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PHYSICS

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Q: How did you become interested in research initially?

Dr. C: Well, I think from childhood I've had an interest in knowing things at a deeper level. For Christmas I would ask for strange presents. One Christmas I asked for a microscope, another I asked for a telescope, and another I asked for some types of laboratory experiments. My mom tells me stories like my dad had this little pocket radio. He retired one of his old radios and gave it to me so I took it all apart and tried to understand it. I am an experimentalist primarily; I do experimental research. I analyze things in the lab. It has been something in my personality from very early on. In college and high school when I studied physics I thought that was the most elegant thing and I decided to become more and more involved. I thought it was a great career to pursue.

Q: Where did you do your undergraduate and graduate studies?

Dr. C: I was born and raised in Brazil, so when the time came for college I was living in São Paolo and went to the university in São Paolo. That's where I did my undergraduate and received a bachelor's degree in physics. I also received a master's degree in condensed matter physics at the University of Sao Paulo and then I went to graduate school in southern California at the California Institute of Technology, and that's where I received my Ph.D.

Dr. Renato Camata

Q: How long have you been at UAB, and what persuaded you to come here?

Dr. C: UAB was very interesting to me when I came here to interview. Evidently I was looking for a job in 2000. After I received my Ph.D., I did a postdoctoral. I was a postdoctoral researcher for two years, part of the time in Japan and part of the time in Brazil. I was looking for a permanent position, like a tenure track faculty position. I interviewed at various places and what really drew me to UAB was, number one, the major diversity that we have on the UAB campus. UAB is really unique in terms of its diversity; not only racial diversity, but diversity in terms of the kinds of people that come to UAB: many different socioeconomic realities and many different nationalities. There are also evidently many different racial backgrounds. I need to be in a place like that. Places that are too homogenous are not exciting to me. That was one of the things. Another thing was the opportunity. I was basically given the opportunity at UAB to pursue any research in my area of specialty, which is nanomaterials. I was given the opportunity to pursue any research on the forefront of materials science or materials physics. There was no set agenda at UAB. Nobody said 'you must pursue these types of projects'. They just said 'look it's your expertise; you can do anything you want. You are just limited by your own creativity and potential'. That was the type of position I was looking for. I wanted to be able to pursue a new, fresh research program. That was another thing that brought me to UAB. I should add that I am very passionate about teaching. Many people have asked me 'you want to do research, so why don't you just work at a national lab or at a company?' I felt that giving up the teaching aspect would not be fulfilling, and I saw at UAB an institution committed to research, especially in creating opportunities for young people, and teaching them in a research environment. Teaching, to me, is not just in the classroom. The classroom is a very important component of teaching, but bringing, for example, undergraduates, into the lab and having them do experiments and actually see physics coming alive in a laboratory is also important to me. That was a third thing. You may or may not know that in the physics department we have a program called research experience for undergraduates (REU).

Q: Speaking of REUs, you are involved in the summer REU here at UAB, correct?

Dr. C: I am involved. For several years I was a co-principal investigator on the actual grant with the national science foundation. The principal investigator is Dr. Vora. Dr. Harrison was also with us. For several years I was officially involved at that highest level. Since last year, due to other commitments and other research directions, I am no longer a co-principle investigator in that grant. I am still involved in the program as a mentor. I mentor undergraduate students who come to the program. Every summer we have 15-plus undergraduates who start doing research, so no single faculty member can mentor all these graduate students; there's a very major commitment. Many faculty from UAB come and give their presentations to UAB students, and then there is a matching of interest. Students choose a project and thereby a research mentor to work with during the summer. So every summer I typically have one or two undergraduates who work with me in my laboratory here pursuing there research, so I continue to be very involved with that.

Q: How would a student get involved with an REU?

Dr. C: Our program typically starts in May, but we received applications very early in the year: January, February. The sooner someone sends in an application, the greater the chances of the student receiving an offer to come to UAB, though they can be UAB students as well. UAB students compete with students from across the country to get into this program. Applications can be found on the web site (http://www.phy.uab.edu/research/reu.htm)

Q: Could you give a basic description of your current research projects?

Dr. C: Yes. We have three major areas of research right now. One of them is in the area of biomaterials. We're very interested in materials composed of calcium phosphate. These materials are bioactive and important in cellular, living processes. Tissues, living cells, living organs, they interact with calcium phosphate on very fundamental levels. For example, calcium phosphate is the basis for the rigidity of our bones and structural, skeletal framework. The inorganic materials that cells use to build our framework are partially calcium phosphates. Of course, bone has more than calcium phosphates. It has polymers like collagen which behave more like plastic. Bone is a mixture of these calcium phosphates, which act more like ceramics, and collagen fibers. It is what we call a composite material. We are very interested in studying calcium phosphates and the atomic structure of calcium phosphates. X-ray diffraction techniques help us understand the atomic structure of calcium phosphate and how that can be manipulated. That's one area. It has applications in dentistry and production of new bone tissues. We have another set of projects in semiconductor materials. One of them that we're very interested in is a material called zinc-selenide. These materials allow for the generation of very efficient laser light in the mid-infrared. It's not a wavelength we can see, but there are many technological applications that require very compact, very small laser sources that will emit light in the mid-infrared. There is also a great need for sensor, detectors of light in the mid-infrared. These materials, the zinc-selenide semiconductor, when we engineer them properly by adding certain impurities, particularly chromium impurities, emit light in the mid-infrared. Through some careful engineering design, we get them to emit laser light that can be used for very compact sources, for examples, to detect dangerous substances. This has applications in detection of chemicals in laboratory settings, in medical diagnostics, or in homeland security. In the third area, I am very involved in the fabrication of nanoparticles. One material that we make is zinc-oxide nanoparticles. We're very interested in how these materials can be produced and how they interact in the gas phase. These are produced by vaporizing solid materials and getting them to condense as extremely small droplets that are on the nanoscale. Each droplet will have between a hundred and ten thousand atoms. We study how these droplets aggregate, how they collide in the gas phase, and how we can use them to make devices that detect light and emit light for use in sensors.

Q: What are some possible future applications of these projects?

Dr. C: With the biomaterials, a classical example would be orthopedic implants. It is not uncommon for people who have accidents to have a big trauma, such as a fracture, that cannot be repaired, unless you put in a metallic implant. This is true particularly for the elderly. People who are more advanced in years, for example, tend to suffer falls and fracture their hips. It is very difficult to repair them. The only way to repair them is to insert a titanium implant to actually replace the hip. This is what people call a total hip replacement. Sometimes it doesn't have to be a trauma injury; sometimes people have degeneration of the articulations, which become extremely painful. These implants are typically made of a strong metal, like titanium for example, which is at the same time strong and light. You want to be able to put these implants in there and have perfect integration between the implant and the bone. These things are a little bit different though. Our bones are not made of metal. So one application of this is taking a metal implant and applying a coat of these biomaterials, which are more similar to bone than the metal itself, and that kind of cloaks the implant in this bone-like material, which tends to improve integration of the material with the bone tissue. One problem of the implants is that they typically don't last forever. So if a person, especially an older person, has a hip replacement, you wouldn't want to have to replace it ten years later. You would like it to last for the lifetime of the person. So one thing that we're working on is improving the lifetime of the device. Usually they last 10 to 15 years, but we could get them to last like 30 years. That's one thing. We're also very interested in developing bone tissue. It would be ideal, instead of having to put a piece of steel or titanium to repair a bone, if you could repair it with the bone itself. The problem is that it's very hard to do that. We can't grow bone yet, but we are working on projects, we have a project now, collaborating with biomedical engineering. I produce calcium phosphate nanoparticles and he produces organic fibers that when combined, create something that is a mimic for bones. So in the laboratory we're trying to grow these bones, or at least the organic and inorganic framework where we can then put the cells on and have them do the remaining job of growing the bone.

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Q: How many scientists work in this laboratory?

Dr. C: The way academic research is organized, each faculty involved in research has a research group. I have my own group including myself, graduate students, and undergraduate students. On any given moment, we tend to have between 5 and 7 people involved in our group. There are larger groups that include postdoctoral researchers as well. In this building there are four groups working. Right now on this floor we have probably 15 people working. Not everybody's here all the time.

Q: What advice would you give to undergraduates who are considering research as a career?

Dr. C: Get your feet wet early, because there are lots of things to learn in research. I think a research summer experience would be an outstanding way to get started. An REU program during the summer is well structured and well programmed so you have a very productive experience. Second to that is involvement during the academic year. I would tell students to come to the school of natural science and mathematics. We in the physics department are very interested in students who want to do research. We also have the department of chemistry and the department of biology, computer science, mathematics, etc. Knock on doors. Touch base with faculty. Ask their instructors who they can do research with and what are the interesting projects that they have for research. I would say also start simple, with not tremendous ambitions in the beginning, but get your feet wet. The transition between the classroom to real research is, of course, a big one, so the sooner a person gets involved with the excitement of research, the better.

Q: A lot of natural science and mathematics majors tend to be pre-medical students. Would you still suggest research for undergraduates who are maybe looking toward a clinical career as a physician or a dentist, or would you think of it as less important for them but more important for people who plan to pursue a Ph.D.?

Dr. C: I would say almost on the contrary. People who are going to pursue, say a Ph.D. in physics, they will do research no matter what. For them, even if they delay they will get into research. Now a person going into a medical career may not have that opportunity, so now is the time for that person to learn a little about research because that will have tremendous benefits for their medical career. Let me give you an example. One day someone will be an orthopedic surgeon. Wouldn't it be beneficial for that person to have actually learned about the materials? That could actually make him or her a better surgeon, a better physician. You know, when you get to medical school, you have a lot of things to learn, and they have to stay in the mind. You know, it's a lot of learning about facts. I think it is very beneficial to have had an opportunity to actually learn about the world of research, where it's not so much about learning the facts that you're going to need, but also thinking in a structured way, where there is no pathway. You have to come up with your own questions and your own answers. Of course on the undergraduate level, mentors will guide you through that process.

There is another added benefit here. Many of the tools that physicians will use in diagnostics, in surgery, in treatments, are based on physics, chemistry, and biology techniques that when you are in medical school you don't have a chance to learn. Now is the time to learn about something like X-ray diffraction, which will teach you about the structure of nature, which may actually give you great insights in the future when you have to use similar techniques. In the area of nanoscience and nanotechnology, there will be many treatments in the future that will be based on nanoparticles. This is the time for an undergraduate to learn about what a nanoparticle is. How are they produced? Why are their properties so different? Why are they used? All of these things are basic research questions that an undergraduate student involved in research will learn. If he or she goes later into a medical career, this is all strong background that they will carry through their lives.