Dr. Robert Langer's work is at the interface of biotechnology and materials science. A major focus is the study and development of polymers to deliver drugs, particularly genetically engineered proteins, DNA and RNAi, continuously at controlled rates for prolonged periods of time.

INTERVIEW WITH MIT'S ROBERT LANGER

UBIQUITY: Your career has been marked by enormous success, including the National Medal of Science in 2007. You've written nearly 1,000 articles, hold more than 600 issued or pending patents worldwide, and in 2002, you received the Charles Stark Draper Prize, considered the equivalent of the Nobel Prize for engineers and the world's most prestigious engineering prize, from the National Academy of Engineering. And the list of your successes goes on and on. And yet you've said some interesting things to say about failure, so please share your thoughts with us on that subject.

LANGER: Sure, I'd be glad to. Well I guess the way I look at failure is that when you do research you probably fail a great deal more often than you succeed. I think that's just the nature of things: when you do experiments they certainly don't always want to obey your wishes the first time, the second time, or the third time. So you have to keep at it. And I guess the way I always look at it, from a psychological standpoint, is that one of the keys to being able to do good research is to learn how to deal with failure, because you will certainly fail. You know, it's easy to be happy when things are going well and when you succeed; it's not as easy when you fail. So you have to really be able to hang in there. So knowing how to deal with failure is an essential key to success.

UBIQUITY: How large, on average, is the difference between the number of successes and the number of failures?

LANGER: Well, it really depends on the experiments, and also depends on your perspective. There's really no simple answer to that, because sometimes things will work out right the first time, and yet I certainly have had situations where I've tried to develop a new kind of medical device or drug delivery system, and I've probably failed hundreds of times before I've gotten the success. But of course in the end, you know, if you have one success and 100 failures, as long as you figured out how to do it, you're fine – but it could be a very large ratio.

UBIQUITY: How have you learned to deal with the surrounding failure? In other words, one has the image of the scientist rather coldly and methodically proceeding through experiment after experiment and he or she is never crushed. Is that an overly idealistic image? Have you ever felt really crushed, really despondent?

LANGER: Yes, I have certainly felt despondent. Not necessarily about experiments themselves. When you first start out in your career, one of the things that is key is raising funding, and sometimes you get negative reviews from people, and try to build a reputation; and I thought I had written some pretty good proposals at the start of my but I remember getting two of those turned down on the very same day. That wasn't very good at all. But with experiments themselves, I guess you learn over time. Sometimes I say that that's what a PhD thesis is about, it's about learning how to deal with all of this.

UBIQUITY: Is that something that you pay particular attention to when you're dealing with your own students?

LANGER: Sometimes it will be natural and inevitable that students get despondent, because they're going to get frustrated, and it's challenging, and there's a certain level of frustration that's probably important for them to accept and know how to deal with. However, you certainly don't want somebody getting so frustrated that they give up.

UBIQUITY: Well, you have certainly are having a magnificently successful career. Among your many other achievements you're the youngest person ever to be included, at age 43, all three national academies – the Institute of Medicine of the National Academy of Sciences, the National Academy

of Engineering, and the National Academy of Sciences. And you're one of only a very few people ever elected to all three United States National Academies. So it's hard to believe that you had too much failure.

LANGER: Well actually, it's interesting. In my early years I probably experienced quite a bit of failure, and I also took quite a bit of criticism too from people who didn't agree with me – who didn't think the things we were doing were right scientifically. I think what happens when you intentionally take an offbeat path (not that I took an offbeat path just for the sake of being different) is that you can go from being very, very low in people's estimation to very high. But you don't know at the time that everything will turn out well, and when you're at a very low point in people's estimation you don't feel so good, you really don't. Lots of my colleagues and friends had won plenty of awards (not that awards should be anything that important), but I didn't get any awards at all until I was 38, and then all of a sudden they started coming in. But certainly early on in my career, the things I was doing weren't recognized or that well thought of.

UBIQUITY: I should mention to you that Michael Schrage, the celebrated technology journalist and author, called you the secret treasure of MIT.

LANGER: Well, he's very generous.

UBIQUITY: How can you be a secret?

LANGER: I'm not sure how he means that. You'd have to ask him, and I don't know, but it's OK. I guess the question is, secret from whom? I'm sure some people know what we do, whereas other people don't, so I guess it depends on who you talk to.

UBIQUITY: I'm curious about what you were like before you chose chemical engineering as a career.

LANGER: I think I was just like a regular kid. I liked math and science, but I ran track and did all that kind of stuff.

UBIQUITY: Do the students that you get now in your courses seem very different from the students of your day?

LANGER: Well, I don't know that they're very different. I think there are a lot of similarities between the students now and the students then. But I do think people go through changes, and students of the 60s and 70s were very interested in social things, and of course the Vietnam War was going on then. For a long time since those days students were maybe more conservative than that, and now maybe it's hard to know exactly where they are. But, still, you see a range of students now, and you saw a range of students then.

UBIQUITY: Are they any better?

LANGER: I think they were good then. There were some good ones then, there are some good ones now. And I think I'd say it's the same. But I do have a concern for education in the United States at the lower levels. Not for the MIT's of the world, but for the high schools and grammar schools. I mean, I am concerned about science education. I think it could be better, and there could be more emphasis on it. I think certainly when people have done analysis on these issues internationally, the United States doesn't stand up so well. And so that is a concern.

UBIQUITY: As you know, Ubiquity and the ACM are primarily focused on computing and information.

LANGER: Right.

UBIQUITY: And I wonder if you could say anything about how those activities impact what you do.

LANGER: Information of course impacts what we do in terms of communicating things to others, but there are even areas such as bioinformatics that we and others have used to try to interpret out data. If we

get large amounts of data can we try to use computation to help us understand what all that data means.

UBIQUITY: You don't use computers yourself much?

LANGER: Just to send e-mails.

UBIQUITY: And do they arrive at the right place?

LANGER: I hope so. I hope so. I'm not even that good at that.

UBIQUITY: We talked about students and whether they're different now from what they used to be, and now I'm wondering if you have any thoughts about whether today's students are a different breed in the sense that they've been doing computing and messaging and all this gaming and everything ever since childhood.

LANGER: I think that certainly people tend to be very computer literate now. They certainly know the best ways to set up a computer. I don't know that they're a different breed, but certainly computers are very much a part of their lives.

UBIQUITY: You mentioned bioinformatics. Does that not play an important role in your Langer Laboratory at MIT?

LANGER: I wouldn't say it's an important role. It can play a role sometimes. It's not a major focus of what we do, but its something that we've used some and certainly that I'm aware of, and certainly something we might use more depending on the kind of findings we make. Because there's a lot of things in genetics and genomics that that can really benefit from that area.

UBIQUITY: What do you think is the most important area within your own field?

LANGER: One of the areas we're working hard on is what we call tissue engineering. Someday we could provide ways of creating new tissues or organs in the body, and that would be a huge development if we could get to the point where we could do that because it would help so many people.

UBIQUITY: I know you don't want make a specific prediction, but what's your feeling about what timeframe is in which that is likely to happen?

LANGER: Based on things we and others have done, you can make new skin for burn victims or patients with diabetic skin ulcers, and my hope is that someday you'll be able to make other tissues. There are certainly other ones in clinical trials right now. I think it will take many years, but someday that will happen; someday you'll be able to make new cartilage, bone, and probably heart tissue; things like that. You'll be able to help people who are paralyzed. I mean, those are all things we're trying to lay the foundation for.

UBIQUITY: Amazing. You obviously are a man of disciplines. What are your thoughts on what kinds of multi-disciplinary activities make the most sense or are most successful?

LANGER: Oh, I don't know that there's really any answer to that, because it really always depends on the kinds of problems people are trying to solve. I think people have done well being in single disciplines, and they've also done well in multi-disciplines. I think there's no answer. I do think that we are doing things in the biomedical engineering field that are almost inherently multi-disciplinary. But there's plenty of ways you can combine things in different disciplines, and that could be good. So I don't have a single answer to that.

UBIQUITY: How did you reach out to other disciplines – did the process start from a specific problem you were trying to solve, and then you went to somebody else in another discipline – or just how did it go?

LANGER: Yes, it did go the way you're suggesting. I studied chemical engineering and learned some aspects of biology as a graduate student, but what happened is that I did my post-doctoral work in a

surgery lab and that really is where I learned about a whole other discipline beyond chemical engineering.

UBIQUITY: I keep trying to get back to you thoughts about the computing field as it stands right now. Do you have any particular interaction with computer scientists?

LANGER: I'd say, to be honest, probably not that much.

UBIQUITY: And why is that?

LANGER: I think it is just not that much a part of what we do. We're a very experimental lab. Most of the things that we're doing are novel experiments like creating new tissues or new devices, or drug delivery systems. It's not like you need high-level computing to do that. You need intelligence, insight and other things – and certainly the computer will help with data analysis and things like that.

UBIQUITY: Let's return for a moment to your thoughts on education. If you had a few minutes and a mandate, how would you change different parts of education?

LANGER: I guess I would try to make it more of a national priority. I would try to make sure that there is more funding for education. More rewards, and higher pay for teachers. I would try to make sure that we developed exciting curriculum, particularly in the math and sciences. And I would try to provide incentives for people who did that. Right now the newspapers and other media are focusing on people like Britney Spears, and that's not a good sign for the future of education. Science needs better ways of communicating with the public. I think for example that what you're obviously trying to do is communicate science and engineering and computation, and that's a very good thing. I wish there was more efforts like yours, that could expose people, and especially young people, to science and engineering and computation fields. I wish there were more efforts to make sure people realize that education is more valuable than sports or entertainment.

UBIQUITY: What does the future look like to you?

LANGER: I think, or hope, that the future will be OK. It's just hard to know. I hope so.

UBIQUITY: I wasn't thinking of politics. Were you answering in a political way?

LANGER: No, no, I'm not. I mean I guess I'm just hopeful that things will be all right. You just don't know. I mean, I'm generally optimistic, but it's impossible for me to predict what will happen.

UBIQUITY: Is there anything you're particularly worried about?

LANGER: Well, the things like I mentioned. As I say, I'm worried about making sure that young people get a really good education, not an education in pop culture.

UBIQUITY: I know you're doing everything you can to make that happen.

LANGER: We're certainly trying to do our best.

UBIQUITY: Great. We really appreciate your doing this. You're a good teacher obviously, and a great man. Thank you very much.

END