# Robert Tanguay Oral History Interview, April 21, 2017

**Title**
“Thinking Outside the Tank”

**Date**
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**Location**
Valley Library, Oregon State University.

**Summary**
In the interview, Tanguay discusses his blue collar upbringing in Michigan and southern California, focusing at multiple points on the ways in which his childhood helped to shape his work ethic and determination as a scientist. He likewise outlines his educational experiences through college and the circumstances by which he ultimately chose to pursue a career in science.

Following a discussion of his master's and Ph.D. research and his early teaching, Tanguay provides an in depth recollection of his post-doctoral years at the University of Wisconsin, where he first began to experiment with the zebrafish model that would come to define much of his career. He then traces his first academic appointment at the University of Colorado, noting the scholarly work that he did during this time and the circumstances that ultimately led him to relocate to Oregon State University.

In reflecting on his introduction to OSU, Tanguay recalls the fraught physical process of moving to Corvallis during a snowstorm. He then shares his memories of George Bailey and of the aquatic lab that Tanguay inherited from Bailey in 2003. From there, Tanguay provides insight into the extensive renovations that the facility has undergone in the years that followed, noting in particular the emphasis on automation that has driven much of the reconstruction. Tanguay likewise details the significant scientific work that has been conducted in this renovated space, focusing in particular on the toxicological tests of 1,200 different compounds that were funded by a major EPA grant in 2009.

The remainder of the interview is focused primarily on Tanguay's future ambitions. After responding to a question about political attacks on scientists, Tanguay details his notions of how the zebrafish model might be used to better understand the human condition. He also speaks of his on-going work to educate both public and private entities about specific toxins in the environment; reflects on the ways in which his role has shifted as his lab has grown; and delineates a few of the many sets of experiments that he hopes to pursue in the years to come. The interview concludes with thoughts on the university as it looks toward its sesquicentennial.

**Interviewee**
Robert Tanguay

**Interviewer**
Chris Petersen

**Website**
http://scarc.library.oregonstate.edu/oh150/tanguay/

## Transcript

**Chris Petersen:** Today is April 21, 2017 and we're in the Valley Library with Robert Tanguay, a Distinguished Professor of Molecular Toxicology here at OSU and we'll talk to him a great deal about his association with OSU and his research, but I'd like to begin by developing a biographical sketch of your earlier life and ask you where were you born?

**Robert Tanguay:** I was born and raised in the upper peninsula of Michigan that's actually not part of Canada. I moved to California in high school, essentially. I did most of my undergraduate and high school career, undergraduate and graduate work, in southern California.

**CP:** What is your family background?

**RT:** Very hardworking, very low-income background. We lived in a really small town, called Menominee, Michigan. The population's been about 8,000 for 200 years [chuckles]. Economically depressed area. Hardworking, rugged folks. That's the community I was in. Large family. There's six of us, six kids, and a single mother. Education wasn't an important aspect of living there, and certainly not in my family, either. So my future was probably going to be working construction. So all the courses that I took in high school were metal shop, wood shop, welding, electronics [laughs]. So I have a lot of those skills and that was my career path. I reflect a lot about where I'm from, and as much as I despised it while I was there, I see the value of that really challenging background to get the tools that I need now to do what I do now.

**CP:** That's really interesting. You're on this pathway of a technical curriculum. I'm wondering if—was there the inkling of science at the same time?

**RT:** Not a bit. Not at all. I think what—and I think again, it's from my family history—always about, the goal is to get something done, right? So have a tangible evidence that you did something. If you have that as a general life goal there are so many ways that you can achieve it. Construction honestly was one of the easiest—you design and build a building and it's standing. You did that. You drive by and you see it forever. I've always liked projects that I was a part of when I was younger. Science was a lot later for me. Probably not until—well, I was always good at it. It probably wasn't until maybe my senior year in high school in my physics class. I really liked physics. Even then I was pre-med. I had declared a pre-med major in undergrad. That was that science was just part of the goal—you needed to take these courses in order to get into medical school, and so I did it.

But then I was actually pretty good at it. Finally my senior year in college was when a specific faculty member, Nicole Bournias—she's still at Cal State - San Bernardino. She harassed me, honestly, to pursue science. She would not let it go [laughs]. Honestly the career trajectory change happened right then. She forced me to take an internship at the City of Hope National Cancer Institute, in Duarte, California. At the time I was working a furniture warehouse to survive, making like $10 an hour, which is a ton of money at the time, given that minimum wage was $3.25 an hour. This internship paid minimum wage, so I was going to take a 300% pay cut to take it, and I told her I couldn't do it.

She just kept harassing me, and I ended up taking the internship. I worked with some folks who were in the National Academy of Sciences, and they really liked me. Within a week they hired me as a research associate and my salary went to like $20 an hour. Not only that. It wasn't just the money. I was now surrounded by really smart people who actually encouraged me and suggested to me that I was actually talented. Again, my upbringing, I never would have made that conclusion myself. It's always been about—inferior to everyone, from class, from money to education. That's just how we're raised up there. So someone to say that I could compete with anybody, really charged me. That's how my career shifted to science [0:05:02]. Then at that point it was do well in that discipline.

Honestly I would say that what still drives me today is tangibly get something done and make the world a little bit better by you being here, and that's good enough. It's never about me, it's about accomplishments for society or whatever organization I'm working for. I try to instill that in my students today. It's funny how the past, which I was always embarrassed about, honestly, admittedly I have to say that it made what I am today possible [laughs].

**CP:** I have to imagine it was a pretty radical shift moving from the upper peninsula to southern California?

**RT:** In so many ways. It's a monocultural society, and really one perspective, of way of looking at the world. That is something that I don't know where that came from. I always had that, and I really don't know how I had this intense empathy for others and the ability to see the world in other people's perspective. I have no idea where that came from because it's nothing in my gene pool [laughs]. I think that's really helped me a lot. When I was in that dramatic shift—I mean the cultural violence I had to go through in the early '80s when I lived in California. It was a pretty intense time. Instantly I just loved the diversity of people that I worked with. So what was scary for maybe a few days, became "Well, this is real living. It's not this artificial bubble—it's complex, it's challenging, different people, different perspectives." At the end of the day that makes life worth living, as far as I'm concerned. But it was tough, it was really tough. I was athletic and I ran track and played football. The first time I ran track against someone who wasn't white was when I was in tenth grade and that was—it seems strange, but that was really for me, "Wow," [nods head]. There weren't many white kids on the track team in my high school, and the coach used to make fun of that fact [laughs]. I actually really enjoyed that, the multicultural, and the vibrancy of southern California versus status quo Michigan.

**CP:** How did you make the shift in your mind, or in your path, to go from a life of a construction worker to somebody who thought about college as a serious possibility?

**RT:** That's a great question. I honestly think I want to prove people wrong, and I'm becoming aware that's a big driver in a lot of decisions I make [laughs]. I want to rise above whatever environment I'm in. I want to rise above it. I think back on why I declared pre-med as my major—to go from the first person in my gene pool to go to college, I'm going to like "super" go to college, I'm going to be an M.D.; I'm really going to show them. I think that was a big driver. Again, it's not for me, it was more to make a point that it's possible for someone like me. I think that's what drove me. Honestly.

Then you just follow your positive reinforcements, right? So I worked at the City of Hope and did a lot of, I think really good work, and the appreciation that I had for my mentors is addictive, right? I think that's what it often is, right? You're driven by seemingly this grand plan that we follow, but it really is more about deliberate decision making, little decisions, that end up years later on a different path. I think I'm very analytical about my decision making. So when you get good positive reinforcements from people you tend to go that direction versus where you're getting abused [chuckles]. So I think it wasn't a dramatic shift, it was a gradual shift that ended up a very different place [chuckles].

**CP:** Were you a good student in high school?

**RT:** I was an average student, probably like a B student. I never studied. I was really active. You could not keep me indoors, and I always had to be doing something, and sitting down and studying was one of the last things I wanted to do. I think I got better at being a student when I did set the goal to go to medical school. You had to really take it seriously. I'm like, "Alright I can do this," and then I adjusted. I was not a stellar student. I would say I was incredibly quiet [0:10:01]. If you asked my teachers, if any of them are still alive [laughs], I bet none of them would remember me, at all. I was the quiet kid who never raises his hand and never had an opinion that I expressed—I had them but I never expressed any. I went to Catholic school for the first 7 years of my education, and that's really the goal, right? Catholic school is to learn to be disciplined, quiet. I took that to heart. It took years for me to come out of my shell a bit more.

**CP:** Was Cal State - San Bernardino a decision based on proximity?

**RT:** [Nods] and money. In fact, this feeling of inadequacy was pretty huge. My first year in college I actually went to community college—Riverside Community College. Academically I could have got in most places. I had like a 3.3 average or something and decent SAT scores. But I didn't think I could afford to go anywhere else. There was still part of me—that I didn't know if I was good enough, because I'm this knucklehead from upper Michigan, right? So I went to community college, and, in fact, some of those experiences—I took challenging classes, but I remember one in particular, I was afraid of taking physics, even though I did well in high school. Instead, I took this general science class, thinking "I'll ease my way into science." The first exam they had extra credit, so I got 110% on the exam and the rest of the class the high was like 32%. I remember the instructor saying, "What the heck are you doing here?" and I'm like [shrugs]. I stayed in the class the entire term. Which wasn't very challenging, but it served its role. I gained my confidence from that class.

I did not want to have loans. So the entire time in high school, in fact, and in college, I worked full-time. Even my senior year in high school. I actually moved from my home and lived on my own and got a roommate, so I had to work full-time

to cover expenses. So that was the reason. So it was a close school, like you said, so I had a job and I was pretty loyal to the job I had. It was really, really affordable, and they transferred all my credits from the community college. When I declared pre-med I could graduate in four years and be right on track.

**CP:** Was that a period of blossoming for you during your undergraduate phase?

**RT:** I would say the later years, scientifically, yes. But honestly I had not an anywhere near what I imagine is a typical college experience as you would imagine it. I spent no time on campus. I would leave work, go to class, and then come back and do a little bit of intramural sports to stay active. I had no friends from college and really no connectivity other than through my coursework, and so this accusation of being very serious—it's accurate. I don't screw around, ever. But in terms of the maturation in science and thinking like a scientist, phenomenal instructors at an institution like that. I could not say enough about that type of a training environment, and I go back every now and then and certainly show my appreciation. I've donated money to do the same thing [chuckles]. I had some instructors for seven classes, right? In many different disciplines. The energy for advancing other people's careers above your own, which you don't see a lot of that in larger schools, the challenge and time to do that. I think for me it ended up being a really great decision. It's funny that some people have certainly judged my career path. It happens all that time. The institutions that I've gone to. And that's fine. They don't need to—they're going to know more if they ever watch this [chuckles]. They make assumptions about people that they take a decision because that was the only path, right? Not that there are so many individual considerations. Could I have gone to a better school? Yes. Would it have helped me advance in certain ways? Probably. But at the same time, that goes back to my—I want the challenge. Tell me I can't do it and then you watch me. And you better get out of my way because it's going to happen. I think that underdog mentality I have is very, very strong and I have helped hundreds of people like me in my career of similar challenges, and that's actually been more rewarding than the scientific accomplishments, honestly [0:15:03].

**CP:** Whatever the experience at San Bernardino, it culminated in an important moment that you referenced at the City of Hope National Medical Center. So you were a research associate there for two years. I'm interested in what happened during those two years.

**RT:** They challenged me and they rewarded me. I had direct day-to-day contact with people who were, like I said earlier, in the National Academy, and they were just great thinkers and made me think more critically. But they were also driven scientists to have outcomes. We had very fun lab meetings, where I was twenty years younger than everybody there. It seems to always be the case. It's probably going to be changing in the future [laughs]. They treated me like a peer—not as a technician, not at all as a technician. So I was doing research presentations and teaching them methods. I mean, guys who are really famous in the field and teaching them new contemporary topics and just learning how to be a critical scientist was really fun. It's smart that I didn't stay there, but it would have been a fantastic place to stay, but the decision to go to graduate school was a necessary one. They encouraged that at the time. They were discouraging me going to medical school. Every single person there was like, "No don't do that. You've got to go and stay in science." So I succumbed [laughs].

**CP:** You did succumb. You went to UC Riverside and majored in biochemistry. Tell me about that process.

**RT:** Again, somewhat random. My advisor, Art Riggs, at the City of Hope, he wanted me to go either to USC or Caltech because he had an adjunct faculty appointment, status there. But my wife, we had just gotten married right then in 1990, and she wanted to go back to graduate school and get a master's in mathematics. She wanted to go to Riverside. So I'm like, "Why don't we just go together?" So I applied to graduate school, I believe it was the end of May, which is a tad late, and I got accepted to that program. A lot of it, again, the little decision was I wanted to go to graduate school where my wife is going to graduate school, and I'll make the best of whatever situation. Was it smart to pick a smaller UC school—some may not think so. Again, if you open up the covers a little bit you realize all I need are opportunities, and I don't need a hand up or a handout. I just need opportunity and I'll go for it. That institution provided me many, many opportunities to grow as a scientist. It's a very good program. So I am still a biochemist, even though I haven't done biochemistry in two decades.

I ended up picking a PI [Principal Investigator] that was starting his career as Assistant Professor with me. You get lots of advice that that's a bad idea. I could understand that. They don't know how to do their job yet and the challenges they're under to hit it fast. I was able to work under those conditions. And they were challenging, but Dr. Daniel Gallie was my

PI, and he's still there. Fantastic scientist. Driven scientist. He taught me—I already was a very efficient, disciplined, hardworking person, but he honed that to another level. In fact, I went back recently to talk to him after years, and he commented that he could not believe that I could meet his expectations because he kept raising them and raising them and trying to break me. He never broke me, to the point that he's never had another student. No one else could do it. I understand that. But its' that stubbornness that I have. It's like, "No, you're not taking me down" [laughs].

He's a terrific scientist and taught me how to toughen up even more your outer armor. I remember vividly when I got my distinguished professor award I remember saying this, because what he taught me, I'll never forget. He's like: "If you can't handle criticism get out of this field." Then he gave examples: you're going to put a paper in, you're going to get critiques; you're going to put a grant in, you're going to get critiques; you're going to go for tenure, you're going to get critiques; you're going to give talks and people are going to argue with you. Never is anybody going to give you a compliment in this field and don't expect it, ever [0:20:01]. Don't expect the words, don't expect—it's like, "Okay, I don't, but thanks for the reminder." And I took that to heart. It really toughens you up from those inevitable bumps, and he's like: "Okay, learn from them and move on." It doesn't take me down. I don't get wiped out by another human being's opinion of me or my research [chuckles]. I got that from him.

**CP:** What was your dissertation topic?

**RT:** I was focusing on really fundamental aspects of gene expression regulations. At the time the central dogma of molecular biology was very clear: you have a gene, genes are transcribed in RNA, RNAs are then translated, and that's the secret sauce of life. So we were arguing early on that there are sequences within RNA that could be modulating the activity of the RNA. In other words, at the time we though that RNA binding proteins were regulating how much protein you make from a transcript. So we demonstrated that. I identified a number of RNA-binding proteins, specific sequences—if you can move them around on RNA they recruit proteins and those proteins either affect the stability of a messenger RNA or the efficiency in which you get protein.

It actually led to a model, which is now fixed in the literature where there's actually communication between the 5-prime end of the RNA and the 3-prime end. They physically interact, and those interactions allow for efficient RNA translation to make proteins. It was challenging. I was in a lab and my PI had zero experience in anything we were proposing. He was a plant geneticist, fantastic one, but he was in a biochemistry program now and so everything had to be developed by me, including new instruments and developing new ways to achieve what we want to do. That is still the way I am. Part of it is from him and part of it is just me. It's like, "Okay what do we want to do and how do we get there? I don't care how anyone else is doing it now. I think there's a better way." They'd just say, "Do it." I had to become a protein biochemist; I had to be a molecular biologist; I had to be plant geneticist. I had to be an evolutionary biologist in a five-year period of time. Be really productive. I think I had 13 or 15 publications or something like that in really good journals. That really catapulted my career. Because people then, regardless of what I did, they figured, "Well this guy can get crap done." [laughs] "So let's get him in our building." [laughs]

**CP:** It was a terrific apprenticeship on a lot of levels.

**RT:** Absolutely [nods].

**CP:** Did you do any teaching during this time?

**RT:** I TAed. That was mandatory in the program. That was a good experience. It was challenging. I taught in biochemistry. That was a didactic class that I had to teach like 100 students. I was actually pretty good at it. I actually won awards for my teaching at the time. But there was also some un-pleasantries to that experience. Me and my colleagues had to run these laboratory practical exams, and we were told by the leader of this program that your goal is to weed out the vast majority of students in this program: "We want to find the top 5 of this 100 students, and the rest I don't care how you separate them out," but [shakes head]. So we put them under really stressful, intensive situations and watching these poor kids—we had to, I mean that was the goal, it's a weed-out class, and watching students crumble under pressure situations was pretty inhumane [chuckles]. I learned to not do that [laughs]. I don't want to treat people that way. But we did our job, and we did identify stellar students. It was basically because there were only a few slots for this fellowship opportunity, so they needed us to help them identify those students. Tight timelines and timers and things to really put a lot of stress in. I did learn that I was an effective instructor, and I think people tend to feed off of my energy and excitement and

examples, that I could make it relevant. I think, again, some of it's from that empathetic eye that's instinctive in me. So I can approach things in different ways to try to make it attainable to different people. I do like teaching. I don't do much of it anymore, very little in fact. But I really enjoy that aspect of professional life [0:25:02].

**CP:** Well you finished up your Ph.D. and then you did a post doc, which I gather was pretty important in the trajectory of your career.

**RT:** That's another big left turn and, again, it's really happenstance. I'm finishing up my Ph.D. and I'm like, "What am I going to do next?" I open up a *Science* magazine on my bench, and I saw in the same journal an article, front cover page was zebrafish, this new model for biomedical science. Len Zon and Mark Fishman at Harvard were pushing this at NIH [National Institutes of Health]. So I read a little bit about that. I said, "Well, that's pretty exciting." They were pushing it from a drug discovery model, and human disease model and developmental biology model. So that they were just trying to petition to NIH that this would be a good idea. At the back of the journal I was looking for post doc ads. I found one at the University of Wisconsin. I didn't know a lot about the campus. I knew it was a very good campus: top ten. My mom still lived in upper Michigan, which is a 3-hour drive from Madison. So I'm like, "You know, I haven't seen my mom since I moved from her house in high school," which that was not a pleasant thing, but we're still very close. I said, "You know it'd be nice to be kind of close to my mom." So I convinced my wife that she could move out of southern California. That was hard for her [laughs].

So I applied for this post doctoral fellowship program. It allows you to select out of a menu of like 20 faculty of who could be your mentor. I had a short list of 8 or 9 folks, and I went there in the middle of a blizzard and I remember vividly—I interacted with many of them. It was positive. I could have joined any one of their labs. And the last guy—I remember telling my wife, "There's no way I'm going to work in a fish lab." It's hard enough working in a plant lab because funding is really slow, and rodent-based research was the in-thing, and still kind of is, so why make it harder on myself? But then I met Richard Peterson, super great guy, and lots of things that I learned in that 2-hour interview with him is I learned what his career accomplishments were. He's about actually my age now. It's kind of funny to think about that. He was really focused on trying to make a positive impact with his research. Again, it wasn't about him, and that appealed to me. He was trying to understand what contaminates that humans are dumping into the Great Lakes, Lake Ontario in particular, were actually the cause of decline of populations. There were many folks at the time believed it was due to overfishing. He argued that no, it's actually from pollutants, ironically mostly from Canada—it wasn't us this time [laughs].

He identified the chemical classes in combination with the EPA and then did laboratory studies in relevant species—we're talking lake trout, brook trout, really huge fish. Really important, careful research but really challenging to do any contemporary research with these models—they spawn once a year, low temperature, and it's just not a good research model. I told him, "I said look have you heard about this zebrafish model? It's this new model that's emerging and nobody is using it to answer questions like you're answering. So if I came here could I develop zebrafish as a model for toxicology?" And he said, "Well, yeah, absolutely if you come here you can do that." And I thought about it and I mean that's the perfect storm, right? You have what I viewed as an impactful research area and there's not a single soul in the world doing it. As a post doc to develop your independent career, I jumped on that and that's what I did.

I brought to his lab—he had a huge lab, a well-funded lab, I'd never been in a well-funded lab [chuckles], and my wife had to finish some stuff up in California for several months before she joined me. I would work with the lab, and I was training them in molecular biology which was really fun and really had a huge impact on a lot of lives there. Then I would go home, I'd go down to State Street and eat dinner and just work for another ten hours. I did that for months and that's where I realized, "This is what I want to do." Everything else has been pretty focused on trying to advance this model that I really love using to make positive impacts in this field and other fields. So I'm recognized as the guy who started it all, which is cool, but now it's trying to continue to push the field. I've been on this PR campaign honestly for over 20 years to advance this model, and it's been pretty successful. So it's been fun to be recognized as the one that—again, it's challenging. I'm disruptive. I'm disrupting fields, approaches, disciplines. I've got to admit I enjoy that. It's not just to disrupt it. I'm disrupting it for a purpose to actually make a positive difference, and I think people appreciate that about my investments of time [0:30:26].

**CP:** What is the advantage of zebrafish, specifically?

**RT:** There are many. Certainly, for a fish species. I really try and understand what chemicals have the intrinsic ability to interact with biology and perturb it. In that way I'm not focused on a specific disease or a specific chemical. I want to use the biology to learn about chemistry. If you want to know whether a chemical can produce harm, the zebrafish is really nice because the embryos develop outside of their mother. Which is great. You can visualize the amazing processes of development in just a few days. They're easy to care for. They're transparent. The genome has been sequenced—we can manipulate genome in any way we want, so we have complete control over the organism. So we can ask specific questions in a very controlled way in a whole animal, which is fairly unprecedented.

So when you start just taking the intrinsic advantages of the model, some of which I mentioned, then you actually can start answering questions that people haven't even *imagined*. This is what I try to tell my lab: you don't want a model just to do what others have done with another model. What's the point? There's enough science that needs to be done, you shouldn't be redoing anything. If you actually can bring a new model to the scene and identify problems that need to be tackled, and if you think you can uniquely answer them with your models then go for it and don't be restrained by anything. So we have a model discipline in our lab, and in my career—if I have a research question that I want to answer and it's better answered in another system, do it in that system. Don't force fit it to your model. There are so many attributes of the zebrafish model, that even with that pretty disciplined approach you can do a lot. A lot of different fields that we work in and others now as well.

**CP:** Well you spent three years in Wisconsin and then you went to Colorado. That was your first academic appointment.

**RT:** [Nods]. I was an assistant professor in Colorado, and I was in the school of pharmacy. In fact, at that point my vision of what I wanted to accomplish scientifically, predictably, was smaller as an assistant professor. I was focused on two main projects, well I guess three: I was looking at trying to understand the processes of tissue regeneration. We developed some models, some early life stage models of regeneration so you can—if you amputate, say, the coddle fin of zebrafish—in an adult they regenerate completely. All the tissues are regenerated in like two weeks. Pretty cumbersome to work with the adult model, so we came up with approaches to do regeneration in embryos that are only three days old, larvae that are only three days old. And our goal—and we're still working in this area—the goal is can we use the zebrafish model to understand first why humans can't regenerate tissues very effectively and then can we find approaches to coerce the human genome to allow tissue regeneration?

It's not as crazy as it may seem. So most of the regeneration fields is stem cell therapy, right? So there's lots of controversy on where you get stem cells, and I understand that. Then you want to induce cells to become, say, cardiac tissue from a heart attack or spinal cord from a spinal cord injury. But I think the approach that may work even better is—imagine when you build a fin your genome is turned on and off at a certain time in order to build that structure, and to build an arm, same thing. The processes to build an arm are encoded in the genome. So when you amputate a tissue in zebrafish that same genome is acted upon, it's called upon to establish the process to regenerate the tissue. It's the same genes. So genetically they're capable of regenerating. So humans, same thing. It's not really a genetic problem, it's a gene-regulation problem. If we can figure out the order of steps that allow tissue regeneration in zebrafish then maybe we can then intervene in human injuries and maybe, therapeutically with drugs, you just turn on genes for a short period of time, turn genes off and choreograph the rebuilding of a structure. That's not as crazy as it may seem.

So we've developed—we have a patent actually—on screening for compounds that modulate tissue regeneration in zebrafish, and the chemicals aren't as important to us in this case because we're trying to find the pathways to act upon. Then once we get enough chemicals that starts revealing these pathways, which are always there, then we might be able to figure out how to turn them on and off in a mammal such as humans. I was working in that project.

I was also working on the effects of ethanol on childhood development—so Fetal Alcohol Syndrome from ethanol consumption during pregnancy. I got both of those grants funded within six months of arriving in Colorado, which his pretty nice. Then I got another large grant focusing on nicotine toxicity on the central nervous system. Everything was going great, honestly. I loved my colleagues there. I loved the city. My family loved there—we adopted our daughter there, so it was a great time. What happened, honestly, was, again, another happenstance that hit at a perfect time when I was vulnerable [smiles] [0:36:18].

The vulnerability came from I wanted to grow. I wanted my program to grow. I just can't help it. I was landlocked in lab space. I was landlocked in not money—I had plenty of money and I had plenty of people, but we couldn't fit them

anywhere, and there seemed to be no solution. Clearly there was some lack of understanding of my needs. Then I invited —I didn't, but someone else in the department invited—Dr. Dave Williams who's here at OSU. They invited him to be the seminar speaker. And I'm an early riser. I also go to bed late. So I was always the breakfast guy. I always picked the people up for breakfast and brought them to breakfast and brought them to campus. And I met Dave. He was telling me what—I honestly never heard of Oregon State. No idea. I mean, I knew where Oregon was and I figured it must be in the state, but that's about all I knew [laughs]. He told me what he did, and he talked about the aquatic expertise on this campus and he asked if I would be moveable. At first, at that breakfast, I said, "No, I'm pretty happy here. Things are going well." Of course, now it's planted in your head [laughs] when other events are happening around my desire to get more space, for example. He called me again and said, "Why don't you just come out and take a look." So I did that, and yeah, so Dave Williams started it [laughs]. He didn't finish it but he started it.

I think I came for three visits. It was a dramatic career change. Again, family was happy, loved the city, loved the quality of life and everything and then to come further west was a big risk for my career. I remember telling my wife on my second visit: I'll be honest I was so unimpressed by what I saw. Partly because of the way I was recruited. They had me meet a lot of the aquatic folks, but most of them were literally were retired or were retiring and all they wanted to talk about was the fantastic benefit packages and retirement. And a 40-year-old assistant professor doesn't really think about those things. I wanted to think about research potential. It wasn't until the second day of that visit that, I don't know if they made a change, but then I saw the A-team. I spent a couple of hours with Jim Carrington. Then I spent a lot of time with Joe Beckman. Honestly if it wasn't for the two of them, there is no way I would've taken a chance to come here. And I will never forget Joe telling me that: "You could go anywhere. I know you could, Robert. You could go to any medical campus in the country and they'd love to have you. But if you come here, you can influence not only your research program but you can influence the institution. And you can't do that in many research intensive universities."

So I saw this idea—again, that underdog thing kicked in my head again—I did see what he saw, the potential. And there's still a lot of unmet potential on this campus, in my view. So it was a challenge. If I came here could I think outside of my own career aspirations and try to make an institution better, society better, and this might be a good place to do it. It was Jo that sealed the deal. And Jim Carrington too. I mean he's such a fantastic scientist and inspiring guy, and we hit it off quite well. So then basically—if I get people of that caliber are happy here then I could probably be happy here too. So that's how they landed me. Then having to move a large lab by myself was another challenge. But we pulled it off [0:40:21].

**CP:** Well tell me about that process of arriving and settling in.

**RT:** It was rocky. It often is. Unnecessarily, I would say. If I was in that position I would not make a rocky start. We had limited moving expenses. I had a post doc and a graduate student who were really important for my career at that time, and they agreed to come with me. But OSU has policies that they can't cover moving expenses. I can't ask them to do it, so what I did was I rented a really, really big truck. I loaded, and they helped me and the other folks from my lab who weren't coming with me, we loaded my laboratory in the front of the truck. And then in the middle of the truck we put my graduate students' entire apartment, and then in the back of the truck I put my post doc stuff. And then we left on I think it was the 22nd of February in 2003. Got hit with a massive blizzard, which happens in Denver quite a bit. And then it melts rapidly.

So we did a caravan. I drove the big monster truck—I think it was a 28' truck—a big yellow Ryder truck. And then my wife and my 1 ½-year-old daughter were in one of our cars. My post doc was in our second car and my graduate student is in the back and we all had Walkie-Talkies. And we're going through Wyoming and an instant blizzard. Instant blizzard. Just zero visibility. And if you've ever been to that part, there are no off-ramps. It was frightening. We finally got to Rock Springs, Wyoming. Found a hotel and we found a place to stay. We got our cars in the parking lot. Got up the next morning and every car was gone. Buried. Gone. Couldn't see—the only thing you could see was the top of the big yellow truck. So then I helped the hotel staff. And it was sunny at this point, and the roads were clear—we just had to get to them [laughs]. So I helped the hotel staff with shovels and we dug ourselves out and then we hit the road. So this little kind of Donner Pass type of situation going on. But we actually made it here. And the rocky part on campus was my laboratory wasn't ready. Not only it wasn't ready, it wasn't started. And that was tough. So lucky George Bailey agreed to let me bunk up with him for about 8 months in the old Weniger Hall. So we were able to launch. But we started so small here. I was at a meeting just last week with one of my earlier post docs here. And it just made me remember how small my lab was

when I came here. We had three people. Our zebrafish facility was smaller than this little conference room here, but it was enough to slowly build. And now it's a much larger operation. So it was fine. I have a strong department. We have teaching and good graduate students. It's been very supportive of, honestly, for the most part—just stay out of his way and everybody will win if we do that. I do like that about OSU. I do everything legally, but I definitely—we have a logo in my laboratory, it's our second design of it, and it says "Thinking outside the tank." A pun there. And that's what we do. We're constantly challenging how we think about things. So I think people have gotten used to that, "Well, he'll figure it out" [laughs]. And I've had great people over the years that help me do what I want to do.

**CP:** Tell me a bit more about George Bailey. He's somebody we wanted to include in this project, but he passed away.

**RT:** Yeah, George was great. George was the, I would say, if there's a scientific God on a campus when I arrived George Bailey was that guy. Highly respected by his peers. In a lot of ways he had some career—I've gotten to know George pretty well—pretty similar, similar past in a lot of ways. So he was a champion for using the rainbow trout model for cancer risk assessment. And he had to suffer from the same challenges I had of getting the field to accept these new approaches, and he successfully did that. He is very well-recognized in the field as a pioneer in that research area. When he started to get up in the years and science started to go in a different direction, I'm sure that was challenging for George because something that he championed for 35 years of your career and well-recognized, and now, honestly, the new guy, the zebrafish guy, comes to campus.

[0:45:34]

I represented, not that I was a threat to him, I represented another era. I sensed that in my interaction with George. And it wasn't personal at all. So that when I, and we worked together a lot, and when I decided to move, I had to actually move from an on-campus facility to the facility, because I directed the aquatic facility from the day I arrived.

I was directing the aquatic facility that supported all of George Bailey's research for a good 6 years. So I had to learn. I knew nothing about rainbow trout. So I had to learn that. I had to learn the processes. I had to learn, you need a PR, face person, for his model to our funding agencies. So ran two cores that were funded by NIH, and his was the research that we were mainly supporting. So I became very familiar. I could, right now, I could pitch an entire George Bailey grant proposal without any issues at all. In fact, some of the staff that he employed 25 years ago they're still there. I made the decision when we had to shift almost entirely to using zebrafish instead of rainbow trout I retained the employees and completely retrained them. So now they contribute in a different way. So their careers are going off in completely different directions.

Also, I changed the name. The name of the laboratory that George Bailey ran—and he didn't start it. It was started by other scientists even before his arrival. And they were mostly doing aqua culture, so trying to figure out how to raise fish for food. He was visionary enough to realize that, for a number of examples of why he figured this out—he could use that expertise to do cancer research. Which would be a hard sell, I'm sure, in the '60s and '70s. But it was called the Food Toxicology and Nutrition Lab. And it's like: "I don't really want to direct a lab that has the world toxicology in it, or food" [laughs]. So I wanted to rename the building and our core facility. So I worked with George and Dave Williams on coming up with a more generic name to capture it.

It was George's idea. Russ Sinnhuber was a scientist that worked out there in the aqua culture days, and he didn't have a Ph.D., but he was a really dedicated scientist and a very careful scientist, and certainly rainbow trout was his passion. So George recommended whatever name we come up with for the building could we incorporate Russ Sinnhuber's name in it somehow? And I was, "Oh that's a great idea," even though I had never met him. He had passed away before I arrived. So that's why we came up with the—so I wanted "aquatic research laboratory," I want to do that, so it could evolve. So it's going to be aquatic, but it's going to be research. So that part was—and we played around with acronyms that were available on the internet. So I put the S first. So that's how we named it the Sinnhuber Aquatic Research Laboratory.

It was actually great that we did it. George helped me have an event naming ceremony. There was no money attached to it. There was no donation for the building. It's just like, "Let's do it." We invited his remaining family and his kids and his grandkids and his friends and people who worked with him who were still here on campus. We had an event out there and they really appreciated that. I had some contact with them recently. They're a little saddened that we don't do rainbow trout work anymore. But I reminded them that his name, the Sinnhuber name, is now associated with a lot of high-impact

research. So I think his family name has done well [chuckles]. But again they just had a passion for what their dad or grandfather did in rainbow trout.

**CP:** I'm interested in knowing more about this space. I gathered that this changed quite a bit over the years.

**RT:** It really has. It was somewhat—it was built cheaply in the past to accomplish research goals of the time.

[0:50:01]

I think the first building was built in the late '50s and then they added on in the '70s, '80s, and '90s. But it was not maintained well, and it was really just meant a building to raise many generations of rainbow trout and to do experiments with rainbow trout. That means large tanks for rootstock and large tanks for experimental tanks—hundred gallon tanks. We had a 750, one of those in the building. But kind of poor construction, because it was done on the cheap years ago. Probably not thinking the building was going to last 60 or 70 or 100 years. We had rotted ceilings and no lighting and rodent problems. I mean just really, really bad. What's hard about that—I was hired as a director of two NIH grants. So National Institutes of Health. So that's the biomedical wing of our federal funding, and we had these two centers that I was a core director with, with Joe Beckman at one center and Joe Williams and I was the deputy director of the other one. And we have site visits. This is where you get scientists from all over the world and they come see your operations, and it was really embarrassing. That started it for me. That embarrassment of dilapidated facilities. We're competing with places like Harvard and MIT, where you can imagine the sparkly hallways.

I remember vividly the first site visit and the scientist I know from Ohio State, and she's very well regarded and she looked at me. I said, "Look, I know. I see it too. Just trust me. We will address this. It's not going to happen overnight. But we'll address it." She said, "Okay." We actually got it renewed, got that grant and the next one renewed. Then it was just all about elevating the quality of the building. It's almost completely renovated, and it's hard to do that here. It's hard to do that it most places but the amount of money we have—if anyone knows anything about OSU the deferred maintenance challenges, many campuses defer maintenance to balance budgets, and we're really good at that here [chuckles]. That building is a good example of it. With some incremental support from the research office and the provost office and other mechanisms within my own grant money and then some NIH investments for the goal to improve the facilities, so I landed one of those large grants. We've been slowly, slowly elevating it. It's a 17,000 square foot facility and probably about 14,000 square feet of it are fully renovated now with actually air conditioning and heating and safety and backup power. It still looks kind of the same from the outside, but when you go inside that building people are really amazed at not just the size of it but the functionality and the energy level in that building.

I'm pretty proud of what we've done there. A lot of it we've done in collaboration with facilities when necessary and we've done many just with the knowhow. Again, I have a construction background, and I have a facility manager, who is Eric Johnson, who is incredibly gifted with electronics and welding, and some of the projects that he's done are just phenomenal. So we work really well together to get things done. Mike Simonich, another staff scientists I have, he's also, he does construction as well, so us working with the facilities and then Lowell Fausett, the Agricultural sciences architect. I've probably worked with him more than any other human being on this campus in designing projects and pulling them off and being—I'm like the guy dealing with subcontractors. All of that while I'm trying to advance the field and enter dozens of students. It's been a challenge. But, again, I'll go back to where it started. Whatever happens to me down the road there's going to be tangible evidence that I was here. If nothing else, the building is going to be in pretty good shape for the next person who drops in.

**CP:** And there's been an emphasis on automation.

**RT:** That's just me. I was actually really good technician on the bench. So I love—even when I'm doing bench work I always think of ways that it could be done better. It's frustrating to me to do repeated actions. It seems so unnecessary. So I'm always thinking to automate.

[0:55:05]

So I think about seven years ago, I really thought it would be possible. A lot of the scientific questions we were answering, I realized that if we could do the evaluation of chemical exposures on biology in a more efficient way,

we wouldn't just be faster at it, we would suddenly be doing things—it just frees up your imagination to do so many other things. It's not just time, it's your imagination is unshackled. So I sensed that. So I had to come up with a funding mechanism to try to show that this could be done. So I had some funding with the Air Force Research Laboratory to do a little bit of instrument development, which that really was the origin of this idea.

Then there was the Recovery Act of 2009. The Obama administration targeted some money into strategic areas of our economy and one of them was NIH. So they were called these Director Challenge Grants. Really competitive, ridiculously competitive. They were like a $3 billion dollar budget. But you had to convince the institute, NIH, that if you were funded you will transform a field in measurable ways and really take it in a different direction. Also there was a requirement of hiring people. That was one of the goals of the Recovery Act. So I proposed in this proposal that zebrafish could be used, what Joe and I called a Rosetta Stone, for biology, use it just as a touchstone for how chemicals interact with biology—could we just start there? No one really thinks that way. But how do you do that? You have to be able to do lots of interaction studies in chemicals and biology and you have to do that quickly. So that's the scientific goal, to have that Rosetta Stone.

But then the technical challenge of pulling it off, there was changes we had to make in how you raise fish and how you get not just hundreds of animals a day but 80,000 a day. That took a lot of engineering and we pulled that off. Again, Eric Johnson really helped pull that off. And then the instruments, figuring out—Lisa Truong, who's now my deputy director and former graduate student in the lab, I hired her back. So she really helped in the mechanical parts. The operational parts. How to set up your experiments and how to move embryos. How do you remove the cord out from the outside? So she figured all that out, fantastic scientist and student and friend. But she's not an instrument person. She'll be the first person to tell you that.

So basically I hired engineers. And I said, "Look I want you to watch Lisa and I want you to make instruments to replace Lisa." That's what I was going to pitch. I was going to say, "It's scientifically important. This is how we're going to do it with instrument development." On top of it I had to prove that it was going to work. So I made an arrangement with a US EPA to get 1000 compounds to test the system. I had 3 years to pull this off, which is insane. And I got the award. They cut the budget for funding reasons, substantially—another aspect that I wasn't going to do because they cut the budget. Then it was we're on the clock. Now, I've never worked with engineers directly. So we hired a chief engineer, David Mendrel, and he hired two sub-engineers and we went after all of those components. Tried lots of different prototyping and lots and lots of interaction with me and the engineers to try to speak a similar language, never spoke the same language [chuckles]. Then we have prototypes and we got them built and then we had to make several of the robots that move embryos around.

Then Lisa's job was, "You're going to implement this thing. So make it work." And we pulled it off and remarkably pulled it off. So we ended up building the instruments, validating the instruments, implementing them, and testing almost 1200 compounds across concentrations. It was by far the largest in vivo toxicological study ever even imagined, let alone pull off. We collected the primary data from like a half a million animals in less than two months. That has led to substantial challenges in data analysis. So I have a fantastic collaborator at North Carolina State University, David Rife, so we're just a team now. We're advancing not only the biology and the toxicology and the systems approaches but the data analytics and data mining and data sharing. That grant has probably led to fifty manuscripts and they're still coming, and this also led to numerous other spinoff projects. But it's strategic.

[1:00:17]

That's what I'm actually looking for now—is, we're not done. Not even close to scratching the surface of what we know we can do and finding the mechanisms to fund the imagination. I think we have a track record that I think if we find other opportunities we're going to take it to another level, and that's what we're working on. Our mission is, and every lab meeting we have, the students go around and tell me what they're doing and I just instantly, okay, "First of all, a mistake happened and that completely could have been avoided if that was automated." Students are concerned, and they should be, that the number of bodies we're going to need to do science is going to go down. It's happening in all sectors of our economy. Trying to get students that their contribution to be about thinking. They need to know something, not do something. Because if there's a way I could automate them out of moving things, liquids around, I'm going to do it. I can imagine we're going to have a higher productivity and a lower personnel cost in the next 10 years. I think that's inevitable. Because it's not—I gave a talk at a private college in New York and this concept of, I used to say, it's not the destination

it's the journey. Science it's the opposite, honestly. It's the destination that matters, and the journey is kind of a nuisance. We want to remove the nuisance as much as possible in advancing science and get there and identify the next destination and aim for that one.

**CP:** It sounds to me that this project with the 1200 different compounds it was sort of a crescendo of a larger body of work that led up to this moment and now you are in the process of figuring out what it is that you've found?

**RT:** In some ways. It really solidified at first that we were right, that the questions we were asking were good ones. What really happened for me is the number of different sectors in society that need the information that we can provide has grown exponentially. Really it came from—and they all, I've given hundreds of talks so they know how I think and what I've been beating on them for years about—if you guys could incorporate some of this type of thinking in your research I think you'd be farther along. That study and the papers associated with it allows me to now speak to regulators, which I do a lot, small companies that are developing new products that are concerned about safety. Large companies that have products and they are curious if they've ever been safe [chuckles]. We're working with companies like that and working with emerging contaminants from fracking and other consumer products.

I don't have a problem working—admittedly, that's not intellectually very rewarding, but okay it's not a problem to me. If I think I can help them answer a question then I'm going to help them. At my core scientifically becoming much more clear about what I want to do before I finish this out, and it really resulted from, like you said, that crescendo, this screaming out loud that this is possible so now swing for the fences for bigger effort. So that's what we're trying to do. Instead of looking at 1000 compounds we're talking about I'd like to look at a million. And not just randomly. I want to look at a million compounds and use their structural variation of the chemicals to bang on biology in any number of unpredictable ways and let the biology reveal itself and let us put those two together in a really, it's going to be almost like a machine learning type of environment. But do that on a common, stable, sensitive, powerful biological system. And we can do that now. So that's what we're aiming to do.

**CP:** As I listen to you talk I find myself wondering what it's like for you to be so ambitious right now in this moment in historical time? Tomorrow, scientists will be marching to let the world know that they are relevant.

**RT:** To be honest. It's always been there, right? This lack of acceptance for science. I do certainly understand the current times are bringing it to the surface in ways that maybe others took for granted.

[1:05:04]

I've never taken it for granted. So we work across many different sectors and disciplines. In some ways that's going to help us weather the storms in a practical sense. I don't care what your political background is, I think it's up to scientists, and certainly I take it very seriously. It's up to us to articulate the importance of science for making good decisions and to advance fields, and economies, and competitiveness. I do a lot of work with educating legislators in D.C. I'm asked to do that a fair bit. It's not as dire as people think. Right now it's seemingly the voice is: "We're not being listened to." But I, honestly, and I challenge my lab all the time, that: "partly our fault, guys." You've isolated yourselves from the majority of society, maybe not intentionally, but that's what's happened. There is a lack of awareness of all the dimensions that science impacts daily lives. Literally daily lives. Every single job. Every economy. Everything has its roots in science. It really does. Sometimes it's a few more degrees of separation. But that's been lost.

This idea—but it can come back—this idea that we're elitist, but I will say there are too many elitist scientists. I will firmly agree with that assessment from some. And I try beating that down out of people, whether they're my colleagues or when I give talks in other places. It's not about you. You're asking to take somebody's else's grandmother's hard-earned money to fund the stuff you enjoy doing in the lab. And that's great. But that comes with a whole lot of responsibility. To take it for granted, which I think many scientists have done, many institutions have done I would say as well, they have to get back to why do people fund you? It's not just for your esoteric pursuits of science. We have those, certainly we have the interest. But it's not about you. I think, if anything—so we're marching and the lab's marching. We have lab t-shirts. So maybe we'll be in the newspaper tomorrow.

But we're not victims. I think we're not victims I think we're part of the problem. Entitlement. I love this concept that they say this new generation, Gen X-ers, are entitled. In some cases I agree with that. But, honestly, which generation is

more entitled? I would say it's the one above me. Let's be real about where we're really at politically and economically. It's going to be rocky, no doubt, but at the end of the day if there's value in what you do and you can articulate it then people will be aware of it. I mean people are busy and to expect them to pay attention to your life—you're not paying attention to theirs, and don't act so dang privileged as a scientist. I wish more of my colleagues would, many do, but I wish more would take that stance to—we're so privileged. I mean, again, going back to where your question started today from my past—I'll admit I make more money than anyone in my, I'll say my genetic gene pool, again, by orders of magnitude. I'm no better than any of them. They work their butts off. So this idea that we somehow deserve something and they don't really bothers me.

So if I'm in this privileged position I take it as a massive responsibility with expectations to do something with the opportunities we have and the fact that it's about me in a certain publication and getting acknowledgement, really? That's not how I want to look back at my life. I'd rather say, "Wow, look at all the things that—things are actually better because he decided to focus his energy." I could do anything, right? I could be that construction worker. I probably would have built 300 houses by now at 50 years old. But I've chosen to do something else. I'm not as worried as some are. I mean it may be rocky, but I have confidence that what we're doing is important, and others will see that.

[1:10:08]

**CP:** In that main, I'm interested in learning more—it seems to me that the ambition has always been to use this animal model to learn more about the human condition, is that?

**RT:** [Nods] Right.

**CP:** Can you tell me a bit about some of the more exciting things that you've been able to uncover in pursuing that?

**RT:** There are so many examples. I started my career as a toxicologist. Even though I'm not really a toxicologist. I think that's kind of hilarious. So back a little bit that fellowship that I received at the University of Wisconsin it's called the NIEHS Institutional Training Grant, so it's funded by NIH. That was really instrumental in my career. I actually became the PI of that program here at Oregon State. So I've been running it since 2007 I believe. Wow, ten years [chuckles]. So now my job is to identify the new "me's" and recruit them and advance their careers. But when I started as a toxicologist I was working in this pathway—the aryl hydrocarbon receptor.

At the time it was just being discovered on how the biology senses these chemicals, like dioxins and PCBs and, so it was really from a tox [toxicology] angle. That's literally strategically I worked on that pathway because the entire field of molecular toxicology in the mid-'90s was focused on that field. Anybody who was anybody in toxicology was studying the AhR-Receptor. And I'm this new guy with this stupid fish model, right? And nobody, nobody wanted me to do what I was doing. I mean, other than my advisor. It was pretty negatively viewed. So I'm like, again, I took it as a challenge. So I'm like, "You know what I'm going to do? I'm going to work on the pathway that you guys are working in right now, and I'm going to demonstrate first that this model has this pathway." That was my first claim to fame, is I characterized that pathway in fish.

Okay, that's a kind of a "me too" science. I get that. But then I said, "Now I'm going to do things with this fish model because of the intrinsic advantages that you guys will never be able to do." That's what we've done. We're still really actively working with that pathway, and what we've learned in the last, even the few years, there's these assumptions. Again, I'm challenging all the time. There's assumptions that if you turn this certain pathway on, this AhR-Receptor pathway, if you turn it on with a compound you can predict what happens downstream. And they've been following one gene for thirty years now. So we demonstrated to the field, and others are doing this as well, that it's not that simple. There are many different shaped molecules that when they bind to the AhR-Receptor, the aryl to carbon receptor, the receptor actually does different things. Those different things affect downstream events in profoundly different ways. I has to all be driven from the structure of the chemical because the receptor isn't changing.

We're figuring out what are the structural features of all these molecules, thousands of molecules, that can bind this receptor and actually predicting what can happen downstream. That can be in disease models, in reproductive effects. Nancy Kirkfleet and Steven Coolery, they're working similarly now in that similar vein of identifying therapeutic compounds, hitting this toxic pathway with compounds to prevent autoimmune disorders and treating cancer, for example.

It all came from this trying to understand what this receptor does. So we've contributed greatly, I think, in understanding that it's not as simple as you think.

Don't think that biology is linear, because it's not. And we don't think that way. I always assume that everything is more complicated than you think. I have dry erase boards all over lab—some of them I've turned walls into dry erase boards. I think that way. We draw simple schematics, but then we add to it and then before you know it, it's like "Whoa that is really complicated." So how do you do an experiment now knowing it's so complicated? I think a lot of what we do is really this systems approach. Don't ask the little questions. If you ask little questions you can go get little answers, and they're usually yes or no. Instead, if you ask big questions, say "What happens when you do this?" and just kind of open your mind a little bit. Every time you do that we have a shift in the field, and, again, it goes against some of the training people get in the field.

[1:14:59]

You ask a very clear hypothesis. You have a question where you can have a definitive—and that's fine if you just want to be busy. If you just want to make sure that you have enough results to ask the next question. But in my mind, because we've done so much more broad I know that it's not that simple. So I won't even allow myself to answer those little questions because I know they're only part of the story.

Why not just think big at the beginning, ask bigger questions, and then be ready to be buried in complexity? A lot of my colleagues in the generation above me they hate that. They despise that approach to science, but I will argue with them. Because the complexity's always there. What is your true goal? Is it the first sentence of your grant—you want to understand this disease process? If so, you better ask your questions a little bit more open-minded and systematically. If anything, the impact that I had in science is really the thinking. How do you think about these problems? Break those old habits that we learned as undergraduates. They don't apply in the twenty-first century. They really don't. Unless your goal isn't to have an impact. You just want to keep busy. You want to keep busy you can keep taking those approaches. If you want to just have enough data you can pop out a paper every six months or so, okay. But that is so not enough for me. So I think, so scientifically the AhR-Receptor pathway has been big.

Some of our work in the nano green nanotechnology with Jim Hutchison at the University of Oregon, a fantastic scientist. Trying to use a combination of really sophisticated synthetic methods on nano materials that you can modulate features of particles in very defined ways, which is very challenging in in a material science point of view, which I appreciate. Then using our system to guide those decision making. That's been really rewarding. We're still working actively with Jim on a couple projects. I would say in the flame retardant area.

There's a lot of concern in the public that flame retardants are everywhere in this room, that everything's coated in flame retardant. They've had a societal impact, no doubt, positive impact of reducing fires. When you see airplanes that crash and the people get off the planes and then right when they get off the plane their engulfed in flames. They didn't have flame retardants, a different outcome. So there are all these positive impacts but there's this tremendous pressure to reduce their use for potential adverse effect on children's health. So how do you marry those two? How do you protect people from fires? So we jumped into that fray in a big way. So we said, "I don't think all flame retardants are created equal." They have the same name but if you think from a chemical point of view they have a different structure. There's hundreds of them. No one's been able to compare them. So we said, "Look what if we get our hands on as many of these as possible, and we just blindly, in fact, evaluate them side by side and identify the really toxic ones from the not-so-bad and then some that might actually might be benign biologically yet they still perform well as flame retardants. Let's help the industry, and regulators and scientists in general tell the difference.

No one thinks that way. And it's shocking, actually. And they didn't have the ability. So again by releasing your imagination. Say, "Look if I can get all these chemicals I can tell you that if you would use these you're going to have a much less negative impact on the world." So we've been working with regulatory agencies. We've been working with consumer advocacy groups and with the manufacturers, the largest manufacturers in the world and getting them to trust me for almost a decade. Because toxicologists are always there to shut a company down. And I'm like, "No I'm literally here to help you make better decisions." So that aspect of using biology to help chemists make better products, high performing but safer products. I have a feeling we'll end up—that'll probably be the most impactful work that I'll do in my

career. We have many examples that we've already achieved that. I think those applications of really advance science has been really rewarding for me.

**CP:** As your career has advanced and your lab has grown and you've been able to attract more money, I have to believe that your role has shifted somewhat, is that true? Can you reflect on that a little bit?

**RT:** Yeah, substantially. In some unfortunate ways sometimes. The woman I mentioned, my post doc, who started with me here. It was just like four or five of us in the lab. I would have the opportunity and time—I could do a swing through the lab and just talk to them and just say, "How's it going? Any problems?" and get to know them more and troubleshoot with them directly, frequently, and I would do that daily.

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I used to love being on the bench, but that's been gone since I pretty much arrived here at OSU. It's already been too much. So this hands-on with all of my personnel has been dramatically reduced and it's getting worse every day, I would say. But I responded.

What I've done is I've hired a lot of permanent technical staff. We've got six of them. So these are some Ph.D.'s and some just advanced research associates. Their institutional knowledge, far greater than mine, some even individually more, but as a whole it's like 200 and some years of OSU experience. I have probably the strongest support staff for new people in my lab that you could possibly imagine. It's a huge payroll too. So I've enabled. I've taken the approach where I'm enabling the environment for people to be successful. It's all driven by me still. The vision and the research direction and the troubleshooting. I do lots of creative ways of communicating with my people, which is not like it used to be where I could just sit down and pull up a chair and talk to them. I literally don't have that time anymore. So we have to create different ways of keeping those communications flowing. I'm sure it's challenging for some personality types who aren't comfortable not having that day-to-day interaction. Everyone certainly knows that about our research environment. It kind of runs like a company, the way my lab works. So you try to target people who can thrive in that environment.

I do miss those days, admittedly. I really, I enjoy advancing the careers and the maturation of the students. I have so many students that I've gradated and I really wish I would do something like this, honestly, where I videotape everyone when they first arrive in the lab and then get an exit interview. That would be a fan—I should really do that. Because I have memories of when they come in and they're completely naïve and when they come out—I'm really proud of what they, I mean how they turn out. They know it too. So now it's done sort of more quietly. I'm still doing all that, but they don't know how I'm pulling it off. When students hit the metrics of success in my labs, almost all of them are being recruited well before they're done. Really people want to hire my people, which is great. I mean, they worked hard they deserve it. My role, and it continues to evolve not just in my laboratory, my role in university, the role externally to university with advisory panels and so many dimensions of my time. I'm still advocating for this scientific discipline in a competitive environment. That's a critical part. My students may not realize that. If you have a PI that is never traveling, you may not be doing very impactful research. There's a correlation there. I may take it to an extreme. But honestly it's because I work in so many areas, right? So I have a responsibility to the nanotechnology field; I have a responsibility to the regeneration field; I have a responsibility to the toxicology field. And then agencies: the EPA, the Department of Defense, NSF. All these things you have to kind of pay back. There's grant reviews. Part of it is my fault. I get it. I've expanded my scope and the size but then it puts a lot of responsibility on me to deliver. Again, I'm not taking it for granted. My life is complex for sure. But it's not dull, for sure [laughs].

**CP:** A couple of concluding questions for you. One is just about the future for you scientifically. One of the things you've already mentioned is an ambition to scale up from the 1200s to the one millions. Are there other things that you hope to pursue in the years to come?

**RT:** [Nods]. Many. There's some specific drill down experiments related to some of the compounds that we've studied. We're doing a lot of disease focus research. So the screening is the beginning. The screening is going to drive the predict-ivity, the modeling that needs to happen. And I think that will have a huge impact. Then there's specific questions, right? One example is air pollutants that we are exposed to.

[1:25:01]

So there's a carcinogen in completely combusted fuels, fossil fuels, benzo[a]pyrene. George Bailey actually studied that extensively as a carcinogen in rainbow trout. Others have as well. We're actually more focused on are there risks from exposure to these compounds on childhood development and impacting neural behavioral outcomes, such as learning, memory, autism, socialization, fear responses? And we can do all that in zebrafish.

So we built instruments, custom instruments that can interrogate those aspects of biology in zebrafish. A couple of my students a couple years ago evaluated the effects of benzo[a]pyrene exposure on zebrafish and from early developmental exposure that would be similar to the first trimester in human development for a very short period of time and then you remove the chemical and then you assess these early life stage animals for behavior. And they're affected. If you raise them up to adulthood many of those effects: fear and anxiety, are also affected. That's bad enough. But then you go to the next generation, and then the next generation, and the next generation that have never been exposed to this chemical we still see the behavioral effects. There's this imprinting, this epigenetic transfer of this effect from that one-day exposure to great, great, great grandad or mom [chuckles] to this chemical and now it's persisting. Those are really challenging studies to do in rodents. They can be done, and they're really impossible to do in humans. So those types of associations of that chemical to that effect in humans will be discovered, unfortunately, in epidemiological studies. Where you get enough kids, say with a reduced I.Q., and they try to understand what was their common life history to produce that effect, and then they try to statistically connect them.

I do not want to wait for epidemiologists to find that many affected people to find the chemicals of concern. I want to do it in advance. That example shows us that this system is sensitive to chemicals that are known to do this in people. Probably through the same mechanism. We can do it faster than anybody in the world. So benzo[a]pyrene, that example, still in proof of concept we can do this for thousands of chemicals now, we're trying to understand mechanistically how does that chemical, and it's actually interacting with that same aryl hydrogen-carbon receptor protein I was telling you about before, how is that molecularly happening, what are the events downstream that set up this animal and every ancestor of this animal for these neurobehavioral effects? What are the mechanisms? What are the genes that are targeted? If you can figure that out, the practical things you can do, like, okay we shouldn't use these chemicals, or we should put measures to reduce our exposures. That's a practical sense. If people are affected, there may be ways to intervene therapeutically. You know these exposures happen, because we have air pollution because we haven't gone to all electric vehicles yet. So people are going to be exposed. Can we do anything to protect these kids when we understand the mechanism? That's one disease model.

We are working in the area of autism as well. I think scientifically trying to understand which chemicals first can produce neural behavioral effects that have an etiology, or origin, from early development and you don't see anything until say you're 20, 30, 60 and these exposures that happened early on are what's causing it. That is imagined by some people now, that there's an early etiology for adult diseases. But there are absolutely no systems that systematically do it. I think we have it. If we invest, and we're doing it, we're building new instruments to interrogate all those behaviors, and we already automated the front end of what I just described. And we have a large building. So all of the unique pieces to really bring the science to a massive level of discovery that I think could protect human and adult health. That's really what I want to do.

Now it's just finding the funding mechanism. The challenge with NIH and NSF and even DARPA is they fund little questions so I need—and you can't do that incrementally. You have to tackle the whole tamale, one big bite. You can't just slowly nibble at it. You have to go after the whole thing. So I have to find a way, a creative way, of funding that. I hope my track record of promising and then delivering will make it a decent case for arguing for largescale investment. So I'm hoping if people look at a video here twenty years or a hundred years from now they're going to see that all the crazy things that he was saying actually really happened. I hope that's the case.

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**CP:** Well my last question for you is one about the institution. As somebody who's been here for a while and seen OSU, warts and all, what is your sense of OSU as it looks towards its 150th birthday?

**RT:** I still see an institution with a lot of potential. I'm not saying that there hasn't been great successes because there has been. The massive growth since I've been here: I think the undergrad enrollment has doubled since I was here, and I arrived in 2003. I think great people. We tend to continue to hire great people. I think some of the big challenges is

funding them and keeping them engaged and staying very active. I think that's a challenge for many institutions. If you look at it that way: every institution has struggled with funding. But other institutions struggle with funding and all kids of other problems [chuckles]. And I don't think we have those other problems. I think a lot of OSU's challenges that you'll hear people complaining about—I'm on advisory committees for advancing this institution all the time, so you can see people, they're being asked to find the things that they're challenging in and that we need to work on, they're all around resources. Every single one of them. So if the institution, the state, other donors would recognize that and all the successes OSU has had already, if you just empower people to do what they're really good at this place could just blow up in terms of impact, because at its core it's a great place with an eye on impact and outreach and not all institutions are like that. I've been to hundreds of them. I think the core is golden here and it may be a little crusty on the outside, but I think there's so much potential, and I think a challenge for OSU is really to figure out what is their strengths going to be? If it can't massively invest in this campus, and I hope that's the outcome, then pick the areas that you're really going to shine. I think the future really is bright for this campus, and I'm pulling for it. I'll do whatever I can to inch it along in that direction.

**CP:** Terrific. Well, Dr. Tanguay this has been a real pleasure, and I thank you very much for taking some time to tell us about your work and your experience here.

**RT:** Happy to do so.

**CP:** Best of luck with everything.

**RT:** Thank you.

[1:33:07]