INTERVIEWER: This is an interview with Dr. Sangeeta Bhatia for the MIT 150 Infinite History project. Professor Sangeeta Bhatia is the John and Dorothy Wilson professor of electrical engineering and health sciences and technology. She joined the MIT faculty in 2005, and her work focuses on tissue repair and regeneration using micro and nanotechnology with a specific focus on developing improved cellular therapies for liver disease and cancer nanotechnology. Among her several advanced degrees, she earned her Master of Science in mechanical engineering and a PhD in medical engineering here at MIT. Thank you for speaking with us, Professor Bhatia.

BHATIA: It's my pleasure.

INTERVIEWER: So let's get started by talking a little bit about your background in terms of your upbringing, your family background, and where you're from.

BHATIA: Okay, well, I was born here in Boston and my parents came over from India in the '60s. And they were actually originally refugees at the time of the partition of India and Pakistan in 1947. And they made their way over here for a better life, for higher education. And they really encouraged me very early on to pursue math and science and just reach for the stars.

INTERVIEWER: And their status as having been refugees, what did you take away from that? What lessons did you learn from your parents and their experiences?

BHATIA: Well, I think they really believed that education was an important part of success in life, both to open your mind and to achieve the lifestyle that you want for you and your family. And both of their families really believed in the education of women, which was somewhat unusual at the time, my mother was actually one of the first MBAs in all of India.

So they were always happy and encouraging of us to pursue the very best education. They also were very resourceful as a result, and very hard working, and believed a lot in entrepreneurship. My father was a serial entrepreneur, is a serial entrepreneur. And so they always thought a little bit outside of the box and really encouraged me to take risks, not always follow the rules.

INTERVIEWER: And what was your father's early educational training?

BHATIA: So he's also an engineer. And he then went on to study business. And he was the one actually who saw in me that I should be an engineer. And I think I didn't realize when I was in high school what an engineer was. And that's so common even nowadays. You don't here in the dialogue of school children-- at least American school children-- that they'd like to be engineers. They don't really have, I think, a strong sense of how much engineering impacts all of our lives.

That it's inside your smartphone and the rocket to the moon, or whatever new gadget that they're playing with. They don't think about the engineering behind it. And I certainly was the same. So when my father suggested that I be an engineer, I took it obviously into consideration. But I think I didn't even know what it was until I was halfway through my engineering degree.

INTERVIEWER: And what subjects early on interested you in school that you remember? And did certain courses stick with you?

BHATIA: So I really was struck by my biology class in ninth grade. It really captured my imagination. And I had always kind of also been good at math. And my dad was, as I said, a really involve parent and had been reading about this new field of engineering meets biology, which was bioengineering. And that sounded like a great combination to me. I wasn't quite sure what it would mean. So to make it more real, he actually brought me here at MIT to the mechanical engineering department.

There was a professor here at the time in the '80s named Professor Lele. And he was a mechanical engineer who was using ultrasound, focused ultrasound, to heat tumors for cancer therapy. And that really captured my imagination as a teenager, the idea that you can make machines, make instruments that could affect patient life. So that got me started.

INTERVIEWER: And w did this idea come about, your father taking you to MIT? That's a pretty amazing opportunity for a teenager.

BHATIA: Yeah, I think he and my mom both really took our futures on as kind of a family project. Let's find out what you're good at, what you love, how you're going to make a difference in the world. And he had a friends who was here and brought us here.

INTERVIEWER: That's amazing.

BHATIA: Yeah, I think I'd say it's really, looking back on it, really so instrumental in me finding my way.

INTERVIEWER: And do you have even earlier memories of this interest in science developing? I know there's a funny story about you as a child and the family answering machine?

BHATIA: Yeah. So there is a funny story about how I was always the family tinkerer, and I liked to take things apart just to see how they work or to try and put them back together. And at some point in my childhood, our answering machine broke. It was the old answering machine with an actual tape in it. And I took it apart and fixed it and put it back together and had a few parts left over. And I think ever since, I've been known as the family tinkerer.

INTERVIEWER: Were your parents impressed with your early skills?

BHATIA: Yeah. I think they've always been just really, really supportive and really big fans in general. And we were raised, my sister and I both, with really high expectations. We were supposed to be the best. And if you've got a 96 on a math test, then what four did you get wrong? So they had high expectations of us, but they were also really encouraging. So I think they didn't say that they were impressed, but they were impressed.

INTERVIEWER: Were those expectations hard to deal with? Or did you already understand from your family's tradition of higher education that this was just what you did to push yourself to excel?

BHATIA: I think a little of both. I think my sister and I grew up knowing that a lot was expected of us. And we had the natural teenage rebellion. So my version of that was my junior year in high school, I wasn't happy with my dad's response to my report card. And I decided not to show it to him anymore. And I remember sitting him down when I went to college saying, okay, this is the big leagues. A C is average, trying to prepare him for the next phase. But we were always seeking their approval for sure.

INTERVIEWER: Who were some early teachers or mentors who influenced your academic, and even your later professional choices, do you think?

BHATIA: Well, as I said, certainly my father was very encouraging. And then also my mother, she was a real rebel in many ways, as I mentioned. And then, when I was in college, I met a physician name Moses Goddard. He was doing research in one of the laboratories that I was volunteering in. And he was the very first person to say to me, you should consider getting a PhD.

And until that moment in time, it literally just hadn't crossed my mind. It wasn't part of my family experience. It wasn't in my life plan. I was going to get a Master's degree, and I was going to work in industry.

And in that moment, I didn't grab onto it that it planted the seed. And years later, it would come up again. And I would realize that it was the right path for me. So he was one of several people in my life who saw more in me than I saw in myself. I think you really need those people to push you.

And the next one was Mehmet Toner, who was an agency faculty members, is also an MIT alum, and he was my adviser when I was here at MIT. And he was the one who encouraged me to be a professor, actually. And again, it was something I just hadn't even considered. And as I was graduating, he said to me, you should think about it. And he's still a great mentor to me, actually. I just saw him yesterday.

INTERVIEWER: It's nice to keep those relationships going.

BHATIA: Yeah, it's really wonderful, as I said, to have people believe in you more than-- see more in you than you see in yourself.

INTERVIEWER: And you obviously have an incredibly impressive academic record with multiple advance degrees to a postdoc training at Mass General Hospital. Obviously that drive came largely from your parents. But what did you learn about yourself with each achievement as you went through your illustrious educational journey?

BHATIA: What did I learn about myself? I think I learned-- I became more comfortable in my own skin as I advanced in my career. I think in the beginning, a lot of my achievements were laced with wondering if I could do it, if I belonged, if I was good enough. And at every level, I was pushed to the limit, especially coming here to MIT. You find yourself amongst more and more elite circles of people, the best and the brightest.

And realizing that you could do it, and that you could achieve, and that you can arrive at the top of the class, I think gave me a level of confidence, just being comfortable in my own skin, comfortable with my ideas. So that now, I feel confident when I have a new idea if I'm in a room full of people that are brainstorming, or if I'm advising a student about which direction to go in a project. I think the confidence that I bring to science comes from the sequential achievements.

INTERVIEWER: And what made you want to include MIT in that stellar list of schools that you chose? Was it that early visit in high school that always stuck in your mind? Was it even earlier that you thought that was a place where high achievers go?

BHATIA: Yeah. I think-- it is hard to place how MIT comes into one's consciousness. I think having grown up here in the Boston area, I feel like I knew about MIT. I can't remember a moment when I didn't know about MIT and thought about it as the pinnacle of technological innovation and the place that you would go. I think I always thought that I would come here for my graduate training.

And I think what I didn't realize as an outsider was that the amount of entrepreneurship that also goes on here and how much time and energy we all spend taking our inventions out into the real world. So I knew that it was a place where there was a lot of excellence and a lot of really smart people. But I didn't appreciate all the elements of the environment that I do now.

INTERVIEWER: And was there anything else about it that was a surprise once you came here versus the mythical perceptions that you had being a Boston native?

BHATIA: I think that we all have perceptions of what it's like to be in a place of such excellence. But the magnitude of the energy and the passion and the round the clock work culture, you can't-- there's just no way to perceive that from the outside. You really have to live with this sort of density of great ideas and great minds. It's really impossible to appreciate from the outside, I think.

INTERVIEWER: And you mentioned that round the clock work culture, which MIT is well-known for. How much of that was a culture shock to you as a student? I've read there was a little bit of surprise over the 3:00 AM Saturday nights here. But tell me what that was like and how tough of an adjustment that was early on.

BHATIA: So I think that one thing that a lot of us go through trying to decide whether we want to choose this as a profession, whether it's science, or engineering, or a technological innovation, is looking at the profession and deciding if it's the right to life for you. So whether it's the right way to make the biggest impact, as well as all the other pieces of the life that you envisioned for yourself.

And so when I came here, I think part of my journey had to do with trying to figure out how-- if I could still be the best, if I could still be the top of the class, and have the life that I wanted. So I had a moment where I came in to do an experiment, to feed myself. My liver cells needed daily feeding. It happened to be 3:00 AM Saturday night. I'd been out. And I walked into lab. And it was literally full of people. It was 3:00 AM on Saturday, and I had this moment where I thought, uh-oh. I don't think that this is something I want to sign up for permanently. I want to be sleeping at 3:00 AM on Saturday night.

So I had to make this decision about how science and engineering were going to fit with the life that I wanted. And what I decided was that I was willing to give a lot of myself to the profession, but not to give everything and to hold a piece of myself for me so that I could have a happy life and a balanced life. And I think that was a really important decision for me because graduate school and actually all of life in science is really a marathon. And you have to figure out how to sustain yourself and your spirit. So for me, that was a really pivotal moment to recognizing how to not give everything, not to be depleted.

INTERVIEWER: And having made that realization, which probably more people wish they had, did you ever have a moment where you thought that decision either cost you a breakthrough, or some achievement, or some extra level of success that you would have had if you spent all weekend in the lab?

BHATIA: I think it is true actually that you give up things. And I think you just have to decide. You have to prioritize. So I went on sabbatical a few years ago and thought about, what are the things I want to achieve in the next seven years? And I realize that it's really not, for me, about the awards and the academies. I think those are wonderful and important parts of science and engineering. But for me, I really care about touching patients.

So I want to make inventions that have a clinical impact or have a technological impact. And so coming back from a sabbatical, I decided to spend time on things that maybe aren't always as visible in an awards or publications perspective. So for me, it's about starting companies or training the next generation of students, or inventing something that inspires a new field. And those are intangibles.

But for me personally, they're more motivating. So I do think that if you're not willing to travel 200 days a year and stay up every Saturday night that you give up some the awards and some of the publications. And I think the time that you are willing to commit to your profession, you have to just really focus on the things that you think are going to be meaningful for you.

INTERVIEWER: And the decision to focus on some of those more intangible goals, how has that been received here at MIT?

BHATIA: Well, I think MIT actually is a really broad minded in what it values. We have all kinds of impact here. If you look across the campus, there's basic science impact. There's media labs. There's software engineering. There's global health. So I think that it really is pretty resonant with the value system of the campus, not necessarily the academic community internationally. But I think that the MIT ecosystem really does value impact. And if you think about what makes us respect another colleague or student, it may well be, oh, he or she started this company, which has now touched 20 million lives, even if it was never a publication.

INTERVIEWER: You were receiving your advanced degrees in the late '90s. What was the climate like-- even though it was very recently-- for women pursuing advanced degrees? Were there any remaining hurdles that you perceived for women even as recently as that era?

BHATIA: Yeah, I would say so. I think that there was a smidge of bias I would say that I experienced. My very first day here at MIT, actually, I was in thermodynamic. And before class started, my professor came up to me and asked me if I was in the right class. And I think he was surprised to see me there. There was only two women in the graduate program in mechanical engineering. I think he didn't mean it maliciously. But it made me feel uncomfortable and conspicuous. And I think it really wasn't that long ago.

There were very few women faculty. Nine percent of the School of Engineering faculty were women. And we've made a lot of strides since then. We're up to 16 percent, which is great given a short time. But I didn't have a lot of peers. I didn't have a lot of professors to look up to. So the climate was, I would say, chilly. I've gotten used to being "the only," the only woman, the only non-Caucasian, the only engineer over the course of my career, so I don't feel it so much anymore. But especially when I was training, I worked hard to overcome that feeling and proves that I belonged.

INTERVIEWER: How do you bridge some of those gaps other than just your sheer impressive achievements? Is there a networking aspect to it, or trying to foster, get more enmeshed in the community somehow? How hard is that?

BHATIA: Yeah, that's a good question. One thing that Nancy Hopkins and her colleagues have done working with the administration is really set in place a lot of policies and procedures to make it part of the fabric of the institution that women are included in decision making and are part of important committees, that they always get interviewed in proportion to the number of available candidates. And those kinds of really systematic policies and procedures are, I think, a really important part of getting more women into the system.

And I think they say that critical mass of women in any institution, which is around 30 percent, actually makes that feeling of isolation go away. We haven't reached 30 percent yet. But I think we are approaching that. And certainly at the undergraduate level, we're already there.

INTERVIEWER: And we talked about the intensity that you found when you were here in your graduate work. How intense do you find the coming as a faculty member? Was there a similar level of pressure and competitiveness?

BHATIA: Yeah, I think so. I was thinking about this earlier. There's this saying that you've probably heard from many of the folks about getting an education at MIT is like drinking water from a fire hose. And I certainly experienced that as a student, absolutely felt the full pressure of the fire hose and was so proud of myself for surviving it.

And I would say now, as a faculty member, I'm addicted to the fire hose. So you skipped this part of my bio that I went out to California to be a junior faculty member and then came back. And I think it's because there's really no other place like it. You just can't step away from the kinds of ideas, and excellence, and energy, and passion that exist here.

INTERVIEWER: We're glad you came back.

BHATIA: It's great to be back.

INTERVIEWER: Back to the work life balance. And you've found a good balance. How much added pressure is there being in a male- dominated field to not take the personal time, or not focus on that balance? Is that just another added layer of pressure?

BHATIA: I think it depends on your career stage. And not so sure how much there's external pressure at least at the moment. I'm sure there has been historically. But I felt-- I think when I was younger, when I was not tenured and not here at MIT, I think I felt like I was being judged for how hard I was working because I hadn't yet accomplished very much. I was just getting started.

And now, I think, being established, I feel like I can be judged for my accomplishments. And how hard I'm working, or whether I have children, or how much I travel for work, I feel like it's not really relevant. So I don't feel a lot of pressure to do more of that. I feel pressure to continue to make an impact. But it seems to me that no one really cares how I get there. So if I felt like I weren't funding my lab, or I weren't coming up with new ideas, then maybe, I think, it would matter more.

INTERVIEWER: And how did you end up back here as a faculty member in 2005? When you went to California, had you always planed in the back of your mind to come back when you left here as a student? Or did you only realize what you were missing when you were on the West Coast?

BHATIA: I think a little of both. I never really thought I would stay in California because I'm a New England baby. My husband is from Toronto. And I think we always envisioned raising a family on the East Coast. My family is still here. So I thought I would come back.

So California was always an experiment. You don't realize what science is like elsewhere in the world until you leave. So I did miss it. And it was a real draw. You see these maps sometimes where they show that Cambridge is the center of the universe. And I think intellectually, if you train this environment, that is actually how you see the world. And I absolutely felt that way.

And I think California, what I found is that I had an amazing time. But I felt like I would eventually plateau in my intellectual growth. I had sampled a lot of the environment. I had amazing colleagues. But I had gotten so used to be here where you could learn every moment of every day and never ever be saturated. Your ability to take it all it is the only thing that would ever limit you. You could walk down the hall and see 100 interesting talks at any given moment. And having trained here, I'm just addicted to that.

INTERVIEWER: And how much did it mean to you-- you mentioned how early mentors often believed in you more than yourself. And then, you would finally come to that realization. How much did it mean to you when you got that first teaching position here?

BHATIA: Yeah, it meant a lot, actually. Having some of my old professors as colleagues was really challenging to get used to. I would still want to say Professor Kirky, or Professor Gray. Now, here they were, they were my colleagues, were coming over my house for dinner. And I have such enormous respect for them. So it was lovely to be recruited back by them, to have them believe in me and champion my case. And now, to have them as colleagues is, I think, just such a gift.

INTERVIEWER: That's great. How do you think men and women are different in how they approach science and medicine in your experience?

BHATIA: I don't know that we are inherently different. I think I approach things differently. But I can't-- you're inside yourself. You can't tell if it's because you're a women, or an engineer, you spent time in the clinic, or whether you were using a hot glue gun with your five-year-old, and isn't that an interesting material? It's hard to separate it all. I would say in general I think women's style of management is different. And mine certainly is different. I'm more of a leader that's a coach instead of a dictator. And I don't know if that's about my gender or just about my personal style. But I think that's certainly true that my team runs more like a team than a hierarchy.

INTERVIEWER: And do you find yourself in the role of a mentor today to a lot of younger people, particularly women?

BHATIA: I try, yeah. So I try to mentor women at every stage. When I was here as a graduate student, I started an outreach organization called Keys to Empowering Youth with another few women graduate students. We all started it together. And the idea at the time, which I think actually still holds true, is that young girls are kind of at risk for losing interest in science and engineering in middle school. And we thought we had some of the coolest technological toys in the world sitting right here in all our labs. Wouldn't it be great to expose those young girls to those resources?

So what we decided to do is bring them here for a day for hands on workshops. And then, over the course of the day, they would get to meet college age women who were themselves majoring in engineering and get to ask them about what's engineering? What do you want to do? And learn that there are different kinds of engineering, and get to see all these really gee whiz technologies that we have.

So we said we started that. And my lab actually now serves as a host lab. So we just had a workshop a couple of weeks ago. And I brought my own girls to that. So that's one way to mentor.

And then, we have undergraduates. So I'm the advisers to the Society of Women Engineers, that's at a college level. And we talk to them a lot about career choices. And in engineering, even at that level, picking between industry and higher education, work life balance. I have graduate students I train in my own lab and postdocs. So I think there's a so-called pipeline for women in science, engineering. And the data shows, really, actually that it leaks all along the way. So we probably need to tend to it at every level.

INTERVIEWER: And that's a wonderful effort for young girls to see labs, and to see successful women scientists. Other than your parents' influence, which sounds like was quite significant in exposing you to science and higher education, were there are opportunities like that when you were younger? Or was science something that in schools, and the infrastructure of schools, was not really expected of young girls to be interested in?

BHATIA: I'm really fortunate. I went to an amazing public school where they had very strong science. I didn't do a lot of science outside the classroom. But I would say we didn't really need to. I think we were really exposed to a variety of ideas right there in the classroom. Of course, here in Boston, we also have the Museum of Science, which was a great opportunity to get more in depth in various areas.

I wouldn't say that I actually found my way into science until graduate school because I was an engineer for a very long time. And I didn't find my way into medicine until mid-graduate school. So my passions have been evolving as I've gotten exposed to different areas. And one thing I think is kind of lacking actually in our educational system is just the exposure of younger minds to all the opportunities that are out there. I think people really have no idea, even after going to college, all the careers that are available to them.

INTERVIEWER: I think you're right. People don't really-- it's sometimes happenstance that you stumble into careers. And people don't always know what's out there.

BHATIA: You probably didn't know this career existed.

INTERVIEWER: I didn't. Why do you think-- other than that reason, which is a good one, are there other key reasons why you think more women, young women, don't choose science as a career?

BHATIA: Yeah. We've actually looked at this a lot, my colleagues and I in biomedical engineering, particularly. We published a paper last year looking at the reasons for the leaky pipeline. And it's really been studied extensively. And there's no concrete sound bite answer. One reason for sure is that role models make a difference. And there are less role models.

And by role models, I mean not just the number of women faculty. So in biomedical engineering, 17 percent of the faculty are women. But to be a role model for somebody, typically for them to aspire to have your job, people will filter the role model through what they hope for themselves. So do you have kids? Are you married? How hard are you working?

And so what you find is that not even all of those 17 percent of women will be necessarily role models for the women coming up behind them. So there's a role model effect. There's a chilly climate effect. There's really interesting data on women who opt out of having extremely high GPAs and being very successful and truly just being drawn to something else. So that's a problem for the profession. Why is it that women see other careers as more attractive, or a better use of their time, or things that they can more fully integrated in their life?

And I think some of that is PR, actually. One of the things that I try to do is to talk about what a full life I think that I have, and how much I love my job and my family, and how strategies that I've taken to try and make that work, and to try to be really open and transparent about that. We were talking earlier about a TV program that I did where I let the cameras into my home, into my bedroom. But part of that is just to really be visible so that people can see that it's such an amazing job.

INTERVIEWER: It's true, and I think it helps educate young women to see those options. In addition to your lab opening its doors to young women, what do you think MIT is doing or can still do more of to buck that trend of the young women not considering these careers?

BHATIA: So I think we've done a lot already. We've made great strides on the faculty level, as I mentioned. So we've really increased the number of faculty women, which is a really important part of it. We certainly have lots of undergraduate women here. I guess I would say we serve as an example, really, of excellent women hopefully for the world.

The quantitative data that we gathered as part of the gender equity report, first in the '90s and in the follow up group more recently, have allowed MIT really to lead internationally. Lots of institutions have followed our example in terms of putting procedures and policies in place to institutionalize against discrimination, against bias. So I think even our follow up report that we published recently will help spread that message and institutionalize against it.

INTERVIEWER: You have two young daughters. How do you raise them to understand that-- they have a great role model obviously in you. But how do you raise them to understand that science is for everyone, and not just the boys in their class, despite what their teachers or others might be telling them?

BHATIA: It's really interesting. Their father, my husband, Jagesh, is also a scientist. I met him here at MIT on the first day of orientation.

INTERVIEWER: Wow.

BHATIA: Yeah. I have MIT to thank for a lot of things. And they are at the age, that pre-middle school age, which you read about where if you ask girls in the classroom if they're interested in science, and in math, and engineering, they raise their hands just as much as the boys next to them. So it's been really interesting.

So my oldest one is eight. She doesn't know yet that boys and girls have different levels of interest in science. She's never experienced it. Just this summer in her robot camp did she notice for the first time that there were no other girls in the class. So she's just creeping up on it. But I think for her, that's the anomaly because there's so much science around her. And she sees women students over the house. And she comes to the lab, and she sees women there. So I think she thought that the camp was funny and unusual, not that-- she thinks the reality is that both parties are equally involved. I hope she continues to think that.

INTERVIEWER: Maybe the trend will change and that will be the reality soon.

BHATIA: Maybe. I think most of the data shows it's just a matter. It's not just a matter of time, actually. But we need to actively work on both gender and minority issues in engineering and science. And if you stop pushing on it, actually the gains recede. I think there has been a lot-- there's the widespread view that it is if we just wait another generation, it's going to be okay. But the data really show that the slopes of increase would not support that.

INTERVIEWER: And what is the consequence if that doesn't change, if the trend doesn't continue, to have this imbalance in the science fields?

BHATIA: I think it's an underutilized resource for a country that's hoping to continue to be competitive. And you have to believe that the best and the brightest minds are equally distributed. So we're just not tapping the best and the brightest in very big numbers.

INTERVIEWER: On the other related issues of diversity, how do you think MIT has been doing? And what should it aim to do over its next 150 years as it looks towards it next birthday?

BHATIA: So we had a recent task force in diversity. And we made great strides on the diversity side, too. So the faculty are up from 4 percent to 7 percent. There's a lot more to do there. If we really expect our Institute to be inclusive and to have the faculty be diverse, that's the next phase, one of the next phases.

INTERVIEWER: Getting a little bit more into your career, is there anything that's keeping you up at night these days? Or conversely, anything that gets you out of bed in the morning that you're excited to tackle that you haven't quite tackled yet?

BHATIA: Yeah, so there is something that keeps me up at night, but it's really specific geeky thing, which has to do with-- we're trying to build livers. And when you build a liver, the liver has 10 billion-- well, we need to build a liver with about 10 billion. The liver actually has about 100 billion cells. But you probably need about 10 percent of the liver to keep somebody alive.

So I worry a lot about how we're going to build a liver that big. Right now, we can build a liver with about a million cells. We have a few orders of magnitude to go.

And on top of that, the livers that we're making don't have anywhere for the waste products of the liver that come out in the bile to go. So I worry a lot about how to build bigger livers and how to get rid of their waste products. And those are the kinds of things that ruminate in my mind, like new ideas to try, or collaborators to call, or whole new technologies that we might need to introduce to the process. So for example, progress in stem cells in just the last few years is something that impacts our work and the direction that we've gone into because we need 10 billion cells. We need cells that will grow.

INTERVIEWER: When you embarked on your groundbreaking work here in getting liver cells to live outside the human body, how supportive was the MIT family, the infrastructure? And why was this the right environment to launch those ideas for you?

BHATIA: So this was actually the perfect environment for the kind of reason that I described earlier, which is that there's so many different activities going on right next to each other that don't necessarily relate. That you have ideas here on this campus that you really wouldn't have in other places because you wouldn't be exposed to those ideas. So the way that project evolved is I was a graduate student in the Health Sciences and Technology program with this joint with Harvard. And it meant that my laboratory work was going on at Mass General Hospital in the lab of Mehmet Toner.

And we were interested in growing liver cells and making them function outside the human body. And Mehmet had had the idea that if we organized them on surfaces that they might be happier if they could be organized. And I had been trying for a couple years to get the technique that he had in mind working. And my then boyfriend, now husband, was an electrical engineering student here at MIT. And at some point he said to me over dinner, you know, we have this building where they make computer chips. It's a microfabrication facility. That's all they do is pattern surfaces.

And maybe you should talk to them about arranging your liver cells. And I literally didn't know the building existed. And I marched into the MTL, the Microsystems Technology Lab, and convinced them to do one of their first biology experiments, which they had never done before. And that became the foundation of my PhD work. And my work in several other projects around that time became the beginning of a field called BioMEMs, the fusion of biology and microtechnology. And that just happened because these two things bumped into each other.

INTERVIEWER: You had interdisciplinary collaboration going on at home as well as at work.

BHATIA: It's true, yes.

INTERVIEWER: Lucky you.

BHATIA: I know.

INTERVIEWER: And why was it so important or so helpful to be doing the work here at MIT, which is essentially the birthplace of the whole notion of nanotechnology?

BHATIA: Well, the facilities that are required for manipulating things on the small scale are actually really resource intensive. There's decades of physics and engineering that have gone into creating these instruments to make our computer chips faster. So the kinds of facilities we have here simply just don't exist on many academic campuses.

INTERVIEWER: What was it about the liver that honed in your laser focus and made you want to direct your efforts towards that organ versus other ones?

BHATIA: I think I fell in love with the liver by accident. The project that was pitched to me by my advisor seemed really interesting. And then, as I got to know it more, sort of like peeling the layers of an onion, it's just such a fascinating organ. It has 500 functions. There's no treatment for liver failure short of transplant, even now. It just seems like an exciting place to make an impact.

When I started my first faculty position, I had a decision to make about whether I would continue studying the liver, or whether I would take the tools that I had developed, the microfabrication tools, and stamp them onto other organ systems. And the reason I kept working on the liver was really emotional. I just wasn't done with it yet. There's just so much left to find out.

INTERVIEWER: Lucky for the liver that you weren't done yet.

BHATIA: Well, I hope so. Lucky for me.

INTERVIEWER: And what is it about this field of nanobiotechnology that's so exciting, and why you think it's really going to revolutionize how we approach medicine in the near future, or how it already is?

BHATIA: Yeah, I think if you look back, the history of really disruptive advances in technology and in medicine, they often happen because two fields that are immature come together. And the fields of liver tissue engineering and nanotechnology are like that in the sense that material scientists and engineers were developing these technological tools to make tiny things for reasons that were interesting to them, for building electronics, or building stronger composites, for better plastics. They were spending time and energy in building mathematical models about them for non-medical reasons.

And then, over here in medicine, we've been learning a lot about how cells work, and how stem cells work, and how to build structures out of the cells using old technologies. And so when you bring them together, you have all these novel tools for manipulating tiny things-- cells are about 10 microns, and receptors are on the nanometer scale. All of a sudden, you have this perfect storm of tools and biology coming together.

INTERVIEWER: And since you had experience at other institutions before you came to MIT, how good is MIT at this interdisciplinary collaboration? Is this a unique talent that this place has compared to what you've seen elsewhere?

BHATIA: I think some of the new models that we've put in place are really unique. So my lab is in a new building, the Koch Institute for Integrative Cancer Biology. And it is really designed to be integrative. So we have engineers and biologists on each half of the building on every floor. So it's architecturally designed to be integrative. That, I think, is really novel.

I think the notion that people need to be working across disciplines is widely accepted at the moment. And people are trying to figure out what the best models are to make that work. So I think that MIT's great at experimenting. And I'm part of the latest experiment which I hope we'll declare a success in a few years.

INTERVIEWER: Are there things going on right now in your field that, to the layperson or the rest of us, might seem almost like science fiction, but are actually already happening, or on the cusp of happening, that gets you excited in your work?

BHATIA: Yeah. There's a lot, actually. So I would say one thing that we're really excited about is the idea that we could give patients an injection. And inside that fluid would be little tiny particles that could circulate in your body and find a diseased tissue and take medicines specifically to that site of disease and cure it, and spare the other normal tissues in your body from the side effects of, for example, chemotherapy. So that's one idea that sounds like science fiction, but is actually pretty far along.

And a related one is an injection that could carry some sort of particle that would look all over your body and sample for disease so that it could diagnose disease. And so we've invented some particles recently that do that. And they send out a signal that comes out in your urine. So it's like a pregnancy test, but for different diseases. So again, it'd be like you get a shot. And then, it could tell you if you have a disease, if it's advanced, it it's getting better, and so on, and so forth.

INTERVIEWER: Do you think the way that we treat cancer within your lifetime is going to be drastically different than what we know now? Are the advances that soon in coming?

BHATIA: I think they are. I think it takes about 10 to 20 years, actually, to get a new fundamental insight into patients. There are advances that were made here at MIT 10 to 20 years that are already planning their way into the clinic. I think that cancer therapy is really on the cusp of changing. We know a lot more about it molecularly. We have new classes of therapies that target the molecular pathways that cancer relies on that we didn't have even five years ago.

And the hope is that at least some kinds of cancer would be turned more into chronic diseases than fatal diseases. And that's, I think, bearing out. The other kind of science fictiony thing that we think a lot about are off the shelf organs. So the idea that if you have liver disease, instead of having to wait for a transplant, which of course means that another patients has to die, that you'd have a refrigerator full of organs. You could just go to the refrigerator and have an off the shelf liver that you could transplant into somebody. And we are making advances towards that vision.

INTERVIEWER: If you did finish with the liver, which sounds like there's plenty more to do, what would be your next? Is there another next target in your sights?

BHATIA: Well, one thing that I'm really interested in which actually still is related to the liver is infectious disease. So it turns out that there's a number of organisms that infect the liver that are really hard to develop drugs and vaccines against. And so we're working on that a lot lately using our ability to make human livers. But instead of making them large and thinking about implanting them, we've been making them tiny and using them for basic biology and also for drug screening.

So for example, malaria actually infects the human liver on the way to the blood. And most people know it for causing fever, which is what it does in the blood stage. But it actually first infects the liver, and that's where it expands tens of thousands of times. And that's actually the place that people think is the best opportunity to kill it with drugs. So drugs that are active against the liver stage of malaria are actually really scarce.

So we've been trying to use our livers to grow malaria in a lab so that we could find drugs against it. And we think this is really important now because there's sort of the latest wave of efforts in malaria eradication. So every 30 years or so, you hear about this. And the newest phase was launched about two years ago by the WHO and the Gates Foundation. So to eradicate malaria, you need to be able to get rid of all of liver stage malaria because there's an organism called plasmodium vivax that can actually hibernate in your liver.

So once you get a malaria infection, you have a fever. You feel better. You're still carrying these dormant forms in the liver. If we really want to eradicate malaria, we need to get rid of those dormant forms because they can reemerge and re-infect the population. And right now, we don't have any drugs against the dormant forms. We don't have any blood tests to see if somebody's carrying a dormant form.

So we've been trying to grow-- it's called the hypnozoite, because it's hypotized in your liver. We've been trying to grow the hypnozoite in collaboration with the Broad Institute and the Gates Foundation, and then see if we can find drugs against it. So I think my latest passion is thinking about how to apply our human liver work to other diseases that could have a broad impact.

INTERVIEWER: And how much of opportunity is there for MIT to have these kind of outside partnerships with people or places like the Gates Foundation? Should they be looking for more opportunities to do more of that? Is that where you think innovation can really be launched and get faster results?

BHATIA: Well, I think science is changing. I think that even as the recent as 10 years ago, it used to be that we primarily raised our funding from the federal government. And that's changing. There's a lot more foundations in play now. There's a lot of international sources of funding. There's a lot of other governments that are interested in innovation. And so the whole landscape is changing.

And I think MIT is evolving appropriately so to try and connect to this really fast and changing environment. It's pretty clear, I think, that the days of just having your federal funding, or primarily having federal funding, are at least gone for now. The other major source is industrial funding. And we're doing more and more partnerships with companies and trying to think about-- so for example, as pharmaceutical companies stop having R&D departments, how can they work with our academic environment so that we can help them innovate and they can help us innovate in a productive yet unconstrained way? So I think they're challenging, challenging conversations because they're different stakeholders than people are used to.

INTERVIEWER: And you yourself hold 14 patents, issued or pending patents. How important is this notion of MIT putting ideas and theories into real world practice?

BHATIA: Well, I think it's really important. It's really one of the things we do best in the world. And the ecosystem that we have here, that's with Lita Nelsen calls, she's the head of our Technology Licensing Office, is really unique because it's not just the innovators, but it's also the investors, and the entrepreneurs, and the industrial base that we have all around us. Just looking at Cambridge since I was a graduate student, it's changed completely. And that kind of ecosystem really helps to take an idea, a publication, a patent, and push it out into the world and into a product, or a start up, or a license.

INTERVIEWER: In addition to your groundbreaking work with the liver, can you relate some key moments in your career where you thought, I'm really making an impact here, or changing the way medicine is going to evolve for society, and other aha moments where all the advanced degrees and all the hours in the lab seemed worth it?

BHATIA: Yeah. I would say we've had a few. In the liver, we've had more. We've had a couple aha moments on the infectious disease side. So last year, in collaboration with Rockefeller University, we showed that we could infect the liver cells that we were growing with hepatitis C virus, which hadn't been done. And the liver cell is the place that hepatitis C goes in your body. And again, it's been a really hard virus to study because people couldn't infect the real cell. It gets infected. So that was a great breakthrough moment. And it happened, I think, because I had a fantastic graduate student and a great collaborator. And he built on years of work that we'd already done making these livers more liver-like.

And then, just this year, we showed that we could establish the same kind of platform for the human malarias, which, again, had never been done. So that's been really exciting. And I got to debut the work at the Malaria Meeting in December, which I've never been to before, never been invited to before. And the community was really welcoming. And I had that sense that it was well overdue that bioengineering was part of the tropical medicine community. It was just a whole breath of technology that they hadn't had access to. It was really fun to be part of that conversation.

BHATIA: And what do you think-- with your unique knowledge of having been a student here and a faculty member, what are some things about this institution that you think people would be surprised to learn having had the inside track on from both perspectives? Or maybe myths that aren't true, or?

BHATIA: I actually don't know what would be surprising about MIT. I think that one thing that was surprising to me as I got to know the faculty better was how many of them who are just the pinnacle of their field and complete thought leaders still really do have full lives. So my department head in electrical engineering, up until last year, he just turned over, used to leave at 3 o'clock in the summer to coach his son's soccer game. And I think people would be surprised to know that, we're not just about leaders all the time.

INTERVIEWER: That's good. And you're leading the way in that.

BHATIA: Hopefully.

INTERVIEWER: And how different do you feel like MIT is today from when you first arrived? You mentioned some of the changes in Cambridge with some of the companies and things sprouting up. But on this campus, have you seen much change?

BHATIA: Well, certainly. I think we are building like crazy. The physical campus has changed so much. So the building that my lab is currently in didn't exist until a year ago. And the quad that it sits on, which is this beautiful green space, was a parking lot full of lunchtime trucks. So we're growing, and expanding, and building new state of the art facilities. And it's really mind- boggling. There's a new media lab. There's the new Sloan School. It's just physically changed.

And I think intellectually, it just keeps growing and evolving. So I'm not sure that it's a change. It's just going a million miles an hour, and it's still going a million miles an hour. It's lovely to have a woman president with a life science background. And it's lovely to experience the changes on the faculty that so many people worked so hard for. It's nice to have them as colleagues. Those are important changes.

INTERVIEWER: Professor Bhatia, what exciting new cancer therapies are you and your colleagues working on that could drastically change medicine in the near future?

BHATIA: So one idea that we're really excited about is an idea I alluded to earlier where you would try and target chemotherapy just to the tumor. But a version of it that we're excited about is one wherein-- when you get an injection, we estimate that's about 10 to the 13th particles that would be given a typical injection. So working with our graduate student, Geoff von Maltzahn, a few years ago, we thought about, well, all those particles don't have to be exactly the same.

And at the moment, that's how people had been designing them, that each particle in that solution should try and find the tumor and home in on it and carry the chemotherapy. We started thinking about how the particles could be different. And maybe they could talk to each other. Or maybe they could cooperate. And so one could find the tumor, and then it could send a signal. And it could recruit another particle. And then, the other particle would just listen to the first one. And it could carry the chemotherapy. And so we think about these as cooperating systems of nanoparticles.

And we were inspired by some natural systems that have sort of natural swarming behavioral, like bees, or ants searching for food. So each component of the system doesn't have to be too smart. But they have this collective behavior. So this is an area that we've recently gone into.

And we built our first cooperative nanosystem last year. And it was able to carry 40 times more drug into the tumor than the uncooperating system. And recently, I've hired a computer scientist, a postdoctoral person who actually studies swarming robots. We're trying to come up with ideas for how to program these little nanobots to swarm inside your body. So that's an area that we're really excited about.

INTERVIEWER: And that does sound to most people like science fiction. But it's coming.

BHATIA: It's coming, yeah.

INTERVIEWER: And you mentioned earlier that you try to always keep the patient in mind. And you want to work on breakthroughs that really impact the patients. Is that ever hard to do in the lab when you're immersed in the task at hand? Or is that something that people here at MIT are good at? Again, that theory into practice, how is this going to change lives idea of innovation?

BHATIA: So I think it is something that we naturally do at MIT is to pick our heads up every once in awhile and look around and think, okay, how am I going to get this out into the world? And I would say that's how it works for us. We try hard to come up with really brand new ideas and not initially be constrained in how to make them deployed in a patient someday. So we try to do work that inspires us and might inspire others.

And then, somewhere along the way when it's working, we take a step back and say, okay, but for this really to go to the next level, we need to simplify it. And we need to make it out of some other material. Or, we need a different partner. So for us, it happens like that in steps. So we try and have the inspirational idea, and then try and morph it into something that could actually get out there.

INTERVIEWER: Is there some secret to what makes MIT this kind of place that incurred such outside the box thinking, such revolutionary ideas, big ideas, not small innovations, but really they're famous for their life changing innovations across all walks of life?

BHATIA: So I think it's the people. I think it's the people that are here, and the people that continue to come here. And I think people come here for all kinds of reasons. But mostly, it's the people and the idea, and enabling those ideas. I don't know that it's a secret. It's just a special collection of 1,000 faculty and continually all of the best and brightest minds that are drawn here.

INTERVIEWER: And what do you enjoy most about your work here?

BHATIA: So I really love nothing more than sitting around with a bunch of colleagues, either in my lab or in their own labs, brainstorming. For me, that's obviously the most fun thing, to think about, either connecting this technology with that technology, or starting with a medical problem and being at the white board thinking about how we might attack it. For me, that's absolutely the funnest part of my job.

INTERVIEWER: It sounds like there aren't probably many moments where someone says, we can't do this, or that's not possible. Is that even in the lexicon here?

BHATIA: Not often.

INTERVIEWER: That's good. What would you like to see MIT accomplish in its next 150 years? I know that's a big span of time. But if the institution were to have a set of principles or things that it wanted to accomplish, what do you think those should be? What areas?

BHATIA: So I think that technology in the service of humanity is the thing that I love about MIT. And I think we have the global challenges of our time-- climate change, and energy, and human health. And I would hope that we play a huge role in impacting those-- peace, and prosperity, and justice.

INTERVIEWER: And in your own field, when you get to the point where you're looking back on your career and your time here at MIT, what legacy do you hope you will have left?

BHATIA: So I'm hoping that our work will really impact human health either directly, by making inventions that go into people, or making tools that make better drugs that go into people. But I also hope that indirectly, that by the trainees that come through my group, that they go on to spread our way of thinking and innovating into the world. And the students that come through my classroom, that they go on to impact the world. So I think both through my research work and through the educational work that we do, hopefully we can inspire the next generation.

INTERVIEWER: And if there was one thing about MIT that you know now that you didn't know when you came here as a graduate student that you wish someone had told you, what would that be?

BHATIA: That I belonged. And I absolutely feel that now, that I belong here. And I think I didn't know that right away.

INTERVIEWER: Do you think a lot of students here, particularly undergrads, probably feel that every day? And how can they be reminded that they also belong?

BHATIA: Well, I think when I first learned about-- there's this thing called the impostor syndrome, which they say women often feel. But I think truthfully, everybody feels it. And it's that feeling that you're an impostor, that you don't belong, that someone's going to find you out, you're not really as knowledgeable about the thing that you are supposed to be an expert in. When I first found out about that, I was so relieved because I had felt that my whole career.

Somehow, I wasn't quite good enough, or I didn't know as much as I should, or somebody would find that one hole in my argument. So I think just being honest about that, that all these incredible minds, everybody feels that way. Everybody gets nervous when they're standing on a platform. I think if the undergrads knew that more, that would be helpful.

INTERVIEWER: And I read that you sometimes have a little secret getaway to go to the movies by yourself to destress and decompress. Why is that so important to have the time, and maybe have that place, especially here at MIT where it can be pretty high pressure?

BHATIA: Yeah. So I think I was saying earlier that you need to tend to your spirit. And you have to find for yourself what those moments are. And for me, it's cinema therapy or getting my toes done. But for someone else, it might be a different thing. And I think that the creative mind needs tending. It's really important not just to work it to the bone.

INTERVIEWER: And if you weren't in my career you have now, what do you think you'd be doing?

BHATIA: I think that I might have been an architect because I really do love that fusion of creativity and technology, of quantitative approaches and building things. So I always had that itch. So maybe I would have been an architect.

INTERVIEWER: Any favorite architectural spots on campus?

BHATIA: Well, so many. I love the Stata Building, of course, which is the Gehry Building, and the I. M. Pei. And we have, I think, actually also a really lovely collection of sculpture, which I enjoy.

INTERVIEWER: Thank you so much for your time.

BHATIA: Thank you. It's been a pleasure.

INTERVIEWER: Likewise.