Podcast with Ulrich Krull recorded December 16, 2016 transcribed

Carla DeMarco (CD): You've been conducting bioanalytic research and development of molecular diagnostics technology for biomedical and environmental applications and nanotechnology and fla-fluidics for bioassays and theranostics…?

Ugh. That's me stumbling through my first question to today's guest.

Nanotechnology, bioassays, theranostics? – This is like an entirely different and mysterious language to me, but, thankfully on today's edition, the inaugural launch of View to the U podcast, Professor Ulrich Krull, known around these parts as Ulli, helps to translate these terms related to his research, and how technological devices such as cellphones, but even more rudimentary material in the form of paper, factor in to his work.

[Theme music]

CD: Hello, and welcome to View to the U: An eye on UTM research.
I'm Carla DeMarco at U of T Mississauga.

View to the U is a monthly podcast that will feature UTM faculty members from a range of disciplines who will illuminate some of the inner-workings of the science labs and enlighten the social sciences and humanities hubs at UTM.

Ulli is a prof in UTM's Department of Chemical & Physical Sciences, he's one of Canada's leading experts in analytical chemistry, the AstraZeneca Chair in Biotechnology, and just an all-around prince of a guy.

Also, as UTM's current Interim Vice-President and Principal, he will speak to the campus's humble beginnings and the vision for its future heading into 2017, the year that marks UTM's 50th anniversary.

CD: You've been conducting bioanalytic research and development of molecular diagnostics technology for biomedical and environmental applications and nanotechnology and fluidics for bioassays and theranostics, and I just want to know, what does that mean? And can you explain it so that people, who aren't science people, understand it?

Ulrich Krull (UK): What it would mean to the average individual is, imagine going to your physician, going to the local clinic, and you have blood samples drawn, three bottles full usually out of your arm, and they come back later and tell you, well, you know, you're fine, or perhaps not because of certain markers and something happened between that removal of blood or fluid from you and the doctor telling you what the results are, and that's the area that we would fit into. What actually happens to those samples.

In a sense the way that analytical chemistry and bioanalytical as it would be called because it's applications to the life systems. How that's evolved is moving from, if you will, these tests that one would do. I think most people are familiar with the fact that you can actually do tests even at home now. Pregnancy kits have been around for a long period of time; you can do cholesterol tests, this type of thing. This all falls into the area of work that we're interested in, and that area of work is really one of trying to identify what kind of selective chemistries might exist to determine what markers could be found in a biological fluid. It could be urine, it could be blood, it could be saliva, whatever. But if you can actually find those particular markers and they can be linked to a disease state, or indication that perhaps a disease is somehow going to present, than you're into the bioanalytical sphere, the kind of testing that we're interested in.

Most of the work we do is not meant to be large scale; it's meant to be more what's called "point-of-care." Can you actually do it, for example, at the bedside rather than running to a central clinic and an analytical laboratory to do it? Can you do it quickly? Somebody comes in presenting a critical issue – a cardiac arrest, something like this. Is there heart attack? Are there markers, for example, associated with the rupture of blood vesicles and the release of certain enzymes from the heart tissues and things like that?

The kind of questions that we also would like to ask, they're going to move us to two different directions. One would be the idea of doing an analysis with very little laboratory resources, and the intention there would be screening. You could imagine you or I going to the doctor's office and simply being screened there instead of waiting for a lab to look at the results. But many areas of the world don't have laboratories, and many areas of the world are suffering significantly from the standpoint of various types of disease. So you can imagine a test kit that could operate, for example, in sunlight just visually that could actually get down to the concentrations and markers that would be the earliest warning for particular types of ailment, and give you the appropriate diagnosis in a resource-poor environment.

Those are very challenging issues, and one has to think about not just how the chemistry would be done – that's more the analytical, academic world. What kind of nifty, new reagents can you invent or find, and how can you put packages together and make them very sensitive. But you get into practical issues also. Is there any access to clean water? Is there any access to power? Sometimes the answer is "no."

What is interesting is that there is access, almost *always*, even in the areas that are the most depressed in the world that seem disconnected, to cell phones. And it's remarkable the penetration that cell phones have had. And so, would it be possible to create a laboratory around the electronics and the telemetry of a cell phone? And so those are the sorts of things we're working on in one capacity.

The idea would be to build colorimetric reagent systems that are amplifying on a very simple substrate that could be stored dry for months to years at a time, so we

take our chemistries, and the novelty in the chemistries that is because we're working in very small scale. Nanoparticles, as I laugh about nanotechnology, yes we've played around with nanoparticles but the concept there is not so much that nanoparticles are somehow unique, different, or strange, it's simply that scale provides you different physical phenomena taking place. It's hard to imagine a computer chip that we can hold in our hand and look at; it looks like a grey block of material. And if you shrank the material – don't worry about the wiring and all that goes with it – but shrank the material, down to the size scale of a few molecules, so it's *pretty darn* small. But when that happens, it can actually interact differently with the world. Light hits it, and light doesn't just bounce off its reflection, and gets absorbed and heated a little bit, but rather the light can be reemitted. So these little nanoparticles of the same material that you make your computer chip out of, they suddenly glow very brightly; they become coloured. And that intensity of the glow is a great way to mark whether or not some area is reacting – you can tag it on to a chemical compound and watch the chemical compound because it's glowing. But again another very strange phenomena that happens with these small particles is that they create an electric field around them.

You can imagine holding a bar magnet in your hand, and you know there's a magnetic field around it; you can't see it. But, if you sprinkle some iron filings around it, you get the field lines, that fun stuff. Well it turns out that these very small nanoparticles made out of semiconductor materials, they can absorb light, and when they do the electric field of the light that they've absorbed gets trapped on the nanoparticle and it creates an electric field around that nanoparticle. That means anything sitting near the nanoparticle can be interrogated, so the nanoparticle becomes, call it a scaffold: a surface that you can build things on. It's solid, and at atomic dimensions, it goes on for quite a distance, so you can build lots of chemistry on the surface. And once you've done that, that selective chemistry that you chose that can bring the target compounds of interest close to the surface so they bind and you can interrogate them with a very high electric field strength. What it does is it gives you sensitivity. Now you can start looking for very low concentrations of materials.

We put all of this onto paper substrates. So rather than working with fancy microfluidic devices, and trying to build these little micrometer-size channels and move liquids around, it turns out that paper happens to have the same size scale as the engineered microfluidics, in terms of the pore size. And paper, of course, allows you to drag solution along – it's called capillary action – but I think everybody realizes if you wet one end of the paper, the moisture goes to the other end; that's the wicking effect. So, in a sense, it's pumping fluid.

Our idea would be, well, can we at the front end of a piece of paper put in reagent chemistry that, for example, would take cells and open them, and can then the wicking action of the paper draw the materials of the cells through the paper through reagent chemistry that would allow you to separate out different components – proteins, nucleic acids. Let's say we have the nucleic-acid traction,

and it moves now to the detection elements, and now the detection elements they simply light up on the basis of the material coming through. And the last part would be, well, how do you actually see it? Our intention is to create amplification technologies and convert the chemical signature into colour, which means that you can now photograph it with your cell phone. And we have the software that decomposes the screen – the actual image you see on your cell phone – into spectroscopy data. We can actually look at the colour spectrum, and pull out different markers – red, green, blue, which is the standard palette that's used for colourization computer projection in cell phones. We can actually pull those different colours apart, and each colour can be used to determine something about the sample. The colours are either linked to selective chemistries or to background control samples so that you can actually calibrate the system.

And that gives you an opportunity to actually do fieldable work, in sunlight, using cell phones, which can connect you directly to a hospital that might be some distance away if you need interpretation of the data that can be done, all in a relatively resource-poor environment, because the resources you require they' re all built into this paper strip. That's a lot of fun. That wasn't the *goal* of the team. This is just an area we're working on because it is an interesting area for us.

The goal was to really understand the surface of a nanoparticle, and how one can build chemistry on that surface because ultimately it's possible for each of the nanoparticles to be designed, with fairly good reproducibility, to carry specific types of chemistry. And the chemistry I've described to you, as binding chemistry, you look for selective chemistry. What does that mean?

Well, let's say there's a marker of a particular peptide or protein, something that a cell has expressed in your body. We want to put something on the surface of the nanoparticle that can grab that. One of the more traditional ways of doing it is to recognize that our own bodies produce antibodies – you're suppose to recognize foreign invaders – and the complementary term there would be an *antigen*. Well, so if your antibodies recognize a virus, it's actually not recognizing the virus. The virus is a large package, but it's decorated with a membrane, well, really the membrane is decorated with proteins on the outside. So the antibody grabs the proteins on the outside of the virus, and then you can say 'yes, I've defeated the virus! I've grabbed it and got it out of the human system.' Well, the same idea, the antigen, as it's called, these proteins on the surface of the virus, they can, in a sense, be found in things other than viruses, in fact most proteins *can* serve as an antigenic component and you can find antibodies.

Our interest in the longer term is to do something that can't be done at all right now, and that is to go inside a living cell and *watch* the chemical dynamics, watch the chemical signaling processes in real time as it happens. And these nanoparticles can be delivered into a cell – they're so small they don't interfere with the cell – and you can sit there and actually watch the chemistry of the cell in real time.

The next step would, of course, be can you interfere with that process? If you watch the signaling of cancer, for example, and you see the onset of something dramatic taking place, would it be possible to drop a cargo off the nanoparticle? Remember it's a larger surface area, it's a scaffold; you can do many things on it, build different selective chemistries together. You could build a cargo-carrying system, along with that diagnostic system, and there's a name for that: it's called *theranostics* – therapeutics and diagnostics all rolled together.

So the question would be, can we build a nanoparticle that can actually detect what's going on in a cell? And then more or less, know what the cell state is because, of course, cells go through life stages also, and make a decision as to when to deliver a cargo. Deliver a cargo by a specific trigger, usually we use an optical trigger, to actually pull the cargo off and deliver a drug or a therapeutic, and then once that's out, you can actually watch whether or not it's been effective.

So, what we see happening, and the target we have for our group in, say, the next 5-10 years if we can do it, is to be able to take a biopsy sample, probably a needle biopsy from an individual, in the area of cancer, for example, put that into a cell-culture plate, and interrogate the specific cells because the challenge, in terms of medicine, is that each of us as individuals responds differently to treatment. This is where you get into what's called *pharmacogenetics*. The idea that our own genetic makeup is going to be, in a sense, something that determines the best *therapeutic* recipes for us. That's why, for example, *combination* cocktails of drugs have become so popular: they work well *together*, not just one at a time, but how do you know the right blend? How do you know the dosages? It would be a lot easier for a physician to work this out in a cell-culture plate, than to do it with you as the live experiment, injecting you with various things to see how you respond. So if we can actually do this in a culture plate it will then inform the physician of treatment regimes in terms of compounded therapies, in terms of moving various types of treatment forward. So that's the long-term goal if we ever get there.

CD: It's amazing, and I can't help but wonder, though, do you see it as the sky's the limit with this technology for various things, because you mention cancer, could it be Alzheimer's or any sort of disease or ailment?

UK: Yeah, and this is one of the interesting aspects of academia: people always talk about fundamental research and what good is it? Where is it going to go? It doesn't solve any particular problem. And that's true. I mean that's what fundamental, investigative research like that is about. But the issue here is that if one can understand *how* these things work, and we have a particular target in mind, but ultimately we're not going to solve this problem. There are other people in the world, *many* other groups interested in this type of thing. I don't think we're going to be the ones coming up with the solution. But by having these different teams, ours included, *asking* how this can be done, it's that learning process that gives you a sense of, well, what do molecules *do* at these nano-scales? How do they actually interact on a surface? One of the real challenges is if you stick a molecule on a

surface, the first thing it does is it *sticks to the surface*. Well, you might be saying I guess you want it there. But that's not obvious because if you want biological function it has to have that molecule that's stuck down, it has to have a certain structure and availability. If it folds over and touches the surface and gets stuck in some other confirmation, in some other shape, it can't do its job. How do you get around all of those issues? How do you get around the challenge of taking particles that were never meant to be in a cell even into a cell without destroying the cell or influencing it in a negative way? After all if you start, in a sense, stressing the cell you may not see what it is you want to see. There's so many questions, so many issues. And that's why it's a wonderful research topic. You can imagine, both undergraduate and graduate students – they have *plenty* to do, and, you know, it's very exciting for them.

CD: I can just imagine, as you say, everybody is sort of contributing to this piece of the puzzle, but it's fascinating.

So, I think you've sort of covered this but I think it's interesting to ask: what do you think is the biggest impact of your work?

UK: I think we've stimulated – and I should probably qualify why I say this – the biggest impact is usually judged by who's contacting you asking questions, who is citing your work in the literature. And in today's digital technology, it turns out to be *real* easy to track that down. Every publication you have will be registered in terms of who has referred to that publication in *their* own publications, and you get citation counts and you get a sense of that your impact is, and so on. So you can actually just print out a list of your published work, right beside it you can have a list of how many people are citing it, and you can pull up any one of those to see whether they're citing for what I'll call the good reason – they liked what you did – or the bad reason, they found a flaw and everybody's criticizing your work; you can also have lots of citations that way!

So of the good things that people point to, it is the fundamental. In a sense our group has tried to convey how significant this scaffolding concept is in terms of putting multiple concepts on a surface. Can you do diagnostics of multiple things at the same time? How do you assemble a *variety* of different selective agents? Can you, from that same nanoparticle, release material? After all if you are trying to release something at the same time that you're trying to grab something, aren't those two kind of orthogonal? They're going in different directions. How does one do that?

So a lot of the contacts, a lot of the citations we have, it really comes back to the fundamental. Very few people had thought about doing this kind of thing in paper, and how does one actually modify paper and use paper to do it? So we've shown how it can be done in certain ways, people pick up on that and do it in other ways and they *build* on that. We've shown how you can do this scaffold construction, putting down multiple things, get release and get selected binding. And people are now taking those ideas in their own directions and moving it forward. So, yeah, it's

been impactful, but more so from the standpoint of that fundamental discovery end of things.

[18:50 Interlude music]

CD: Coming up: Ulli talks about UTM and the vision for its future heading in to 2017, the year that marks its 50th anniversary.

CD: I'd like to switch gears a little bit, and talk about the time that you've spent at U of T Mississauga. And as I understand you've been on the campus for much of its 50-year history, having started here in the Chemistry Department in 1984, and since then serving in a variety of roles including Vice-Dean, Graduate, Associate Dean of Sciences in the 1990s, my boss as the V.P., Research a couple of years ago, and now as the Interim Vice-President and Principal, and I just wondered if you could speak to some of the changes you've seen, and also what you envision on the horizon for UTM?

UK: I can address this, but I'll do it in my own way – everything's compartmentalized, it's the only way I get through the world. There's too much data. I have to put it in bins.

If you take a look at the campus when I arrived here, there were two buildings, and, well, I guess, two and a quarter buildings – I don't know how to describe the student pub. It was basically a Quonset hut, a storage hut. You could see this kind of thing in World War II where they put up a sort of semi-circular shell to put planes inside it. They had decked it out pretty nice inside, but it *was* a Quonset hut. That was the pub. And I mention the pub first because, in many ways, a university, it's the people; it's not the buildings, it's the *people*. And the camaraderie you have, even that's secondary. It's actually the inventiveness of the people. The idea that you're working for common goals, that you actually have the concept of a loosely defined team. And that tends to find its way through in socialization. So the pub becomes a social point of connection of people. And that's a very valuable aspect. I wish we had more of that on campus. If I had to lament something on campus it's that we have not that much available from the standpoint of the social interactions that exist, and I'm sure that will come with time also.

But clearly moving from a population of what might've been about 4000 students to today's present 15000 students, with well over 20 major buildings on campus: yeah, things have changed quite dramatically. The one aspect, and I'll put this in another bin, is the issue of the community spirit that existed here and still does.

The campus here was built as an element of the University of Toronto but it was an experiment; it wasn't clear how this was going to work out. And the conceptualization by the government was that this would eventually become a stand-alone university. Of course the local municipality thought that was wonderful, and onwards it went. But the intention of the University of Toronto was that this

would be part of the University of Toronto. And thankfully, because we, as UTM, we really do gain a great deal of benefit in a three-campus system. The intention is for the three campuses to have some diversification, and in a sense, be symbiotic. Strength in numbers, but strength in terms of, if you will, a collaboration and the distribution of diversity that a unit like that can actually provide.

And so the issue from the standpoint of how we started was very small community, sub-critical mass in any particular field, other than perhaps areas like Biology and Psychology, which had larger numbers of faculty members. And the question in something in an organization like that is how do you actually compete at the international level? The University of Toronto sees itself as an international university, and rightly so: it's in the top 20 ranked, year after year, so it actually is there. And the question for this campus is how do we participate and contribute to that vision, that the University of Toronto is an internationally significant institution?

Well, when you don't have enough faculty members in any one department, then what you find is that collaborating with departments becomes *very* important because that's how you overcome the critical-mass issue. And that's the history of what was Erindale College became the University of Toronto Mississauga. It started off as a College in Arts and Science. The way it was structured was that students, to a large degree, couldn't even finish their degree here; they would have to go for their senior courses to the St. George campus. Clearly that's changed; you can do all of your work here with some outstanding people and outstanding resources. But that sense of interaction across the departments, that has maintained. And there's really quite a good sense of communication and collaboration across the campus.

It's the advantage of starting off somewhat smaller, and still being very concentrated and relatively small in terms of how the administrative structure works. We have much less in terms of hierarchical structure than they would on the St. George campus: we're on *one* campus, we have, in a sense, *one* leadership, there's one Dean and Vice-Principal, Academic, here, as opposed to what you'll see at St. George, simply because there are so many different divisions and faculties available; it makes things very effective here from the standpoint of communication and collaboration.

So when I sit back and reflect on what *was*, it was a challenge to actually maintain a level of international competitiveness. But that challenge: we rose to it and we did some pretty interesting things simply because you're crossing between disciplines. So Biology, Physics, Chemistry, Psychology, they could work together and create some, what I'll call, "*unique* opportunities" simply because of the nature of the people that were here and the pressures that were, in a sense, applied from the standpoint of structure.

Today, there are no such pressures anymore. There's critical mass virtually everywhere you look in terms of the number of people and what could be done. But

that *sense* of collaboration: that hasn't disappeared. That may be again because of an external pressure: the way that the world looks at doing university-level research that's going to have international impact; it's almost always looked at from the standpoint of being a collaborative experience across many individuals where real change is going to take place. A crass example would be, let's say we deal with global climate change. How do we address that? Well, it's not going to be *an* individual that solves global climate change; this is cultural. And that means you're going to have to have those that are involved in culture, as well as those involved in technology, coming in to actually deal with something like that. You need to have collaborative teams.

I think UTM is in a very good position for that because of the nature of how much interaction exists between the departments, and that willingness, that history of collaboration already being in place. So you're going to see some really exiting projects over the next few years. I'm going through the "visioning" exercise, happens to align with our 50th anniversary: what perfect timing, very appropriate. UTM is going to, in part, I'm going to describe it as "reinvent" itself. We've, in a sense, expanded with all these wonderful facilities and people largely because the province has realized there's a demand for increased enrolment, and this is largely at the undergraduate level.

So much of the investment here on campus has been for classrooms and undergraduate laboratories. Very little investment from the standpoint of research capacity, yet it's the research capacity that even the undergraduate students would like to become involved with because that's now described as what we call "experiential learning." What a wonderful way to learn about the world: by actually *doing* it, not sitting in a classroom having somebody *jabber* at you. But get into a laboratory, get into a library, get into an environment where, for example, historical artifacts exist, and *actually* do it on the ground, next to people that are professionals doing it for their own publications, their own work. That's how you really learn, and we'd love that experience for every student but what it requires here is much more investment in the research infrastructure. So the cultural change that will happen over the next few years is that UTM will be investing much more heavily in terms of building out research facilities that will encourage that type of interaction for students and faculty to be able to move ahead, and make this much more, if you will, the flavour of what the University of Toronto would describe itself as: an internationally significant, research-based institution with excellence in undergraduate and graduate teaching.

The plans that exist for UTM are, I'll describe it at two extremes: one is moving to a point of zero growth over the next, probably, 4-5 years at least; the other is a moderate growth, maybe up to something on the order of 17-18000 students over a longer horizon, maybe 6, 7 or 8 years out. One of the original plans that goes back some years, indicated this campus could grow to about 20000. So we have these different models. But all of this is predicated on what I'll describe as "smart growth." You don't just grow because you can grow; you have to grow in a sense to maintain

balance. And we've had challenges in that. We have students but we've been struggling to hire on enough faculty to keep up with the student numbers that are coming in. This is all carefully orchestrated in the sense that, yes, we have a good balance still of students and faculty. One of the interesting aspects of the university is that they like to work on the basis of, if you will, comparison numbers. And so the comparison number that would be used for student/faculty would be the student-faculty ratio. And in fact UTM, right now, sits as one of the poorest student-faculty ratios – those are the numbers that are bandied about.

What is interesting is that those numbers are based on the way that you count out the number of instructors versus students, and they deal with the numbers reflecting how many permanent people you have. It's not a reflection of whose actually in front of the students in the classroom. It doesn't actually reflect how many instructors there are per student, and so one has to look through statistics. And this is why we encourage our students in science 'have a statistics course.' You ask the right questions. Don't just take a number for granted but begin to understand where that number came from, and that there are other ways of measuring things. If you actually look at the number of instructors in front of the students, you'll find that the kind of ratio we have puts us, in fact, in a position at least equivalent to the Faculty of Arts & Sciences as it stands right now, and they're fairly well resourced, and we're in fairly good shape. So this issue of the student-faculty ratio is a little bit biased in the sense that somebody has taken a number at the very top, averaging everything together and said 'here, we can represent the entire campus on the basis of a number.' It doesn't work that way, clearly; one has to start digging into the details.

Now that said, what we want to do is move away from what we have as contractual instructors to instructors that would be here on permanent-base budget. If you will, the research-tenure stream people, the teaching-stream people that would be, in a sense, permanent. And that's the conversion that we're going through right now. So that's an investment that will happen over time, and it's one that we do very carefully because these individuals when they join the university we intend on them to be here for their career. They may chose, ultimately, to leave and go elsewhere, that's great, but we have to think of this as a hire for 40 years when these people come in, and remember there's no retirement age. So this is a long-term investment. And you're choosing people that you feel will flourish in this environment. And because they flourish, because they have that energy and that creativity, that's what makes the university: this is what I referred to earlier – it's the people that make the university. So *choosing* those people wisely, bringing the most exciting people – those that have the energy, the drive, the vision – that becomes important. And those that have the fit, because not everybody has the cultural fit either in terms of what UTM is versus another large urban, for example, centred university. If we do that well, than we'll be in good shape. And the intention right now – this is the plan for the 50th anniversary and then four or five years out, we intend not to grow the undergraduate student ranks. We would like that to level off. That will give us the opportunity to catch up in terms of conversion of, if you will, the temporary

instructors to the permanent instructors. And it comes at the perfect time because the demographics in terms of student demand from Ontario-based students, that actually is in decline; that was not expected. Ten years ago when all the expansion started, that was not anticipated.

But, in fact, system-wide across Ontario, year-by-year, there's at least 1 or 2% reduction in Ontario student demand, and that's expected to last until the early 2020s – whatever we call that now. So you're looking at a time horizon that could be anywhere between 6-10 years before it really starts moving forward again, and that gives us the opportunity than to just say to the government, 'well we're going to just level off, we'll meet our targets,' and we're not going to need to increase because there's no demand for that. And it just meets the system, the university system in Ontario collective decision. We simply don't need more space right now, but we need to rebalance after this very rapid period of growth that's been unending since it started with the double cohort, really, in 2003 – that sort of timeframe. So it's time to rejig, if you will, and solidify. But this gives us the opportunity than to say well we're going to do a different type of investment also. Timing is everything, and it just happening that all these things come together. We have a stabilization of the undergraduate enrolment, and we have still the opportunity to invest in the campus, to develop infrastructure, and hire individuals to rebalance, well, now would be the time to actually rebalance culturally and invest more into the research, which, of course, allows you to bring in even *better* people on a permanent basis because they come to your campus, they would like to have a career that is fulfilled through the research and the students that are available for that research. So it's a great time – 50th anniversary, couldn't ask for more opportunity lining up to move ahead to the next 50 years.

CD: An investment in research, being in the research office, I'm happy to hear that!

UK: Does it resonate with you?

CD: Very much so. But driving off of your point about people, I can't think of a better person to have at the helm for U of T Mississauga's 50th, so we're happy to have you driving the boat, Ulli.

But, I want to thank you so much for coming in today, and I think you've given us a lot of things to think about, and I think I understand nanotechnology a little bit better.

UK: Alright! Thank you, Carla. Now I'll leave one final comment also, and that's an invitation to the entire community to participate in the 50th. We have many events, some of them are more academic, symposia, this type of thing. But there will be many other types of celebration, and I'm hopeful that everyone will participate because it is a time to really reflect on all the good things that have happened here on campus, and importantly to start participating in what this campus can be. As we move through the visioning exercise, the next step, and the faculty and staff and

students will see this at the beginning of January, it's going to be to move to strategy. How do we invest to take us forward for the next decades? And we hope that the entire community will participate in providing suggestions and answers to what it is we can be. Thanks, Carla.

CD: Great. Thank you, Ulli.

[Wrap-up music]

CD: I'd like to take a moment for a quick word of thanks to a few people.

I would like to thank everyone for listening to today's show. I would like to thank my guest, Ulli Krull, for taking the time for speak with me and explain his work.

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