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Bioengineers at UCSB Design Rapid Diagnostic Tests Inspired by Nature

By mimicking nature's own sensing mechanisms, bioengineers at UC Santa Barbara and University of Rome Tor Vergata have designed inexpensive medical diagnostic tests that take only a few minutes to perform. Their findings may aid efforts to build point-of-care devices for quick medical diagnosis of sexually transmitted diseases (STDs), allergies, autoimmune diseases, and a number of other diseases. The new technology could dramatically impact world health, according to the research team.

The rapid and easy-to-use diagnostic test consists of a nanometer-scale DNA "switch" that can quickly detect antibodies specific to a wide range of diseases. The research is described in an article published this month in the Journal of the American Chemical Society.

The design was created by the research group of Kevin W. Plaxco, a professor in UCSB's Department of Chemistry and Biochemistry. He noted that, despite the power of current diagnostic tests, a significant limitation is that they still require complex laboratory procedures. "Patients typically must wait for days or even weeks to receive the results of most STD tests," said Plaxco. "The blood sample has to be transported to the lab, its content analyzed by trained personnel, and the results sent back to the doctor's office. If we can move testing to the point of care, it eliminates the lag between testing and treatment, which would enhance the effectiveness of medical interventions, and, for infectious diseases like STDs, reduce transmission."

The key breakthrough underlying this new technology came from observing nature. "All creatures, from bacteria to humans, monitor their environments using amazing ‘molecular nanoswitches' that signal the presence of a specific target by changing their structure," said Alexis Vallée-Bélisle, a postdoctoral scholar and co-first author of the study. "For example, on the surface of our cells, there are millions of receptor proteins that detect various molecules by switching from an ‘off state' to an ‘on state.' The beauty of these switches is that they are able to work directly in very complex environments such as whole blood."

Plaxco's research group teamed with Francesco Ricci, professor at University of Rome Tor Vergata and co-first author of the paper, to build synthetic molecular switches that signal their state via a change in electric current. This change in current can be measured using inexpensive electronics similar to those in the home glucose test meter used by diabetics to check their blood sugar. Using these "nature-inspired" nanoswitches, the researchers were able to detect anti-HIV antibodies directly in whole blood in less than five minutes.

"A great advantage of these electrochemical nanoswitches is that their sensing principle can be generalized to many different targets, allowing us to build inexpensive devices that could detect dozens of disease markers in less than five minutes in the doctor's office or even at home," said Ricci.

The authors noted that it may take several years to bring the devices to the market.

The additional co-authors are Fan Xia of Huazhong University of Science and Technology in Wuhan, China; and Takanori Uzawa of Hokkaido University in Sapporo, Japan.

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† Top image: An electrochemical DNA-switch (red ribbon, or blue in the animation) detects its target antibody (green) directly in blood. By mimicking nature's own sensing mechanisms, Vallée-Bélisle, Plaxco and Ricci have built a synthetic molecular switch that enables the fast and convenient detection of diagnostically relevant antibodies. The sensing principle is straightforward: Upon antibody binding, the switch opens and separates a signaling element (bright circle) from the surface of an underlying electrode. This causes a signal change that can be easily measured using inexpensive devices similar to those used in the home glucose self-test meter. Using these "nature-inspired" nanoswitches the researchers were able to detect anti-HIV antibodies directly in whole blood in less than five minutes.

Credit: Peter Allen

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