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Interviewee: Ignacio Chapela
Interviewer: Matthew Booker, Jason Delborne, and Brad Herring
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START OF INTERVIEW

[00:00:00]

[Matthew Booker] So my name is Matthew Booker. This is 22nd of February, 2015. We're here at North Carolina State University. Could you tell us your name, your institution, and your role?

[Ignacio Chapela] My name is Ignacio Chapela and I work at the University of California in Berkeley. I am a professor.

[MB] In which department are you a professor?

[IC] I'm a professor in the department of Environmental Science, Policy, and Management. And I am an aspiring biologist. I aspire to be a biologist and teach biology, but in the meantime I am a microbial ecologist. That's what the institution recognizes.

[MB] And how would you describe what you do?

[IC] I do so many things. Being a professor, I think, as a profession, is something that I think requires many things, especially learning and so that implies doing work in the lab. So I have several projects going on that imply mixing juices and working on a bench and a microscope and so on. But I also do a lot of fieldwork to feed that lab work. And I also do a lot of work with people, which is probably the most important element. And among those people students are a very important and special category of the people that I deal with through the format of lecturing, but more interesting in my mind, through the less formal format of seminars and field experiences that I have developed over the years. I'm particularly interested in the peripatetic approach to learning: Thinking while walking or thinking while paddling on the water and thinking in common during those things is something that for the last ten years or so I have been developing.

[00:02:17]

[MB] Do you see yourself as having an audience outside of the university? Who do you think of as your audience when you're--

[IC] I think my audience is not the university per se. I think the university is a safe haven, a monastery space, a protected space, where my audience comes and meets in this protected space but I really do believe my audience is very wide and open-ended audience in different parts of the world. It changes over time, depending on what I'm doing and what's happening in the world, but I believe that the context of the university is simply a vessel in which protected thinking can happen.

[00:03:15]

[MB] Is that what you wanted to be when you grew up? Did you know what you wanted to be as a child?

[IC] I knew what I wanted to be as a child. I did not know that it would be a professor in an academic institution. So I think critical thinking is the thing that I've always been pestered with. It's almost like a disease that doesn't let you be. As a very young child I think I already had that interest in question and asking. I'm not a straight pureblood academician by any measure. I'm really a mutt. And I did not really expect to be teaching or dealing with students in an academic context for a long, long time. I had a career as a researcher in different institutions, simply doing research—biological research. And it wasn't until 1996 that Berkeley showed up and started talking to me and said, "Will you come?" At the beginning I didn't want to. I didn't want to enter that world. And slowly over the years I have come to appreciate it more and more and feel like I've grown into this. I've matured to the point that I feel I do want to be a professor.

[00:04:51]

[MB] So would you tell us a little bit more about how you came to this career? I mean, what were you doing? Where are you from and what were you doing before you came to your career in research?

[IC] I was born in Mexico City. Why? It's a long history I guess but as far as I'm concerned it's kind of an accident of history. Where you're dropped in the world is an accident in a way. So much so that I felt always the need to move out from Mexico City. Mexico City is a very constraining space. It's very high up in the mountains and surrounded by much, much higher mountains in this kind of vessel. That used to be very beautiful when there were fewer people there. It used to have a big lake in the middle of it; it was surrounded by forests. But by the time I came to it [the lake], it was paved over and drained out by whatever forces. And so it felt to me [to be] a very constraining space and so I had this drive to walk out of the city. I walked around,

went on a bicycle in this centrifugal kind of way. And I think that was a very important driver in the making of who I am in that it was a very important way of understanding that one has to put effort into changing and becoming something different. I became interested—because of my time in the university I became interested in fungi, as a, again, a window into the world that is very different from anything that we have—that we as humans understand. And it was kind of like falling in love with this group of strange beings and I wanted to understand them. I wanted to learn. I remember thinking, you know, if I could understand how they talk to each other, how they communicate, that would be good enough. If I could understand how to, I don't know, interact with them in some kind of reasonable way, I would be very happy. So I just got it into my head that I wanted to learn about fungi. And there was no one in Mexico that would help me with that. I found one exile from Uruguay who was the only person that knew anything about them and I worked with her for some years. But then it became, again, the same centrifugal force pushing me out and for the next twenty years or so I changed countries, I changed places, I did all kind of things, but it was always really following that interest and that drive. And that of course led me to all kinds of other places but I think it was—maybe those are the forces, the centrifugal force—seeking beyond what is known and what is constraining us. And then this understanding that it is true—that understanding the other [is how] we can liberate ourselves from our own constraints. I think those would be the two drivers that took me to where I am today.

[00:08:46]

[MB] Were there particular people along that path who were influential for you, who shaped your career, who you wanted to emulate? Was there anyone along the way who you think was especially important?

[IC] Yeah, there have been many people that have been very important and influential in my professional career, but of course my personal life too and I think I would find it difficult to pull out a list of them. Since you seem to be interested in me as a person, maybe I should say that my father died when I was eleven and he was basically disabled since I was like three. So I think those people that I sought to emulate or that I found inspiration from were always kind of *ersatz* [German: imitation] father. So I think I was just jumping from father to father in a way for a long time and many of those father figures were also figures of people, mostly men, who would know something about—first about fungi, and then eventually it became much more complicated and complex about social relationships, history, very important inspiration from history and historians. To this day, I think the last fifteen or twenty years, I haven't had that strong of a father figure but I think it's still kind of like a good way of moving for me.

[00:10:25]

[MB] So this Center that's conducting these interviews is the Genetic Engineering and Society Center. And so of course we're interested in your relationship to those themes in your research and more broadly in the way that you imagine your career. So what brought you into that world of genetic engineering from your interest in biology and fungi in particular?

[IC] My personal professional history pretty much overlaps the history of biotechnology. The first transgenic organism came about at Stanford in 1972, '73, '74. At that time I'm twelve, thirteen, or fourteen years old and I'm really avidly reading into biology. By that point I'm really focused on learning biology and I'm reading about this happening. So there was a very clear sense of a momentous change in our understanding and especially in our capacity to manipulate life that had existed in science fiction before but all of a sudden was becoming something practically real. So obviously you become interested in it and you become even enthusiastic about it. The idea that we could improve on living things and maybe use that for some kind of social betterment was very powerful and very strong, especially at the beginning of this. You know, we're talking the early eighties perhaps. So I was reading about it continuously really on the side of my training as a mycologist. You know, there's training and then there's the education, right? That's two separate things. So I'm training on one side as a mycologist - microbiologist but I'm trying to educate myself as a biologist. And so my education is completely influenced by this. It wasn't until I had a job in the industry in Switzerland that I became much more focused on it. And by now we're talking about the late eighties, early nineties. And this is the moment where biotechnology is coming out of the lab really and hitting the possibility of being applied somewhere, especially in outdoors [and] open fields situations. And so I am working for the industry and I'm looking from inside the industry, and by that I mean the large whole established transnational industry rather than the little biotech companies that are beginning to just scurry around the room like little mice. We're looking at them and I remember thinking, why are we not doing that? I was too naïve and too young I guess because I didn't know how this works. What we were doing was just waiting it out, seeing who among all those little mice in the room was going to survive and then of course you wait until that happens and you just grab it and bring it into the house once it's nice and fat. That was exactly what was happening. And at that point I left the industry and moved—I was moving, at that point, driven a lot by an interaction with indigenous communities in Mexico. I had this very long term—about fifteen years of work, [working] very intensely and very intimately with a group of indigenous communities. And that was informing my reading of what was happening outside in biotechnology. And so when I came out of the industry I engaged very strongly with the problem of the who's of biotechnology: who produces, who benefits, who gives, who takes for whom, and not so much the consequences but the actual people involved. I was working at Tom Eisner's lab at Cornell; an entomologist, one of those father figures for me. And Tom was very engaged with the negotiating, but more importantly, with the conceptualizing of what became the convention of biological diversity. And I was, you know, working very closely with him on all kinds of questions of framing the problem of biodiversity laws, the role of technology and

addressing this, the role of social policy, economic policy, in shaping what we do with non-human things. Rainforest was the thing at the time, the rainforest. That, together with the point of view of the indigenous communities, really changed my way of understanding what was happening in the field of biotechnology; how these different people and industries were interacted, but more importantly, what was driving them. What were there incentives and interests? And at that point I started becoming more and more critical; more and more troubled by the way things were actually developing, not in theory but in actual practice. You know, the actual existing biotechnology was becoming something very different from what we thought it would, or I thought it would be in the seventies. And so I started developing a more critical point of view. And I started seeing how little there was about critical thinking going into it. And I was witnessing really from the inside of it, how this whole thing was being driven by this incredible desire to make it succeed no matter what. So that, in this drive to run towards it, any question and any opposition or any critical thinking was just being set aside—let's go back to that later, let's go back to that later, let's just move forward and have all this in supply because they're so important. I used to think they were important for things like improving social wellbeing and saving biodiversity and all that but it became really clear to me that what was at stake was benefit, profit. And very quickly the role of profit making out of this became the dominant theme and eventually the only theme, dressed up as if it was some kind of social economic ecological benefit, but very clearly what was actually happening was all driven towards just profit. And at that point I really became more and more concerned. I can keep going on like this for a long time. Is this too long?

[MB] No.

[IC] Because I'm trying to—I'm going to get to Mexico and corn.

[MB] Please.

[IC] So this is happening with me as a person sitting in Ithaca, New York, while at the same time interacting very intensely with these indigenous communities, having still connections with the industry on the other side, and asking questions, okay so who is going to tell us that there is a problem here? We're leaving all these questions behind. We're moving way too fast and who is representing, in all this debate in discussion, who's representing those people that I know are there, who are interested and not particularly critical or anything. They're just saying, what is this? And you come and you tell them, well there are people who are thinking of bringing fish qualities into corn. And they're like, that sounds kind of strange but tell us more. Well that's it, you know? You're just going to get qualities from fish and put them into corn. And when you say that in the middle of an assembly of indigenous communities in the mountains of Oaxaca, Mexico, it has a very different value then when you say it somewhere, in Ithaca, New York or somewhere else. And so these people started just saying, so what are the consequences of this?

What's going to happen? And of course I would say to them, I don't know. And is the corn going to be bigger or smaller? I don't know. And what other side effects will it have? I don't know. And how are we going to see it? And the answer is I don't know. And at that point it became really, really clear that nobody was going to be asking that kind of precautionary question. I was developing this---finally growing into understanding that there are two ways of understanding. There's one very promotional and one very precautionary way of looking at biotechnology. And I was seeing that the promotional way of looking at it was just completely overshadowing the precautionary. And so, because we were working together with these indigenous communities, they decided—this happened over the period of about three years or so—lots of discussions, lots of backs and forths, and many assemblies, and many people talking about it there, until they say, well we want to know. It's clear that the people who are producing it are not going to tell us. The academicians who are surrounding them are not going to tell us. The government of the US where they come from is not going to tell anyone. And, by consequence, the government of Mexico is not going to do anything and the academicians of Mexico are not going to do anything. So the idea came up that they wanted to have the capacity to look for themselves. And because of the history of their relationship, I was in a position to help them set up the technical capacity to do it, basically running PCR [polymerase chain reaction] and analyzing DNA [deoxyribonucleic acid]. We ran a workshop, I got the nascents of equipment, and we set up a lab. They trained their own people and so the lab was run by their own people. And then, David Quist, who was a graduate student in our program in my lab, was really in charge of running the workshops and dealing with a lot of this. And he went and did a workshop on running PCR and detecting GMOs [genetically modified organisms]. He brought positive controls, little cans from the US, canned corn, and his narrative controls were to be the pristine, beautiful, native corn of, you know, the cradle of corn in Mexico. We thought, what better than that? And the surprise came on the first run. He ran kind of like a dry run before the workshop where he was going to demonstrate this to many people overnight. And he called me in the morning and he said, all these negative controls are coming out positive. What do we do? It was a very critical moment right there where we had to decide—I was at Berkeley at that point and we were on the phone. So over the phone we had to decide what we were going to do with this. Are we going to come out public or not? Knowing full well what the consequences were going to be. And we decided of course to confirm these results and then go try to publish them. Eventually they get published in *Nature* and there's a big story following that. But I think that this point for me, from my point of view, this phone conversation with David was a very important kind of turn point for me because it finally pushed me to be public about what I had been developing as a point of view, as a frame of mind, and a, you know, an academic frame for how I understood this biotechnological development. And so, for me from that moment on—from that phone call from David Quist to me on, it became a much more public and, in a way, much more integrated way for me to bring together all these different forces that before had been really separate in my life. Gosh I can't continue like this forever. I'm sorry.

[00:24:28]

[MB] I'm not sorry. The idea is for you to speak about these issues until you feel satisfied. But I can certainly ask you more questions.

[IC] Yeah I think you should because I can keep talking forever.

[MB] Well, one would be, have you continued to work with transgenic issues or particularly in your own research or were you regarding this as a kind of single moment? Have you continued to investigate transgenic issues in your own research?

[IC] Yes I have continued to investigate transgenic issues in my own research but I obviously had to be careful about it and strategic about it. The finding that David Quist and the people running the lab in Oaxaca did of finding that there was transgenic DNA within native varieties of corn in Oaxaca to everybody's surprise, to everybody's surprise—that led to a very big battle, first over the validity of these results and then over the importance or lack thereof of the results. In a way it was like taking a photograph with a Polaroid camera, a very simple cheap camera, of something completely unexpected. Let's say Martians on the planet earth, right? You take a picture of a family of Martians in one photo and its only father, mother, and son, let's say, no daughters you can produce. It's a very, very small piece of evidence, very modest but very important. That was enough to cause about eight years of battles for me. I was embattled in all kinds of different ways: labor problems, social problems, marriage problems, all kinds of things that culminated in a way or had a cataclysmic change with the decision by the University of California to give me tenure. Part of the battle was portrayed in the public scene as if I was fighting because I felt that I deserved tenure at the University of California. And I always said, no tenure is not for me to say anything about. What I am here for is simply to show what I have, show what we saw, and say that it's okay to say that kind of thing. And whether the University of California decides to do whatever, it's up to them. For whatever reason, it's complicated. They end up deciding that I should be tenured at the University of California and at that point I started thinking, okay so what does one do with that? What does that mean? I think for most of my colleagues, tenure is something that people deserve. It's like a right, some kind of thing that you get, like a prize or something. But for me, precisely because of the public history of how I got to that point, it was very doubtful that it was any kind of prize. In fact, I doubted very much that I wanted it. I actually set a very conscious period of three to four months of consulting with many of those people that I admire and people that have supported and people who had studied the case. And I held many, many, many interviews asking questions, should I take this offer to be tenured or not? Eventually I did because I realized that I could use that if I understood it properly, I think, as a privilege, as something that is given to someone from the public—this is a public university—as a privilege to do what? What does that mean, tenure? Well it means that you can ask questions that nobody else can ask. It means that you can engage in projects that

nobody else can because you have the staying power of a job. And so I went into a long-term really thinking process of saying, what does that look like in the lab? It's fine to know about fungi, it's fine to know these little details about how things are put together and how they operate, but I was kind of done with that. It wasn't enough for me. I really felt that if I'm going to take this tenure thing I'd better come up with something that is more than that, just continuing to add papers to the mycological literature, right? Not that it's not interesting or important but I felt that my own personal history had really taken me to that place where if I was going to take it I better come up with something that was ambitious, that was risky, and that was exposing in the way that other event had happened. So for the last ten, twelve years, up to this point today, I've been working on this one project that is focused on providing an independent horizontal network way of looking for or looking at transgenic DNA in the environment. What these people in Oaxaca in the year 1998, '99, and 2000 were not able to do until we came and we gave them this big lab that required a lot of investment and was very centralized should move to become a horizontally distributed capacity. I think of it as providing people glasses that you could put on, that would allow you to see where transgenic organisms are. If you ask anyone around here, where is the closest transgenic organism to where you are right now? They don't know [the answer]. And you cannot know and you can guess and go and take a sample of, I don't know, whatever you guess—your tortillas chips or something. And in order for you to find out whether that tortillas chip has GMOs in it you have to send it to a lab and pay about 400 dollars to get a yes or no from this commercial testing company. That's no way of really giving a widespread horizontal way of thinking and relating to this thing that I consider to be very important, this transgenic manipulation. And so we've been dedicated to produce a completely new series of methods and even an instrument that is—so if one detection today costs about 400 dollars. The level that we are at today is 70 cents. So this price deferential is really huge and it's still very expensive. We're clearly able to drop that price a lot more. At which point, the hope is that people who want to know about transgenics will be able to just test everyday; in different corners of their house or in their field or their, I don't know, roads or whatever, without having to rely on the centralized and monopolistic testing laboratory. So yes, I've been really dedicated—really, really dedicated. We've put a huge amount of effort into producing this very ambitious project because we really did have to come up with completely new techniques and methods. It's nothing new that we invented but putting together things that have been invented outside this package that allows people a very quick, very simple, and very cheap detection if you want. Detection that eventually should become mapping where people can actually see where these things are and how much it is changing overtime. They see it moving from, let's say plants to insects, which is something that can happen, or plants to bacteria through horizontal gene transfers. Who is checking for that? Nobody. But we're trying to provide this capacity so that people can do it and do it at a very widespread scale. The publication started coming out last year or the year before. We've been very careful not to be visible online or anywhere else because of my experience that I know that they'll come and shoot us before we are even born. And so we've been putting out publications in a very strategic way, in such a way that the

method is validated first. So if you go online and search for a paper that came out last year, it's a paper on the detection of pollen from certain trees that could have various allergens for people who are allergic to pollen. You'd never guess that it's about transgenics but the paper that we're submitting right now finally has the use of this method—exactly the same method for the detection of transgenics on corn pollen. So the idea is really that we're able now to take samples from the air and produce many, many, many results—many yes's and no's for very little money and very quickly.

[00:35:33]

[MB] Earlier you drew a distinction between training and education. It was a really interesting distinction and I wonder how that might be playing out as you imagine this major project that you're doing. I mean, to detect the presence or absence of transgenes seems to me to be in the realm of training but you clearly have something bigger in mind. Can you speak to that? How would education arrive?

[IC] Sure. It's kind of funny that I would be dedicated to a technical problem and a methodological problem when I have been so critical of technique and method as a goal in itself. And in a way I find it interesting because it's kind of contradictory with - critical of my own decision against technique and method. To give people the capacity to see is a technique. So the glasses are an instrument and there's no question about it. The polished glass or plastic or whatever it is—the lenses are an instrument, a technique. But what that enables is much deeper than just what the technique provides. And it's something important because it doesn't imply any judgment about what you see, what allows people to decide what to think about what they're seeing. Just giving the capacity to see, I think, is, in a way, allowing people to make up their own minds and decide—even if they want to ask the question. You won't see if you don't want to see. And if you want to see you will see what's there and then you'll make up your mind about what to think about it. And so I guess the educational part of it or the more socialized aspect of it is one where I believe there are techniques and there are methods that can enrich this social engagement with the world. Just as there are techniques and methods that limit the social engagement with the world. And I feel like with this method and this great big life bet that I've made on this I'm betting on the capacity or the interest of people to know, to see, and to make informed decisions about where they live and where they want to live. I don't know if that's education enough.

[38:47]

[MB] I want to ask you some more questions, but before I do, if you'd like to have a drink of water—

[IC] I'm okay.

[MB] And also if either of my fellow interviewers would like to add anything, if you have a question at this point before we change gears.

[Brad Herring] Kind of a little bit on that, I mean I wrote down a question that came to mind. You keep talking about people in this detection. Are you initially looking at scientists as using this detection or you actually looking at people and is that, in a way, going to in the future you see kind of replacing the label of—We can read labels, right? But we don't necessarily know what that is.

[IC] Exactly. Yeah the question is whether this is yet another technique that will, what shall we say, will technologize people's lives more? And my response to that is that I believe it's not—I could be wrong. I could really be wrong but we have made a really big effort to from the ground up build this up in a way that it cannot be centralized. I think the main question is the power to centralize and therefore control from a central position, which is what we have today. The PCR reaction is such that you need a certain amount of instrumentation; a certain kind of laboratory and training that makes it impossible to do that without having expertise and a centralized lab. What we have produced is something that, on the contrary, gets the expert, that means ourselves, out of the picture as quickly as possible. And so the idea is that people will be able to go in, get a result, and know without having to ask anyone. The way it is at this moment—I can just describe technically the way it is at this moment, it's the equivalent of a pregnancy test where you get the test and, I guess the woman is the first one to see the result, and then she can decide what to do with this thing. For some people that's enough reason to commit suicide and for others it's a reason to just have a big party and celebrate and let the world know, right? But that woman with this thing in her hand has that capacity to decide without asking an expert. And so the goal of removing the expert and this centralized laboratory from the picture is really the central goal of this. So does that replace the labeling? That's a really interesting way of thinking of it. I think so. I never thought of it that way because that would be one of the many consequences of this. You don't need labels anymore because you can see directly. My obsession really is with the possibility of having maps; maps that are changing with time as things are changing and maps where each person can see themselves in the context of others. So if I have, let's say, a sampling point in my house here, that information will be fed into the internet probably and then put in as a layer on a map where other people can see what I'm seeing and I can see what they are seeing so the whole thing starts building up as a map. You cannot do that with a pregnancy test because for the same reasons someone can say, "Oh I'm not pregnant." If it's self-reporting then you cannot really trust it because there is that layer of translation. So we have ideas how to make this automated so that the information can move directly without having to go through the interpretation of the person but we have not implemented that yet. That

will take more money than I can afford at this point. We have the concepts and the ideas. What we have, as I said, at this point—we're at the level of just the individual interacting with it.

[00:43:27]
[Jason Delborne] I have a follow-up on that vision. Recent developments in genome editing promise a kind of transgenic activity that is not detectable and so I just wonder—I mean, I don't know if you want to get into weeds, but does the technology that you're developing have the potential to identify genetic changes that are done by technologies that we haven't seen yet?

[IC] The method is very clearly definable and it will simply—it is equivalent to PCR in the sense that you see only what you are looking for and what you're looking for are specific sequences of DNA or RNA [ribonucleic acid]. And so if two organisms have exactly the same sequences then no you wouldn't be able to distinguish them but then they would be the same individual, right? I mean different more modern techniques of gene editing insert pieces of DNA without so much of the rigmarole of the big old transgenic set, right? So instead of having four or five or six or ten different origins of DNA plus the ones that you're trying to insert you might have fewer, but you still have an insert of something else—I don't know, zinc fingers for example or something like that. And also what you have is a disjoint between the original genome and the insert. Even if it doesn't carry any vectors or any of the other things, the actual sequence from the original genome to the insert is distinguishable—or am I getting it wrong?

[JD] Well I was thinking about a deletion. I mean I think you're right that that creates—

[IC] A new sequence.

[JD] A new kind of sequence. But there's also, you know, discussions of cisgenic transformation, for example, where the insertion of a gene from the same species that might have gotten there through a kind of transgenic technology but—

[IC] So the most common example of cisgenics is to take one piece of DNA and reverse it, right? That creates a sequence difference. I would say in principle, anything that will be useful by definition will be different. Otherwise you cannot patent it and you cannot use it, right? If it's the same then it's the same. But yes, it creates questions and, you know, we're working still with the old cauliflower mosaic virus markers on corn because they're the most abundant ones and they're easy to distinguish because they're so different. So yeah we are working with things that are easy right now.

[00:46:35]

[JD] I have one more question. To take you back, you talked about the phone call with David Quist as a key moment, but I wonder if you could not try and rehearse the entire controversy for us because you've obviously been interviewed about this many times. But with the benefit of looking back ten years, what are the other key moments of that story that stand out for you, either as moments when you learned something or moments when you had an impact on the debates around genetic engineering?

[IC] Its fourteen years now—fourteen years since that happened and—I developed a good relationship from this. One of the things that I learned from the whole experience of the debate and scandal, because it was a real scandal, around our publication in *Nature* where we managed to publish the fact that there was transgenic DNA within the local landraces of corn in Mexico. One of the big things from that experience was my social relationships changed so dramatically. I started meeting people, wonderful people like yourself, and I started making friendships that I never imagined I could have, and a lot of friendships with historians of all things. And one of those great friendships that was a very influential friend in my life was David Noble. And Dave would say, "In academia there's only the bought and the broken, and you can't choose." And I remember at that time I said, "Come on, you know, David used to be so loud and boisterous, yeah he's exaggerating." But I've come to realize that there is some truth to that that we are either bought or broken especially when it comes to fields that are so socially and culturally relevant. You know, this field of biotechnology didn't use to be relevant at all. Biology wasn't relevant or interesting to anybody and all of a sudden it became central to politics, policy, economics, and culture. And so when you all of a sudden find yourself in that situation maybe you call it taking sides but I would call it more taking a clear position. It causes you to have trouble or be pacified by being bought. So you break under pressure from having trouble to some extent, we all do and I am kind of a broken person. We are all a little broken and a little bought. That understanding, I think for me, has been one of the most important ones. The understanding that—another friend who came into my world was Marti Crouch—you should interview Marti Crouch. Do you know about her? Yeah you don't know about her because she went into the broken side. Marti Crouch was a super star plant biotechnologist at the beginning of plant biotechnology in the eighties, with massive NSF [National Science Foundation] funding, a huge lab with postdocs and graduate students, a big budget, all that. She discovered many things about how to manipulate the oil pathways of palm trees, incredibly important thing that many people are just crowing about these days. That's all her work back in the eighties. And at some point she discovers who she's working for. You know, she starts asking the who's of biotechnology: who am I working for? And she decides to stop. She realizes, decides for herself that there is no way she can do this and not work for the people she doesn't want to work for. And so the amazing thing about her is that she was able to write a piece in a scientific journal where she explains what she understands and why she is shepherding her last students out and then closing off all her grants, closing down her lab, and stopping. It's a really important thing because we never hear the negatives of this. You hear me as a survivor but—David Noble also

taught me this—I stand for a huge number of people that you don't know about because they either chose to close down or were closed down without having been heard. So I feel that responsibility to represent them. But Marti Crouch taught me something by example because she would say, "When I was a scientist…", and I would say, "Marti, you are a scientist. You cannot stop being a scientist." "Well, no, you know, when I had my big lab" and so on—I realized that she showed me that she had put all her social value and her self-worth in the hands of the people who were pushing this biotechnology forward. She was friends with all the big stars of biotechnology who became the big players and when she wrote that piece, stepping down, she described how every person just turned their backs on her and all she could see was backs and cold shoulders and how painful and how difficult it was for her to negotiate this social vacuum. All of a sudden she was isolated. Her friends—it was not just her colleagues. But the people, you know, their children went to school together and they would have parties together and so on. All the sudden she had no social networks anymore and she had to start from scratch by being the mushroom identifier at the farmer's market in Bloomingdale, Indiana. And from that point to now, she has a completely different social world. I was fortunate that I had that before the scandal came to me. So yeah, of course I lost a lot of friendships and a lot of social relationships within academia but I had many others and I developed them. So for me it was a great, I don't know, a great blessing. This whole disaster was a great blessing. Disaster means a realignment of the stars, right? Disaster, it's a realignment of the stars and it was for me a real disaster because it just realigns the stars for you, it kind of shows that there's a different kind of orientation that you can align with: ideologically, technically, academically, and socially. So for me, that was a very, very valuable thing, painful and difficult but something that I really tried to pass on to students, to graduate students, and to colleagues. Where I say, really if you want to make a difference, you better watch out who you're putting your worth with. If your validation comes from the people you could hurt by being critical and thinking critically then you're in trouble. You're not going to do it. I don't think I answered your question.

[00:55:28]

[MB] I wanted to ask you about—you've mentioned many times about the opposition you've found. Are there people who you disagree with or who you've disagreed with who you respected? And were you able to develop any of those relationships or maintain any relationships?

[IC] People whom I disagreed with but respected and maintained relationships with after—I don't know how I'm going to answer this but I can talk about something. As we went from the eighties to the nineties and into the two thousands and really around the scandal of our paper in *Nature*—but a few other scandals that were, you know, around the year 2000 was a year of a lot of scandals—The field became so polarized and the group of promoters became so beleaguered and felt so much under attack that they really closed up. That was my experience that they really

closed up and started developing like this ideological tendency to almost apply a litmus test of whether you were for or against. And if you had any questions you were outside and if you were inside you better just stop asking questions and move on. There's a lot to be done over here. Please don't rock the boat. We have enough people outside just knocking at the doors. And so, I think from the nineties or [the] two thousands, this whole thing felt more and more to me as a religion, much more as an ideological positioning than anything to do with who's right and who's wrong. So when I am asked, "Is there anyone who you disagreed with that you could get along with?", I feel pretty much the same as with the religious friends I have, you know? The Catholic friends I have or the very strict Jewish friends I have. I can get along with them. But I know there is a point where, you know, there is a barrier that cannot be crossed. And we can talk about it but we still know that there is an inside and an outside of that barrier that seems really impenetrable. It's actually quite amazing how strong it is. And because it carries a lot of perks for those who are inside this religion, people seem to be happy with that separation. So I'm just trying to think of actual real examples and in most cases I come up with people who do something else. For example, ecologists with whom we talk about ecological things—ecological theories and evolution and so on and so forth—and we avoid the topic of biotechnology because that's almost like a religion, you know, a religious belief somewhere on the side and this friend just happens to believe that that is going to save the world, okay? Let's just talk about something else, right? Yeah it's difficult to breach that gap.

[00:59:21]

[MB] I asked the question, in part, because I've heard this argument made about anti-GMO or anti-gene modification activists that it's a kind of religion. And there's a stridency to it. And so that's why I was so interested in your experience and I wonder if there are people, I'm interested in this dialogue or this ability of dialogue. And I value your experience there.

[IC] Yeah I wish there could be a dialogue. I really wish there could be dialogue. I think it's really admirable that you guys here in North Carolina are trying. Again, it's really great. But I think the people who say that the anti-GMO crowd is very ideologically loaded and acting as if it was a religion are kind of right but so are the other people on the other side. They, in general, seem to me to be very close to arguments. The difference is that, I think, the people inside the religion of biotechnology, let's call it that now, have a very reasonable way of justifying their ideology and so they believe that because it's reasonable then it's right. And of course I don't think that's really true. I mean, they whole edifice of the Catholic Church is very reasonable as long as you assume the constraints of, you know, the foundations of that ideology. So it's a reasonable ideology but it's still an ideology. And so what I find very difficult to do with people inside the church of biotechnology is to get them to move to different assumptions, to get them to go and stand in a different place, to start questioning the very same things that we're talking about. I feel that there are a few places, and I seem to think that you guys have one of them here,

where—I mean you told me at lunch today that you try to help young people go and stand in different framings to look at the same problem and understand that there are different ways of establishing your basic assumptions and your preconceived ideas and then come to completely different conclusions of what your policies should be and what actions should be taken depending on where you're coming from. And that is something that many people inside that biotechnology church find very difficult to do in my experience.

[01:02:34]

[MB] I have a couple of fairly big picture questions for you. Broadly speaking, I'm interested in what you think are the main drivers of genetic engineering and agriculture. And so here are some possible answers before you to seed the ground, so to speak: serious proven needs from farmers and consumers, environmental threats like drought on farmlands and climate change, or structural forces like grants from big foundations shaping university research agendas. What do you think is really driving the passion that some have, this enormous energy around genetic engineering and agriculture?

[IC] Can we just do check boxes and you tell me to just check no?

[MB] Or none of the above of course.

[IC] So the main actors who justify biotechnology are practicing, mostly laboratory based, publicly recognized scientists. Those scientists have been trained to find fine levels—to find some kind of verbiage, ideological verbiage to include a first paragraph of every grant application in every paper that connects whatever they really want to do, which is usually technical, with some kind of big, as big as possible, kind of world and societal need. That's usually the wording, right? Societal need. So we are trained to go out and say, the world is falling apart because of global warming. The world is falling apart because of water depletion, or water pollution, or lack of soil, or big oil—whatever. That will always be the first sentence in a grant application but if you ask almost anybody practicing in the field, do you really mean that? Oh well yeah, you know, of course that's the end goal but in reality what we want to do is get money to be able to figure out how to use zinc fingers, to move DNA from this place to this place because it's fun, and it's powerful, and it's interesting. So what they want to do is really this little thing that is beautiful. It's just amazing and it's very powerful and it's very interesting. The problem is when that is used as the foundation to justify the whole edifice of something else that reaches out to Washington, D.C. policy or European Union policy on what gets funded and, even more, what buildings get built and who is to inhabit those buildings in the temples of science—making; universities, research institutes, and all the other different varieties of this thing. So it is really a political question that is being justified as if it was a technical little lab bench kind of question. So the connection between these two completely different kinds of

activities that politics and the wet lab technique is obscured. It's really not transparent and not cleanly laid out for people to see. And so that's always been the case and for most fields in science or in engineering, this link is more or less accepted as somehow connecting one with the other. Why should we have a better screw? Well so we can have better bridges and therefore we support their research on better screws. And the same logic was being applied to biotechnology or genetic engineering without really having any proof that this connection really existed as solid [fact]. So, you know, you have to go to politics to understand what is the main driver for this, not to technique on the bench. And the politics of it are, you know, written. There are books about it and the whole documentation is there. And you end up in Dan Quayle's committee and competiveness where they say, this is what we're going to do—not let's find out if this will work, not let's fund this a little more. No, this is what's going to replace computer technology and information technology that was going away from the US. Dan Quayle was right or his committee was right that a replacement for those technological applications as economic drivers had to be found and he was wrong in thinking that it was biotechnology. And yet, they made the political decision to put the burden off politics on to biotechnology and said, now you're going to produce—you're going to go into this field and make PC [personal computer] be a personal cloner, not a personal computer. Let's put it that way. And, you know, the scientists, I think, at that point—or the technicians should have said, wait, we cannot deliver on that. We're not going to save the world. I think they knew that. We are not going to end hunger. We are not going to end global warming and stop plate tectonics with biotechnology. Don't put that on our shoulders. But it was just too sweet. It just became a political decision that came with money and so there wasn't anyone there to say, you know, we should wait and see if we can really deliver on this promise. There was none of that. They just said this is it. You're going to deliver. So they have to continue to say, yeah we're going to end world hunger. We're going to address farmer's needs here and there. They never say where. They never say specifically what kind of farmer they are talking about. And when you start digging, you know, you start finding out it's all just really like a surface that everybody has to put as a dress on these applications because of that politicalization. The problem with suppressing critical thinking about this by this political decision is that in any other reasonable place one would have already realized that it's not working. PC continues to be personal computer not personal cloner and it's fantastic. Computers really work. Biotechnology doesn't [work]. It's forty-two years now—forty-two years of development for this thing for what? It's not delivering. It has not delivered—the produce herbicide resistant plants and insecticide producing plants. And everything else is always promise. It's like; yeah we're going to do this. Let's just produce a lot of food out of nowhere. The problem with the political decision was that it suppressed critical thinking and therefore removed the possibility of finding out that we were wrong. We had to be right and we're still stuck with that idea. And the more we continue with it, the bigger the burden of proof and the bigger the debt we have with this promise that we cannot deliver on. That's at least my understanding, that it was a promise that nobody should have taken seriously at the beginning but

it was just too sweet to pass [on] and now we're stuck with this equivalent of the emperor's clothes that nobody can afford to say are not there.

[01:11:39]

[MB] You've had enough of a career, I think, a long enough career that you could answer this question.

[IC] Okay.

[MB] And it is: what do you think as a particularly significant moment in the history of genetic engineering and agriculture? I mean, is there a particularly significant moment? You've just mentioned one, politically. Are there others that are just kind of key markers in the story of this technology so far?

[IC] Yeah, I mean, the markers are there clearly. But I would say that moment to me is probably the most important one because it's at that moment where, for example, the principle of substantial equivalence is coined out of nowhere. It's just conjured up out of a hat. The substantial equivalence principle is basically saying we are not going to look and we're not going to ask questions. Because they're equivalent, they're the same. So stop asking questions. Yeah, I mean, I'm just going through the many years of events. You know, the adventitious contaminations, that—rice contamination that happened in 2001, that's when our paper came out and that was a big scandal. To me, that paper was important because it showed that they didn't have control—that it was out of control. And the same thing was confirmed again with the rice contamination. I'm blanking out on the name of the rice variety that was found adventitiously mixed in with other rice when it shouldn't have been. So, at that moment, there is this realization. The bubble really burst. It cracks opened where we realized that the idea of control is not there and we're really dealing with something that is everywhere and nobody knows where it's moving. You know, it's hard to decide what would be—if I had to write a history of agriculture of biotechnology I think I would find it really difficult to decide on chapters. But definitely Dan Quayle is an important one.

[01:14:16]

[MB] So here's the corollary to that question, the other half, which is: what do you think are the most important emerging issues in genetic engineering when it comes to agriculture? Or another way of putting that is: where do you think this suite of technologies is going in the future?

[IC] Well I think I've already said what my belief is. My belief is that it's not working. It's not going to work very well from here on. All the proposals—you know, we had for example, in

2007 we had BP [British Petroleum] come to Berkeley to fund one of the biggest—or what was billed as the biggest investment into synthetic biology, which is another name for genetic engineering, into environmental applications. You call it agriculture because you're thinking only of crops but they moved away from crops. They really have moved away from crops, to a large extent, for the more fundable, I guess, biofuels and that kind of thing. A few weeks ago, BP just pulled out quietly and halfway through the funding period they said, it's not working and it's not interesting. They moved away. That's happened also with large companies. You know, the company I used to work for washed their hands and sent them off. This all happened in 2001 and 2002. People who knew what was happening in the field moved their money away from it. The Deutsche Bank—you know, another way of analyzing this would be to say where's the money and where's the money going. They said this ain't working. Move your money away from it and much of the investment that was building up—the public investment has gone away. So now it is really funded by the United States government. The European Union is putting very little money into it. China keeps going back and forth and nobody knows exactly what it's doing but it's not particularly interesting. So it doesn't seem to me like it's going anywhere with agricultural products. The environmental habitations, which I would consider together with agriculture, seems to have a little bit more life in them because of the big investment of public money into global warming and global change—amelioration, whatever that might mean. But, if I can just say this, I believe it won't work because the foundation of it is wrong. The very foundation of the concept that you can mix and match traits by mixing and matching pieces of DNA just doesn't work. In the last fifteen years or so we have learned so much about something that was already known at the beginning of the twentieth century, which is that DNA might be very interesting as a molecule but it's not the molecule that has the code of life or has the instructions and the manual for how life has to work and so on. It's not. There are so many other things that you would have to engineer. If you want to engineer living things you would have to engineer all kinds of other things. Genetics is a really good place to go just to disjoint this monolithic way of understanding living things as just lumbering robots, right? That's Richard Dawkins' image—living things. We are lumbering robots just doing the big move of our genes and our genes are DNA. That linear thinking of DNA, genes, and form and function over here, doesn't work. It just doesn't exist as possibility and so it's not going to work as long as they continue doing that and the alternative, even considering just epigenetics—there are, by my count there are twelve different fields like epigenetics that question the validity of that hard connection between DNA and form and function. But just with epigenetics, there's nobody that can really engineer or manipulate that reliably. So that, I believe, is the reason why we haven't seen anything beyond the two products of agricultural biology and I do not see anyone in that field doing anything to bring anything different to market. And what I do see is venture capitalists and other investors getting very cold feet and getting bored with it and moving on to whatever is next, you know, personal satellites or whatever the next gadget will be.

[01:19:44]

[MB] So that will inform this next pair of questions, which is about your greatest hopes or fears for the way this technology will go in the coming years.

[IC] So because I believe this ain't working—there is a concept that particle physicists have and it's not, being not even wrong. You know, it's so beyond the being right or wrong. It's not a little bit more and it would make it right. It's not even wrong. It's not even approaching a possible way of dealing with it. Because I believe that—and of course I could be wrong but that's my belief after a lot of time and effort has gone into it. My hopes are really mixed and very diffused because I do not see anyone coming up with some kind of application that is going to be great or is going to be very useful for something. I don't even know what it is because I've never seen a real public discussion about what would be desirable, what would be useful, what would be acceptable as an application of this. So because of that I cannot even imagine what we're talking about. We haven't gone through that at all. But that doesn't mean that what they are doing out there with all those millions and billions of dollars is not real. This is the really important thing about biotechnology, unlike, let's say electronics or any other technology that doesn't reproduce, [where] you get it wrong and the thing just ends up in the trash can. And it might be a pollutant because it has lithium or it has mercury or something but it's still there, just sitting there. With genetic engineering, if you get it wrong and you dump it down the drain—I mean this is what high school students do. They run their little experiments, trying to transform E. Coli [Escherichia coli] and at the end of it, you know, they do not have the capacity to contain these things. And so high school students do it and big companies do it. They put all their little mistakes and all their little monsters down the drain, out in a corner, in an abandoned field—some seed collection that didn't work and it's still there and it can reproduce. So, for me, there is a real not only possibility, but I would say reality of these organisms existing in the real existing reproducing world and we have no clue, no idea what they do. We have no idea what they will do now or in ten, or twenty, or a hundred, or a thousand years, which is what life does. It survives, right? And so a world that has just wild and violent—I think the word is appropriate—violent mixes and matches of reproducing organisms. It's a world that is pushing in a direction that can see a lot of harm. The way I look at it is, and the way I think it's appropriately analyzed is the way you analyze the movement of one biological species from one ecosystem into another. You can bring a Tasmanian wolf into California and it will probably die. I guess there are no Tasmanian wolves anymore. But you can bring a plant from Africa into North Carolina and it will probably die, but if you do it enough times, one of them is going to survive. And that might not be very relevant. It may stay very restricted but if you do it enough times you'll get enough of a population that is self-sustaining and if you do it enough times you'll hit the one species that really likes North Carolina and takes over. For example, Kudzu— [it's an] invasive species. It's not that every species is invasive but if you're doing it over and over, eventually you will get one that is not to your liking. And to me that's what we're doing. We're just releasing a huge number of transgenic organisms that are not doing what they were supposed to do but they're

certainly doing something and it is playing with something that can certainly come back and bite us. Let's put it that way.

[01:25:03]

[MB] I have two questions about trust and about trust broadly. The first is, how do you feel about American publics, in particular—but you've engaged with others—about their level of trust in governments, and universities, and in private work in genetic engineering?

[IC] Yeah, the question of trust is a sad one for me because I find myself, you know—I do go out whenever the possibility arises. Not anymore [however]. In the United States there are no more protests out in the streets to say, I want to know more about GMOs. Let's talk about it. Let's label it. The labeling is the last little bit of that push that people had to come out on the streets and say, hey we're not having enough of a discussion here. So I go out with those people. I go out in the streets. It's fun and there's a band playing and so on, but very frequently when I am in that situation I find myself walking next to people who say they hate science, who portray the white coat person as the evil most hated kind of character and it's very painful. It's very sad for me to be in that situation and unfortunately I feel like it's deserved, like we have spent these forty years driving without the possibility of return or recourse to public debate. It's something that is not working and people don't like. So pushing those things against people's understanding, whether it's right or wrong it doesn't matter, without having them be part of the discussion is just basically playing with our reputation and with the reputation of science and the reputation of academia all together. Like we're putting the whole cart into it and I think it's incredibly reckless. To me, that's the most important damage that this does—yeah it is to the reputation and credibility of something that people recognize as science. They may not distinguish between the biggest science of the establishment of science and the littlest science, which is simply critical thinking, but that's our loss because we didn't really put in the effort to make that differentiation and to socialize what was happening. So yeah, it's terrible. I think there's a terrible distrust and dislike, not only in the United States but also in many other places, of anything that carries that word behind it—that word science.

[01:28:05]

[MB] What would you like the general public to know about genetically engineered organisms and the policies that surround them? What is the thing you would most like them to know?

[IC] Just the one thing?

[MB] Things would be okay too.

[IC] Yeah, you know, I was asked to be part of the curriculum committee at the UC [University of California]. So I don't know how it is in North Carolina but in California the University of California has control or power over the curriculum of K-12 [Kindergarten through twelfth grade]. We get to decide what children in kindergarten learn all the way through high school. And so I was invited once to this committee and reviewing the biology curriculum and of course my questions were so indigestible that I was never invited again. I mean someone who questions the use of the word "gene" or the centrality of that molecule called DNA, is kind of really heretical and not digestible by the system, by the curriculum of high schoolers. What I wish is that we were engaging with that problem. I feel and I really believe that we present a very reasonable and sensible story that makes absolute sense as a tale to our young people without any alternatives; without any possibility of questioning. It's just such a perfect beautiful story with all the little interlinking [parts] that make sense within it but without the possibility of looking into it from the outside and without this critical distance that would be necessary for a critical mind of young people to develop. And so what I wish is that we could work at that level. I think [that] working with adults that have been indoctrinated into this way of understanding life as lumbering robots being driven by their DNA is very, very, very hard. I cannot imagine anything that I would like to just do with that. I think I would like to go to Kindergarten really or even before to nursery rhymes that already contain these deterministic and fatalistic ways of understanding life, in which we are doing nothing but fulfilling the fate that is written in our code of DNA. If you think about it, it's completely fatalistic. And so that's what I wish. I wish that we had a chance to go and revisit how it is that we understand life and how it is that we understand ourselves and ourselves in our position with the world. Then genetic engineering would gather a completely different value that would be very interesting. I think it would be interesting to talk about it with this different understanding. Unfortunately, we're not anywhere near that. I'm sorry.

[01:31:41]

[MB] I have one last question but before I ask it I wanted to offer Jason Delborne and Brad Herring a chance to ask a question.

[BH] I can go. I'll ask the one I seem to always come back to. So you've mentioned these scandals that you've had. You mentioned this woman Marti who just quit science.

[IC] She didn't quit science.

[BH] She didn't quit science, right. I apologize.

[IC] She quit technology.

[BH] So what is it that gets you out of bed every morning? Why are you continuing?

[IC] What keeps me going—the same thing I think that used to keep me going when I was fifteen, which is asking questions and learning. I'm learning so much so quickly these days, especially through my teaching. My poor students, they have no idea what's happening in front of them. They think that I am projecting these kind of finished monoliths of what I am thinking but I'm learning so much. This understanding of, for example, liberating one's self of the deterministic power of DNA is a fantastically beautiful thing and that, in itself, is enough to keep me going.

[01:33:16]

[JD] I'll ask a question that's on the list that Matthew skipped over and I'll just simplify it a little bit. How do you negotiate the tension between the worlds of science and advocacy?

[IC] How do I negotiate between the—what?

[JD] The tensions between the worlds of science and the world of advocacy. And you can take as long as you need to answer that. I know it's a complicated question.

[IC] It is a complicated question. It is complicated because it almost suggests that there is separation, and that there should be a separation, but my problem, as I said, is that I'm a mutt, you know, I'm not a thoroughbred and so I find it really difficult to separate one and the other in the sense that I think you mean. I see many of my colleagues who say you should never talk to media and you should never talk to the public. You should stick to your papers and then let someone else interpret them and present them to the world, and I just cannot do that. I can see someone doing it and I respect it, but it's also not what most people do. I get accused of doing advocacy or activism because I present my biases in as transparent a way as I can by people who are doing a lot of activism and advocacy for the promotion of genetic engineering. That is advocacy and activism too. The difference is that they say they don't do it and I say I do. I believe that there is no way to avoid bias, that we are all biased; the only difference is whether you have a critical distance to your own biases and whether you try to present the reason why you're biased, the background of your bias in a transparent way. You know, when I stand in front of students I try to help them both see the world the way I look at it but also understand why it is that I look at the world that way; so making my biases as transparent to them as I can in a way that they can say, well yeah that's only you because you come from that background and you look at the world this way and so on but I don't—which is critical thinking, right? They can take that critical distance because they understand where my biases come from. So activism—talking to you and talking to this camera is activism and is advocacy. I've said so many things in

front of this camera that are advocating a point of view and I just don't find that it is possible. I don't find it possible for myself and I think it's not possible for anybody to separate those things.

[01:36:48]

[MB] So my question is, are there questions you expected me to ask but I didn't or, another way of saying it, what questions should I have asked that I didn't?

[IC] I did not sleep on the plane. That's such a nice question, such a generous question. No, I don't know. I can't think of anything.

[MB] Well thank you.

[IC] Thank you.

[MB] Thank you Ignacio Chapela, Brad Herring, Jason Delborne, and Matthew Booker.

[IC] Thank you so much.

END OF TRANSCRIPT
[01:37:30]