Special Episode – Ramu Ramachandran: The Chemistry of Success – Season 1, Episode 4

Amy: You're listening to Beyond 1894, a podcast where we hear from Louisiana Tech University scholars, innovators, and professionals on their personal journeys and the impact they are making in the world around them. I'm your host, Amy Bell, and my co-host is Teddy Allen.

Amy: So, Teddy, do you remember the last chemistry class you took?

Teddy: I do. I knocked over a bottle of sulfur in Mr. Anderson's class, and fortunately, we all had our safety glasses on. That was the beginning and end of my chemical career.

Amy: Yeah. Was that in high school?

Teddy: It was. And I can see Mr. Anderson just dropping his head and just shaking it and said, "God bless his heart. He's just not going to make it. He's not going to make it."

Amy: Yeah, I was never that great at science. But I did like chemistry because I was always pretty good at math, and there's a lot more math in chemistry, at least at the high school level. Like we had to do, we had to convert moles to grams. We had to balance chemical equations. And those are all things that I actually enjoyed doing, where all my other classmates really hated. And I think a lot of people at that age really wanted to be doing lab work. And I actually really didn't like lab work because I was clumsy, and because that just wasn't as interesting. So, but I didn't know that there is such a thing as computational chemistry or computational science at all. So, I think as a high school student, I would have loved to know that.

Teddy: I was just excited about the colors on the periodic chart. Remember those?

Amy: Yeah, the colors, yeah.

Teddy: Those were neat. Different things were colored different stuff. Computational science, not computer science, but it's the application of computing to scientific problems. And we've got some studs on campus who are good at that.

Amy: Yeah. So, Davy Norris is the chief Research and Innovation Officer for the research and innovation enterprise. He's going to be doing a couple interviews for this podcast. So Davy interviewed Dr. Ramu Ramachandran, who is a computational chemist. He is the Associate Vice President for Research, the Dean of the Graduate School, the director of the Institute for Micromanufacturing, and a TL James Eminent Scholar chair professor.

Teddy: And Ramu Ramachandran. They're going to... they're both doctors. They're going to tell you, one, how Rama got here from South India, which is a funny deal. He didn't plan it. It just kind of happened. You don't immediately get up in South India and say, "I got to get to Ruston, Louisiana by next Tuesday." You just don't do it. But the weird series of events, he got here, and these two guys are funny guys. And they're really smart guys. And they're involved in the CIMM project now, which is a $24 million project involving five Louisiana universities. And what they're doing is advanced science on manufactured materials, and is probably the most advanced in the world, is happening right here in our state. And they're going to explain to you how it's going to impact our region. Employers can't do research and testing on promising materials, but that's what this project does. And for instance, I'll say, this is the cheapest, most cost-effective thing for you to use to do that. That's what that's about. And the reason the state's invested and the universities invested is because hopefully that'll end up making the economics around here better.

Amy: For sure. So, let's go ahead and go straight to their interview.

Davy: I'm Davy Norris, and I'm here with Dr. Ramu Ramachandran. Ramu is the TL James Eminent Scholar chair at Louisiana Tech University, Dean of the Graduate School, and director of the Institute for Micromanufacturing. Good to have you, Ramu. Thanks for being with us today.

Ramu: Pleasure. Pleasure to be here.

Davy: Tell us a little bit how you get from, uh, Kerala in South India, uh, to Ruston Louisiana.

Ramu: That's interesting. I think most people will say that their life was a series of coincidences or accidents. That's not much different in my case. Uh, when I was growing up, my grandfather was the first, uh, physician with a Western education in my village where I was born. And so the expectation was I would go to medical school and take over his practice. I happened to grow up in a family that's full of doctors, so that was the expectation. And I followed that path, went through high school, and became a chemistry major because, A, because I met this chemistry professor who truly inspired me, and B, everybody told me you need to know chemistry to get into medical school. But as I completed that chemistry degree, I realized that I have no interest in going to medical school. And so then I looked at: what next?

Davy: You liked chemistry too much to go to medical school.

Ramu: That is correct.

Davy: And so, you came to Manhattan. The big apple. Very exciting, right. That had to be quite a move from Kerala to come to Manhattan.

Ramu: That’s right. So, there was another step in between, which then landed me in Manhattan, Kansas.

Davy: Oh, Manhattan, Kansas. That’s not nearly as exciting.

Ramu: Not Manhattan, New York. A little Apple. Um, I went to get my master's degree at the Indian Institute of Technology in Madras, now called Chennai. The city has been renamed. And that is, uh, one of the top places to go in India. Uh, especially for an engineering and science education. And so I was actually, I still maintained that I got in by a clerical error because the admission is based on an entrance exam, and they take the top 20% or something like that. So, I managed to get in, and I'm studying for my master's degree, and we had a visitor, an Indian fellow who had earned his PhD in the United States. He came, he gave a seminar about his work, and I was fascinated. And I asked him who his advisor was and whether I could go work for that same person. And he was from Cal Tech. And so, his advisor happened to be a man by the name of Rudy Marcus, who won the Nobel Prize in chemistry in 83, 84, thereabouts.

Ramu: Uh, so I wanted to work for Rudy Marcus, and I wrote to him, and he wrote back saying, “Sadly, I don't have a position in my group at this time.” He was politely saying I'm not smart enough to get into Cal Tech. Um, “But there is this brilliant scientist at Kansas State University that I admire greatly by the name of Kenneth K. You ought to take a look at him.” And this was before the internet, and so the only way to look at someone was to write to that person. And so, I wrote, and they welcomed me there. And that's how I ended up in Manhattan, Kansas.

Davy: That's a great way to get to Manhattan, Kansas. And then the question is, what do you do after you get there? So, you got your PhD there.

Ramu: I got my PhD in 1987 and along the way to getting a PhD, you kind of get a sense of, you know, who's doing what in this field. And so, I very much wanted to work for a certain professor at UT, University of Texas at Austin, uh, Bob Wyatt. And so, I wrote to him saying, “Can I come work for you as a postdoctoral fellow once I graduate?” And by my great fortune, he said, “Yes, you come on over.” So, then I ended up in Austin for two years, and at the end of those two years, I started applying for what is, what we call, a real job. I got two job offers. One was here at Louisiana Tech, driving distance of Austin, if you consider six and six and a half hours of driving to be driving distance. The other offer I got was in North Dakota. And so, I said, “No, I think I’ll go to Louisiana.”

Davy: Quite different. You need a whole new wardrobe to go up there. So, it's, it's interesting that the story of your path from Kerala to Ruston has some interesting relationships, personal relationships, that you reached out, and other people's relationships that helped connect you. And that was really important in the development of your work and your path here. And it seems like maybe you took that lesson and have tried to play a role like that here at Louisiana Tech.

Ramu: That's right.

Davy: And relationships with other faculty, young faculty, or with graduate students.

Ramu: One thing I recognized early on in my life is that receiving good mentoring can be invaluable. Um, provided you actually take what, what is good and, and uh, make use of it. So, I'm a great beneficiary of the mentoring that I've received at various points in my life. And so, having recognized the value of it and how much good it did to me, I tried to be as good a mentor to the faculty and students that we have here to the best of my ability. Yes.

Davy: So, your research interests, you're a computational chemist, computational material science. So as a chemist, there's not a lot of risk that you're going to blow things up or set things on fire while you're working because you're sitting at a computer. Now, you might overheat your high-powered computers, but you use these high-speed networks and high-powered computing networks to do your work. Tell us a little bit about that work, kind of how it was earlier in your career and how it's evolved.

Ramu: Right. Yeah. So, um, I became a computational chemist again by a series of accidents. Um, I was very clumsy in the lab. Um, so I did break a lot of things. So, at the end of my master's degree, once I finished my thesis, my advisor called me aside and said, “You know, you may want to go into computation. Clearly you're better at that than doing experiments.” The best advice I ever got, you know, this is what mentoring is all about. So, I, when I arrived at Kansas State, you know, that kind of directed my attention to where I wanted to go. And this person that I was directed to by Rudy Marcus at Kansas State, happens to be someone who did everything on a computer. And later on, I found out that he was even more clumsy than I was. Uh, so we were a great partnership.

Davy: Perfect match.
Ramu: Yes. So computational chemistry has evolved greatly over time. And so when I was getting my master's degree, and then my PhD, computational chemistry was all about studying small molecules at certain, some, level of accuracy because that's all you could do with the computers that were available at the time. If you wanted to study larger collections of molecules, you had to make some really bad approximations. That's the only way to even approach larger molecules. From there, as computing power grew, we are now able to look at materials, large collections of molecules, with enough accuracy, with enough sufficiently solid theoretical foundations, that we can actually trust the results. So much so, that these days, you know, we, most of the drugs that we take these days, most of the new drugs coming to the market, started their life on a computer, not on a lab bench. And most of the materials that we design now, with potentially industry applications, we test them on the computer first before anyone ever goes into a lab and tries to…

Davy: It's much better to make a mistake in your computer simulation, or find a mistake, than it is to find it in a real-world test.

Ramu: And Louisiana is blessed at least since the advent of LONI back in the early two thousands. LONI started out as the Louisiana Optical Network Initiative. It since has been renamed, at my suggestion, to the Louisiana Optical Network Infrastructure because it's no longer an initiative. So, uh, but that has been a tremendous blessing to computational science in Louisiana. Louisiana, as a state, has undergone a, what I would call a, revolution in computational science. And that's different from computer science. Computational science is the application of computing to scientific problems. Um, so thanks to LONI, now we have lots of high-performance computing power available, and because of the availability of the computing power, we've been able to hire some outstanding faculty who are studying all kinds of problems using computers. So as a discipline, computational science is one of our strengths in my opinion.

Davy: We have a PhD in computational analysis and modeling.

Ramu: That's correct. Yes, and we have produced a number of graduates. Many of them have gone on to tenure track positions at other universities. So, that is something we ought to discuss. In the biomedical engineering center, our Center for Biomedical Engineering and Rehabilitation Science, we currently have a project funded by the National Science Foundation to understand the behavior of the brain when it goes through epileptic seizures.

Davy: It's part of the national BRAIN initiative.

Ramu: That's correct. And that is a promising direction for…

Davy: Leon Isomedes. He's leading that work and other folks involved, Mark DeCoster and some other faculty.

Ramu: Terry Murry, Prabhu Arumugam.

Davy: And several universities collaborating with us.

Ramu: Two others. Medical school at Birmingham, Alabama, and University of Arkansas at Little Rock Medical School.

Davy: Does anything funny or surprising ever happen in computational chemistry?

Ramu: Well, there are, of course, lots of stories that go around various personalities that we, in the field, we all know. And when you go to conferences, there's always jokes about certain people. And um, but um….

Ramu: Well, personally, when I was at Louisiana Tech, I came to Louisiana Tech shortly after, uh, Louisiana Tech got a new president, which was Dr. Dan Reneau. I came here in ‘89, and I believe he became president in ‘88, maybe ‘87. So, he was a fairly new president. And, uh, as a new faculty member, you know, the president of the university was someone that, you know, was sort of inaccessible to me, anyway.

Davy: A celebrity.

Ramu: So, one day, I was asked to come to the president's office with the physics department head, Dick Gibbs, and to discuss a new degree program that we were proposing. And so, when I went to Dick's office and we were going to walk over together, Dick reached behind his door and grabbed a tie and put it on, and he said, “Where's your tie?” And I actually happened to have a tie in my office, but I'm not one of those people who wear a tie to work every day. And so, I ran back to my office, grabbed my tie, and I decided I'll try to knot this thing on our way to the president's office.

Ramu: And clearly, I couldn't do it without the help of a mirror. So, after several unsuccessful attempts, I said, “I forget this,” and I stuffed it in my pocket. And I don't know. Dr. Reneau, at the time at least, he was somewhat of a formal person. So, he noticed that I didn't have a tie, but Dick Gibbs did, and complemented Dick on, uh, “Hey Dick, that's a nice tie you got.” And I didn't want a…

Davy: Backhanded way to point out that Ramu doesn't have a tie on.

Ramu: I don't know what prompted me to do this, but I reached in my pocket and said, “I've got one, too”, and I pulled it out.

Davy: You brought a tie. That's a good idea. I haven't thought about that, but I should keep a tie around. I don’t wear a lot of ties, but you can bring it, even if, you know, if you're not wearing it. It sends the right signal.

Ramu: So, this was a time when most of the engineering faculty wore ties to work, but the scientists did not.

Davy: So, you've had your individual work. Tell us a little bit about, um, kind of the most rewarding part of your work, the most rewarding project that you've worked on over your career.

Ramu: So, um, I actually, I want to give two answers to that question. Um, one is a project that I worked on pretty much all on my own back in the early two thousands. My work back then was trying to understand reactions between atoms and very small molecules. In fact, basically the whole system consisted of three atoms, uh, and in some detail. And I was able to work out a new way of doing certain calculations, and it was fairly intense mathematical work. So, I sat and cranked through all the math myself, all the equations. And finally programmed it into a computer code and got some very interesting results. And actually, got some recognition from others in the field for doing that work. So that was very rewarding.

Ramu: More recently, I've, uh, about five years ago we had a project very similar to CIMM called the LA Sigma, the Louisiana Alliance for Simulation Guided Materials Applications.

Davy: So, another big multi-institutional project.

Ramu: That was the first of two major projects with which I have been associated. I was a Co PI of both LA Sigma and CIMM, both funded at $20 million by the National Science Foundation. So, for the LA Sigma project, um, I worked on one of the electrode materials for lithium ion batteries. So, every battery has two electrodes, positive and negative. So we were looking at one of those electrode materials and trying to understand how the chemistry of this electrode worked, and to figure out what kind of materials can be used in order to improve the capacity of the battery so that, you know, we don't have to charge our phone so often.

Ramu: And so that was a very rewarding project. We were able to make a contribution, provide some new insights into how the electrode material behaved, doing nothing but computation. And part of the reason it was so rewarding was we did this in collaboration with an experimentalist at Xavier University in New Orleans. And early on we…

Davy: The experimentalists actually got physical things in a lab that he's working with, not on the computer, right?

Ramu: That is correct. So, he came to us, and he showed us his results and says, "These results don't make any sense. We need to figure out what's going on here." And so, we thought, "Okay, let's find out what is going on." And we were able to actually find out what is going on. So that was extremely rewarding.

Davy: So, the capacity of batteries is a huge topic these days, right? And in so many different industries, but the one people might be most familiar with is for electric cars. And as we try to move to autonomous vehicles, the capacity of the batteries is such a crucial issue, um, to making these cars more marketable, and more suitable, and better performance. And that's something that over time, so many different areas of technology are advancing fast, but our battery capacity's kind of been slow in catching up. And it seems like, you know, everybody knows the solution is somewhere around materials. Where is that going? And is Tech involved in that in any way?

Ramu: We are. Uh, we are perhaps not as involved, um, as we were during the LA Sigma project. However, we still have people who have the expertise and very much interested in pursuing this direction. There are some very, very fundamental challenges and barriers to overcome, and most of that has to do with using lithium as one of the ions.

Ramu: Lithium is a pretty dangerous substance. It bursts into flames when exposed to air, which is a bad thing. And so, if your battery pack were to crack, you're in big trouble. Some, not that long ago, Samsung had these phones that spontaneously burst into flames. They had a little bit of a…

Davy: It was bad for business.

Ramu: So, packing a lot of energy into the current battery is not the answer to increase the capacity. So then what are alternate materials that we can use for these batteries that give us the energy that we want in the same form factor? At the same time, it can be reliably and commercially produced and distributed.

Davy: What's CIMM and what's so amazing about it?

Ramu: CIMM stands for Consortium for Innovations in Manufacturing and Materials. It is a five-year project involving five universities in Louisiana, funded by the National Science Foundation for a total of $20 million, matched by the Louisiana Board of Regents at $4 million. So, it's an overall $24 million project.

Ramu: Thirty-five faculty members distributed across the five campuses are directly involved. We offer seed grants to about 10 faculty members every year. So, there are more people who have been benefiting from this funding. Currently, about 80 graduate students in Louisiana are funded through this project, and they are, of course, doing research with us. So...

Davy: And this is some of the most advanced science on materials and advanced manufacturing taking place anywhere in the world. And, looking at how that can impact manufacturers and some of our biggest employers in the state and around the country.

Ramu: That's correct. Yeah. This is, uh, this project is aligned with the theme of the so-called Materials Genome Initiative from the federal government. One of the biggest challenges in materials and manufacturing is, you know: what materials should one use in order to get parts that meet certain specifications? And the choice of materials can be quite, quite large. Uh, but companies cannot afford to take the risk of trying things until they find something that works. So, there's a lot of fundamental research that goes into it. And our job at universities, especially with this funding from the federal government, is to do the testing and find promising materials that then can be translated into manufacturing processes.

Davy: So, this could be science that helps my iPhone stay intact whenever I drop it on the concrete, or science that helps a bridge be more stable and stay up longer without falling into the river.

Ramu: That's correct. And in this particular case, we are also interested in 3D printing with metals and alloys. And so if you want a highly customized spare part that you don't happen to have on the shelf, you know, you want to print something, depending on the specification for that part, we can probably recommend a material that will produce the part you want.

Davy: So, batteries is an important, relevant aspect of your individual work and some of your collaborative work. What are some other, uh, relevance to the man on the street or taught to the companies that are employing a lot of folks in our state and in our region, of your work? Or some of these, especially these big collaborative projects like CIMM and where that's going in the future.

Ramu: So, one of the things that we are studying right now has to do with the interface between metal and ceramic. Ceramic is simply a metal oxide. We might think of ceramic mugs and things, but basically these are metal oxides. And the reason we are interested in that interface is that, uh, in many cases, uh, many applications, you want the material to last longer, perform better. And it's been discovered by trial and error that a thin coating of a ceramic on a metal helps in several ways. So, you may remember when we were growing up, a transmission rebuild for cars was, it was actually a big business. Cars is, usually cars, the engine would still be good, the transmission would go out. That problem has been largely solved by putting a thin coating of ceramic on the gear wheels. Material science in action.

Ramu: So, GM can now offer, you know, a hundred-thousand-mile warranty on your drive train. Your suspension, and engine, and all other parts may break before the transmission breaks. So, we are looking at what makes good interfaces and bad interfaces. There are cases where the ceramic layer comes off, delaminates, and there are cases where it lasts a long time. So, if we were to change the material for the transmission, say from a heavy metal to a lightweight metal, how would you design a new ceramic interface that lasts on that material? So those are the questions we are trying to answer.

Davy: Ramu, thanks for joining us today. Thanks for the information, for the time, for the conversation, and it seems like you've got a lot going on, so you should probably get out and go do some of that now.

Ramu: Yes.

Davy: Thanks for being with us.

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