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# SCIENTIFIC AMERICAN

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PUBLIC HEALTH

## 9. Paper Diagnostics That Cost Pennies

Cheap, rapid screening for diseases such as Ebola and tuberculosis could save lives in remote and impoverished places

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By Prachi Patel



ILLUSTRATION BY [Name]

A patient checks into a rural African clinic with a high fever. The diagnosis could be anything from mild typhoid to Ebola. Even if laboratory blood tests are available, it will take days to get results. What is a doctor to do: Prescribe antibiotics or order a quarantine?

Researchers have been working for a decade on quick, cheap paper diagnostics (think home pregnancy tests) that could save lives in such situations. The first generation of those tests is now inching toward commercialization. The nonprofit organization Diagnostics For All is awaiting regulatory approval to deploy a blood-based liver-function test in Africa. The Bill & Melinda Gates Foundation—funded Intellectual Ventures in Bellevue, Wash., is working on an ultrasensitive malaria test, as well as a urine-based tuberculosis diagnostic tool. Paul Yager, a bioengineering professor at the University of Washington, is developing a sensitive test for the Ebola virus protein in blood. None of these devices costs more than a few dollars or requires special training.

At the heart of these diagnostic tools are strips of paper that are either engraved or overlaid with patterns that split, concentrate and mix fluids. Paper naturally wicks blood, urine and other fluids, so samples flow through the devices under their own power. The patterns steer the fluid through the dilutions and reactions necessary for identifying a pathogen or disease marker. For example, Diagnostics For All's liver-function test contains a filter that screens out red blood cells, allowing plasma to flow into a bottom paper layer loaded with reagents that combine with an enzyme that indicates liver damage. A color change indicates the patient's enzyme level.

The first generation of paper diagnostics will generally detect disease by spotting molecules produced by the infected body or by the culprit microbes themselves, but tests that directly detect the DNA of pathogens could follow. These so-called nucleic acid tests would allow doctors to accurately identify diseases in their earliest stages. Yager, Harvard University chemistry professor George Whitesides and other researchers are independently pursuing paper-based nucleic acid testing. Yager is developing a nucleic acid–based home Zika virus test and is applying for funding for faster, cheaper tests for Zika, dengue

and yellow fever.

Technical challenges remain, but researchers say the biggest barrier is financial. Pharmaceutical companies see little profit in devices that cost pennies, so most funding comes from governments and private foundations. “We and others have shown that the technology works,” Whitesides says. “A lot depends on whether we can get over the last hump of commercialization.”

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