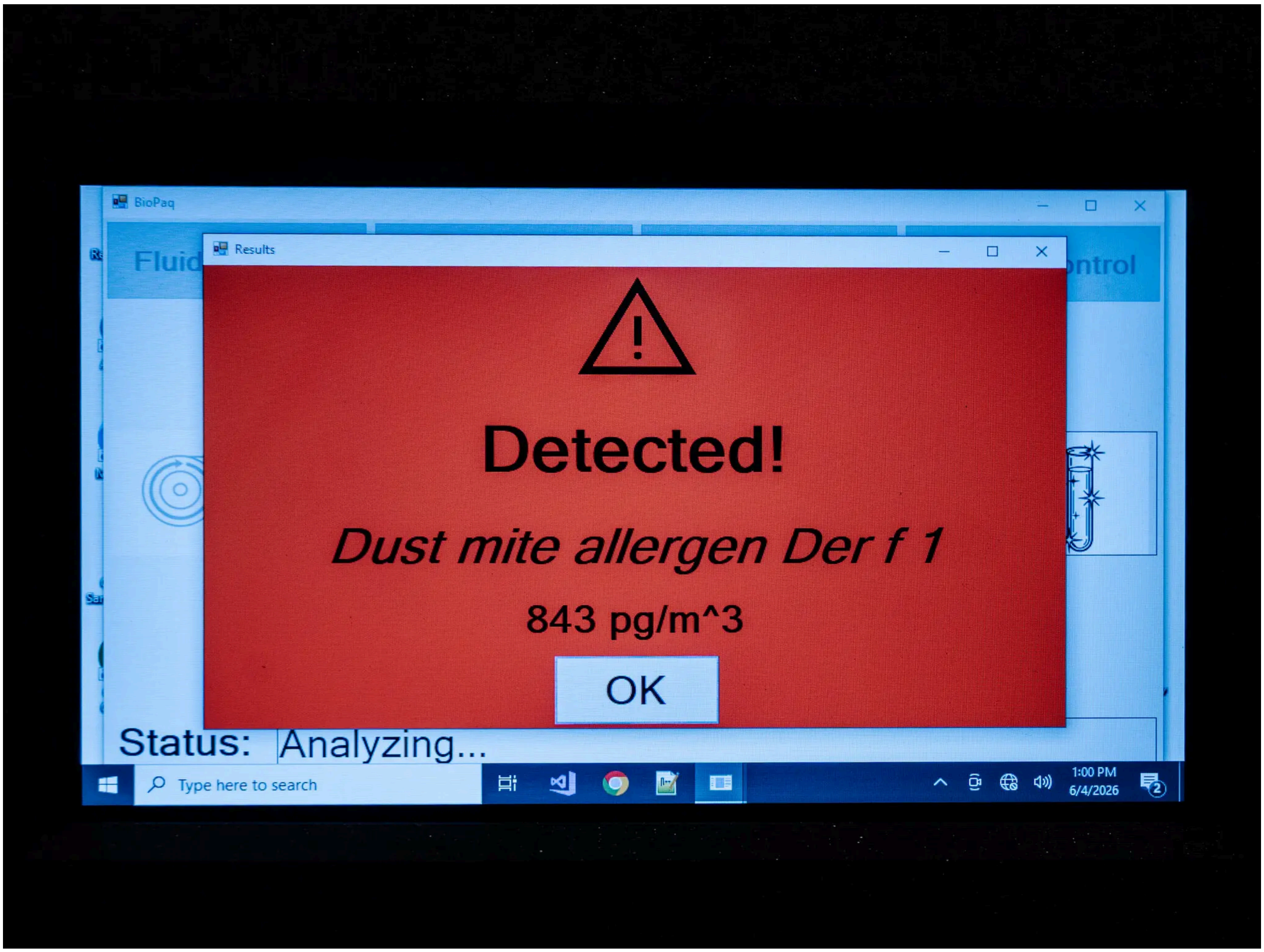
At the start of the event, the program manager, Jessica Green, gave a brief welcome speech. “We have the right to be breathing healthy indoor air,” she said.

Lost Lessons

Dr. Green was echoing the words of William and Mildred Wells, a husband-and-wife team who discovered the threat of airborne germs in the 1930s. They famously protected children in Philadelphia schools from a measles epidemic in 1940 by installing ultraviolet lamps that disinfected classroom air.

"I believe that a provision of pure air for children (and adults) to breathe should be looked upon as of equal importance to the provision of pure water and pure milk," Mildred Wells later wrote.

But she and her husband failed to sway their colleagues, and the threat of airborne germs went underappreciated for generations. When Covid hit in 2020, the World Health Organization emphatically stated that it was not airborne — which turned out to be wrong.



Sensors can detect trace amounts of biological material in the air, such a dust mite protein that causes asthma.

Dr. Marr, who teaches at Virginia Tech, played a leading role in getting the public health authorities to recognize that the coronavirus SARS-CoV-2 was in fact airborne. She and other researchers were frustrated by how hard it could be to identify such pathogens.

“We’d spend a day collecting samples onto a filter, we would take it to the lab, and the next day it will take us several hours to figure how much is in there,” Dr. Marr said. “And by the time you have that number, it’s too late to do anything about it.”

As a stopgap measure during the pandemic, Dr. Marr and other experts recommended finding ways to keep the coronavirus from building up indoors to dangerous levels. Some schools bought air purifiers for classrooms, while others resorted to D.I.Y. hacks made from box fans and filters.

As the pandemic ebbed, attention turned away from airborne threats. In U.S. schools, air purifiers came to be seen as noisy annoyances rather than lifesaving technology.

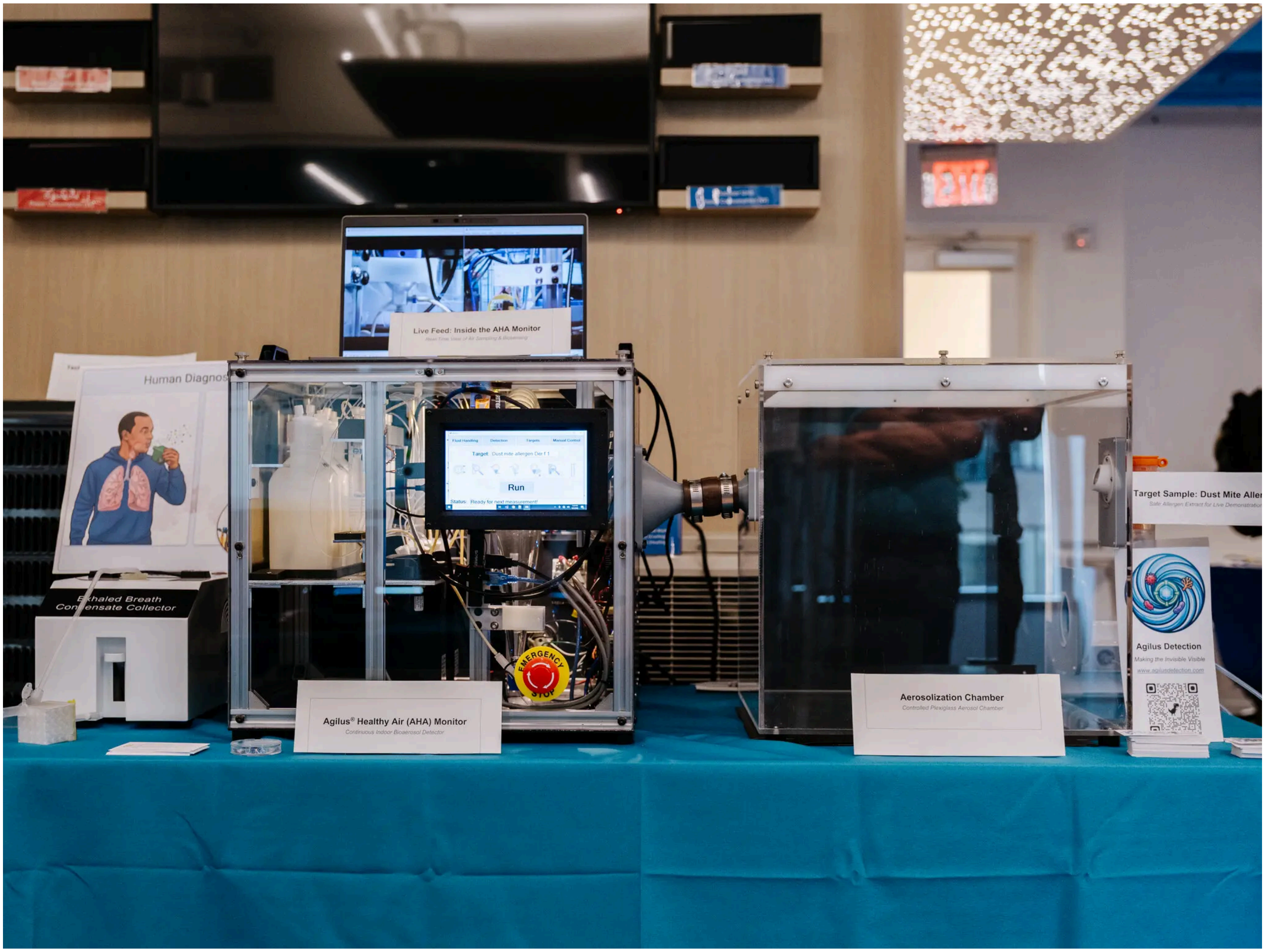
“A lot of them got thrown out, which is really sad,” said David Carel, a co-director of the nonprofit organization Clean Air for Schools. “Kids were actually breathing much cleaner air three or four years ago.”

Covid never left; it only joined a growing cadre of airborne pathogens.

Measles, which is entirely airborne, is having a resurgence in undervaccinated pockets of the United States. Influenza spreads by several routes, but the air appears to be an important one.

Beyond infectious germs, indoor air can also harbor other threats, such as dust mite proteins, mold spores and pollen grains.

Engineers have continued to develop sophisticated systems to keep air healthy. High-end apartment buildings occasionally boast about the technology used to keep their tenants safe. But these systems are far from ubiquitous.



A prototype of an airborne sensor on display. Pathogens or allergens are sprayed in a mist into the chamber on the right. A pump draws air to the sampler in the chamber at left, where electrodes can detect 10 species.

"One of the reasons I believe that healthy indoor air solutions have yet to scale in the marketplace broadly is because they're expensive," Dr. Green said in an interview. "What we need are solutions that can both be energy-efficient but also be healthy."

Dr. Green, herself an expert on airborne microbes, started the program at ARPA-H to work toward those solutions: BREATHE, for Building Resilient Environments for Air and Total Health. The goal is to have buildings fight disease the way they fight fires.

When smoke triggers smoke detectors, a building’s control system can respond, spraying water from sprinklers or releasing fire-suppressing chemicals.

It doesn’t have to wait for someone to inspect the signals and decide how to respond.

Four teams won contracts to create these systems. All face major engineering challenges.

It’s a lot harder to identify floating pathogens than to detect smoke. A very low concentration of germs or allergens can be dangerous. That means sensors have to sample huge volumes of air, storing droplets and particles in liquid to analyze them.

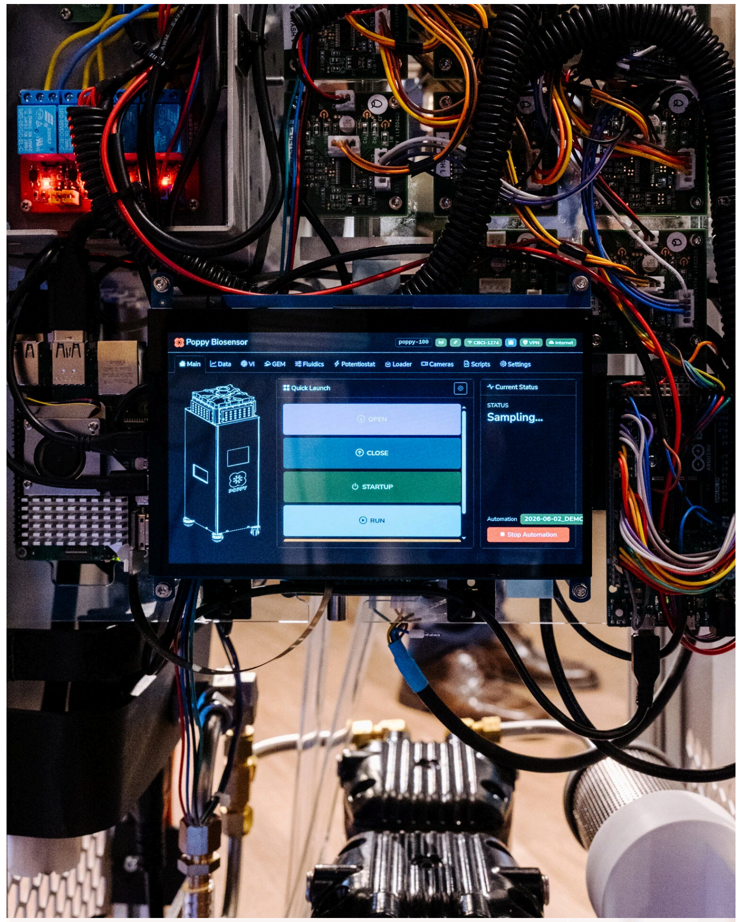
“These teams are needing to concentrate something like a swimming pool of air down to a tablespoon,” Dr. Green said. Each team is trying a different strategy.

SafeTraces, a California company, leads a group building an air sampler that’s a wide, low, white metal box. Air flows through the box into a cartridge, where chemicals break down cells and isolate genes they contain.

The cartridge contains molecular hooks, each of which can snag a specific sequence of DNA or RNA from a pathogen. If a hook catches any genetic material, it gives off a flash of light.

The researchers hope their sensor will detect up to 100 pathogens. They’re also building software that can recognize when the sensor signals mean that occupants are at high risk of getting infected.

The software might then respond, perhaps by turning on ultraviolet lamps in the hospital’s ventilation system. (In addition to measles viruses, UV light kills many airborne hazards.) Hospital personnel might get messages to use extra protection so that they wouldn’t inhale the pathogens. And once the sensors detected that the threat is gone, the hospital could return to business as usual.


Poppy Biosensor
Quick Launch
CLOSE
STARTUP
RUN
Current Status
STATUS
Sampling...
Automation
Stop Automation

Clockwise from top left: A sensor designed to detect genetic material from pathogens floating in the air of hospitals; a control screen for an air sampler being created for schools; a louver from a hospital ventilation system; beaded strings that light up under ultraviolet light, which can disinfect air.

Another team, led by the Florida company Poppy, is designing a system that would work in schools. The signals from the team's air samplers would switch on air filters in classrooms. They would run until the air in the classrooms was safe again.

Dr. Marr's group has focused on day care centers. They are creating software that can make models of the rooms in a center, predicting how air flows between them and the threat each room would pose if someone entered the building with an infection. The system could pump fresh air from the outside or switch on air purifiers to reduce the threat.

All the teams are working toward putting their systems to the test in the real world. SafeTraces has plans to test a prototype in the Walter Reed National Military Medical Center in 2028. Dr. Marr's group is preparing to test its system in day care centers in California, Michigan and North Carolina.

The technology is intended to reduce respiratory illnesses by at least 25 percent in each setting. But the systems also need to be affordable to buy and run. ARPA-H will expect the systems to provide a 10 percent return on investment.

Giorgio Buonanno, an environmental engineer at the University of Cassino and Southern Lazio in Italy who is not involved in the projects, said that BREATHE's approach is fascinating but a bit fanciful.

"I'm skeptical regarding its real-world plausibility," he said. Dr. Buonanno favored simpler strategies, such as requiring buildings to exchange a certain volume of air each hour and using carbon dioxide sensors keep track of how much exhaled air is accumulating in them.

"I don't think these things are mutually exclusive," said Joshua Santarpia, an aerobiologist at the University of Nebraska Medical Center who is developing the air sampler for schools. But he said it would require an ambitious effort like BREATHE to raise indoor air safety to a higher level.

“We didn’t get the internet just by sending a lot of mail,” Dr. Santarpia said.

Carl Zimmer covers news about science for The Times and writes the Origins column.