SANAM: --the founding of Genentech. Yeah, so a little bit about these two people, first. We have Herbert Boyer, who was born in 1936. He was a biochemist from Pennsylvania, an orchard in Pennsylvania, and then worked at the University of California in San Francisco. And he's, sort of, considered one of the first pioneers in the field of molecular genetics. And we also have Robert Swanson, who was born 1947 and died in 1999. He was from Brooklyn, went to MIT, and then eventually got into venture capital. And he was instrumental in finding Genentech and, kind of, developing the financing structure for that.

So here's a list of some other players that were involved. They kind of came in throughout the process of various towns that were recruited, both, nationally and internationally. Boyer worked with Arthur Riggs and Keiichi Itakura from the Beckman Research Institute, and the group had become the first to successfully express a human gene in bacteria when they produced somatostatin in 1977. And then David Goeddel and Dennis Kleid, as well, were brought on later on, in 1978, I believe. Yeah, and they went on to be instrumental figures in the company as well.

So I'll go into a little bit about what they accomplished-- just, sort of, the early history of the company. They really were the first, kind of, kickstarted the American biotech industry. And it all started when the two of them kind of met-- Boyer and Swanson met over beer and lay down $500 to start this pharmaceutical company that would explore proteins that bacteria could be engineered to make. And they first targeted human insulin because that was, kind of, a competitive area at the time. And there was a lot of demand for treatments, but there was a worry that there wasn't enough supply of animal insulin to meet this rising demand. So they kind of decided on working to make synthetic insulin up to scratch and be competitive with what was previously used. And they targeted meeting the requirements of Eli Lilly, who they, kind of, wanted to get his business to-- they targeted his requirements, they could get his business eventually and get the company going.

So getting money was kind of a tough process throughout the entire time. They both really

staked a lot of their career on this endeavor. And Swanson, at the time, was very young and went through many periods of unemployment as he was trying to get the money for financing this. And Boyer continued his day job teaching. So eventually-- so they ran into many obstacles financially, but they also, at the time, when they decided to target humans insulin in the first place, that kind of kickstarted a nationwide race to do this. And so there was a group at Harvard and another group at some-- another university in California. I'm blanking on the name. But, yeah, they were particularly formidable rivals, and they had those other two groups who were, kind of, entrenched in academia. And they had all the resources that that brought them, whereas Boyer and Swanson were relatively resource-poor. But they had one advantage-- Boyer was working with synthetic DNA, which would allow him to get around regulations that the NIH put on natural DNA during this process.

So they faced a lot of other obstacles, but they still had advantages-- other teams still had advantages of scale and sales ability. Swanson's goal was to make Genentech a fully integrated pharmaceutical company, and they wanted-- the eventual goal was to be able to produce and sell a wide range of drugs. And they believed that if they were the first to make the insulin, that would give them the lift up in the industry that they needed. So Swanson went on a hiring spree and recruited talent. We were able to open up their own lab, eventually. He was able to get 100k from various sources for that initial push.

So eventually, by August of 1978, they were able to make their first 20 nanograms of the insulin. And they immediately contacted Eli Lilly, and Swanson kind of went against convention and had this huge televised press conference, where he announced that they had achieved what they wanted to achieve. And that kind of did what he intended, and put Genentech-- really put it on the map in the public eye. And eventually, Eli Lilly's company came forward with $10 million for Genentech, and they were eventually able to fast-track it for industrial production. And in 1980, they had their IPO, and it was one of the most spectacular IPOs seen from this industry. And they were eventually able to-- in 1985, they were able to release a second drug. And these are some of the early products of-- thank you.

Yeah, so going on to the types of qualities of great groups that we've been talking about. So I think one of the main things was Swanson's leadership. So the article mentioned that he had a very down-to-earth style and was well-connected with everyone who was involved, as well as a great generosity towards everybody. And so he was-- he offered, basically, everyone, from the top scientists to the custodians, a share of the company at one point. And he had a really

great-- effective recruitment of talent. He was able to see where they needed people and how they could fill those positions.

Another really important element is that there was a real conviction of cause. So Boyer initially wanted to get into commercialization because he felt that university research and government-funded research wouldn't allow him to see the real benefits-- practical benefits-- of his work. So it's kind of a really altruistic goal of his. And that mission kind of carried them throughout this process-- that they were going to be making something that would better people's lives, save lives. Another important element is that they were working against a common enemy. So it wasn't exactly an enemy, but they were-- there were those other teams that they were working against, and that competition really fueled them. And going along with that, they were kind of like the underdogs and the young company that didn't have the resources and didn't have the funding, so that really was another motivating factor as well.

Another one is optimism and a degree of naivety. So that kind of came into play when they first made insulin, but Eli Lilly said that they needed-- had put really strict timeline on them for developing it for industrial production. And most people would have said that that was impossible, and that they couldn't do that in that frame. But they were none the wiser and kind of went for it anyways and it ended up working out for them. Another thing is that the people were not interchangeable. So like I said before, they were-- that list of players that I showed you were very instrumental in their very specific expertise that they brought to the project.

Also that there was relative freedom for a lot of the scientists involved in Genentech. So one of the things that Swanson did to get people on board, especially David Goeddel, he said that they could still have the freedom to publish under their own name, even though they were contracted to Genentech, so that was a real incentive for people to join them. And lastly, there was a really casual environment in the office-- T-shirt attire, and there wasn't any strict rules or a sense of top-down management.

So some other dynamics that I think are important-- this was an interesting case of a great group because it came at a time when there was kind of a changing relationship between science, and business, and academia, and the commercial sector. And Boyer's journey was pretty interesting. He started out firmly in academia, but he chose to look beyond that. His words, like I said-- his words at the initial meeting with Swanson-- about wanting to see the real practical benefits of his work kind of carried the whole team throughout. But the flipside of that was that in the early history of Genentech, he was a target for academic scientists, who

dismissed the idea that corporate science would ever be able to achieve the kind of things that they would be able to achieve. And his move to commercialization really drew the animosity of academia because he was one of the first of many scientist at the frontier of molecular biology, who sought to capitalize on the commercial opportunities.

And one of Swanson's, and Boyer's, to some extent, strength was their ability to recognize the exact moment in basic research in molecular biotechnology that was most beneficial to open it up to a commercial endeavor. So they were able to combine an extensive knowledge of the science that they're trying to do and also the business acumen needed to move it forward. And this really set them apart from other big drug companies at the time, and, I think, ultimately contributed to their great success as well. So this is a quote about Swanson, who was really, kind of, one of the first figures who was able to really bridge that partnership between science and business. So in a way, you can kind of think of him as like an advocate for the scientists that he was representing and the people at Genentech who were looking to really advance in this field that was quite new.

So I guess one of-- going on to, sort of, discretion questions, one of my main questions was-- did the relative newness of this field and this industry really help them? I mean, did that offer opportunities to Swanson and Boyer that maybe more established industry or field would not have? Did that allow--

WILLIAM BONVILLIAN: So I'm going to put that on hold for just a second and just throw a couple of framing points out. But I think that's a key question, and I'll lead up to that, Sanam. This is the first biotech, right. This creates the model. And as you point out, this combination of Boyer and Swanson is a fascinating combination, because they are, as you put it, able to kind of bridge this divide between business and science, and that is the inherent brilliance of the biotech model. And these folks really figure out how to do it, and Genentech, to this day, is an extremely successful company. So it has been able to keep on that innovation pathway, which means that the culture that they set up here has been able to keep innovation occurring on a kind of ongoing basis.

And some of the points you made, Sanam, just to emphasize some of the points you made-- The fact that Boyer and Swanson allowed their researchers to do their own publishing, right, that they didn't treat what they were working on as a complete trade secret-- that was a huge enabler in enabling the academic community to kind of enter into these biotechs. In other words, their academic role was going to be respected. Their role as researchers and scientists

who contributed in general knowledge was going to respect it here. And that created a rule in this biotech that prevails to this day, and it very much influenced that kind of model.

But the ability-- So in the biotech model, and Swanson and Boyer pioneer this, they create this revolving door capability. So in other words, scientists at universities now in the United States that work in life science areas and related areas are able to have careers, whether in the Academy-- they move to a biotech as a scientist for a period of time. They can move back to the Academy, right, taking their advances with them. In other words, they can move between these sectors, so there was, in European science, an historical upstairs-downstairs treatment, right? The academic scientists thought they were in curiosity-driven basic research and should have nothing to do with the, kind of, ugliness and, kind of, downstairs of commercialization of products. And that these worlds ought to be kept separate.

And biotech is the first really serious attempt in the Academy in America to kind of bridge these worlds effectively. And they do, brilliantly. And part of it is, as you point out, Swanson is a chemistry major at MIT. So he is not afraid of science, just as you suggested. He understands what it is. He has the ability to be in the room with these academic scientists and be in the game. But he also comes to this with early venture capital experience. So he first goes to work on Sandhill Road in Silicon Valley, outside Stanford. And they're only interested in doing IT. They have no idea about this biotech stuff. So he has to leave this major event-- early venture capital firm that he's with and essentially starve, eat hot dogs for months at a time as he tries to figure out how is he going to work in this biotech area?

And famously, he, as Sanam suggested-- famously, he starts cold calling. He has this idea that bioengineering is going to be this incredibly creative new field. He's aware of it from his own training. So he starts cold calling scientists that are working in this bioengineering field. He only has to get to the bees, right, to Boyer. And then they have this famous meeting at Churchill's Pub, where they actually so much hit it off-- exactly as Sanam described-- Boyer is concerned that if he just stays in the Academy, nothing he works on is ever going to get out, right? And he wants to get his stuff out. He truly believes this. He is not out to get rich here. He is really out to get-- to save people and get the technology out the door.

So there's a statue in front of Genentech, to this day, that pictures Boyer and Swanson sitting at the bar, each putting the $100 down on the table as they toast each other with beers. That's what you see when you drive in and see the company headquarters at Genentech. And that's symbolic, I think, of what's happening here. These folks figure out how to make a really

workable marriage between business and science that's remarkably productive on both sides of the world. Boyer is totally ostracized for doing this, right? He faces tremendous recrimination at UCSF for having gone this commercial route. And it's only when they come up with these stunning successes that the scientific community really has to rethink the kind of way that it went after him.

So this was not easy for either of these players, but it's a really-- it's a fascinating moment, in a way, creates a culture that, to this day, kind of still dominates that whole sector. That's a fair summary. Now, let's come back to your great question. Why don't you just pose it again, quickly, Sanam, and then we'll do it.

SANAM: Yeah. Do you want to say something?

AUDIENCE: Actually, I had a curiosity question. I was wondering, well-- You had mentioned the ability to publish under their own name. Was there anything else that might have spurred the success of this marriage, as you put it, between academia and business?

WILLIAM BONVILLIAN: Well that's [INAUDIBLE] recruitment tool. In other words, if you leave academic research-- university labs-- and come to work for Genentech, you don't have to abandon your academic career. You can still keep doing your research work and building your research reputation while you're working at a company. And that's what that enabled. So it enabled academic researchers to feel that they weren't leaving the universe that they had-- that had nurtured them. They could continue doing terrific academic work, as well as practical work in this kind of company setting. And that was very reassuring, and it was a great-- it broke down a whole divide between the worlds, because previously, in pharmaceutical companies, everything was secret, right? Everything was treated as a trade. So there was no outside discussion allowed until patents occurred. This really changed that culture. But Sanam, restate your question, because it was a very good one. Let's go back to it.

SANAM: Yeah, so my question was, do you think that the fact that this field was so new and so-- starting very few years before that really helped them or afforded them certain opportunities that they might not have been able to have in a more established, entrenched field or industry?

AUDIENCE: I'd say absolutely-- because there was no previous infrastructure. There was no establishment to fight. There was just the scientific challenge and then trying to commercialize it. Of course, I mean, there were other-- there were other companies that were trying to do these things, but

because it wasn't as established as, I don't know, coal, or the railroad industry, or something like that. I think it certainly made things a lot easier. The market was a lot more fluid, and they had a lot more areas to expand into.

AUDIENCE: I think not only that-- sorry-- there is also a lot more room for error, especially as they're getting started initially. They're able to experiment. They have more leeway in the way they can market and present their product, because there is no established market.

AUDIENCE: I was wondering if someone could share, maybe, what they thought the regulatory challenges that they didn't face were?

AUDIENCE: I mean, I think it was mentioned that they pretty much used the ability to use synthetic DNA in order to get over a lot of regulations. Also, it's relatively early. Nowadays it's a lot harder. I think the price point to make a drug is over a billion. Back then, I really don't know what it was. So really it was a great opportunity. Also their investors were Kleiner Perkins. Also one of them was--

[INTERPOSING VOICES].

WILLIAM BONVILLIAN: --Swanson had originally worked for, and then had to leave, because they didn't want to do biotech. But he went back to them with this advance, and they gave him some money.

AUDIENCE: And I'm pretty sure they were in different spaces that are difficult. They would have helped. But the investors were adequate in that space.

AUDIENCE: What about Chris? Do you have any thoughts on the regulatory challenge?

AUDIENCE: Yes, so definitely using synthetic, kind of, molecules in an approach definitely helps, because you can surpass that whole clinical challenge, which not only is hard to pass, but also takes a long time. right? And especially, they were mentioning there was a real time crunch. A lot of groups were doing this kind of approach and research in this field. They really had to be the first ones out there so they could establish themselves as the leader and the real innovators in, kind of, this new biotech field, so. I think their approach was smart.

WILLIAM BONVILLIAN: Right. I mean, this is a moment where there's a deep concern that comes up from the public, but also in the academic community itself, about the implications of this genetic engineering, right? I mean that's what Genentech stands for-- genetic engineering, right? That's what they're all about. And there's a major effort to put this whole movement on pause, right. And

there is an outcry in the city council in Cambridge, here-- a wild hearing by the city council trying to shut down related research at Harvard and MIT, because they're very worried about the implications of what's going to be happening here. So then there's an effort by the scientific community-- this famous conference called Asimolar out in California, where the whole community comes together and kind of really begins to work through the ethics. But their principal competitor, Wally Gilbert at Harvard, is forced, because of this limit on genetic engineering and the ability to use genetic DNA-- he has to go to England, where they're still allowing that research, and enlist a whole group of British scientists to undertake his research. But Swanson and Boyer get around that by using synthetic DNA, and they avoid the whole outcry. So it's a very interesting development. It slowed down their competitors pretty considerably. Wally Gilbert was a great talent to be up against-- I mean, a famous scientific leader and researcher.

AUDIENCE: I didn't do this reading or know that much about the genetic backgrounds at all, but were the pharmaceutical companies at all their competitors? Or are they very much so focused on just chemicals?

AUDIENCE: I think Boyer really came-- you saw that drawing with the pseudo-- that's a bacterial plastic DNA.

WILLIAM BONVILLIAN: Let's go back to that, Sanam-- that original picture of the two of them.

AUDIENCE: And you insert your synthetic gene into it.

WILLIAM BONVILLIAN: There it is.

AUDIENCE: That--

AUDIENCE: Yeah.

AUDIENCE: --rectangle. He basically came up with-- that wasn't in existence before, and now it's used every day, in almost every molecular biology lab. Yeah, so they don't think that the pharmaceuticals were onto this.

WILLIAM BONVILLIAN: Yeah, looking at that, you can try and guess which one went to the Sloan School, right?

[LAUGHTER]

AUDIENCE: I know. They're wearing the same kind of tie, though.

[LAUGHTER]

WILLIAM BONVILLIAN: Yeah, Boyer almost never looked that good, let me tell you.

AUDIENCE: Oh, yeah. [INAUDIBLE]. They look pretty similar. I mean, also, Swanson was chemistry every day at MIT and then Sloan masters.

WILLIAM BONVILLIAN: Right.

AUDIENCE: He was like pseudo-Sloan [INAUDIBLE].

WILLIAM BONVILLIAN: Right.

WILLIAM BONVILLIAN: How about another good question, Sanam?

SANAM: So something that some of you who had read this kind of raised, and I was curious about as well, was-- so the initial years, because it was so new and because they were doing something that hadn't been done before, there was an increased amount of risk-taking that was needed, and they both really staked their careers on it, especially Swanson, who ended up having to check himself into hospital when they had setback. So I wonder if there's, kind of, a way to encourage more sustainable risk-taking in people who have the visions, like Swanson, and people who are starting up endeavors like this? So there is a way to make it that they are incentivized to take these risks that are necessary to further their careers, but also, maybe not to the point that Swanson did.

AUDIENCE: At this point, I've led three innovation groups, where I teach, sort of, people-- not just students, but people-- the engineering design cycle. And I think one of my big takeaways-- having taught students as young as five years old to individuals as old as in their 50s, maybe 60s-- is that there really needs to be a sense of safety and security-- which was something that was brought up, I think, in the Biederman reading-- which is, I think, one of the reasons why there's

that, sort of, big paradigm of founding a company out of your dorm room. Because there's something that's implied there-- which is that you have a place to live. And that if you attend an institution where you have a dorm, you also have access to food. And you're also not super concerned about getting a paycheck. And so, I think that sense of security, sort of both mentally, to sort of take a step back and explore your dreams, is really important into the sense of stability. Like, literally, access to shelter, access to food, access to health care becomes really important.

So in those circumstances, I feel like universities-- and not just, maybe, in their undergraduate programs, but maybe universities generally-- provide really interesting opportunities to innovate for these kinds of very disruptive innovations, because they do provide this real holistic support to an individual. But that's still a theory that I'm working under and sort of hope to continue exploring over, maybe, a master's thesis or a PhD. But I think the other really big point about mental health is something that was also addressed in the Biederman reading, and it goes back to that sense of safety and security that, a lot of times, individuals who don't feel comfortable in their, sort of, organic or natural ecosystem feel more stressed, and thus, that prevents them from being productive. And so, I think about that in the context of the current political situation and the ways in which, maybe, some people who might be interested in innovating or pursuing innovative projects, may not be able to do so effectively because of the ways in which the political situation is literally motivating stress in their lives and is preventing them from innovating.

So those are some thoughts. I have a lot of them. [INAUDIBLE] share those too.

AUDIENCE: I mean, on the other side of that, I think this-- the aspect that having stress, a necessary stress, is important. I think with the Manhattan Project-- like there's no safety and security in thinking the Germans are going to get the bomb first. I mean, I couldn't think of a better impetus than this has to work, or I don't have a house to live in, or food to eat.

AUDIENCE: Well, actually, that's actually not what they had to deal with at all. I mean, granted, they would say, yeah, oh, we don't have any lives, but-- so I kind of agree, but-- I mean, Oppenheimer did mention in that paper he went six months, and he didn't even realize he had a paycheck-- he hadn't received one. And I saw that, and I just thought that was such privilege. So the fact that someone could have that sense of, OK, well if this-- ignoring the implications of, obviously, failing on this project, outside of the Manhattan Project, any other technological pursuit, I think that definitely helps someone think more creatively when you think about, oh, how am I going

to pay for my car? Or how am I going to get to work? Or whatever.

WILLIAM BONVILLIAN: So one of the important rules, I think here, is that the group needs to be on a protected island. And the point you're adding, Steph, I think, is a significant one. It needs to feel secure in itself, right? People have to be comfortable in this group to be willing to be creative together and contribute to each other. I think that's an important perception here that probably applies to a lot of these groups. But--

AUDIENCE: --has to do with that scarcity-- why having too little means so much. You don't have your full bandwidth if you're worried about what you don't have and what you need to work on. So that's part of creativity.

WILLIAM BONVILLIAN: Sanam, did this group have that sense of security?

SANAM: I think from what I read here, they definitely did. I mean, a lot of them were--

WILLIAM BONVILLIAN: You don't see in this picture the whole team, but there's a whole team here.

SANAM: Yeah, there's a whole--

WILLIAM BONVILLIAN: It's very collaborative with this duo.

SANAM: Yeah, and I think that that was an interesting point about-- I did kind of get a sense that class came into this in a way that really benefited-- he went into commercializing because he had an altruistic vision, which is interesting. But he had that ability to not have to worry about making money and things like that. So I think that's a very interesting point that you all have raised. And yeah, what you're saying about how people who feel like they are actively under threat, or they actively don't have the basic necessities taken care of, would not be able to function, maybe, in the way that make those innovations that--

WILLIAM BONVILLIAN: Right. They're on an island. They're not starving on the island.

SANAM: Yeah, exactly.

AUDIENCE: I think an addendum that would be-- have any of you read *When Breath Becomes Air.* It's a book by Paul Kalanithi. He was a neuroscientist, who was a resident, I believe, at Stanford. [INAUDIBLE] neurosurgeon, who is a medical resident at Stanford, who's just about to complete his neuroscience residency when he was diagnosed with brain cancer and ended up passing away, just shy of completing his residency. But there's a really incredible portion in his memoir, where he talks about what he had to do in order to be able to achieve what he did, which is, essentially, after going to Stanford undergrad, he spent a year, essentially, being homeless, living in an abandoned home and taking classes at Stanford while studying for the MCAT.

And I think there's a really-- the reason I recommend everyone read this book if they're interested in, sort of, becoming innovators, or entrepreneurs, or people who change the world is that he elicits a really great point about not necessarily just quote unquote male privilege, but just privilege, generally, because he was able to, sort of, opt out of being alive and utilize whatever money his parents were sending him, or whatever money he had saved up, in order to take these classes, in order to study for the kind, and then go on to do incredible work in medical school and then in residency.

And I feel like that's, sort of, close as you get and the clearest, sort of, articulation of the process of giving up your whole life in order to pursue this big dream that you have. And so, Paul Kalanithi's book, I think, is a really, really great study, not just of a great group, but of a great individual, and a person who's sort of a risk taker, and willing to give up their life for their work, and then ultimately, obviously the conclusion of it is quite beautiful, and the narrative arc is there, but--

WILLIAM BONVILLIAN: And these folks are giving up medicine to pursue the dream.

AUDIENCE: We're also looking at the winners, though.

WILLIAM BONVILLIAN: We're only looking at the winners, right?

AUDIENCE: I would say that pretty much every biotech entrepreneur ends up with ulcers and high blood pressure. That's just-- they do. And--

AUDIENCE: Or is it every entrepreneur?

AUDIENCE: Probably.

WILLIAM BONVILLIAN: She only said biotech. You're safe.

AUDIENCE: I know I'm more familiar with the biotech side. But I think that because these-- I think that's also a characteristic of the great group leaders-- that they're able to take risks and get ulcers so that the rest of their team can feel the insulation and as though they have the opportunity for success, resources, and security. So I that's an aspect of this.

SANAM: Yeah, I agree. There was a quote in the paper that the scientist at Genentech had no boss other than the Swanson's nervous vigilance, so that really carried them through [INAUDIBLE].

WILLIAM BONVILLIAN: That's a great line, Sanam. That's good. All right, let's do Venter, Lily.

LILY: OK. So I'm going over the Craig Venter great group today. A few of you have heard of him. Most have not. The leader of the great group, of course, was Craig Venter. And just going through some of the Bennis and Biederman necessities of great groupness, or greatness in a group.

His mission from God was to sequence and decode the human genome-- so check, we have a mission from God. The island-- in this particular case study, while they were decoding sequencing and decoding the human genome, their island was Celera, which was a biotech that was-- it's complicated. I'm going to try to keep it as simple as possible for the purposes of this presentation. Just know that Craig Venter had many, many for-profits and non-for-profits institutions all running at the same time. He now has now more than he even used to, so I'm just really going to talk about Celera for the purposes of this presentation.

And then the mainland-- he has connections with the public. There's a lot of publicity going on at this time over the Human Genome Project. So that's sort of their highway to the public, or the mainland. And he has contacts, still, at the NIH and adversaries at the NIH as well. And they are, indeed, the underdog. Craig Venter's great group defect from the NIH, and they're up against funding from the US government and, actually, international collaboration, especially with the British government. And the enemy--

WILLIAM Sorry-- I think it's actually Watson rather than Crick, right?

BONVILLIAN:

LILY: Oh. Yeah. Yeah, yeah, yeah. Sorry.

WILLIAM BONVILLIAN: Right. OK.

LILY: It is Watson. I put the wrong one in there. No, Francis Crick had nothing to do with this. It was Watson.

WILLIAM BONVILLIAN: And Watson was heading the Genome Project at NIH at the time.

LILY: Yeah. Yeah.

WILLIAM BONVILLIAN: And he drives Venter out.

LILY: And Venter and Watson begin as a very powerful duo. And Venter thinks that the genome needs to be sequenced in a slightly different way, and Watson is not OK with that, because so much money and so much effort has been put into it-- the sort of outdated way. And he completely undermines Venter in front of US Congress, et cetera. And I'll get into that a little more. But yeah, basically, the enemy is anyone who pisses off Venter, which turns out to be quite a lot of people over the years. Venter-- Craig Venter, I think, is one of the more-- one of the most controversial scientists in biotech in our time. He's a very-- a little bit of a hothead, and he-- people in science either love him or hate him.

So a little bit of background. His early life-- he's sort of-- he is reminiscent, for me, of Thomas Edison. He has some severe learning issues, almost flunks out of high school, does not go to college. He ends up a surfer bum in Southern California on Redondo Beach.

WILLIAM BONVILLIAN: Now I want to add one fact. Not just one parent, but both his parents were Marines sergeants.

LILY: Yep, so--

WILLIAM BONVILLIAN: You can only imagine what that does to you.

LILY: From this militant household and decides that as soon as he is-- I think he's 17 when he graduates from high school. He decides, I'm getting out of here. I'm going to live in Redondo Beach, in a surf shack, and grow my hair out long, and wear cutoffs. So that was his, I think, rebellion against his parents. This is during the time of Vietnam. Venter realizes-- he comes from a military family, first of all, so I think he has a somewhat a sense of duty. But he also realizes that he's probably going to get drafted, and it's better for him if he joins the Navy voluntarily. He's actually an extremely good competitive swimmer, possibly Olympic quality. So he joins the Navy, thinking that he's going to be on the swim team and not actually see active duty. And this turns out to be-- couldn't be farther from the truth.

Vietnam ramps up, and he is trained as an EMT and deployed to Da Nang. And he actually has two active deployments in Vietnam-- sees some things that I think changed his life forever. In the interview, he talks about how he is the person he is because of his time in Vietnam. He survives and attends community college in California. Transfers to UCSD, which is University of California San Diego, gets a BS and then a PhD there. I think he completed his PhD in three years. It was the fastest-- at that time, it was the fastest biochem PhD in UCSD history.

He goes immediately to a faculty position at Buffalo, in New York. Interesting transition for him, yeah. That's part of the interview. He talks about how he's this Californian with long hair and then goes to goes to Buffalo, where he begins to make people angry, actually. So he starts young on his path. So he marries his PhD student, Claire Fraser. He's very clear that they get married after she graduates, so there's nothing wrong with that at all. And in 1984, he leaves Buffalo, pretty much so that she can start her-- prove herself as her own scientist at the NIH. And I think this is where the great group really starts to coalesce and starts to form.

Some sequence of events. So while at the NIH, Venter is traditionally trained as a neuroscientist working in receptors. So is Claire Fraser. They have separate lab at the NIH, but something that Venter gets really interested in is molecular biology. He sees it as this field that's going to explode, is extremely important, and is, basically, our path to future medicine. So he starts to try to get funding to do molecular biology experiments and get into this field, buy the machines necessary. And he's totally stonewalled at the NIH. He's basically told, no, you're a neuroscientist. You can't work in this other stovepipe at the NIH. That's just not done. It won't work. So he becomes increasingly and increasingly frustrated with the bureaucracy, basically. And he says that he looks around, and he sees people who are lifers at the NIH, who just go through the motions of being a scientist, who couldn't really compete in the academic,

or the outside, world.

So he does something a little maverick. He creates this-- he's reading about and hearing about the Human Genome Project because it's a big initiative at NIH. And he decides, well, if they're not going to let me get into molecular about biology and sequencing the human genome, then I'm going to sneak in by, basically, sequencing a gene involved in neurobiology. So he does that, and he invents this thing called EST. And I'm not getting into it. Honestly, it's such an outdated thing that I didn't even learn about it during my studies. And then Watson and Venter have met.

WILLIAM BONVILLIAN: So Watson is running the huge Human Genome Project at NIH.

LILY: Right. Venter comes up-- he has the sequence of this gene. He's made some pretty cool breakthroughs and goes in and meets with Watson. And Watson gets excited about it at first. But then, Craig Venter goes off and, kind of, procures a machine, sort of behind Watson's back-- it's what Watson thinks-- and makes Watson really mad. So he totally undermines and vilifies Venter in front of Congress and the US public, because this is a huge-- this is a huge initiative. People are talking about it at the dinner table. It's a big deal back in the mid-1990s, I would say. So Watson basically doesn't like the way Craig's doing things. So--

WILLIAM BONVILLIAN: So let me just add one quick detail, Lily. So there is an issue here on what gets patented on a project like the human genome. Can you patent the genome, right? So this whole issue is coming up. The general counsel at NIH advises Venter that, yes, we are going to be able to patent a lot of this emerging genetics field, so let's protect-- he's a researcher for NIH. So he's intramural researcher at NIH. Let's protect NIH by filing a lot of the patents ourselves. And the confrontation with Congress is where Watson attacks Venter for patenting genome technologies. In other words, it's not going to be available to the scientific world. It's not going to be open based. It's not going to be in the commons, even though Venter had received-- had been told by the general counsel's office at NIH that that's what he had to do. So that leads to this explosion of anger by Venter.

LILY: Yeah, so--

WILLIAM BONVILLIAN: Is that a fair summary?

LILY: Definitely.

WILLIAM BONVILLIAN: OK.

LILY: Yeah, from Venter's side of the story, he says, I didn't necessarily want to patent these genes. The NIH advised me to. It was their initiative. And Watson used it as a way to undermine me in front of the American public because he didn't want me to use my technology that I had come up with. So that's the-- sort of the backstory. Venter is insanely angry, and he and his wife defect from the NIH and form Celera with the help of venture capitalists, who later also anger Venter, and that explodes. And they take with them 12 men of their lab members from the NIH.

So the team. And I think that Craig Venter really exemplifies a great group leader in that he seems able to identify talent in others. So they start out with the 12 from NIH. They have their island of Celera. And the team that they start to form-- this is not including the board of directors and such, which also seemed to be pretty amazing people. But they recruit Hamilton-- actually I think-- Well, Hamilton Smith comes onto the scene, and he's their premier molecular biologist.

WILLIAM BONVILLIAN: And he's a Nobel Prize winner.

LILY: Did he?

WILLIAM BONVILLIAN: Yeah.

LILY: OK. At--

AUDIENCE: Was that during the time period or after?

WILLIAM BONVILLIAN: Prior. [INAUDIBLE]

LILY: Yeah. Yeah. So I don't think any of-- this is actually a question I'm going to pose to the class at the end of my presentation. I don't think anyone in this great group has won a Nobel Prize, except-- like for this. Previously Ham Smith.

WILLIAM BONVILLIAN: Right.

LILY: So Marshall Peterson is this computer geek because not only is Hamilton Smith literally coming up with the sequencing technology to do this-- this is 30 billion base pairs of DNA. The most anyone has sequenced at this point is like C. elegans, or like a worm-- tiny, tiny genome. So this is a huge deal. They have to come up with new sequencing technologies, new ways to decode the sequence, and new computing. So they literally build the third largest computer on the planet, I think. The DOE has a larger computer, and there's someone somewhere else in the world. And they build this massive computing facility and then bring on Gene Myers as this coder who's coming up with the algorithms to try to piece together all these little pieces of DNA and build a 30 billion base sequence.

So in the meantime, the public sector-- academia, the NIH-- are becoming increasingly angry with Craig Venter, saying that he's defecting to the private sector, and he's going after the human genome for profit. Craig is saying, I don't-- I'm not in this for profit. I'm in this because we need a human genome so that we can promote human molecular, biology-based medicine. In the meantime, he sequences the drosophilid genome and gives it-- publishes it in science. Gives it--

WILLIAM BONVILLIAN: Fruit fly.

LILY: Yeah, the fruit fly genome, which people have been trying to figure out what genes in fruit fly do for decades and decades and decades. And so, there's this really cool part in the interview where he talks about this community of fruit fly researchers, who, I think, are kind of like the physics community. And they're pretty close-knit. They have their conferences, and they try to get together, and decode the fruit fly, which they don't have the basis or the knowledge to do that yet. So they're doing it gene by gene by gene over many years. And Craig decodes the fruit fly genome and says, come to Celera. I have all of the information that you've been looking for the past few decades. And you can have it. It's here. So he says, maybe on the order of 100 or so fruit fly researchers come. And they are just like kids in a candy shop. They stay up all hours of the night and making these breakthroughs that they've been looking for for decades. So that's pretty fun, pretty cool.

So fruit fly sequenced, NIH. You would probably know more about the interplay between

Francis Collins and Venter, because that-- I don't-- I'm not-- it's a little fuzzy for me. I can never figure out if they're working together or against each other, but eventually, what happens in 2001-- the NIH and the public-- like academia, so people from different universities-- come together and publish the human genome in the journal *Nature.* And two days later, Celera announces the--

WILLIAM BONVILLIAN: Same day.

LILY: Oh it is the same day? It comes out in *Science.* So this is--

AUDIENCE: Was that planned?

WILLIAM BONVILLIAN: Yeah.

LILY: Yeah.

WILLIAM BONVILLIAN: So there had to be-- I mean it's a fascinating story, right? And there's rich MIT history, which MIT was on the side of NIH, just so you know. So Venter, through a research model that was extremely focused on getting this project done, right? Everything was to be organized for the project. NIH is on a research model that could be described as, let's let 1,000 flowers bloom. We'll have a lot of RL1 researchers out there. Eventually, that will turn into the Human Genome Project. Someone made the analogy to that research model as, OK, if you put a whole lot of monkeys into a room and give them typewriters, eventually we'll get Shakespeare, right? It's obviously exaggeration here, but Venter, with his very focused research project, and these computer scientists, and Venter himself, becomes a master of the computers that he's working on building, and EST technology is from that-- versus a much more decentralized research operation.

So slowly NIH realized, it's going to lose the race, unless it gets its act together. So they begin to focus on getting rid of the 1,000 flowers. Let's get down to a small number of focused research centers. And it's a race, really, between-- who's that Broad Institute head? What's his name? Oh, how can I forget? Eric Lander. Yeah, of course. Sorry, excuse me. So Eric's a mathematician. He's not a life scientist, right? And he becomes the leader of the Human Genome Project for NIH. Collins is heading it, but Eric is the one who's carrying out the computational parts of it, right? And they do it in cooperation with this Department of Energy

supercomputer labs, because they need their own supercomputing capability. Venter's built his. NIH uses DOE.

So this race is ongoing. The NIH crowd is attacking Venter constantly for, essentially, trying to profit from patenting the genome. That's their complaint-- that he's going to take this critical scientific advance, critical to the future of medicine, and take it out of circulation and access to science, and patent it, and prevent anybody from using it. That's the case being made against him. It's pretty far, in reality, from what the truth is, but that's the case being made. And Eric and the NIH team are gradually-- they are using some of Venter's technology. They're originating, certainly, many of their own. They're within range. So at that point, a negotiated truce is arranged so that nobody gets embarrassed here, right? And the real worry was that NIH would lose the race, right? So eventually, Venter is prevailed on to declare a tie, and each side will publish, in the two major scientific publications, their version of the genome. And that's, in fact, what occurs. It's-- Go ahead.

LILY: Two points I want to make. One is that in this interview, Venter says that he finds out that Francis Collins, the head of the NIH, has budgeted less than half of what it's going to take at their current rate to complete the human genome. So in his mind, Collins has no intention of really completing it. And they can't-- as the way things stood. The other point I wanted to make is that the NIH-- Venter's enemies and adversaries keep bombarding him in the public by saying he's going to profit off the human genome. And there is a little-- there's actually a lot of friction between Venter and his venture capitalists, because he wants to publish. Publish, publish, publish the findings that they're making so that other people can utilize them. And the venture capitalists keep saying, no, we don't want-- you can't do that. You can't do that. It's private. We want to patent, et cetera. So there's that friction going on. So yes, eventually published at the same time. Celera actually-- Venter is-- both quits and is fired from Celera at the same time. And--

AUDIENCE: Which one came first?

LILY: In Venter's mind, he was about to quit anyway, but yeah, he was basically asked to leave on a Monday morning.

AUDIENCE: He's truly the Steve Jobs of biology.

LILY: Yeah. Yeah. Yeah, there are a lot of parallels.

AUDIENCE: Even the hippie phase.

WILLIAM BONVILLIAN: But Martine, he's different, right? He creates this group, originally, at his NIH lab. It's basically still with him, right?

LILY: Yeah, they want to follow him.

WILLIAM BONVILLIAN: Right. This is not Jobs's abrasiveness, right, and screaming. This is somebody who is really-- he's a pretty charismatic figure. I've spent a little time with him. And he is able to keep an absolutely remarkable team together for a remarkably long period of time. So it's a different personal atmosphere, a different kind of leadership style.

But remember what it must have been like. I mean, he comes back from the Vietnam War full of Navy and Marine Corps tattoos, right? He's a veteran of this ghastly war, and he's been-- he's seen some of the worst outcomes, running a whole hospital wing, virtually on his own, in Da Nang, and sees death and loss of life, and trying to save life, firsthand, in a very personal kind of way. He's completely different than the kind of culture of NIH. He's up from a working class, military family, and it's just a different world that he's been exposed to. And he doesn't get along with this kind of established liberal community of scientists at NIH. So that's part of what's going on here, I think, really.

LILY: Yeah, I think what's--

WILLIAM BONVILLIAN: He's just a really different character.

LILY: What's always pushing him at the NIH is and throughout the Human Genome Project is, decode the human genome so we don't see the situation, or the things that he saw in the hospital at Da Nang. He doesn't-- he thinks that modern medicine should eradicate those sorts of injuries. His vision is synthetic biology. Regrow. Regrow everything synthetically. Regrow human limbs. He's very forward thinking as far as the medical uses of knowing genetics.

AUDIENCE: I had this question. So what exactly were they trying to patent on either side that we see?

LILY: Lots of things. So I think that one worry was that his invention-- Craig's method of EST would be patented itself. And it's an extremely-- it was for a-- well some areas of biology still use it. Not my particular field, but a lot of areas of biology still use it. And if it were patented, they wouldn't be able to, obviously. So it's widely applicable. It's technique. And there was worry

that he would try to patent EST, or there might have-- I think there was a patent in, and the NIH pulled it, or something like that, with so much negative press. There were a couple of other things up for patent, maybe, but I don't know the specifics.

WILLIAM BONVILLIAN: Why don't we get in some questions.

LILY: Yeah, OK.

WILLIAM BONVILLIAN: Do you have any more slides?

LILY: But I wanted to let you know--

WILLIAM BONVILLIAN: Oh. Oh yes. OK.

LILY: What does he do? So Celera--

WILLIAM BONVILLIAN: This is what he's doing now.

LILY: Celera goes boom with the dot come bubble. It's worth $15 billion, and the stock goes from 500 bucks to $6. At that point, Craig had already left. One of the reasons that the stock dropped so drastically was because people found out that Craig left. So now-- well not now, but then, he decides, well I'm going to do my own science, and I'm going to sequence the entire ocean. I'm done with the human genome. Now I'm going to go to the ocean. So he gets on this 100 foot yacht-- the *Sorcerer II.* And a couple of people-- I taught with a woman who's a professor at USC, who was on some of the *Sorcerer* legs of the journey. And then her husband, John Heidelberg is on-- he was on my thesis committees, so he's the third author on this paper. And they have lots of fun Craig stories as well. And one of the-- I think one of the themes throughout the great groups is that, there are a lot of partiers. If they're not doing really crazy, good science, they're partying. So they dock, and they just have the big huge party.

So then he finishes sailing around the world a couple of times and sequencing all the bacteria in the ocean and sets up the JCVI, which is located in La Jolla, right next to his alma mater, UCSD. So that's a picture of Craig from a few years ago. So to conclude, a few choice quotes

from Craig. "I've gotten some pretty nice awards. And I'm having trouble finding places to put them all." And then one that's more pertinent to this class is, "The environment has fallen to the wayside in politics." And lastly-- oh, I wanted to go over Venter's thoughts on innovation, but that's not-- we're getting close on time, so that's not really necessary. These are better.

WILLIAM BONVILLIAN: How about some questions?

LILY: OK, so show of-- I wanted to see, in the class, by a show of hands. Who thinks that Venter, or maybe a couple of people within his group-- I mean, they decoded the human genome, which was-- just the amount of new technologies that they came up with, both in computing and molecular biology, in order to do that are astounding. So who in here would say he should be a Nobel Prize winner? Or people in his group?

AUDIENCE: I'm sure there's got to be some other equivalent, biology-centered award, right?

AUDIENCE: I mean, he could just make his own award and then.

AUDIENCE: Yeah.

LILY: Well, he's got a lot of them [INAUDIBLE].

AUDIENCE: I mean, but [INAUDIBLE] give out your own award.

AUDIENCE: If there's a Watson and Crick award, and he wins it, imagine how hilarious that would be.

WILLIAM BONVILLIAN: That won't happen.

AUDIENCE: --it was self-critical and then was like--

WILLIAM BONVILLIAN: Watson.

AUDIENCE: Oh, Watson.

LILY: Yeah, sorry.

AUDIENCE: When they started, a lot of their stuff was based off of Schrodinger's *What is Life?* That's how they come up with the DNA, because it was mentioned. And they were seen as nobodys up to

that point. It's really interesting.

AUDIENCE: Lily, can I ask a really simple semantic question? Why do they call it decoding, and not encoding, the human genome?

LILY: I think it would be called decoding because--

AUDIENCE: You're only reading it.

LILY: What this looks like when you actually read the bases is fluorescent dye. So you have to read-- you have to decode the fluorescent signature in order to get the base pairs.

AUDIENCE: So it's not about-- it's about, more so, evaluating the results than it is about, sort of, expressing the result?

LILY: Yeah. Yeah, I would [INAUDIBLE].

AUDIENCE: They also did something cool that's you inject DNA into like a bacteria and it changed the way it was. [INAUDIBLE] changed the lifeform. I was--

WILLIAM BONVILLIAN: One thing about this effort here-- you have to get a sense for how transformational this seemed in the 1990s, because it was really quite amazing. But this was one of the great scientific competitions of all time, right? This incredible race to do the-- to decode the genome. And this is being-- this a major news story, right? And Francis Collins has a Harley motorcycle, and sings in a blues band, and he has his own fast-- he still rides his motorcycle into work at NIH. Venter is a yachtsman, who buys these wild, incredibly dangerous sailboats and loves that kind of wild adventure of being in a tempestuous sea, close to the wind, and near capsize danger, with these monster sailboats. So both of them have their, kind of, wild side here. There's no question about it.

But this competition captures the public imagination. And it's a very important race, because the race forces incredible speed in the project. So what had probably been originally viewed as a 40-year project that gets knocked down to well less than a decade by the time these characters kind of complete the race and agree to a truce by publishing on the same day. And in turn, I was working in the Senate while this is all going on. And the public was getting a sense, gee, we really are getting fairly close to some absolutely fundamental answers, here.

And when two US senators-- Senator Specter and Senator Harkin from Pennsylvania and

Iowa, respectively-- were chair and ranking on the appropriations subcommittee that handles NIH. They actually-- there's was-- in the Clinton years-- because of the IT revolution is creating a lot of extra tax revenue-- were balancing the budget. So there's revenue, on one of those rare moments, there's revenue in the federal government Specter and Harkin go down and take the revenue. And that's what doubles NIH. And nobody says they're wrong because of the excitement that this race to get to the genome has created and what it's scientific possibilities are. So sure, there's a whole political effort to radically increase NIH funding, but the enabler here is the public excitement around the genome race and what its possibilities might be to accomplish. So this has enduring, kind of, lasting effects that spill over in many kind of ways into the life science arena. Next question. How about-- you want to pose a couple of questions, and then we'll wrap things up.

LILY: Yeah, one of the things I was thinking about while reading this and the other readings in the class is that Venter seems to form and dissolve and reform multiple great groups throughout his lifetime-- from the 80s to present day. And in thinking about other great--

WILLIAM BONVILLIAN: But Lily, he's only changing the formal structure. The team really follows him from one organizational model to another--

WILLIAM BONVILLIAN: That's true.

WILLIAM BONVILLIAN: In many way.

LILY: So do we think that most great group leaders have a great-- one great group, and that's their opus. They don't go on and-- they have one mission.

AUDIENCE: When you say group, do you mean a following? Or a team?

LILY: One team.

AUDIENCE: Yeah, I mean, I would disagree. Well just a counterexample I'll give is Apple. Because there is the Mac team-- those are very unique. So I'll take certain products. Or if it's a one particular problem, you have a group. And them you can choose to decay the group after.

WILLIAM BONVILLIAN: Yeah, Apple is remarkable for its ability to go from one major technology launch to another in sequence. It's really--

AUDIENCE: It's hard, yeah.

WILLIAM BONVILLIAN: --very hard and very difficult. And interestingly, it hasn't happened since Jobs died.

AUDIENCE: That we know of.

WILLIAM BONVILLIAN: That we know of, yeah.

AUDIENCE: Who else is a [INAUDIBLE]

AUDIENCE: I feel like they'd release some information about that, seeing as how the hype around Apple's kind of starting to die down.

WILLIAM BONVILLIAN: There's a model in history. I mean, how does a big company innovate? It's a terribly difficult problem, right? They're the suits. They're the bureaucracy. Lockheed is kind of noted as the experimenter here. They set up something called the Skunk Works as a completely side, separate organization on a protected island, with a bridge back to the Lockheed management. And they do remarkable advances in aeronautics and aerospace. So they do the U-2. They do the SR-71 Blackbird, which many people to this day think is the most remarkable plane ever built. But then a whole sequence of other aircraft. And they do stealth, right? They're the implementers of a lot of the stealth technology. So that's an example of how a corporation is able to create an entity that can move through a series of great groups and keep innovating. That's kind of held up as a kind of iconic model. So it is possible. So when your-- the small companies that you all set up become major corporations, read about Skunk Works, because that'll be your clue to continued survival.

AUDIENCE: Ray Stata did something interesting like that, where his company, they wouldn't fund--

WILLIAM BONVILLIAN: That's Analog Devices, just up the street.

AUDIENCE: They wouldn't fund [INAUDIBLE] to digital technologies. And so what he had to do is, he personally putting in his own money to make a new company that the old company could not buy back. So he had to get over it that way.

WILLIAM That's Interesting. Lily, how about a closing thought for us about this amazing crowd?

BONVILLIAN:

LILY: Let's see. I think that Craig is right when he says you have to take risks. You have to take risks or else you're not going to do anything worth writing about.

WILLIAM And that's a great way to close.

BONVILLIAN: