Medical Xpress

'DNA wires' could help physicians diagnose disease

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In a discovery that defies the popular meaning of the word "wire," scientists have found that Mother Nature uses DNA as a wire to detect the constantly occurring genetic damage and mistakes that — if left unrepaired — can result in diseases like cancer and underpin the physical and mental decline of aging.

That topic — DNA wires and their potential use in identifying people at risk for certain diseases — is the focus of a plenary talk during the 244th National Meeting & Exposition of the American Chemical Society, the world's largest scientific society.

"DNA is a very fragile and special wire," said Jacqueline K. Barton, Ph.D., who delivered the talk. "You're never going to wire a house with it, and it isn't sturdy enough to use in popular electronic devices. But that fragile state is exactly what makes DNA so good as an electrical biosensor to identify DNA damage."

Barton won the U.S. National Medal of Science, the nation's highest honor for scientific achievement, for discovering that cells use the double strands of the DNA helix like a wire for signaling, which is critical to detecting and repairing genetic damage. She is a professor of chemistry and is chair of the division of chemistry and chemical engineering at the California Institute of Technology in Pasadena.

Damage is constantly occurring to DNA, Barton explained — damage that skin cells, for instance, receive from excessive exposure to sunlight or that lung cells get hit with from carcinogens in cigarette smoke. Cells have a natural repair system in which special proteins constantly patrol the spiral-staircase architecture of DNA. They monitor the 3 billion units, or "base pairs," in DNA, looking for and mending damage from carcinogens and other sources.

Barton and other scientists noticed years ago that the DNA architecture chemically resembles the solid-state materials used in transistors and other electronic components. And DNA's bases, or units, are stacked on top of each other in an arrangement that seemed capable of conducting electricity.

"It's like a stack of copper pennies," said Barton. "And when in good condition and properly aligned, that stack of copper pennies can be conductive. But if one of the pennies is a little bit awry — if it's not stacked so well — then you're not going to be able to get good conductivity in it. But if those bases are mismatched or if there is any other damage to the DNA, as can happen with damage that leads to cancer, the wire is interrupted and electricity will not flow properly."

Barton's team established that the electrons that comprise a flow of electricity can move from one end of a DNA strand to the other, just as they do through an electrical wire. In one recent advance, the team was able to send electricity down a 34-nanometer-long piece of DNA. That might not sound like much — a nanometer is one-tenth the width of a human hair. But that is just the right scale for use in medical diagnostic devices and biosensors to pick up on mutations, or changes, in DNA that could lead to cancer and other diseases.

Barton's research suggested that DNA uses its electrical properties to signal repair proteins that fix DNA damage. If the DNA is no longer conducting electricity properly, that would be a signal for repair proteins to do their thing. Barton's team is applying that knowledge in developing

"DNA chips," devices that take advantage of DNA's natural electrical conductivity and its ability to bind to other strands of DNA that have a complementary sequence of base units, and thus probe that sequence for damage. Such a DNA chip would help diagnose disease risk by changes in electrical conductivity resulting from mutations or some other damage.

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