King Abdullah University of Science and Technology

Sciencetown podcast — Episode 23

Portable biosensing technologies — Part I

Sciencetown host: Julie West
Sciencetown guest: Dana Sulaiman, assistant professor of materials science and bioengineering

Transcription

Dana: The goal of these biosensing technologies is to enable us to move from these invasive tissue biopsies towards what we called liquid biopsies. And this is where what we want to do is be able to screen patients even before they present any symptoms and check if there are these biomarker signals of disease.

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Sciencetown voiceover intro: Welcome to Sciencetown, a podcast about the most unique research community on the planet. With every episode, we will bring you cutting edge tech, science and startup culture through the eyes of pioneering men and women. Their journeys cross disciplines and cross borders in the pursuit of world-changing science.

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Julie: Welcome to episode 23 of Sciencetown. I'm Julie West.

KAUST researchers are developing innovative portable technologies across scales and disciplines with applications in fields such as healthcare, carbon capture, water treatment, environmental monitoring and reef restoration. Sciencetown delves into examples of these technologies and their benefits in a three-part podcast series. In this first interview, Dana Sulaiman, an assistant professor of materials science and bioengineering, introduces us to portable biosensing devices, and explains why they are a novel way to detect cancer, and help physicians and clinicians choose the most effective treatments for patients.

Welcome Dana.

Dana: Thank you Julie for having me. It's great to be here.

Julie: Your area of research is in biosensing technologies in the context of healthcare. First of all, what is meant by biosensing?

Dana: Great. That's a wonderful question. Biosensing, or the field of biosensing, is quite an interdisciplinary field. The main idea of biosensors is that these are devices and technologies that enable us to gather clinical pathological information from biological samples from a patient; and we use this information to then inform clinical decisions.

Julie: And you are teaching a biosensing materials class at KAUST, so what kind of pursuits might your students be looking at?

Dana: That's great. I just developed this course. It's a hybrid course that's offered to both bioengineering students and materials science and engineering students. I tried to approach this course in an interesting way where you're looking from two perspectives. The idea is that I introduce the students to five different classes of materials that they can manipulate and engineer to develop sensors, and then I introduce them to all the biomarkers — the clinically relevant molecules found in the body that we can detect and get information from, and then bring everything together. What are the biomarkers of interest, and how can we use materials to actually detect them?

Julie: What is it about cross-disciplinary that becomes of value or even essential to this particular field?

Dana: That's a wonderful question as well, Julie. The main thing about this field, and particularly biosensing, is that it really does introduce concepts from different areas, and you need to be able to integrate them with each other in order to design effective technologies and effective tools to address healthcare problems. And in the world of biosensing, this means understanding what are biologically relevant molecules, and how they can inform us about the disease, and then — from the other side — from an engineering perspective, what types of tools and fundamental engineering concepts can we apply in order to see these biomarkers — to see these molecules of interest and detect them in an efficient way.

Julie: What are the current technologies being used to detect cancer, and what role would biosensing technologies play in this?

Dana: Currently, the gold standard conventional techniques to detect cancer, unfortunately, rely on technologies that are very invasive; they're quite expensive, and they detect disease at its later stages. The most gold standard method is to take a tissue biopsy at the site where the tumor is, and that's very invasive. And typically, a patient only comes into the clinic to start off these diagnostic strategies at later stages when the symptoms arise. So the goal here is to move away from invasive tissue biopsies towards developing techniques called liquid biopsies, where we can use biosensors to get information from liquid samples, even before a patient presents clinical symptoms, so at the asymptomatic stages, and this is super important, because within

these stages is when the patient is most treatable, and that's when the tumor is most amenable to being treated.

Julie: So this is really critical for future healthcare assessments.

Dana: Exactly. And this is what we call the field of precision medicine. We listen, and we look at what the patient's biological fluids are presenting, whether that's in their genetics, epigenetics, proteomics … and we're then trying to inform clinical decisions from that.

Julie: So where does the portability component come into play?

Dana: Biosensors comes in very different shapes, forms and sizes. They can be quite big pieces of instrumentation; and they can be as small as a microchip. The field is moving towards portable devices, miniaturized devices and even wearable sensors, because that means greater accessibility, and that also means lower costs and faster devices. So you can look at devices in many different shapes. We are moving towards these small patches that can be applied on the skin to detect these biomarkers. Other people are looking more to fingerprick type biosensors very similar to glucose monitoring devices that we see commonly.

Julie: You mentioned the patch; and you mentioned the fluids. Are you actually working to develop something portable involving those, and if so, what might those be?

Dana: Oh yeah, so when we're looking for biomarkers, you can find them in different parts of the body. And as I said, we don't want to look at tissue samples, we want to look at liquid samples. And actually, biomarkers are found — particularly the biomarker I am interested in, microRNA — in *all* biological fluids, so that means serum, it means interstitial fluid, it means urine, saliva, and everything like that. So when we're trying to decide what format, or how do we develop and design our biosensor, we first ask ourselves where can we find this biomarker? We want to choose a fluid that is non-invasive, as in, when we take the sample, it's not painful for a patient and doesn't cause bleeding. For example, for this patch, the fluid that we're detecting biomarkers from is called interstitial fluid of the skin. And that's this fluid that lies … it bathes cells; it's all around cells everywhere in our body, and you can also find it in the superficial layers of your skin. So when you apply a patch onto that and reach just the superficial layers, you actually don't cause any pain or bleeding, but you still absorb these clinically informative molecules, and that's how we're trying to develop these patches for that. Now if I'm trying to detect molecules from blood, then I'll have to do a fingerprick-type device, so it really depends.

Julie: So what information are you getting from that? OK, you've put the patch on. You've come to me, maybe I wouldn't come to you. I'm in a rural setting, potentially, and can't make it to the highly specialized hospital. I want to know if cancer might be an issue for me. You put this patch on. And then — what happens to the information? What's going on? How do you actually get a readout, I guess?

Dana: Yeah, that's great. So when I place this patch onto the skin, there are different methods of absorbing this interstitial fluid from the skin onto the microneedle patch. Now once it's there, on the patch itself are bioreceptors that are specific towards the biomarker of interest. Now when it binds, something happens. There's a transduction mechanism that can either result in the release of a fluorescent signal — some type of optical signal that we can see and detect — or it causes an electrical signal; an electrical readout, like a digital signal. So it depends on how we design the sensor, but you'll get either a color, a fluorescence, or an electrical signal.

Julie: Wow! All that in a little patch. But would that give you just a general feedback of — "Yes, we know there's cancer based on this fluorescing or electrical signal?" Or could you actually hone in and see more specifically — "It's exactly this kind of cancer, and we know that because of X, Y and Z that we're seeing."

Dana: So the nice thing about our readouts — our transduction mechanism — is that it results in a signal that is extremely quantitative, so I can see exactly how many of these molecules are floating. Now if I have this information, I can correlate it to the disease. The other important thing is that we're not detecting one molecule floating in there, we're actually detecting multiple at the same time. So I get this profile. And when I see this profile of biomarkers, I can use this profile and compare it to what I know about cancers, and I can tell exactly what kind of cancer, so I can stratify disease, not just detect its presence.

Julie: That's fascinating. Are there other related components of portability surrounding this technology?

Dana: Yeah, the main thing is that the sensor itself — the whole sensor — is very portable and can be placed ono the skin, onto the body; but the second component is that the signal itself, once we get it, we can wirelessly transmit it to a phone or other device. So both components.

Julie: I see. So that could be transmitted back to the clinic or to a doctor.

Dana: Exactly.

Julie: So this sounds like you would need clinical trials behind this. Are you actually at that stage of development yet? What might be next after you've perfected the technology?

Dana: Right now we're at the stages of validating technically whether the biosensor is sensitive enough and whether it's specific enough, so that's the first thing that we're doing. We're also now starting to collaborate with clinicians in local hospitals, so King Faisal Specialist Hospital is providing us with real clinical samples from patients. They're taking samples, including healthy control samples. We're getting these biological fluids, and we're testing them to validate them clinically. Now in an academic setting, we only have a certain capacity to validate with clinical samples, but ideally the next stage is to get this work patented, and then further on we can do much larger clinical studies before it can get approved.

Julie: So like a proof of concept?

Dana: Exactly we're at that stage.

Julie: Are there key challenges or considerations concerning scale and portability that you'd need to factor in the design of these instruments?

Dana: That's a great question. I think one thing that a lot of us bioengineers forget about is that at some point we want these devices to reach a patient, and for that we need to make sure that they are manufactured in a sustainable way. And you can have very large quantities being manufactured, also at low cost. So we actually try to think about that from the beginning through the choice of material that we use. And sometimes this means the polymer we are using is biocompatible and biodegradable. Sometimes this means that the receptor itself can withstand very extreme conditions, and that means it can be placed into conditions where the manufacturing is quite versatile and robust. So we hope to factor that in, and I think this will play out in the later stages when we want to upscale.

Julie: So I'm curious, is that consideration for sustainability specific to KAUST and your role here, or is the medical community, in general, having these conversations?

Dana: I think I see that the medical community is moving towards that. Of course, last year KAUST had the KAUST Research Open Week. The theme was about sustainability, so these ideas definitely were inspired by this and the importance of what I heard, but I have started to notice that the entire community is moving towards this, especially after the COVID pandemic when we've been using so many biomedical devices, and a lot of them have been just thrown out and cannot be recycled. So people are starting to think that the healthcare field is going to be using a lot of these materials, so we need to make sure that these materials are sustainable and recyclable and biodegradable.

Julie: Really good to hear. And what drew you to this area of cancer research?

Dana: I guess there are many different reasons, but one of them is because it's more of a personal situation that happened in my family and with friends, where I had some family members get diagnosed with this disease. And I had already been, I guess, initiated into the field of biomarkers for disease diagnostics, so I decided to choose to focus on biomarkers that can inform us about cancer. And that's when I started working in this field and dedicated my research towards that.

Julie: OK. I learned that when you were a girl, your mother gave you interesting engineering problems to solve. Like what?

Dana: Yeah, so I don't know why — but since we were really young — I guess … we were five kids and it was really hard to control the five kids; we'd get quite rowdy — And so my mother would sit us down at least once a week; we'd sit together after lunch, and to get us thinking

about things apart from playing outside, she would come up with these interesting engineering problems. I remember one very well. She said, I want you to design one bottle, but this bottle can house many different drinks; so I want it to house water, juice, milk … how can you design this such that we're minimizing waste — you have one bottle, but it can contain all the different types of drinks that you want to have. And that took me weeks to think about it. It was a very practical problem, but these ideas of initial engineering design were really seeded at these initial stages, and I'm very thankful that my mom put these ideas in my thoughts.

Julie: Have you had an opportunity to work with young girls to encourage them on a STEM path potentially?

Dana: Yes, that's a wonderful question. I'm really passionate about outreach and inspiring young girls into STEM and to stay within the STEM fields. I actually did a couple of courses when I was at MIT, and one of the things I learned with evidence-based research is that, unfortunately, girls — they love science at the initial stages of their academia — and, unfortunately, they begin to leave at some stage— and the reason why is they feel that they don't belong. And when I heard that reason, I was shocked. Is it just that, that they feel that they don't belong? So when I heard that, I wanted to be a part of the solution, at least some type of role model in that young girls can see that, yes, there are women in this field, and I can do what she's doing, and I can achieve what she's achieving.

Julie: Yes, and you're young and accomplished, and undoubtedly set a powerful role model. Well Dana, thank you so much for joining me in the podcast studio today.

Dana: Thank you so much for having me, Julie. It was a pleasure.

Julie: Thanks to everyone who took part in this episode. Sciencetown is produced by Julie West and Alex Arias. Thanks for listening.

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