Podcast Interview: John Rogers

PNAS: Welcome to Science Sessions. I'm Taylor Gedeon.

Wearable electronic devices for health monitoring are becoming increasingly common in both medical settings and the marketplace. But not all such devices are flexible enough to easily adapt to the contours of the human body. National Academy of Sciences member John Rogers of Northwestern University is trying to devise soft electronics that conform to the human body, allowing the wearer to accurately and consistently monitor an array of health indicators. I spoke to Rogers at the 2018 American Association for the Advancement of Science Meeting in Austin, Texas, where he presented his skin-like electronic patch. The patch is designed for a range of applications, from analyzing total sweat loss in athletes to tracking rehabilitation in stroke patients. Rogers describes how he first became interested in the idea of wearable health monitors.

Rogers: I guess it dates all the way back to the work that we were doing in flexible electronics back at Bell Laboratories where I got my career start. I ended up giving a talk at the University of Pennsylvania in their electrical engineering department. They have a very big medical school, very active programs in neuroscience and it turns out that a couple of the neuroscientists came to my talk. I was describing all of these kind of flexible, you know, light weight plastic-based electronic systems. They came up to me after the talk and said have you ever thought about putting these devices on a brain. And we had never really thought about that kind of application space but it occurred to me as like a really interesting opportunity afforded by the flexibility of the platform.

PNAS: Following that new path, Rogers explored soft, stretchable mechanics. While he initially considered applications involving the brain and the heart, Rogers ultimately decided to start with the least invasive point of integration – the human skin.

Rogers: For a long time we were focused on how do we create skin-like electronics that will allow intimate integration with the skin where the skin could be used as a window for measuring underlying physiological properties with clinical grade precision. And we decided you know maybe the lowest hanging fruit was to focus on sweat, because it's very easily captured in principle in a non-invasive way. So we begin to think about whether it was possible to take the kinds of rigid, planar, microfluidic lab-on-a-chip technologies that people have been developing over the last 20-30 years for doing chemical analysis, for doing point of care diagnostics, and rendering those devices into these kind of skin-compatible formats that are flexible, soft, skin compatible in that way.

PNAS: Which is how Rogers came to create a skin-like patch for sweat collection and analysis. Here's Rogers with an explanation of how the patch works.

Rogers: Yeah it's basically a molded piece of silicon, soft silicon, material that adheres to the surface of the skin. The bottom of that platform has specific inlet ports, openings, that allow sweat glands in the corresponding location on the skin to pump sweat up into the device, the guts of the device, which consist of collections of micro-scaled channels, valves, reservoirs, color-responsive chemistries for doing analysis on the sweat. From the extent of filling, you can determine the sweat loss at any given moment. And it turns out there are calibration factors that will allow you to convert that local measurement of sweat loss to full body sweat loss. We can embed color metric chemical reagents that change in color by an amount determined by important biomarker concentrations. We also have printed color calibration markings right next to the reservoirs, and right next to the serpentine channels, so you can just visually, by a comparative analysis, determine whether your chloride concentration is high, medium, or low just by comparing the color of the reservoir where chloride concentration is being measured to the color calibration markings that are printed right next to that reservoir. If you want to extract information at a higher level of precision, then you can just take the camera on your phone, snap a color picture of the device, we have algorithms that extract quantitative color level values from each of the different reservoirs, and those values then get converted via calibration to specific concentrations of different biomarkers. So you can do things at a high quantitative level, which also gets the data into a digital form that can be shared with a physician. And so what you end up with is a very low-cost, microfluidic patch, skin-like in its properties, and visual in its readout mechanism.

PNAS: To improve the accuracy of these skin-interfacing, sweat-monitoring devices, Rogers has entered into a partnership with Gatorade. This collaboration allows Rogers and a team of engineers to continue developing the technology with an eye toward making it commercially available.

Rogers: So we have a partnership with Gatorade to develop these devices out as the new standard for sweat analysis. They have sort of standard methods that they use and have used for decades in determining total sweat loss and sweat chemistry. Mostly it involves taking an absorbent pad, and taping it to the skin. There’s a lot of deficiencies associated with that because you don’t do the analysis onboard, you have to have a separate instrument to do that. You can’t visualize how much you’re sweating. You have to take the patch off and weigh it before you really know how much sweat loss has occurred. And so these devices would be a significant qualitative leap beyond that technology, but we’re working with Gatorade to establish the accuracy, using that as the standard.

PNAS: Although the partnership with Gatorade is helping to drive basic research, the patch has several applications. In one setting, the technology is being used to track rehabilitation in stroke patients at the Ability Lab, a research hospital in downtown Chicago.

Rogers: We’re using these devices to measure right-left asymmetries in the sweat rate associated with patients who’ve experienced a stroke. And it turns out that that degree of asymmetry turns out to be a very powerful metric for tracking the patient’s condition, and the improvement in that condition over time. So we work very closely with rehabilitation experts, clinicians, at the AbilityLab. We have very robust collaborations there so at this point we know enough about the microfluidic technology that we can produce it at scales that are relevant for clinical deployment onto real patients.

PNAS: But before those medical applications can be realized, the technology must overcome several knowledge gaps and technical hurdles.

Rogers: Well I think one gap is there are certain things that we can measure about sweat that people understand and can interpret and act upon. There are other things that we measure about sweat where the underlying biology and the underlying clinical medicine is not fully developed. The other thing is I think having some capability for two-way operation in these devices. Most of what we build operates in the realm of sensing. It would be nice to have devices that could go the other direction and actuate or deliver drugs or an electrical stimulation. So you could kind of close the loop in a sense. You could sense something and then based on that sensor response the device could actually act on the body in a helpful way. So I think the biggest challenges are getting things out of the lab into the hands of the patient in a way that can benefit them personally.

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