Speaker 1: You're listening to Further Together, the ORAU podcast. Join your hosts, Michael and Jenna, as they discuss all things ORAU, through interviews with our experts who provide innovative scientific and technical solutions for our customers. They'll talk about ORAU storied history, how we're impacting an ever-changing world and our commitment to our community. Welcome to Further Together, the ORAU podcast.

Michael: Good morning and welcome to another edition of Further Together, the ORAU podcast. I am Michael with my co-host.

Jenna: Jenna.

Michael: How are you this morning?

Jenna: I'm doing really well. How are you?

Michael: I'm really good.

Jenna: I'm excited about our topic today.

Michael: I am, too. This is our first official scientist researcher that we've interviewed and a really important one for us here at ORU and ORI.

Jenna: And it's a cool topic.

Michael: It's a very cool topic.

Jenna: That, I think, not a lot of people know about.

Michael: It's really exciting. So, without further ado, let's get started. Dr. Balajee, welcome to Further Together, the ORAU podcast.

Dr. Balajee: I am delighted to be here. I have never done one like this but I am really excited to share some of our work.

Jenna: Cool.

Michael: Excellent. So, tell us a little bit first about who you are and what you do for the organization.

Dr. Balajee: Let me give you a brief history. I did my PhD from India and then I went to the Sylvius Laboratories in the Netherlands to pursue my research on DNA repair and genomics [inaudible 00:01:42]. I exclusively worked on ultraviolet light in just DNA damage. UV light because lot of people do get skin cancer because of the melanin content. So, that was our main interest, so what causes skin cancer after exposure to ultraviolet light. After working there for three years and I moved to National Institute of Health, Baltimore. Many say Baltimore, people say "no, it's [inaudible 00:02:12]" and no, it's Baltimore. Two institutions, actually, a laboratory of aging and a national institute on alcohol and drug abuse. So, these two institutes are still in the Johns Hopkins Bayview campus. I work there with Dr. Vilhelm Bohr. He's the grandson of Nobel Prizewinner, Niels Bohr. So I always say that he does not like it. [crosstalk 00:02:40] So I want to boost myself [crosstalk 00:02:42] the grandson of a Nobel Prizewinner, so that's why... he [inaudible 00:02:45] the attention of the people.

Michael: Two degrees of separation.

Dr. Balajee: So, I pretty much continued what I was doing in the Netherlands, again working on ultraviolet light and just DNA damage and repair. So, we identified some genes and we also got some insights how UV causes the skin cancer. We also worked on premature aging syndromes.

Michael: Okay.

Dr. Balajee: There are five syndromes in humans, so when I say premature aging syndrome, so the patients develop aging features very fast. A 16 or 18 year old person will look like 80 or 90 years old person.

Michael: Wow.

Dr. Balajee: So, we were interested in understanding how the aging occurs. First of all, how do we age and why do we age and why all the important functions, including the cognitive function, decline with age. So, that was our main interest. We found a lot of interesting information. That was my work at the NIH. Then I move to Columbia University Medical Center, where I worked the longest, 16 years.

Michael: Okay.

Jenna: Oh, wow.

Dr. Balajee: In the Department of Radiation Oncology. There I worked on various aspects of low dose radiation. How it affects people and what are the biological effects one could experience. Our focus was mainly on cancer incidents. How low dose radiation causes cancer. That was my main interest and, of course, I continued to work on cancer. The research in my laboratory identified a biomarker for advanced stage prostate cancer. Then we went on to do more work on that biomarker. It's called [inaudible 00:04:42] L4. It's like a gene protein. If you suppress that, the cancer cells will get killed. We were pretty excited and this is not only a biomarker for prostate cancer but also for breast cancer,

Jenna: Oh, wow.

Dr. Balajee: Gastric cancer, colon cancer, you name it because this is one of the most important gene for cancer cells because it helps to proliferate. So, this gene is what were expressed so the cancer cells keep growing so when you suppress it, the cancer cells will get killed. Then, I moved to ORAU in 2015. I took up the position of Technical Director for the Cytogenetic Biodosimetry Laboratory and I am here since then.

Michael: Excellent and we're glad you're here. What does the Cytogenetic Biodosimetry Lab do?

Dr. Balajee: The Cytogenetic Biodosimetry Lab is really unique. We have only two federally funded labs, one is at AFRRI, Bethesda, the other one is at Oak Ridge. In the Cytogenetic Biodosimetry Lab, we use a chromosome anomaly test, which is known as a dicentric chromosome [crosstalk 00:05:57]. We use this test to estimate the absorbed radiation dose in humans. People get exposed to radiation, especially nuclear workers. It could be occupational or accidental or incidental, like radiological or nuclear terrorism. If people are exposed, we just collect the blood samples and then we do this process and then estimate the absorbed radiation dose.

Michael: Okay.

Jenna: Okay.

Dr. Balajee: If the dose is really high, they can seek medical attention and, if the dose is low, they don't need any medical attention. They can go back home and wait for the signs to appear, if at all, if they appear.

Jenna: So, where do you get the blood samples from? How does that process work? How do you end up...

Dr. Balajee: Yes, so if someone is exposed... we usually get samples from the nuclear workers or people who are working in sterilization industry. They use lot of X-rays and gamma rays to sterilize stuff, culture results, flasks, pipettes and stuff. So, they do get accidental exposure sometimes. They all vet the physical dosimeters so they know the dose, but the physical dosimeter will only tell you the dose outside the body.

Jenna: Okay.

Dr. Balajee: So, how much of your blood cells have affected or different body parts are affected. You have to turn to biodose. We collect the blood cells, so basically someone from the industry from HR and also the Health Safety Officer, they usually have a primary talk with react staff. They will tell them the scenario and then they will tell the physical dose from the dosimeter and then they will discuss whether it is even worth doing a cytogenetic analysis because the cytogenetic analysis is good from point one grey [inaudible 00:07:57]. If it is extremely low. If it is less than point one grade, there is no point in using the dicentric chromosome assay. So, once they decide the dose is high enough for cytogenetic analysis, if you lost the blood samples and we receive the blood samples and run the assay, but the request for the cytogenetic test has to come from the physician so we don't deal with the patient,

Jenna: Got you.

Dr. Balajee: Or the exposed victims. When we get the request, we do the test and we inform the physician about the dose. Then they will take appropriate medical action, if at all it's needed.

Jenna: Okay.

Michael: Right and the test that you're doing, you talk about the dicentric chromosomal assay's essentially looking for damage to the chromosomes.

Dr. Balajee: Yes. Radiation actually damages the chromosomes and some of the chromosomes are mis-rejoined because of the DNA [inaudible 00:08:58] threshold. So, if it exceeds, you get the dicentric chromosome and I forgot to mention the dicentric chromosome formation is radiation dose dependent. The frequency of dicentry will tell you the dose, the absorbed radiation dose.

Michael: You're essentially, sort of, counting the numbers of dicentrics.

Dr. Balajee: We're actually counting. Yes. We were doing manual counting but now we do this automated.

Michael: Sure.

Dr. Balajee: We have two [inaudible 00:09:27] microscopes and so these microscopes can detect the dicentric chromosomes and give you the data. It's fantastic. We recently complied a manuscript on this.

Michael: Excellent

Dr. Balajee: Because we are always thinking of high throughput tools because, in case of radiation, mass casualty incidents, hundreds and thousands of people will get exposed so if you do everything manually, it's going to take a whole lot of time

Michael: Sure.

Dr. Balajee: And the exposed persons need to know the dose almost immediately.

Jenna: Sooner, yes.

Dr. Balajee: So they can seek medical attention. We are really focusing on developing a lot of high throughput automated platforms for radiation dose assessment. If there is minimal human intervention, there'll be a lot of high throughput data coming out, in case of mass casualty incidents.

Michael: As you mention, mass casualty incidents involving radiation, the cyto lab is part of the REAC/TS, the Radiation Emergency Assistance Center Training Site, that we manage for the Department of Energy, which essentially is, for folks who don't know, a team of people who, if there is a radiation emergency, are basically dispatched either to the site or available to provide assistance in the event of a mass casualty or a radiation emergency and your lab essentially does the counting to help measure the [crosstalk 00:11:05] or does the assay to measure what the radiation dose looks like for future reference.

Dr. Balajee: Yes, the REAC/TS staff actually give a lot of consultation. They have done in the past. REAC/TS is a world renowned-organization. They work 24/7. They do a lot of consultation. They give advice for decontamination, sometimes deployment. They do all kinds of stuff, radiological emergencies. But, the CBL, we do the radiation dose assessment. The first step is actually done by REAC/TS. Doing all kinds of consultation, what is needed and what is required and then, if there are some highly exposed cases, then it'll be referred to us for do the radiation dose assessment to confirm.

Michael: It's really interesting. It's one of my favorite actually parts of what we do is just the whole REAC/TS cyto lab piece of this incredible set of skills but also the great team of people that we have in both places and people don't really know about it. We know about it and folks here in Oak Ridge know about it, but

Jenna: It's a hidden gem.

Michael: Yes, it's a hidden gem. It's one of those things that we love talking about because it doesn't get enough attention, really.

Dr. Balajee: Yes. I think they are doing such a wonderful job and everybody should be aware of that. In case, if they need, they should know where to turn to.

Michael: Right.

Dr. Balajee: And I must say that REAC/TS has a wonderful team and, of course, CBL is part of REAC/TS. REAC/TS is the big picture. So, it is fabulous to work here because I learnt a lot ever since I came here in 2015 and I learnt at Columbia University Medical Center as well, but it's all lab research. But, at REAC/TS, it's reality. You know, it happens to people so, rather than working with cells, I always prefer to work with humans because you have the satisfaction of doing sometime to human welfare and human health. I'm really fascinated. I think it's a really very good experience for me.

Michael: Well, and as you mention, there are only two cyto labs in the country so it's a very, very specialized process and group of skills and, obviously, team that you lead.

Dr. Balajee: One thing I should mention is that the dicentric chromosome assay is considered to be the gold standard because normal healthy people will not show any dicentric chromosome and it happens [inaudible 00:13:44] after radiation exposure.

Michael: Right.

Dr. Balajee: The downside of it, it takes too much time. It takes anywhere between three to four days. A lot of people are pretty upset about that so we are developing a lot of novel techniques to reduce the turnaround time. My concept is that if you develop a faster technique, really, for the screening. If you have 10,000 people, you have to screen them very quick and then you segregate who are exposed and who are not exposed so then you focus on those exposed people because it's usually, it's less than 10 per cent. If 100,000 are exposed, it's usually down to 10%. You need to have some screening so that's what we are planning to do. We are developing a lot of novel biomarkers for radiation exposure, which will work complementary to the dicentric [crosstalk 00:14:39]

Jenna: That's great. I can imagine if you think you've been exposed, your emotions are running high, you want those tests results back pretty quickly, but you want them to be correct, so I can

Dr. Balajee: One problem we always have to deal with is the psychosomatic illness. So, if the people are not exposed when they think they are exposed, so they have all kinds of prodromal symptoms, so they have nausea and vomiting. When you think psychologically, you are exposed, you develop all kinds of these symptoms. When you do the biodosimetry, using cytogenetic assay so you can relieve them of their anxiety. "You are not exposed, you are fine". That way, it helps.

Michael: You mentioned screening before the assay and other things, you do a lot of research in this area, not only to improve the process but of the impact of radiation in general. Talk about some of the research that you've done and that you're doing.

Dr. Balajee: Yes, absolutely. I must thank ORAU for such a program. I mean, that is a great program. I really appreciate and I got the [inaudible 00:15:52] award fourth time, ever since it started in 2015. So, it's really great. It gives you enough funding to try out new things and once you get good results, you can actually seek for some more funding from many federal agencies like DoD, or NASA or something. It's really great. One of the project, which I always talk about, Dr. Abelquist also mentioned about this. This is about the bioprinting of human tissues.

Michael: Right.

Dr. Balajee: So, this work we did in collaboration with Florida Institute of Technology, Dr Huang Yong. He is my collaborator. We recently submitted a proposal to NASA, using this bioprinted tissues to assess space radiation induced healh risks. This technology is not entirely new. It has been going on for the last four or five years and there are a lot of pharmaceutical companies. They do all the bioprinted tissues. So, it has got great opportunity. I have to tell you that we have so many different organs and tissues in our body but, some of them are more radiation sensitive than others.

Michael: Okay.

Dr. Balajee: When you are exposed to radiation, those sensitive organs will be affected much more than the resistant ones. For example, our skin is not as radiation sensitive as the lens of the eye.

Jenna: Oh, okay.

Dr. Balajee: So, people do get cataract. We have done on mice and also other animal model systems, when we expose the animals to radiation, they develop cataract and the cataract has also been reported in some of the astronauts after their space mission. So, if we develop a bioprinting for the lens of the eye, for example, so we can study what causes cataract. So, why these cells are more radiation sensitive. You can understand the molecular basis of it or the mechanistic basis. Why is [inaudible 00:18:01] organs more radiation sensitive. The DNA repair is compromised in those tissues so they suffer more damage, are not able to repair those lesions or damage, whatever. So, this bioprinting technology really is going to help us because you can actually do bioprinted tissues for our heart, our liver, our kidney, any organ you wish for and you will radiate so these are three dimensional that is similar to other tissues in vivo, like in our body, so we can actually study the response, so what are the signaling mechanisms, how radiation causes damage and what leads to tissue degeneration.

Astronauts, they also suffer from cardiovascular misfunctions. Thickening of arteries and so they have all kinds of cardiovascular problems and also neurodegeneration, cognitive impactment and they are also floating in air in space so there is zero gravity so this is microgravity affects are far more deleterious because you are hanging so your fluid distribution is different. You are standing or if you are floating, so there is a fluid redistribution that also adds up to radiation effects. The radiation effects are pretty different under zero gravity or microgravity. You can address all of this by using bioprinted tissues.

Michael: Okay.

Jenna: That is so cool.

Michael: That is. It's fascinating. You don't think about... who would have thought about fluid distribution. It makes logical sense, obviously.

Jenna: Perfect sense.

Dr. Balajee: [crosstalk 00:19:40] They do this in international space stations, so they actually simulate, so it's all really fascinating.

Michael: So, is the goal of having the 3D printed tissue to help figure out how to mitigate those effects, ultimately?

Dr. Balajee: Yes. The ultimate goal is how you can mitigate the radiation effects. That's what it is. You can also use this for drug discovery. So, our novel biomarkers. We need novel biomarkers to predict the early and late effects of radiation. For example, for the heart, for the brain. If you come up with some protein biomarkers, which can predict the dysfunction of that organ, you can seek medical attention.

Michael: Got you.

Dr. Balajee: And also for developing novel radioprotectors, for example. So now, the mars mission is in the future and in mars, the radiation is several folds higher than on the earth, so you have to protect the astronauts. That's why NASA is investing lot of money to find out ways to mitigate the space radiation effects.

Michael: Wow. That's incredible and we're part of that. That's so

Dr. Balajee: I'm really excited about many of the research avenues initiated in the CBL. We are also using cell phones as emergency dosing meters. I was talking about, you have to do a fast screening [crosstalk 00:21:16] people. Everybody uses cell phone and cell phones are almost tied to people so we can actually use the cell phones and then estimate the absorbed radiation dose from the cell phones and then you can segregate the people.

Jenna: Really? So you would test the cell phone to see

Dr. Balajee: Yes. Cell phone absorbs radiation. So, the Gorilla Glass, they call it, and also the resistors and capacitors you have inside the cell phones. They all absorb radiation, so you can actually detect the signal.

Jenna: Wow.

Dr. Balajee: They absorb radiation and then you can do electron paramagnetic resonance.

Michael: Oh my goodness.

Jenna: And then put people in different... separate them out to say you have maybe got a little bit more. That's super cool.

Dr. Balajee: People have done this on the nails. The finger nails and toenails and also the teeth, enamel. So, you can actually detect the radiation dose because they absorb.

Jenna: I think Dr. Abelquist talked about the boar's teeth [crosstalk 00:22:22]

Dr. Balajee: It's called EPR. The downside of EPR is it's not really sensitive so it has to be really high dose to gray and above and there is also a lot of noise [crosstalk 00:22:35] the background. But, once you're optimize, you can use the cell phones.

Michael: That's amazing.

Dr. Balajee: We have got great success using cell phones as emergency dosing meters. We compare actually the physical dosimetry by the cell phone by the biodosimetry by the DCA. It's really close.

Jenna: That's cool

Michael: That's incredible and that's happening right here. That's incredible.

Dr. Balajee: And again, thanks to ORAU program. Without the seed funding, we would not be able to do any of this, what I explained. That seed funding is really, really critical for us to venture into new avenues because you don't get funding to do all the pilot studies so the ORAU program really helps. They give you some money and then you do some work and then take this to federal agencies for further funding because you need a lot of money.

Michael: Right, especially for testing and for

Dr. Balajee: Yes.

Jenna: And that's ours too.

Michael: But essentially it's ORU directed research and development projects.

Dr. Balajee: Yes. ORU directed research and development.

Michael: And you've gotten funding for, as you said, for projects, for

Dr. Balajee: Yes. I got the funding for the four projects. The one is the recent one and the three in the past.

Michael: Awesome. Anything else that you would like to tell us about you, your work. We've [crosstalk 00:23:59]

Dr. Balajee: To be really honest, if I have to rank all the organizations I have ever worked for, ORAU is at the top of the list.

Michael: Excellent.

Jenna: That's good.

Dr. Balajee: I really enjoy working here. I am not just saying that. It's really fabulous. The employee empowerment is just really appealing to me because you have to motivate people, so if people are not motivated, they will not give you the best so you have to keep the people motivated all the time. They have to be inspired to do something. It's not like you come at 8 o'clock and then you leave at 5 o'clock and then you are not satisfied with your work. In that aspect, I am really lucky so I really love what I do and I hope that people at the CBL also feel the same way.

Jenna: I think that shows. We were talking earlier that you go down to the cyto lab and you get so excited about being down there because your excitement, the scientists that work down there are so passionate about what you guys do that it excites the visitors and I know nothing

Michael: It does. I'm not a scientist.

Jenna: I mean, you go down there and everything that comes out of your mouth, you can tell your super excited about it and just the passion is there so it's a fun place. If your in Oak Ridge and you ORU and you can get down there, you should go because it's not only talking to the people that work there but it's also, for me, the visuals. To seeing the chromosomes, it's gorgeous. I never knew that looking at chromosomes could be beautiful and it's a really cool experience.

Michael: We highly recommend it.

Jenna: Yes, we do.

Michael: Moments of inspiration. We're just going to go to the CBL.

Dr. Balajee: You can edit this, but [inaudible 00:25:55] at the CBL, the one downside, I feel on my part, is I keep the people for too long.

Jenna: No.

Dr. Balajee: Beyond the scheduled time. No, No, we have to go, we have to go.

Jenna: Well, I would rather the excitement. I would rather be overly excited than underwhelmed.

Michael: Than not. Exactly. Exactly. Dr. Balajee, thank you so much.

Jenna: Thank you for being here.

Dr. Balajee: Thank you, Michael. Thank you, Jenna, for this wonderful opportunity so I can really express myself today.

Michael: We appreciate it.

Jenna: All right.

Michael: Thanks, everybody.

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