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DIVERSITY GOES TO WORK PODCAST

EPISODE 50: DR. ELIAS ZERHOUNI – FROM AN ALGERIAN VILLAGE TO DIRECTOR OF THE NIH: ONE IMMIGRANT'S LEADERSHIP STORY

Female Voice
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Phil Wagner
Welcome to a special crossover episode of Leadership & Business and Diversity Goes to Work. If you're a regular Leadership & Business listener, my name is Phil Wagner, host of the Mason School's Diversity Goes to Work podcast. I'm stepping in temporarily to fill in for Ken White on this special crossover episode. Our guest today has had an incredibly inspiring story of pursuing the American dream while never forgetting his roots. Born in a small village in Algeria, he came to America in his 20s with only a few dollars to his name. Yet through hard work and mentors who saw his potential, he rose to become the director of the world's largest biomedical research agency, the NIH. Our guest pioneered breakthroughs in medical imaging, including MRI techniques still used today. His scientific innovation, combined with leadership skill, earned him roles like department chair at John Hopkins in his 40s. But few expected a boy from a small Algerian village could someday lead the NIH and its multibillion-dollar budget. His diverse background gave him the global mindset needed to advance the NIH mission and promote better health worldwide. He championed science diplomacy to build bridges between nations and ensured doors were open for emerging leaders of all backgrounds. The trajectory of his life says much about the boundless opportunities America provides to those who dare to dream. I'm honored to have with us today Dr. Elias Zerhouni, radiologist researcher and former director of the National Institutes of Health. Elias, thank you so much for being here. It's an honor to have you on our podcast.

Dr. Elias Zerhouni
Thank you very much. And it's an honor for me, too, Phil.

Phil Wagner
So, I want to waste no time today. I'm hoping that we might unpack the many different elements of your story. So, let's start at the beginning. You were born in Algeria and moved to

the US in your 20s. How did that immigrant experience shape your worldview and your approach to leadership?

Dr. Elias Zerhouni

I think it's fundamental, actually, to who I am and what I became. Right. If you go back, the reason I came is because I was pursuing the potential of doing research in a way that hadn't been done before. My father was a teacher of mathematics and physics, and so I was interested in math and physics first. Medicine came in later, and actually, my father opposed that. He said he thought medicine was for less than stellar people, that they just learned by rote and they wrote prescriptions, and it wasn't really challenging. He said you'll get bored. And indeed, I was getting bored after a couple of years because you had to learn all the muscles and all that until somebody showed me a CAT scan, the first CAT scan obtained in the world. It was a radiologist, a mentor. And he told me, he said, you know, this is the future, this is how imaging is going to be. We're going to be able to peek inside the human body without having to open it sort of image. That really was the fuse, if you will. And then, I decided that I was going to pursue radiology and imaging because it was a disjunction of math and physics and biology and medicine. But to do that, you had to come to the United States. I mean, in those days, very few countries, the UK and the US, had that, and that was the foundation. I didn't really know what I was getting myself into, frankly, because when you are sort of taking a chance like this, you know you're leaving, you don't know where you're arriving, and so that was the beginning, if you will, of my career.

Phil Wagner

So you have a very vast, and I would say, complex leadership story from being a medical consultant to the Reagan administration in your 30s to ultimately leading the NIH. Talk to us a little bit about your journey from the University of Algiers to the NIH. Can you give our listeners a little taste of that leadership story?

Dr. Elias Zerhouni

Sure. First of all, when I came, I asked my mentors again. The dean of our med school had been at the NIH, and he knew folks here in the US. And he said, well if you want to do what you are proposing to do, you need to get an exam equivalency so that you can be certified in the US. So I studied that, and then I succeeded, and then he said, well, would you like to go? I said tell me which schools are the best? And he said Harvard, Hopkins. I said, well if you can find me something one of those. I was arrogant at the time. I'll go, and we called the Dean at Hopkins, who he knew, and the Dean of Hopkins was a radiologist. And he also believed that this was a new era that mathematics and physics would converge with medical imaging and medicine in general. So what he heard what I was wanting to do, this converging of physical sciences and medical sciences, oh yeah, bring him over. So that's how I got into the Hopkins program, not as a resident, just as a visiting researcher, if you will. So that's what started it. And then when I got there very quickly, I mean the environment was exceptional, people were not like, you know, saying, well he's an immigrant, what does he know? I spoke, barely spoke English, but in my first interactions, it was very obvious that they were excited by the concept

of research that would really combine these things because radiology has always been at the edge of biology and physics with radiations and so on. And so over a few month period, I got to know everyone, and I decided that, yeah, I wanted to stay, but there were no positions. And so, I looked for positions around the US. I was going to go to Loma Linda. I had a job offer. Then, when I told my mentors there, they say, I'm leaving. I got a job at Loma Linda. They said, wait a minute, don't rush. Turns out there was one resident at the time who really didn't like the specialty had spent a year and he wanted to go into dermatology. So he left, and they gave me his slot. And so that is how I became a resident in radiology at Johns Hopkins. But then, I was doing research on pulmonary nodules. One of the things that I always followed is the sense that you can learn more by quantitating a biological phenomenon than by observing it. And medicine in those days was more observational qualitative, and I wanted to bring numbers. And my chairman, Stan Siegelman, Dr. Siegelman, he had the idea that measuring calcium in tumors would be a good thing because it turns out that previous studies had shown that calcium, when it's high, is usually a benign disease, not cancer. And so we started to do that, and one thing led to another. We were successful, except that we were successful at Hopkins. Then, when people try to replicate that, they couldn't. And when that happened, obviously, people always wonder if you massage the data or something like that, and we know we didn't. So I studied why that was. And what I found was that in those days, scanners were not standardized, and people forgot that the image you looked at was really the result of a computation. And the computations were different from company to company to company, which means that they give you different numbers, and you couldn't really make a diagnosis because using a scanner from company A wouldn't give you the same results of company B. And so I solved that problem by creating what we call a reference phantom. And the idea that with computerized imaging, which was becoming standard, whether CT, MRI, ultrasound, the world was going to need a way to standardize, right? So it's like having a meter and a mile or a kilometer and a mile. You need to agree on the measure, right? Well, but you need to provide that measure. And that's what I did. Now, you mentioned I was a consultant of the White House. I was not a political consultant. I was a medical consultant because it turns out President Reagan had pulmonary nodules, which were found after he was operated. And I got called in because, at that time, I was the only one who could use that method to determine whether they're benign or malignant. So, I was asked to be a medical consultant. I met the president. I studied, I examined him, and so on, and told him that it was benign, that they need to reoperate again. And that was really the beginning, if you will, of this research career. And I was coming back to Hopkins at the time and essentially continued to follow the same theme quantitative biology. Bring numbers, bring rigor, bring real data to medicine. That was the trend, and I applied that in many ways.

Phil Wagner

You mentioned earlier you said I was arrogant at the time, but I've listened to your story a lot, particularly over the last few weeks, and I think it's one defined by such humility. And I've heard you talk openly about how you very clearly didn't have the expected pedigree of someone who would eventually find their way into the White House and serve multiple

administrations. What do you think it ultimately was that landed you such impressive roles in your career?

Dr. Elias Zerhouni

Right. That's a good point. You don't have that phenomenon as much today as you did then. But in those days, if you were what they called a foreign medical graduate, meaning you have graduated from a foreign university, foreign medical school, and then you got your equivalency, people thought you were inferior, that you didn't have the same level of education, skills, capabilities as a US trained. And that was part of the aura at the time to see we have the best of the best medical system. There was a little bit of arrogance behind that, but then the consequence was that when they looked at you, they, you know, there will be a glass ceiling. You'll make it to assistant professor, associate, maybe professor, but that's it. No more because you're a foreign medical graduate, and it's indeed in your Pet degree. You don't have, like, Harvard or the big Ivy leagues. I mean, University of Algiers, who knows where that is? I mean, they thought it was out of a movie or something. So, you really had to establish your credibility on the ground. And that's where, you know, it really happened because as I was there, I worked hard. I asked a lot of questions. If you ask my professors and Stan Siegelman, somebody asked him what distinguished him from the others you had. He said well, you would never be satisfied by just what we told him. He said, Why you're telling why is that that way instead of oh, I get it. Okay. I understand. The bone is broken. All right, fine. It fixes itself this way. Why? What happens, really, at the molecular level to repair a bone? I mean, can you imagine the mechanism of self-repair?

Phil Wagner

Yeah.

Dr. Elias Zerhouni

Do you imagine if you had a motor that self-repaired itself? Isn't that fantastic? And so this feeling of the world is fantastic. Nature is fantastic. You observe it, and you see things that we cannot do ourselves. We cannot engineer ourselves. A larvae that becomes a butterfly. So the complete amazement at the discoveries that we made inside the human body, both with imaging and trying to coupled with the curiosity, really led to people saying, well, this guy's a little different. And that's where it started.

Phil Wagner

Your tenure at the NIH is notable for a variety of reasons, but I also want to draw our attention back to the timeline. So we're talking the Bush administration, and we're talking post-911 America. And so I'm wondering, during that time, as you rose into this position of prominence, did you face any backlash in that era? We see a lot of anti-Arab, anti-Muslim backlash. Here, you are leading a very well-known and well-regarded entity. Did those collide in any way that were complicated for you?

Dr. Elias Zerhouni

Well, first of all, you know, I have to give credit to Johns Hopkins University. I mean, it's a merit-driven university, and I never really got the direct feeling of, except for what I told you before, if you're a foreign medical graduate, there was, you could know there was a little perception difference there, and people saying, well, it's just not as good. My English got better very quickly, so that was obviously an advantage. But I never felt that at Hopkins, although I felt that it was there. Nobody would come to you and say anything. And when it came time to be promoted to professor, there was no discussion. It didn't matter. What counted is, what did you do? What did you publish? And the rest of it was irrelevant. And so that was the culture that I came from. Hopkins has this culture of merits first, and then when the chairmanship of the department was in question, I always thought I would never make it because of pedigree reasons and so on, but it didn't bother the search committee, and I became that and quickly after that became the executive vice dean, all of that because I brought a different perspective. And I'll tell you what the different perspective was. When I started my research in MRI, I realized that I couldn't do it as just a physician-scientist, and I was a biomedical engineering associate if you will. But what happened was I realized quickly that if you didn't have a multidisciplinary approach to science and your lab was not multidisciplinary, you wouldn't succeed. So I went to the dean. I said I want to recruit a physicist. People raised their hand say, oh, my God, a physicist in the medical school? Are you kidding? We're not doing atomic research here. And I said, no, you don't understand. But without a physicist, we won't be able to understand what is it we're seeing with MRI. So my first recruit was actually a physicist, and then I recruited an engineer in radio waves, and then a biologist in cancer, and then another type of mechanical engineer and electronic engineer that could do signals. So, pretty soon, my lab at Hopkins was unique in the sense that it combined multiple disciplines in one lab, and that had never been done before. So, it was a model that actually attracted a lot of attention because it was successful. We very quickly became one of the most granted lab. We received grants from National Science Foundation and NIH, and so there was a lot of interest in that. And I kept saying, you know, you're not going to be number one again unless you combine molecular biology with mathematics, with physics, with computer science, but nobody knew how to do it. I didn't know it was not possible because, at the time, I didn't really appreciate that the basic science departments and the physics department, the math department wanted to control their faculty. They want to select them. They want to tell them what to do and so on. And I sort of broke that mold. So I broke the barriers between them by just basically saying, don't worry about the salary, we'll take care of that, and bringing them into one lab. Now, I'm telling you that story because that's the fundamental reason I became NIH director. So I pushed a new way of doing research at Hopkins, which, you know, as soon as I became chair, they had seen that model. It had been reported actually in science as the model of the future. And I practiced it, and then I extended it to the whole Medical School as the executive vice dean, and I was dean for research. And if you look back, what happened was that I was more looking at the system than any one project in particular. So, I have this sort of systems engineering mind. And I said the system requires you to break barriers between departments and disciplines. And we created these institutes that had no departmental barriers. They were multidisciplinary by nature, and it became very successful. I think that fast forward. After a few years of that, I got noticed I was elected to the National Academy of Medicine, and I was

known as somebody who broke barriers, both as an immigrant, I broke barriers, I broke the glass ceiling, but more importantly, I broke transverse barriers and glued people together. And that's what they thought NIH needed at the time because NIH had 27 institutes and centers, none of which talking to each other. So I can tell you the details of the story, but that's the fundamental thread that led to that connection.

Phil Wagner
So clearly, some big wins mapped throughout that story. What are the biggest accomplishments or initiatives that you're particularly proud of from your tenure at the NIH?

Dr. Elias Zerhouni
Well, first of all, you have to understand what was happening there because your question was related to 911 and the period of time. Right. And at the time, there was a lot of concern in terms of security. You remember there was an anthrax event where they distributed anthrax around, and it turned out not to be a foreign operation but a soldier from the US laboratories. So, it was clear that at the time, the country and Congress was supportive of NIH. They actually agreed to double the budget, and George Bush, the president, also was a big supporter. At the time, I, like you, thought that I'll never make it. I mean, you know, Muslim, Arab, there's no way. I got interviewed by the White House by a fellow Ed Moy was the presidential personnel. And they had had my name by people who said, you should look into this guy. And the president of our university, Bill Brody, was asked, do you have anybody? And he said, oh, I don't want to tell you his name because it's like giving my arm away, but this is who you should talk to. And so when they talked to me after the first interview, they had a very clear idea of what the problem was at the NIH. It was basically a confederacy. It was not a federation. There were lots of things that needed to be done that no institute wanted to do because they say, wait a minute, that's not my business. I'm focused on my budget, with my diseases, and so on. So lack of coordination and lack of synergy, if you will. And I had noticed that because what you don't mention, and that is important, is that in 1996, I was asked by the director of the National Cancer Institute to write a strategic plan for imaging for cancer. And NIH has a bureaucracy. And I said, no, I'm not doing that. And Rick Klausner was his name, and he was a young, very aggressive, very smart scientist. He called me back. He said, you know, nobody turns me down. Why are you turning me? He said because I've seen that we do work for you guys. You put in the drawer, you never do anything about it. And he said, no, I'm the new director. I'm different. I said, okay, well, let's make a deal. If you're different, I just want you promise me to do the following. If I put a plan together, you have two options. You can say yes, or you can say no, but you cannot tell me what you all always say maybe I don't want any maybes. So that was the conversation that I did work, and I told him I said, I don't want a typical plan made by cancer specialists. I want a multidisciplinary team, which is my mode of operation at the time. And so we did the plan, and he loved it, and he put in the resources. It really transformed the way imaging is done for cancer from molecule to men. But then, as part of that, he said, I'd like you to be on my advisory council. So I end up on the advisory council at the National Cancer Institute in 1996 seven, something like that. I sat there, and I started to know the inside, the NIH from the inside. That led to a second step, which also is important

in the story because relationships play a huge role in what happens to you. You don't plan, but it does drive the decision that the relationship was the following: Harold Varmus Dr. Varmus, who had become the president of Memorial Sloan Kettering, who was the outgoing director of the NIH, was asking someone to review his imaging programs. So I did. And as part of that, he was happy. He said, well, why don't you become a member of my advisory, so remember, I was on the advisory council of the National Cancer Institute. I was on the advisory council of the former NIH director with his, and then all of a sudden, the White House calls in and says, oh, we'd like you to consider this job. Well, I wasn't unprepared. It wasn't coming out of the blue. People knew me, and I knew them. And that the conversation immediately related not to who you are, what you do, what's your politics. I was independent. I was neither independent, or I mean, Republican or Democrat. So I was completely out of left field choice, right immigrant, not even born here, so on. No, I mean, it was completely out of character for selection. The problem is the conversation led to a convergence of thoughts that said he's thinking systems. He's not thinking his specialty. So that drove the conversation. Then, at the end, I said, but aren't you worried? I mean, I'm not the pedigree you want. He said, look, President Bush, as long as you're an American in good standing, it doesn't matter who you are, what your relation is, and I was shocked. I was really he said, oh, don't worry. If you make it, we'll back you. So that was it. So when you ask about, obviously, discrimination and lack of diversity and so on, I personally did not experience that, although it's there, there's no question. But I didn't because of factors that I described to you. And in other words, you had something unique that was not available; otherwise, you see things from a different way. The system needs a change. And that's when my contributions to NIH started. From a different point of view.

Phil Wagner

Your story is one defined by so many wins. Not just wins for your career, but wins that have changed the lives, livelihoods, health, longevity of, I mean, millions. Is your story one of victory and victory alone? I mean, what are some of the challenges that you have faced or faced during that time that might help our listeners as they find themselves configuring their leadership story?

Dr. Elias Zerhouni

So, first of all, I don't think there's a little bit of hubris in what you're saying, changing the world and life. Who can do that? The second is it was always driven by observations in medicine that told me this is accepted, but it's not acceptable. So, for example, my first thing was to look at these people who came in with a nodule in the lung that you saw an X-ray, and they would get operated. I mean, major surgery. I mean, Thoracotomy, which is opening of the chest, is not benign. And yet you realize that a third of them or more had benign disease that didn't need to be operated. So, it was accepted. But to me, it was not acceptable. Right. And that's what drove the first project if you will. The second message there is that you try to do something, and then you realize that the entrenched patterns of behavior oppose it. So, anytime you try to change, you had a resistance. The problem was, how do you overcome that resistance? Right. And then I was lucky to meet Bruce Holbrook, who was an accountant, and he said, well if the people don't want to change, create your own startup company and

convince them. Well, it was bad advice because we almost went bankrupt trying to sell the technology to the big companies. Why? Because the big companies said, look, our main customers are the surgeons, and what you're asking us to do is to prevent surgery. That doesn't make a lot of market sense. And sure enough, there was a lot of resistance to it. So then I realized very quickly and learned that, yeah, you can see that something is accepted. You think it's unacceptable, you find a solution to it. That solution is rejected. And that made me understand that you cannot be just a specialist in your field. You also have to understand the context around your field. And when you talk about wins, that's the secret sauce to wins. Not just be good at what you do, but understand what you do within the context of the times.

Phil Wagner
That's good. You talked about relationships just a few moments ago. You said relationships often define what happened to you. Can you talk to us a little bit about mentorship? The mentorship that you received as you were growing your career, or the mentorship that you've now given and doled to others, developing future leaders? Talk to us about the role of mentorship in careers like yours.

Dr. Elias Zerhouni
That's a very great question. I didn't know how important it was until later. I get it now, but I didn't then. And you look back, and you say, how did it work? And I tell the students that there is a pattern to that, and that is that to really be good leader and innovator and bring new things, you need more than just knowing your specialty, your discipline. Right. You need connectivity. It's like what I call the balance T.

Phil Wagner
Yeah.

Dr. Elias Zerhouni
The letter T that has a horizontal bar and a vertical bar. The two have to be equal because if you just have a vertical and not a lot of horizontal, you're basically a nerd in your specialty, and you connect to no one. If you just talk, talk, and connect to everybody, like a good cocktail conversationalist, you know, a lot of people, a lot of things, but you have nothing to contribute. And so that concept of the balanced T is really what underlies, in my view. The advice I give to students that you got to grow that. Now, why is that? I'll give you an example. So Paul Wheeler was a radiologist who was at Johns Hopkins, and he believed that you cannot be a good physician scientist unless you're a good physician. And then he came went to me one day and he said, let's go read some films. I said, I'm tired. I got to go. Listen, you know what the difference is between a great pilot and not so great pilot? I said no. He said, do you think a pilot who has 40 hours of practice is as good as the one that does 1000 hours? No, obviously not. And the one that does 1000, is he better than the one who does 10,000? No, obviously not. So, okay, let's go. Let's go get 10,000 films at 100,000. So he was teaching you that fundamentally, you need to be good at your game. Your vertical of the T had to be really solid. Otherwise, you didn't have the right to talk. So he taught you that hard fact that at Hopkins, at least, you know, you had to be a good doctor before anything else. So that's

mentoring number one, right? And then we had another Bob Gaylor, who was very wise, and he understood the tensions between the interests of different departments and different so he was more like a wise man. And so you talked to that person, and he said, well, don't push. If you push, you're going to get a pushback. And those conversations were really important because you can be an innovator. But if you innovate against people and you don't understand, then you really don't place your innovation in the right place. Networking is also important because it opens new world. So I always tell students, look, 50% of the people you know should be around what you do, but 50% should be completely different. So I have one of my best friends, an accountant. I have friends who are basically artists and friends who are completely out of medicine and kept them for years from childhood to today. So I think nurturing your connectivity, your horizontal bar, is as essential as anything else, but you can't do it by being passive. In other words, mentoring. People say, oh, well, somebody put me under their wing. Listen, mentor; good mentors are busy. They don't have time to go and look you up and put, oh, come in, come it's not a cafeteria plan. You go and pick the mentor you think is attractive to you resonates with you, and you work at it. So it's as big a work from the mentee than it is from the mentor.

Phil Wagner

Let's go and lean into that vertical bar for our final question here. Let's nerd out just a second because you're someone who I think is uniquely qualified to speak to the next generation of medical innovation. So, where do you think medical science is leading us? There's a lot of cause to be concerned if you're a human living right here, right now. You've got wars and rumors of wars. You've got ChatGPT and Generative AI seemingly taking over the world and our jobs. Is there a case for hope as it relates to where medical science is taking us? What do you think?

Dr. Elias Zerhouni

I don't think there's been as much breakthrough discoveries and advances in medicine as there has been last 25 years. I mean, that's just not mince words. I don't think we've ever seen something, the wave of innovation that we've seen the past 25 years. When I became the NIH director, I assembled a 300 scientists and said what is the roadmap for medical research in the 21st century? And if you ask me so, what did you do at the NIH? That's what I did. I reset. It was like a reset button. And 300 people came, Nobel Prizes, great scientists. And I asked them a simple question. I said what is it that the science needs to see done that none of the institutes of NIH is doing but that the NIH has to do? And through those conversations, what appeared was a few concepts that really are underlying what you call medical sciences of today. One was computation and computational capabilities and quantitative capabilities, and the ability to have larger data sets. Okay, so data sciences. And the reason for that is because people were saying biology is more complex than we thought it was. In 1970, President Nixon said war on cancer. Everybody was waiting for silver bullets to come and cure cancer, right? But it wasn't the case. Cancer is not a disease, single disease. It's like 2000 diseases, different ways, different molecular arrangements that make the cancer cell grow. So that complexity was awesome and at the same time, frightening. And so people said we need to unravel the

complexity of molecular pathways of disease. And you realize that a disease was not just due to one cause. When you look at cancer or inflammatory disease, it's due to multiple things. And then, when you treat them, you treat them with a combination of drugs because you don't really modify it otherwise. So that emerged, and that posed the question what exactly should medical sciences be in the 21st century. So when you come to that, you then go back to your question and say what did we need to do? We needed to do the blueprint, what's the code, what's the genetic code? So the Human Genome Project, which finished in 2003 to complete the and then, we said yeah, but that's not enough. You need to understand the DNA, but you need to understand the RNA. So whole field of research was put into RNA, and we invested to understand the behavior of RNA, and oh, wait a minute, that's not enough. RNA is only there to code and make proteins. Okay, so what about proteins? So, a whole field of research was invested in what we call proteomics. And what you've seen in each one of these fields, the technology that was needed progressed. And so people today, I would say there is no separation between science and technology. You can't really explore the complexity of science or biological systems without an advance in technology. And so this concept of convergence, of physical sciences, engineering, and biological sciences, is what's driving medical sciences today. Let me give you one example that blew my mind away, frankly. It's a company called Alpha Fold Two. It's not a company. The company is called DeepMind. If you recall, there was these people; these young guys were playing with algorithms that would beat the chess champion, and then they divinely made a game called AlphaGo. AlphaGo was for the game of Go, which is mathematically the most complex game played by humans. And over a period of few weeks, they beat the world champion. And then Google was really amazed. So they bought this company, and one of the scientists, John Jumpers, had really worked on the fundamental problem of protein structure. What I mean by that is everything you have in your body, all the functions that the life undertakes, is related to the shape of proteins and their interactions. Okay? But, we had no idea about how to deduct the shape of a protein from its gene sequence. So we had the human genome, but we didn't know how that translated into shapes. Very fundamental problem. Not new. It's been around for 80 years. And we use crystallography with X-rays and then Tomography, all kinds of methods, magnetic resonance to try to deduct the shape of proteins. These folks came in out of left field. They were not even doctors or physicians or biologists. They came out of mathematics, and they said, well, give us all the known structures which had been studied over 60 years, thousands and thousands of them. They put them into their computer, which is an AI computer with a neural network. And so from that, they started to deduct the roles. And each year, we had a championship where we would provide unknown structure, I mean, unknown structures. And we provide a sequence, and we say, okay, figure out the structure. By then, by 2017, 18, 19, we were able to do 20% of that, and 80% we couldn't. Until these folks came in their first year, they got 40% correct. And then, two years later, with Alpha Fold Two, which was their improved, they got 85% correct. Now, going from 20% to 85% is the equivalent of 200 years of research with the old methods. Not only that but this year, they gave all of their structures, 2 million structures, to the European Molecular Biology Lab, publicly accessible. Now, there's not a single lab that I know that is not using this methodology. I work on antibodies on multispecific antibodies today in my lab. And I tell you, you go, and you basically use AlphaFold to sort of define where your antibody is docking on your target protein. It saves you months and months and

gives you insight that you wouldn't have otherwise. So, to answer your question, scale of research is going to be bigger because it's complex. So, data is going to be much bigger. Depth of understanding of the atomic interactions has to grid bigger. But more importantly, we got to understand the disease at the population level, not just the individual, and that is made possible by data sciences. So I think a marriage of complex biology that need to be very specific at the atomic level, at the individual level, at the population level, is what's really going forward. The last frontier is brain sciences. And to me, that's the frontier of the century is the brain and how neurons are amazingly working together. I mean, you look at your child, and in a period of months, they do things that no machine in the world does by itself, self-assembly, if you will, of skills. And how does that happen? Well, what is the miracle of that? So to me, I think we need to continue is to continuously be inspired by nature. There's no smarter teacher than nature itself.

Phil Wagner
Fantastic. Well, what a rich conversation this has been. Clearly, pulling from a rich life and legacy. Elias, thank you. I appreciate all of the insights that you've given and how you've really walked out a commitment to being a T-shaped leader, something that resonates deeply here in these halls in the Mason School of Business. So, thanks for a wonderful conversation.

Dr. Elias Zerhouni
Thank you, Phil.

Phil Wagner
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