The Genetic Engineering and Society Center History Project
Interviewees: Fred Gould and Jennifer Kuzma
Interviewers: Matthew Booker, Alison Wynn, and Brad Herring
Videographer: Brad Herring
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Biographical Note:

START OF INTERVIEW

0:00

[*Matthew Booker*]: Actually, the hardest question is the first one.

[*Jennifer Kuzma*]: Okay.

[*Brad Herring.*]: So we're recording.

[*Fred Gould*]: All right.

[*M.B.*]: So, Jennifer could you tell us your name, your institution, and your role.

[*J.K.*]: Sure! I'm Jennifer Kuzma. I'm with North Carolina State University and the Center for Genetic Engineering and Society—actually—the Genetic Engineering and Society Center, and I am the Co-Director of that center and also a professor in the school of Public and International Affairs.

[*M.B.*]: Fred, could you tell us your name, your institution, and your role.

[*F.G.*]: So I'm Fred Gould, and I'm in the Entomology Department at North Carolina State University. And I am the Co-Director of the Genetic Engineering and Society Center. And I'm also affiliated with the IGERT Program, director of the IGERT Program.

[*M.B.*]: Jennifer could you tell us your name, your institution, and your role.

[*J.K.*]: Sure, my name is Jennifer Kuzma and I'm with North Carolina State University, The Genetic Engineering and Society Center and also the school of Public and International Affairs and I'm a professor there.

1:05

[*M.B.*]: Fred could you describe what you do?

[*F.G.*]: No [*everyone laughs*]. Could you ask that question again, Matthew?

[*M.B.*]: Sure! Could you tell us what you do here at NC State?

[*F.G.*]: Boy, that's a tough question actually. So I'm in the entomology department and I do research on the ecology and genetics of insect pests and I have a laboratory with students and postdocs and we investigate, especially how insects adapt to control technologies, and now we're working on whether we can genetically engineer insects so that they are less pestiferous. So that's my role as a researcher. I also teach courses in genetic pest management. I also teach some lectures in a course on Christianity and Darwinism. And a number of other courses around the University. And then I also am the director of the IGERT Program on Genetic Engineering and Society: the case of Transgenic Pests. So that has involved most of my time for the last few years. Just making sure that things are running well. There's lots of pieces to that. And then more recently, with getting this cluster hire for genetic engineering and society, which is writ much broadly than genetic engineering and society, the case of transgenic pests, is genetic engineering and society in general, having Jennifer come here to spearhead this thing has been great, but it has also required more of my time.

2:45

[*Alison Wynn*]: Can you explain a little bit about what a cluster hire is?

[*F.G.*]: Yeah, I could try that, too. So, [whistles] it was about two years ago, I think it was. The provost --and the chancellor--decided on trying to have this program called the Chancellor's Faculty Excellence Program. And the idea was that basically, at NC State, we were so focused on departments that we had these tunnel--you know these--silos, and people weren't able to be rewarded for doing inter-disciplinary work and we needed more of this at NC State. So, the interesting approach they took was to have a bottoms up approach, where they asked for proposals from the faculty for cluster hiring, meaning hire somewhere between two and four faculty in an inter-disciplinary area. And so, we had the IGERT grant already and we had a group of interdisciplinary faculty working on that. And we decided we'd go for it. So we wrote a proposal to broaden the IGERT as I mentioned before, to look at things as diverse as synthetic biology and transgenic human beings or whatever was coming down the pike, to take a look at that. And so we were one of 72 proposals that was submitted. And they funded 12 of those and we were one of them! And so we went ahead, uh, to try to recruit people in specific areas where we thought we needed more strength. And, that was an interesting process with an inter-disciplinary search committee and um, that's how we got Jennifer here.

4:29

[*M.B.*]: Jennifer could you tell us about your role at N.C. State? What you do?

[*J.K.*]: Sure.

[*Brad Herring*]: And Jennifer, could you look at me when you answer?

[*J.K.*]: Absolutely.

[*B.H.*]: That helps, yeah.

[*J.K.*]: Okay, well generally my work falls in three different areas: teaching, research, and outreach and engagement. So, most of my activities at NC State also fall in those three areas as a professor here. So I teach in the Public Administration, uh, Department and I also teach in the Genetic Engineering and Society Program. And I also do research and my research is generally on the governance of emerging technologies. More broadly in governance systems. How we manage and how we oversee things that enter the society. Please start again.

[*B.H.*]: Okay.

[*J.K.*]: Okay, so [*laughs*]. Start the question over.

[*M.B.*]: Can you tell us about what you do at North Carolina State. Your role here?

[*J.K.*]: Sure. Well my role as a professor falls in three general areas, and that would be teaching, research, and outreach and engagement. And my teaching is both in the Public Administration Department as well as the Genetic Engineering and Society Program, and also in my research I have been focusing for the last 12 or so years on governance systems, and how we oversee emerging technologies in society. All the way from funding, research and development, to maybe formal regulation, and how they're deployed and how they're perceived in the marketplace as well. And then on the outreach and engagement side, I spend a lot of time meeting with stakeholders and partners of the center and in general ones related to my work to get a sense of what's out there in the community. What are the problems? What are the areas of emerging technologies in society that are important to people outside of academe. And also giving a lot of talks on my work and things that professors normally do in that area.

6:14

[*M.B.*]: So, Jennifer when you were a kid is that what you wanted to be when you grew up? How did you...

[*J.K.*]: Yeah I didn't even know that science and technology policy existed when I was growing up and I wanted to be an oceanographer even though I hated fish and couldn't touch them—

[*A.W.*]: [*laughs*].

[*J.K.*]: --but, so no it wasn't. And it was interesting how, and I tell my students this when I'm advising and mentoring them, of how you kind of find where you want to be as you go along. It wasn't something necessarily that I envisioned myself doing when I was a child, but with each step in my career it became more and more clear what I should be

doing and how to shape and blend my interests in both science and technology and with how society is impacted by technologies and science. So it's an interesting area and I think even undergraduates and some graduate students don't even know that the area of science and technology policy exists as a field of inquiry or a study.

[*M.B.*]: So I know you have had quite an interesting career. You have done many things in your career. How did you end up arriving at genetic engineering as a particular interest? Were there especially important figures who helped direct you?

[*J.K.*]: Well it was, again, it was a series of sort of small incidents building up. But it generally happened during my undergraduate time. And I came in as a chemical engineering major but then I took an introduction to biology class and in high school, when I went to high school in the early '80s, our biology textbooks didn't have anything related to molecular biology or really even much biochemistry. And so all of a sudden in my undergraduate biology course I discovered that there was this thing called biochemistry molecular biology, and how a lot of what we see and experience in the natural world can be partially at least explained by the way that molecules are interacting and genes are interacting and being expressed. So that's when I really was turned on to this field of genes and molecules and how they relate to their environments and adjust and adapt. And then as far as genetic engineering during my undergraduate time, I also was a philosophy minor and I went to a Catholic Liberal Arts college. So there was a lot of emphasis on religion, morality, ethics, and I was very interested in that as well. And so, it just made sense that I should pay attention to genetic engineering, which was being developed at the time, really in the early-to-mid '80s. And my honors thesis was then on genetic engineering and society, believe it or not. And that was in 1985. And so, at around that same time I'm not exactly sure of the year, but Jeremy Rifkin came to speak at my college. So all these things kind of came together. So it was my undergraduate biology professors with Jeremy Rifkin, with this combination of religion and philosophy that was sort of coming together at that point and getting me very interested in this in the early '80s, early-to-mid '80s.

9:16

[*M.B.*]: Why was Jeremy Rifkin influential? What about his speech?

[*J.K.*]: Well, I don't know, I don't know if his speech was necessarily influential. In fact, I don't even remember the content of it. But he was an influential figure at the time in that he was putting pressure on the Federal Government to develop a regulatory process for genetic engineering. And he was one of the people in society that was most concerned about the technology. And fighting, almost, in opposed to some of the other forces that were more pushing for the technology. So he was a historical figure. Although I'm not sure of the... you know I can't remember that far back to the exact context of his speech and whether that moved me in any way. But I think it was more of the subject that moved me. And really, was fascinating to me.

[*M.B.*]: Are there any paths that you didn't take that you regret or...?

[*J.K.*]: I wanted to be an artist. I still dream about painting in a cottage by the sea, playing cello in an orchestra. I actually was a classical guitar major--or not major, excuse me--but I played in a classical guitar orchestra in college. And, so I thought well, maybe if I weren't working in Genetic Engineering and Society, it would have something to do with music or the arts.

[*B.H.*]: I mean you realize that there is this big push now for STEM to become STEAM--

[*J.K.*]: Mm...yeah!

[*B.H.*]: --that art is engrained in this. So I mean you still have an opportunity.

[*F.G.*]: [*laughs*].

[*J.K.*]: That's right, that's right!

[*B.H.*]: And I think that visualizing the future and visualizing some of the genetic engineering possibilities. There's, you still have some...you can still do both.

[*J.K.*]: Yeah, and research always involves a little bit of creativity. So maybe I can write a song about it someday.

[*M.B.*]: Fred, can I ask you some of the same questions?

[*F.G.*]: Yeah.

[*M.B.*]: What did you want to be when you grew up and how did you end up in entomology in particular?

[*F.G.*]: Yeah, so I don't know...I don't know that I had some grand plan when I was a kid growing up, what I would be. But by the time I got to college, there was I would say, subtle parental pressures to be Pre-Med and go to Medical School. And I went along that path sort of unsure of what I would actually do. And I have to say that in the background here as I grew up in New York City during the year, that every summer I got to go to Rhode Island, where I worked on a dairy farm that my friend's father owned. So that had a big influence on me. I loved doing that. You know, I had hay fever--it didn't matter--I was out there bailing hay and you know, shoveling manure and stuff like that. Something about that did appeal to me. So while I was in college, I, at one point being so confused decided to take one of those tests that tells you what you should do instead. And the test came out that actually I should either go into art or something about growing things. Whatever thing, you know, it didn't say be a farmer, but...and in the end I didn't know what--it didn't help me. I had been taking a biology major and I was doing pottery, was my big thing. And taking some art courses too. So many there is some kind of commonality there? I don't know. But, of course I went through summers doing things and deciding oh, just want to be a hippie as was happening at the time. And then I finally, every time I'd get back to school, everybody was so intense about

applying to medical school. This was the only way you could actually survive as a person almost. And so I applied to Medical School and got in. And, then when it came down to the line I realized there were so many people that wanted to do this so badly. And I just said, okay, you do this and I'm gone. And so I was, dropped out for a while. So I really [*laughs*] didn't have any idea what I wanted to be! And it was a little scary sometimes. [clears throat] You know, I drove a cab and I worked in a psychiatric clinic and things like that where sometimes I wasn't sure if I was the help or the patient, you know, but after a while of doing that, the nine-to-five routine, I realized I did want to do something. And I loved natural history, so I thought I'd apply to some graduate schools that were involved with that. And a friend of mine had some extra applications, in those days you actually filled things out, you know, with pen and paper. And I sent in two of them and, I wound up going to State University New York at Stony Brook, thinking I was going to learn about natural history, where of course the first year was all about statistics--biostatistics. So it was a little disappointing, but I got to go to Costa Rica and got really excited. So I went through graduate school, and that school is very much basic, science. And it was definitely a kind of thing of, if you can't do basic science then maybe you could do applied work. There wasn't quite--you know--there was a bit of a differentiation, but that is what I wanted to do, so I happened to find some faculty members who were wonderful, who were interested in plant/insect interactions and allowed me in the end to do a thesis that looked at both, basically the, coevolution of plants and insects but looking at a crop pest and how it adapted to specific crops. So that's what led me in that direction, so when I finished my thesis, again I wasn't sure. And I was about ready to drop out again [*laughs*] and start doing pottery.

14:54

[*J.K.*]: [*laughs*] This all sounds familiar.

[*F.G.*]: [*laughs*] You know, it's the way it goes right? And then, I got this one-year NSF Post-Doc thing to come down to NC State, based on trying to do more of this plant/ insect interactions and how it applies to agriculture and evolution. And that's how I got here. I started out as Post-Doc and then they kept me as a soil entomologist. Although I have never had, I guess I should say the truth is I never had an entomology class. So… that’s me.

[*M.B.*]: So both of you came to genetic engineering through particular paths. Jennifer if I can come back to you...

[*J.K.*]: Sure.

[*M.B.*]: What do you think about this field? Genetic engineering...how do you define that? What do you think are its components if you're put on the spot as I am now...?

[*J.K.*]: Yeah, I mean it's a really good question because I think we're still struggling with the definition of genetic engineering and as some newer techniques come in synthetic biology and genome editing, that definition is being reshaped I think all the time. So I

define it where there is some point of pretty intense human intentionality and engineering that purposefully up-regulates, down-regulates, introduces--in a very specific and deliberate way--genes into living organisms or within living organisms. So, you'll find a lot of different definitions, but for me it's kind of the human intentionality and directedness that defines it to me.

16:30

[*M.B.*]: So if you were describing, no better yet, if someone else were describing your contributions to this general field of genetic engineering, what do you think they would say, what do you think they would identify as your contributions.

[*J.K.*]: Well, I don't think many people read my academic papers [*laughs*]. I mean they are cited in the academic literature, but I think society writ large or decision-makers would probably not read them. I think it's probably more of my contributions, at various meetings of governance of emerging technologies and some of the work I've done in more practical kind of policy settings either at the National Academies of Science or now as a professor when I go to workshops on synthetic biology or genetic engineering, you know, perhaps the things I say there may have some impact. Some people do read the articles and I think that's important as well, but I think I've developed ways of analyzing government systems that are a bit more, I think, methodical and deliberate than maybe some other people who talk about governance systems and whether they're good or bad. I've developed more policy-science approaches and interdisciplinary, multidisciplinary approaches to evaluating governance and other parts of governance on the funding side and the consumer side as well. So I think maybe my contributions would be more on the methodological side in the academic literature. And then in the practical policy realm, I think my contributions to the National Academy reports as well as the contributions that I have now in the synthetic biology community where I make my little nudges or statements that hopefully somebody is listening to at some point [*F.G.* and *J.K.* laugh].

18:13

[*M.B.*]: Was there a particular case study or maybe even a controversy that really first drew you in to the policy or method side? Was there one particular moment or issue that you think really drove that shift in your own interests or career?

[*J.K.*]: Not really, I mean for me the entry into policy was somewhat random. I was doing a post-doc in molecular biology and I had always wanted to work on things in the lab that had some sort of tie to societal needs. So, during my post-doc I was working on drought salinity tolerant plants and trying to figure out the biochemical pathways. And actually that article is one of my most-cited articles, was elucidating part of the pathway for drought and salinity tolerance in plants. And so I always chose my research project to kind of be more applied to what a great societal need would be like hunger or growing things. But I was really miserable in the lab. And so I was looking for alternative careers and I chose policy as something to try and then I ended up loving it. So it wasn't a

particular controversy, more as associated with genetic engineering, more as then when I entered the policy world I started gravitating more toward projects or positions that had something to do with genetic engineering because I still had this interest from the '80s and combining it with policy. So I think it was more of a confluence of the two interests that came together, than any particular event. Although, there were some controversies in the late '90s and early 2000 that I was working on when I was in Washington D.C. that were quite important like the monarch butterfly, the StarLink episode. A lot of these took place during some of the reports that I was study director for at the National Academy of Sciences. So those are some pretty key, I think, moments in genetically engineered crops and controversies.

20:20

[*B.H.*]: I have a follow up question for your definition of synthetics--genetic engineering and something I struggle with as well in my field is the difference between synthetic biology and genetic engineering. Is that something that you feel is important to define here? Is there a strong difference? Is it...

[*J.K.*]: [to F.G] Do you want to go ahead?

[*F.G.*]: No, no... I'll let you go ahead

[*J.K.*]: I think it's more of a... of a scale to me, as opposed to a bright line where one ends and the other stops.

[*B.H.*]: Can you repeat the question? So, yeah sorry.

[*J.K.*]: Sure! Yeah, so the question was--

[*B.H.*]: Or just say the difference between synthetic and--

[*J.K.*]: What's the difference between genetic engineering and synthetic biology. I think it's a really good question and we're still struggling with it. Genetic engineering when it first started it was the introduction of just a few genes, you know, maybe two, three at the most, not entire metabolic pathways or imparting really new characteristics on organisms to make them do substantially something that they weren't able to do by the use of really a lot of genes. It was just a few genes and some sort of intentionality, but not a large-scale engineering of the genome. Now we're able to engineer more and more genes more quickly, more easily. Develop metabolic pathways in organisms that weren't necessarily there before. And I think that's where we start slipping into the realm of what people are now calling synthetic biology. When things become more and more engineered there's a greater and greater engineering component to it as oppose do putting in just a few genes, it's a lot of genes or its entirely new genes, or reviving extinct organisms by resynthesizing their DNA. Now synthetic biologists also define synthetic biology by having a more engineering component. Even more so than genetic engineering where you're putting together different parts, biochemical parts, into

different devices and different hosts and so it's got more of kind of this lego block mentality, you know, the really truly synthetic biology, where you could combine parts from many different organisms to make something completely new. We're not quite at that point yet, but we're getting there.

22:37

[*B.H.*]: I think that's kind of what I was thinking more as genetic engineering like you said is messing with a couple of genes, synthetic biology is kind of building from nothing, from the bottom up--

[*J.K.*]: Right, right. Or can be taking the top and making enough changes in it so that it becomes something very different than what it was before.

[*B.H.*]: Interesting.

[*M.B.*]: Do you see those as having fundamentally different policy implications? I mean, you both have been around long enough that you've seen the evolution of the field. Do you think that synthetic biology as you just described it, has fundamentally different kinds of policy problems or questions? And are you anxious about the synthetic biology that's being practiced or imagined?

[*J.K.*]: Do you want to take that one first?

[*F.G.*]: No, this is more your area.

[*J.K.*]: I'm not sure if the policy pathways are entirely different, but I think there is a point where it becomes more concerning to me as an individual. And my bias is that perhaps the more that we change things away from what they're used to being, or the more that we go away from organisms and types of devices that we're used to seeing, that we need to have more care about the unintentional side-effects or what we're not thinking about by placing that new thing, whether it's a synthetic organisms or something that's not even living, but the device that has biological parts, I think we need to be more careful about envisioning what the potential side-effects may be. I think there's more unknowns. Because it's something we haven't necessarily encountered before. It may not behave like anything we've seen before, like reviving the wooly mammoth which is a talk in the synthetic biology community. Synthesizing the DNA and putting the wooly mammoth back into the world. I mean, that's something that we don't know in our historical time period, what kind of ramifications that could have. And I think, I'm not sure if it's an entirely new policy pathway or there are different tiers to aid policy pathway. And regardless I think there's a lot of improvements we can make to the policy pathways that we're embarking on or we use right now.

25:05

[*F.G.*]: Well when you talk about that, you know, as you say we're getting more and more sophisticated, right?

[*J.K.*]: Yeah that's right

[*F.G.*]: And every year something changes in that direction [*J.K.* agrees]. So there was recently a paper out where they were building a strain that would have a different amino acid in it that didn't exist ever before. Alright, so you can see these things moving ahead and we had a talk by somebody about our official life, so you know when you have your progress from genetic engineering to synthetic biology, where does synthetic biology turn into artificial life? [*J.K.* agrees]. And that too would probably be just this little path where you can't really tell, and all of a sudden, we have something that's self-replicating, right? That goes negative entropy or whatever it is and keeps going. Yeah, so how do you keep improving the regulation and keeping on top of it? Interesting. [*J.K.* agrees].

[*J.K.*]: And I think that starts how we govern it needs to start at where we fund and what we would prioritize things. And would we want to embark on certain applications that we're not exactly sure of the side-effects or the consequences.

[*F.G.*]: And actually related to that is this issue of as we start with genetic engineering, there was something that you did need to fund. It had this huge amount of funding, and the only person who could put one gene in was a big multinational corporation and we're seeing this stuff with the new Cas9 CRISPR Systems where it could be possible in your garage or your basement or something to make something. So you can have all the regulations you want in the world and what happens if we do enough research so we get to that point where it's not something that is in the, I don't know, the realm of our tech--well, whatever, in the realm of being regulated.

[*J.K.*]: That's right, and so you can buy these kits over the internet to make different things and there are do-it-yourself synthetic biology labs across the U.S. and elsewhere where people are starting to do this on their own. And I think that's good for people's engagement with the science and the democratic kind of nature of the technology. But on the other hand, how can you govern something like that is, I think, a really difficult question. It's not all going to come to the federal regulatory level or the international regulatory level.

[*F.G.*]: Yeah sometimes the analogy with computer stuff is a little...fits, right? Because you know in the beginning you had these huge things the size of this room, and then you went up with it on your desk, and then you always think that oh, you have these hackers, but you could always stay ahead of the hackers. But what happens when the hackers... it's sort of an even battle right? So what happens if we get to that kind of a point where somebody who wants to get rid of a certain species on Earth just could do that? Or I don't know what else, but there could be some mischief or, maybe state-sponsored mischief. So we have to deal with those kind of things that would be outside of the regular regulatory thing.

[*B.H.*]: Does that involve thinking about nefarious uses of certain technologies? Does that start by educating graduate students on thinking outside of their own lab? I mean, a lot of times their thinking about what's in their petri dish. They're not thinking about the communities out in the world that may be using this. How do we work around kind of getting our graduate students trained, not even the public, but the people who are actually developing these technologies, and thinking. Is that an important area?

[*F.G.*]: Well I think it's very important and actually there's a call for proposals right now that Jennifer is responding to in terms of leading a proposal to look at ethics in that way. How do you get scientists to have a better perspective on the ethics of what they're doing? But I'd have to say, I'm not sure how much that would help with these issues that we've brought up, because those are the people who are willing to go to the ethics classes. You know, so you may have two different sides, so I don't know.

[*J.K.*]: Yeah I think it may be monitoring as well. You know, having a heightened state of not paranoia, but at least awareness that this can be done, your neighbor can be doing this, just like they can be stocking arms [*laughs*] or I don't know! And having maybe a heightened state of awareness that we're watching each other. Hopefully not like Big Brother, but where there is some sort of monitoring system in place where people are aware that these things can be going on. Now the problem is you can't really monitor the unseen, right? Or the tiny very well. Maybe it has to be a technological solution to the nefarious uses. Maybe you need monitors everywhere? You know, where you could monitor for certain bad genes or uncontrollable foreign organisms.

[*F.G.*]: Yeah, and I think that is where this tech--comparison with computers goes, because we're getting better and better at scanning a genome. So you can get pretty good at that, but yeah...Well, one of the interesting things with this new CRISPR Cas9 System is when you, it's called gene editing--and basically you change a gene and when it's done there is no way to tell the difference between that and something that occurred naturally. I mean, you come up with algorithms and stuff to say "huh, this looks weird," but it's not like the same kind of thing with regular genetic engineering where you have this big hunk of stuff in there that obviously doesn't belong because it came from a bacteria or a virus, you know. It's different.

[*J.K.*]: And some of these systems are designed to thrive through the population. Which would be good for pests that you don't want, but maybe not so good if somebody wanted to like you said--do away with the species.

[*F.G.*]: Yeah.

[*J.K.*]: A certain subset of the species.

[*F.G.*]: Right, and of course we talk about it as if it could happen. The chances--something will always go wrong with these things, probably. But at least we need to discuss it.

[*A.W.*]: So where do you see it in like 2100? Where do you see things--this going in the far future?

[*F.G.*]: After global warming we won't have to worry [*everyone laughs*].

[*B.H.*]: Start again, start again.

[*F.G.*]: [*clears throat*].

31:25

[*A.W.*]: So where do you see this going, in the far future? Like 100 years from now or past?

[*F.G.*]: That's a great question. I certainly don't have a crystal ball on it, but I would say that if we look at the rate that the technology is changing. And I think George Church made this comment not too long ago. Is that Moore's Law about computing and stuff like that and then some other law about some other thing changing a little faster. And his comment was that genetic engineering was going to change faster than that. And if you look at the progress in terms of how fast human scans a genome, how quickly you can make a genetically engineered organism. You know, we are going to be living in a very different world that way. And as our humanities colleagues say, how does that affect our view of ourselves as humans? It's going to be a big deal. Of course when you can genetically engineer humans. And that I don't think is very far down the line. They're already dealing with engineering mitochondria so we have those three parent babies, right? If you can cure real inherited single-gene diseases, I don't think that's very far away--

[*J.K.*]: No, we can certainly select for them now with IVF and PGD.

[*F.G.*]: But I mean in terms of actually causing a genetic engineering change if it wasn't for--

[*J.K.*]: I don't think it's fair, I think there's gene therapy trials on that kind of exact things with some of these--

[*F.G.*]: That would be inherited--

[*J.K.*]: Gene, well, I’m not sure about inherited.

[*F.G.*]: But I think you can certainly do it in mice so the chance that you could do it in a human if the community accepted that, wouldn't be very far away. It's less a technical problem now than it is a social issue. So maybe the human race will decide not to do that, but when you think about these things becoming much more within society, right, that it's not something that's funded by big companies or by the government and somebody could do that. And you think about somebody worrying that their kid is, you know, born with a defect that they could fix. You'd pay a lot of money to have that kid fixed.

33:35

[*J.K.*]: I'd like to watch science fiction. If you think back where we were 100 years ago, what was that, 1914. Right? [everyone *laughs*] So think of where we were with biology in 1914. We were just starting to maybe accept Charles Darwin or not even? I don't know...

[*F.G.*]: We haven't done that yet, but that's okay [*laughs*].

[*J.K.*]: Well and so, you know, I can't even imagine, given that, I have a really hard time imagining the next hundred years, but I think science fiction gets us closer to that. And if you watch old science fiction, you can see that there are things that we can do now that they were envisioning back then. So I think the arts has a really important role in envisioning this. Not that it would predict, but that it might prepare us for what comes down.

[*B.H.*]: I think that's one of the things that we're doing in the museum field is that we are trying to get kids, any of our visitors, to use their imagination for the future and then to inject their own values into those imaginations. And seeing how if we were to build a space elevator to the moon, which a lot of people think will never happen, but just getting them to imagine the future and putting themselves in that and injecting their values, they may think about cloning human beings differently. I mean, think about some of these option differently, and so...

[*J.K.*]: Yeah, and on the flip-side though, we've have biological weapons for...you know, maybe 40-50 years, we've been able to do that kind of thing and it hasn't happened yet. Kind of your standard biological weapons like anthrax and smallpox and, we could've been spreading a lot more diseases than we actually have been spreading intentionally. And so, there is something that slows these down, I think. There's something there that is slowing some of the more outrageous applications down. We probably could've tried to clone a human being by now, at least a couple times, and there was one cult that wanted to for a while there, but other than that we really haven't seen it popping up. So there is something that gets us not to cross that line. Maybe not everybody, but the 99.999% of the human--humans--or population. So, you know, I have a little more faith that there will be something there to slow us or stop certain things, but I also think it's just as important to look at how the changes in society build up over time, even the little changes. And then try to think about, well where are those little changes getting us?

And is it not where we want to be from where we are now? So sometimes I think it's not only the outrageous things we need to pay attention to but also is this the change that we want? I wonder how many people would go back and say, "I don't want email." I mean, if I could do away with email today I would do away with it. Because honestly, we spend probably 75% of our days dealing with emails. Or maybe not 75% but a lot of time. And I can't--

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[*F.G.*]: I'm not with you on that one [*laughs*].

[*J.K.*]: Oh, come on! You're always on email!

[*F.G.*]: I am! But I would not want to see it go away--

[*J.K.*]: Well...possibly and I'm not sure I would either?

[*F.G.*]: Yeah, yeah, yeah. It's sort of like--it's one of those kind of things where you love it and you hate it.

[*J.K.*]: But wouldn't you like it to only be there on maybe Mondays?

[*F.G.*]: [*laughs*]

[*J.K.*]: Like Monday was the only day anybody could email each other--

[*F.G.*]: Right, right, yes.

[*J.K.*]: Like in France~

[*F.G.*]: That would be nice...

[*J.K.*]: They say you can't email after 6:00, you know, so that--

[*F.G.*]: Yes, actually I agree with that one--

[*J.K.*]: Yes, that's the kind of thing I think we're talking about. Obviously, we don't want the outrageous things to happen. The things that really violate human rights or the majority of cultures' ethical beliefs. But there’s also these little increments that build up over time that get you somewhere that you don't necessarily want to be.

[*F.G.*]: Right.

[*B.H.*]: In the year 2100 they're going to say, what's email?

[*J.K.*]: That's exactly right! Yeah!

[*F.G.*]: It's the mental telepathy right?

[*M.B.*]: So both of you have alluded to this, really, or implied this. But in each of your careers you took part in a series in what had been revolutions in science. The molecular biology revolution, the shift to thinking about applications of--well Fred in separate conversations you've mentioned IPM and other forms of both adapting to and then rejecting or attempting to dial back the use of chemicals in agriculture. And so I wonder if you think that there are--it sounds like there are lessons from the 20th century that might be somewhat applicable here. That for example, where I'm trying to go with this question is to get you to tell me why you added the "S" to this Genetic Engineering Center? So, Genetic Engineering and *Society* is the name both of the IGERT program, but particularly of the Center. Why the "S"? Why not just have a center for genetic engineering?

[*F.G.*]: Well I guess I could answer that, but to go back to the historic thing that you bring into context. So obviously, the Green Revolution is what comes to my mind. There were a lot of reasons why the Green Revolution happened. You know, societal things, political things, repression of people. But a lot of the scientists who were involved thought, look there's all this hunger in the world. Is there a way for us as geneticists to help to feed more of the world? And there were all very good intentions in all of that, but it was in some ways, I think, on the part of a lot of the plant breeders and geneticists, more of a narrow thing of just reading the media, the news, that said people are starving in Bangladesh. Look, the U.S. is being great and it's going to give out all this U.S. aid and it's going to build these places, these laboratories that you could go to and experiment with plants and give more rice to the people in Bangladesh. And I think most plant breeders felt so great about that, you know. Can you imagine the fact that you could be something like a Norman Borlaug who saves millions of lives. But if you, you know--at that time I think it was very appropriate for those scientists to just listen to what they were told by the politicians and everything else, it seemed just like a beautiful thing. But now, when you look at it in retrospect you see all of, well I don't want to say nefarious, but all of these different motives behind why that happened. And also what you see is that in changing that technology it all looked like it was going to be beautiful because all it takes is to change the seeds and every farmer can get those seeds because it was being done by the government, it was being given out free. But then you find out that, well, those seeds only perform best when there was fertilizer, and then there were pests that were involved because they were growing so well they attracted more pests, they needed more insecticides. And it led to this thing that could only be afforded by some of the poor farmers. They were all pretty poor who were getting that, but it led to some changes so some people moved ahead and some didn't. So it becomes this very complex thing that I think we've seen historically and now we're doing it again. And in some ways, the geneticists sort of scratch their head a little bit, because they said, "Oh the population has grown, we need to feed the world help us!" Now that we've helped them have a bigger population, they say, "Oh the world is having more people, we need you to help us again, we need to double the production!" Maybe the geneticists should say, "Wait a minute, we can't do this again." Maybe there should be a different kind of answer this time. So I think that just at least thinking about those

things. Maybe there is no other answer. Maybe that is what we have to do. But at least we shouldn't just be swallowing all of this stuff that's given to us on the surface. And I think it's helped a lot of the biologists in our program to see things framed a lot more broadly.

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[*J.K.*]: And I think for me it was the way we dealt with chemicals in society and the environment. That was one analogue that I saw with genetic engineering and the need for the society part. The chemicals, I mean, we've done a great job with the air pollution and the Clean Air Act has helped with air pollution. Air quality has generally gotten better in major cities. But with other types of chemical pollution, we're exposed to thousands and thousands of chemicals a day. And there's really no stop to it. I mean, there's not really a good way to deal with that, all the chemicals we're putting into the environment and how many chemicals people are exposed to. And the regulatory system for that has some of its problems and challenges. So that was one thing that motivated me and the genetic engineering and society realm. But it was also working in D.C. at the time where in the late 90s and early 2000s where you could see the technology developing in ways that people and consumers were not really responsive or supportive of and why did we choose at that point to go a particular route with the technology. We meaning society at large. And have it so concentrated and so targeted to a few traits and a few applications. How were those choices made? And then also seeing some of the, I would call them mishaps--they weren't serious events--but events that raised some concern like the contamination of Mexican maize and the gene flow in Mexico. Or the cross contamination of crops in the U.S. like the StarLink. Or the reports that the monarch butterflies are things that we didn't think of prior to the crops being released. And so to try to have a Center that could get out in front or at least think of those things and think of them in a more, I want to say holistic way with a number of voices and a number of different perspectives. Because I think any time you get real narrow, whether it's just scientists and engineers, or just social scientists, or just government people, or just industry people you don't see the whole picture. And we needed a space I think in academe that could help bring stakeholders in to help see--and different disciplines in--to see the broader picture. To help guide things in responsible ways and in ways that society most needs them. So I think you could go back to a series of sort of...misfortunes with whether it's the Green Revolution or Chemical Revolution where the intent wasn't bad, but things happened in ways that we didn't necessarily intend them to or intend for them to. And I think that's sort of what we're trying to get at here by opening up the picture to a wider range of players and disciplines that we might be able to not only contribute in a scholarly way, but hopefully also in a practical way.

44:34

[*F.G.*]: Yeah, that's really great.

[*A.W.*]: Why N.C. State for the Center?

[*F.G.*]: Well, maybe it's worth--you know, I never filled it in your first question about how did I wind up working on genetic engineering. I said I came here because I wanted to apply evolution and ecology on crop pests. So I came here with this idea that maybe we could come up with things that got rid of chemicals and instead use the natural resistance of plants to pests. And this was a big thing with integrated pest management as well as just biological control that we get away from chemicals and go to these other control mechanisms that would be more natural. And I was very into natural. So anyway, there was a lot going on at that time. You talk about the chemicals, you know, all of the Rachel Carson stuff, and there were people at N.C. State who were doing both. Some people were toxicologists testing the chemicals and they worked with the chemical industry. And others who were in biological control. Well, when I was coming up for my post-doc, I got a post-doc I could take anywhere at any university. And for me, as part of being a hippie was that I was going to go to Berkeley, right. I was going to get in my truck and drive out over there. And, there were people there working on biological control and toxicology and I needed both of those to do the project I wanted to do because it was about chemical, you know, how does the natural--becoming resistant to the natural chemical--effect your ability to deal with the synthetic chemicals. So, are there some insects that are just pre-adapted evolutionarily to become resistant to these chemicals. So I needed both those kind of people. Somebody who knew how to work with the insects and somebody who knew the toxicology. And I got half-way through the process at Berkeley and then it turned out that they--I was bringing my own money--and they couldn't figure out how to do this cross-link kind of thing. There was a lot of disagreement at Berkeley at that time. And a lot of animosity. I don't know what exactly happened there but it couldn't work out, so I had to figure out another place. And I looked around the country and I wound up coming here for an interview with a toxicologist and a biocontrol person. I went to the biocontrol person first and we had this nice conversation, southern gentleman, you know, told me they were trying to do their best here at N.C. State, but we weren't like New York, but...anyway, went through all of that and he said okay, let me bring you over to see Ernie, the toxicologist. And we go over there and he said, can you wait a minute Fred? I want to talk to Ernie about something. And it turned out they were trying to figure out how to pass off a key for a cabin in the mountains that they were sharing. And I thought, this is where I'm coming. And it's been that way. And you're asking, "Why N.C. State?" it's not just a simple technology thing or anything like that. There has been a spirit of cooperativeness at N.C. State that's--as opposed to just competitiveness--that I think, probably not throughout the University, but there's more of that here than I think at some other places. So as this thing began to evolve--so I did do that post-doc. The hypothesis I was trying to test turned out to be an artifact [*laughs*], but I wound up getting a position here and what I wanted to work on was this natural host-plant resistance and figuring out how we could stop insects from adapting to it if we put it out there, because there was this knowledge that people would spend 15 years coming up with a variety that was resistant to a pest. They put it out in the field and in 5 years and sometimes less, the pests would adapt to this. It took so long. And we were trying to figure out ways to slow that down. And I was publishing on this both theoretically and doing empirical studies. And that's when genetic engineering started. We were trying to come up with resistance to this corn ear-worm that's in cotton and in corn and we couldn't find the natural

variation that would really work well. And then all of a sudden here's Monsanto sticking a gene from bacteria--wasn't only Monsanto, CALS, you know, other groups were doing this and beginning, Genetic Plant Systems, or whatever, were doing these things, putting these genes in. And it was like, “Wow, how can you do this? You have a gene from a bacteria and you think that the plant is going to make that if you stick it in there?” And it didn't work in the beginning, and they, you know, and finally they got it working and then it was the same kind of question. Wow, they had this and it was going to be expressed throughout all the year, you know, the constitutive expression. And not only when you put it in corn, they were going to put it in soybean, they were going to put it in cotton. So you just see the whole landscape full of this. And that's what got me into genetic engineering was, "Oh my goodness, they have this great thing and I've been working on all of these models, but it's been hard to get traction in the conventional thing." But all of a sudden all the organic farmers were worried about this, and the pressure politically came to a point where they were funding the research. And they were interested. So all of a sudden, something--we were in this little side venue at NC State, became much more public. And that's how I started getting involved, because we had all the background data on this stuff, and the theory. So as this stuff came out and the companies wanted to put these plants out, we were coming out with alternate ways of using it so it would be more sustainable. And that's what got me into the genetic engineering, but I started much more on the biological side, just trying to figure out how to do this. Once you know how to do this, they stick you up on stage, and you have to debate with somebody, and we had that kind of thing going on. And I was realizing that there was a lot of this social stuff that, you know [*whistles*] I didn't know what that was coming from. And I started learning more about that and I think being on that committee, with you [Jennifer] being the report--you know--person on the staff, it was a committee to write a report on genetically engineered crops that had pesticidal genes in them, and how to do that. And that's where we first met.

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[*A.W.*]: That's right, that was going to be my next question.

[*F.G.*]: Yeah.

[*J.K.*]: Yeah, I think that was the 1999 or '98.

[*F.G.*]: Yeah, maybe '98. Because the report came out in 2000--

[*J.K.*]: Yeah, it must have been '98. And that's right about the time I started working for the National Academy of Sciences. And I was the study director on that report, which was the Genetically Modified Pest Protected Plants--

[*F.G.*]: [*laughs* and *whistles*]

[*J.K.*]: And we called it genetically modified instead of genetically engineered because there's this debate in the scientific community of conventionally bred plants are

genetically modified to certain degree. I mean, there's some sort of human intervention in there in conventional breeding, although it's not as targeted as putting genes, you know, particular genes, and it ends up doing that, but it's a longer process. And so, and that report actually, the history behind that report is that there were some members of the scientific community that didn't want EPA involved in regulation of genetically engineered plants at all. And they thought USDA has a handle on it, you know, let's not get EPA involved. Whereas EPA had some authority for pesticides, right, under the Pesticide Act. And so, EPA was thinking about regulating genetically modified crop traits that were pesticides which then effectively would have been the plants that were regulated by EPA. And there were some molecular biologists generally biotechnologists, who were National Academy members that were very much opposed to that. And, therefore, asked the National Research Council, which is part of the National Academy of Sciences to do a study on whether or not this was needed. And so we struggled with that for three years, two--three years.

[*F.G.*]: Oh, to even come up with the committee?

[*J.K.*]: No! To do the report.

[*F.G.*]: Oh, to do the report, yeah.

[*J.K.*]: And so we recruited Fred, of course, to be on the committee. Because he was one of the people thinking of this early on and had already been working in this area of Bt crops and management and pest management. So, he was one of our star committee members. Yeah...

[*F.G.*]: Yeah, I was on there. And actually my post-doc advisor was on there as the toxicologist--

[*J.K.*]: That's right! Bernie Hodgson, right? Or Ernie Hodgson.

[*F.G.*]: Yeah, Ernie Hodgson, it's interesting.

[*M.B.*]: So one critical point I'd like to follow up on here is something that Fred said earlier and you both just raised. Many of us think of regulation or of genetically engineered organisms, as a new technology, which needs to either be stopped or to be regulated in some ways so it doesn't have unintended consequences. But what Fred I think was just saying a few minutes ago about your work with Bt Corn--bach-cillus thuringiensis--is that correct?

[*F.G.*]: Bacillus thuringiensis.

[*M.B.*]: *Bacillus* thuringiensis, thank you. Is that, in fact, the problem was the overuse of the new technology. Is that right? It was your concerns about resistance that were the real heart of the question. Is that correct?

[*F.G.*]: From my perspective, that was really the issue. Other people had other issues that they were concerned about. From how it affects the ecological system, right, how it's going to affect monarch butterflies and other things like that. But, yeah, from my perspective, it was "Wow, this could limit the use of insecticides, but if it only lasts for five years and then they move on to something else, then what?" And also about the organic farmers, who would say "wait a minute, we have only one thing in our armament and that's this Bt and you're going to overuse it and then you're going to move on but we can't?" You know, so anyway, those...but indeed in terms of your question, yes, that's what really got me involved was this idea that we have this new technology and we're going to abuse it.

[*M.B.*]: So I think just to underscore this for, for the everyday person who's watching this. I think what you're saying is that pests will find resistance, will create resistance, to any tool that is used to control them.

[*F.G.*]: Well, I don't want to say that [*laughs*]--

[*M.B.*]: Tell us a little bit more about why Bt corn...what you mean by abuse. And why that would be a problem.

[*F.G.*]: Well, so you asked that they would adapt to just about anything. And, you know, I guess what it is something from, Jurassic Park or something. Life will come through or something like that. But there have been insects that have not been able to adapt to certain insecticides. So, it is feasible that you could overuse something and it seems like it's abuse, but somehow the insect just doesn't have the natural variation to deal with it. But my sense is, from everything we've learned, that's the exception not the rule. And so when the Bt came out, there were people, same as with you, "Oh, USDA can't handle this." There were people who said, "Oh, but this is Bacillus thuringiensis. It has been in the environment for *millions* of years. If these insects had been able to adapt to that, then they would've already adapted to it." Well, it didn't take a little bit of brain power to think, "Well, wait a minute. If it costs more ATP, you know, takes more energy to become resistant and you only encounter it when you're in the soil at a certain time in a certain place, there's not a lot of pressure to adapt. So on average, it's not worth it evolutionarily for that trait. It's not going to be selected for strongly." So it could be hiding there in low frequency and then all of a sudden you come in there and this whole area of North Carolina-- it's a beautiful place for that because we had tobacco, we had corn, we had soybeans, and cotton, and that pest feeds on all of those crops and you could just envision this landscape turning from green to--if you had the right glasses, you'd see Bt everywhere--all the time. And that changes the equation. Am I getting at your point?

56:05

[*M.B.*]: You're describing pest resistance and that you could have too much of a good thing.

[*F.G.*]: Yeah...

[*M.B.*]: When it comes to pest control.

[*F.G.*]: Right, and this was one of those things that came out of the whole IPM approach. And this was stuff that was really strong at NC State. We were [a] really strong group in integrated pest management. And one of the big things within integrated pest management is that a low level of pests isn't worth controlling. And that you just wanna get them below what's called an economic threshold where they're causing more loss in dollars than it would cost to control them. And a lot of farmers under this pressure of, you know, more insecticide, more insecticide, were losing money by spraying for insects, and--to say less about the environment that was going on. So here we were coming from this school where that was the idea and could we contribute to this kind of thing and not let this new technology wind up being used. Is there some way of having that economic threshold, and in our way [with Bt crops] it was to have this refuge. A certain place where the pests could be. They'd feed a little bit on your crop, they wouldn't increase that much. And we could all live together.

[*M.B.*]: So it was a lesson from a previous kind of scientific experience--

[*F.G.*]: Yeah, yeah! And people had been working on insecticide resistance management for a long time. And the idea of not spraying as much as you would, or only using a lot of insecticide or none. There's all of these different things, but the plants--the great thing about the plants was that you could control the level. So when you did the modeling of the genetics, you had much more control on how you would face the pest with a hurdle that it couldn't get over easily. So it was a great tool for us. So in some ways, academically and practically, it gave that possibility. And that's why when we went to the EPA and the EPA was trying to struggle with this, and we laid out a number of possibilities, some which the company saw as too onerous and back and forth and back and forth. This is the one that stood out as the possibility. Other things that they could do at that time, and some companies were doing it, it would only turn on the Bt production in the plant at certain times. And so there were all sorts of things that were possible and it narrowed down to this one. So it was kind of interesting how that process went. And it was both the society and the science going on. So when you ask about Genetic Engineering and Society, if you go back to that era. And we'll have people coming in to talk about the history of this...it really was this back and forth between the public and industry.

[*J.K.*]: And I remember our report, too, was highly controversial, the report on the genetically-modified, pest-protected plants, which really gave Fred and I a flavor for the societal placement for these things. We had protestors--

[*F.G.*]: Yeah! I remember...when we were going to release the report we had to go through the basement to get into the building.

[*J.K.*]: Dennis Kucinich was one of the protesting, and people expected the report to say something. And protested it without reading it. And then the report kind of came down somewhere else I think, then some people expected it to.

[*F.G.*]: Yeah, it was interesting, so you brought up what was called genetically modified and I forgot about this story. But we had a long discussion about if we're going to regulate these genetically engineered crops because they might be dangerous both to the environment and to people's health. What about the conventionally bred varieties? Everyone knew, anybody who was a scientist knew, that it was less precise than the genetic engineering. Sometimes we didn't even know what we had changed. And so it could be a bigger thing. And some people wanted to push--that look, the genetically modified by conventional parts, was actually likely to be more dangerous than the genetic engineering. And in some ways I guess what they wanted to do was to push the whole thing down. Look, we've accepted these, why won't we accept something that's safer. And we went on...in the end. I remember this argument very clearly, because in the end, we said...in the best of all worlds, we would be monitoring those just as carefully and have just as many regulations. But if we did that tomorrow, the whole seed industry would collapse and there was no profit to be made in those crops and it would have just made things catastrophic. But we did say in the report, that down the line we have to consider those issues. Right, I think that's...I think I remember that,

1:00:42

[*J.K.*]: You know, the National Academy--at least this National Academy--reports we were supposed to stick to the science, but I think we all learned and recognized that we just could not make any recommendations by just sticking to the science. And so there were things that we had to, you know, like think about the seed industry. Or we had to think about our lack of familiarity with genetically engineered crops. Our societal perceptions of these crops in order to come down in any fin--, not findings necessarily, but recommendations. And the committee, I think, struggled with that a lot. Is that they knew there was this science, but it wasn't the basis for--it could not be the sole basis, really, for any decision. And I think that's true. And I think that sometimes where we have this misperception that the science is going to tell us what to do. It's not. It's going to inform what we do, but it can't tell us what to do. And I think the scientists on the committee--not Fred, but I think many of the other ones struggled, kind of, with that.

[*F.G.*]: Yeah! Well I struggled with it too--

[*J.K.*]: I think we all struggled, yeah--

[*F.G.*]: But I think that was the one that was so clear that this was not a science-risk issue. And actually, you'll have...that was the first time I was exposed to these ideas about risk. That there was a report by the National Academy on risk that was called The Blue Book--

[*J.K.*]: Yeah there's the Blue Book--

[*F.G.*]: And another one that was the--

[*J.K.*]: Red Book.

[*F.G.*]: Red Book...now one of them was the old book--

[*J.K.*]: And one was the Orange Book too--

[*F.G.*]: Yeah, there was one that had been done a while ago where risk was how likely are you to get hit by lightning versus anything else--

[*J.K.*]: That was the 1983. The Red Book, yep.

[*F.G.*]: And then there was a newer one that had come out that took risk into account with values and whether or not you had the choice to make--

[*J.K.*]: It was the Orange Book--

[*F.G.*]: [*laughs*] Orange Book.

[*J.K.*]: The blue one was the in-between. So, yeah.

[*F.G.*]: Yeah! I mean, I had never...I thought, "Risk, oh yeah, chance of lightning hitting." That was my view when I went into that committee. And I really came out the other side thinking very differently from that. And it took, you know, you think now--I look back and I think, "Huh, of course." But when that was happening to my brain, it wasn't so easy.

[*J.K.*]: Right, yeah.

[*M.B.*]: So we moved quickly through a really important point for people who might not understand the science here very well. Which is that in calculating the risks of, or considering, the risks of a new technology, in this case, the genetically engineered, new tools, you discovered, or remembered, or acknowledged that there were probably higher risks from the conventionally grown crops--

[*J.K.*]: Could be...

[*M.B.*]: Or common risks. That is to say, or at least, that the tools for making new seeds, new hybrids, were more imperfect and more chancy in the old system than they were in the new one. And do you think that the public understands that or is aware of that? Because what I'm trying to get to here is what is really new about genetic engineering and also about why people are more concerned about the new than the existing risks.

[1:03:42]

[*J.K.*]: Well I think there's the argument that conventional breeding is more--less precise. And therefore, you're transferring more genes back and forth than a less-directed way. And that may contribute in some cases to higher risk in some products. Then the flip-side is that, with genetic engineering they are often controlled under different light switches or promoters and there can often be in different contexts. Like you can put a bacterial or human gene into a plant. And so there's less familiarity, there's probably less natural control if you want to call it that in a genetically engineered plant. So really the arguments on both sides for categorical risk, like as categories of products, were pretty even one way or the other. And so what the National Academy came down to in the '70s and '80s was that it's the product not the process. So the products of conventional breeding could be as risky as genetic engineering and vice versa. Because of these arguments when you thought about just the technologies, there was no way to predict which products would be more or less risky. However, this committee and I guess other people, have used the argument that, well because we have less experience we cannot regulate everything. Because we have less experience with genetic engineering and because there's public concern about this unfamiliarity, which is a risk-perception factor, in the risk-perception literature. That there is a basis--a societal basis, a social science basis--to take a special look at these for the time being. But if we ever have the resources and capacity, we should also take a look at conventionally bred products as well. So that was sort of where the committee came down. They agreed with the science of the previous National Academy reports, but sort of differed in incorporating a bit of these other societal and unfamiliarity factors into it. In order to take a special look at genetic engineered plants.

[*F.G.*]: I think that unfamiliarity thing was a big deal and it was laid out there. I think that's a really important thing. And I think the other thing that I learned in that report was this whole issue that governance is not about necessarily limiting risk, but it's in getting its citizens to trust the regulatory authorities. You know, because if you don't have trust of the regulatory authorities, you wind up with people not taking in a new technology or something that could be safe. But that it was a really complicated thing, because wait, if you as a scientist and as a regulatory authority, you decide that something has zero risk...should you still do regulation? Because of maintaining the public's confidence. And I know people who work in integrated pest management who, when they see a pest and they know it's not going to cause any damage, but the farmers worried about seeing the crop being chewed on, will do something with the farmer to give the farmer something to do, just so that they know that you're concerned. And you know a lot more that I, but all I'm saying is that I had no concept of that. It was sort of like, you know, in the end you wind up putting on a big space suit in terms of doing a simple experiment, but you might want to talk more to that.

1:07:03

[*J.K.*]: Yeah, no I think that's good. I think that there's two, maybe, additional things to trust. And one is that there has to be a reason to trust, right? And so, in order to be trusted, you need to be trustworthy. And I think that's what we have some work to do on the governance side, I think. In not only the U.S. system, but in other systems is that

trustworthiness. That the burden of trust doesn't rely on, "Oh, just believe us, trust us," but we need from a policy standpoint, in our policy systems, need to strive to be more trustworthy. And then the second thing is that I think sometimes the public is a bit more savvy than the scientists in that, "Well yeah you said that DDT wasn't a problem, but now it is!" [*F.G. laughs*] Or, "All these chemicals you're putting into the environment, oh good living through chemistry and plastics..."

[*F.G.*]: Yeah, yeah!

[*J.K.*]: "...but look at it now!" And so they remember these things. And if you, you know, there---and that doesn't make them uninformed, it just gives them a level of skepticism. And so I think that that trustworthiness needs to develop over a period of time and that skepticism--and a lot of the policy scholarship talks now about this bi-directional communication of public engagement and being transparent--more transparent; being more deliberative in the decision making, opening up the process a bit to other voices and other perspectives. And maybe that would help with some trustworthiness I think.

[*F.G.*]: Yeah, well if you're willing to go on to a different semi-topic, it's how we got into genetically engineering pests, right? And it was a very interesting transition, because here, you know, you say about the deliberative process and all that. But when you have an industry that's pushing ahead and you have stakeholders and stockholders, right? That process seemed like it was one of...they figure out everything, they get the product ready and then they ask the public for their approval.

[*J.K.*]: Right.

[*F.G.*]: And, you know, it just didn't feel very good. And then when you had genetically engineered pests that you were able to -- genetic transformation--you either get rid of their populations or make them less of a pest, like not transmit disease, there wasn't very much of a business plan to make a bunch of money. If you let these things out of your lab and that was it, you could sell once to one person--I mean, that's the extreme, but the idea that you could do that and then the question was, given that it's not motivated by a profit, could we now have a new genetic engineering where we start from square one and we do this in a deliberative way and we find out what the public would want before we have the plant. And this is how things started out here, and we had, I think, a very important meeting that never really got published about, but I think it was... 19--can't remember the exact date. What was the date of that...2008 or 2009.... What it was called, genetically engineered pests, I think, social and ecological issues. And we brought people together. We specifically brought people in who were against genetically engineered crops: Sierra Club, Physicians for Social Responsibility, concerned scientists. All of these people and presented them with these possibilities of genetically engineering a mosquito not to transmit malaria. How does Physicians for Social Responsibility feel about that? Let's say if you were the person, not that you were going to react to somebody pushing it, but if you were asked, "Okay, should we not do this? What is the cost of not doing it versus doing it?" And the same thing with the Sierra Club when we were coming up with approaches to get rid of invasive pests. And it was

a very interesting meeting. For me, probably the most interesting meeting I've ever been at. Because in the beginning everybody had their stances, but over time, a little bit of trust developed and people were willing to say where they were coming from a little bit more. And I think we got pretty far. It doesn't change the universe, but at least for those people who were there, it was pretty interesting to see. There may be another way. And there were some people who were at the meeting from philanthropic organizations that were worried that we were going to let the cat out of the bag too early and people were going to have too much to say instead of us moving ahead first with what we wanted. And that group was pretty pleased that it didn't erupt into craziness, because that's what they expected. So how can you get the public engaged in a....I don't know...real substantial way? And I don't think--nobody has the answer to that. That's what we're trying to do here at the Genetic Engineering and Society Center, is to engage the public in something substantial that's not about stances, but rather about the fact that our val--you say this a lot--everybody's values are different. How do we do this? And we had this first group that worked in IGERT on genetically engineered mosquitoes. And they worked together for a year. They had pretty similar opinions in the end about what would be the best pathway, but they differed because of---I couldn't tell you why, necessarily. And they point out that it wasn't just a natural scientist versus social scientist defining what you would come up with, so. That's what we're about is a lot of deep discussions. And I have to say that they--New Technologies in Social and Cultural Contexts course that's part of the IGERT has been a tremendous gift to us in terms of getting students to think; outside people see that a lot.

[*M.B.*]: So Jennifer, as director...as director of the Center,Fred has just made the claim, and I think you agree, that there's this public audience--

[*J.K.*]: Yeah, absolutely.

1:13:00

[*M.B.*]: There's the students that take the course, there's the faculty who are involved, and then there's some other broader, perhaps a bit more amorphous, "public." I mean, just to be totally broad--blunt about this. Why? Why should you speak to a broader public with your Center?

[*J.K.*]: Well...

[*M.B.*]: And what do you want them to hear or say?

[*J.K.*]: I think because almost everybody is going to be impacted by technology...and this technology. And so I think, my bias is that everybody has the right to have a say in it. And I think the challenge is, how do you get people to have a say in it? How do you communicate information that they need to make informed decisions and then have them have a voice in those decisions? And trying to reach every single person in the world is probably unrealistic, but at least to try to engage the people that would like to

be engaged once they become attentive to these issues. That's really what we're about. I think it's the only fair thing to do, actually.

[*M.B.*]: Is there a reason why a university has--is there some particular role a university plays in that as--

[*J.K.*]: Yeah...

[*M.B.*]: --opposed to one of the other possible venues?

[*J.K.*]: Well, I think so. I mean...I think in many ways it's a good place to bring together scholarship and knowledge from the ivory towers if you will, or from the scholarly community, with the knowledge and scholarship of people together. So I think it's a good place to translate--in both directions--research and information. So I think that's one reason. The second reason, is that I don't want to say we're neutral territory because we're not. You know, universities are not completely neutral anymore and we're not either. But, the people engaged in this program, even though we come from different perspectives and have different biases, I think we all have the motive of, like you said, honest and open discussion and not...we don't have an agenda as a Center. Like, either to push the technology or to stall it. So I think we're probably in one of the most neutral territories that you could be in with the Center. I mean, I can imagine maybe a Think Tank that's not funded by any particular stakeholder group could also be that territory. But I think we come from a pretty, a pretty safe space, I think.

[*F.G.*]: Yeah...and I think it's great for our students--

[*J.K.*]: Yeah.

[*F.G.*]: --because there is no one answer, right?

[*J.K.*]: Exactly.

[*F.G.*]: So they have to really wrestle with the...

[*J.K.*]: Absolutely. That's the other reason is to train the next generation, because you know...we're not going to be around forever.

1:15:35

[*B.H.*]: You obviously know about my work...

[*J.K.*]: Yeah!

[*B.H.*]: And we're reaching tens of millions of people--

[*J.K.*]: I know!

[*B.H.*]: --in this network of science museums. And we built this infrastructure over the last ten years. Forty million dollars. And we're actually meeting in D.C. on June 9th to...our last reverse site visit with the National Science Foundation to say, “Here's what we've done. We've reached tens of millions of people a year on this one topic. A third of which is social.” And so what you're saying is basically, we don't know how we're going to reach the public, but science museums are a great way and I think that, you know, these partnerships that we're developing, that we're working on a new ground in synthetic biology, is a great way to reach the public and reach a large amount of them. And it's so...

[*F.G.*]: Yeah--

[*B.H.*]: We need your voices too-

[*F.G.*]: [*laughs*]

[*J.K.*]: Well and I think... and I think that's, you know, I think what you all did with the NISE Net was brilliant. And now, if you can partner--and you've already partnered with universities--but, partnering with Centers like us and the ASU Center, and now we need to get the decision makers to pay attention to what people are saying from that network.

[*B.H.*]: So I just was in Arizona and I interviewed [David] Guston and Clark Miller and some folks out there to talk, just about that. I’m making a movie for our reverse site visit on why a network of science communicators--the benefit of not just partnering with the university, but partnering with a multi-million-dollar Center. And the same case can be said about this Center here and this partnership that we've had with ASU has been extremely successful. And why that Center network relationship is so important. And I think that it's just important that we make that--take that message to the National Science Foundation and say science...because it's gone from the media. And I'd like to also have you talk about that, I mean. The media is firing all of their science writers, right? So there is no more science that's getting--except in formal education--so how do we reach these people and why it's so important. Yeah...

[*F.G.*]: Well this may be off tape here, but just to say that, you know, I'm involved in the National Academy and the National Research Council now has a committee called PILS--Public Interfaces of the Life Sciences--and they have a bunch of people both from communication and different kind of media kind of thing to be thinking about how do we interface? And of course they're using interface instead of "communication" because they're concerned about both the deliberate and un-deliberate interactions between scientists and the media. And they are going to try to influence, you know, have an impact on a new committee that's being formed to look at genetically engineered crops to bring in the social science aspects in a stronger way. And they want to do that with a lot of National Academy reports to bring more of the public into that. But they're also interested now in the issue of trust of scientists because the media, you know, like every

week you learn that hamburgers--are good for you; hamburgers are bad for you--you know, this is good for you, and that.

[*J.K.*]: Right.

1:18:46

[*F.G.*]: Why is science any more trustworthy than anything else that you hear about? So just to say is there is that concern and they also might be interested in this.

[*B.H.*]: Is it PILS?

[*F.G.*]: PILS, P-I-L-S.

[*B.H.*]: P-I-L-S.

[*F.G.*]: Public Interfaces of the Life Sciences, yeah.

[*B.H.*]: I'll look that up.

[*F.G.*]: Yeah.

[*B.H.*]: Sorry to hijack, [*F.G laughs*] but I've been meaning... you were just hitting on something--

[*F.G.*]: Yeah, yeah, yeah, yeah! Yeah!

[*B.H.*]: --that is so embedded--

[*F.G.*]: So I think I think there's just more...you know, you might be at the right moment--

[*J.K.*]: Yeah, that's right--

[*F.G.*]: Where a lot of people are sort of seeing that we need more of this...work.

[*B.H.*]: Yeah.

[*M.B.*]: We have two more questions and Alison is going to ask the first one.

[*A.W.*]: So, what are your dreams and nightmares about the future of this Center? And why?

[*F.G.*]: [*laughs*] Oh you have some dreams?

[*J.K.*]: Oh my goodness...

[*B.H.*]: About the Center or about the field? What did you...

[*M.B.*]: About the Center.

[*A.W.*]: About the Center itself. So, yeah, so where do you see the Center going? Where would you like to see the Center going? And where do you definitely not want to see the Center going?

[*J.K.*]: Right. Well I don't want to see it disappear. I think that's my worst nightmare is disappear after these first five years. Or maybe the even worst nightmare would be to do something incredibly stupid that does more harm than good, but I can't imagine us...I don't know.

1:20:05

[*F.G.*]: Yeah, that's a... but I think that is, you know, like. We are actually in some sense on a fine line.

[*J.K.*]: Yeah.

[*F.G.*]: In terms of who are our university stakeholders and what is it that we're trying to get across, right? Because, you know, the university is very much impacted by the industry in North Carolina, right? That's part of the stakeholders. And the farmers and everybody. And how do you sit...and they have products and they want to get them out. And they're pretty confident! And again, it's not like they're badly motivated necessarily or anything like that. They think they have a great product that's going to decrease pesticide use! And conserve soil! And everybody is telling them, “Oh this is terrible.” And they get really angry after a while that the public doesn't understand them and it's just this liberal kind of thing, or whatever it is. And so they have rightful, you know, disagreements with what's going on. And here, we are supposed to be this university Center, that I think a lot of people feel like we should be doing the science. I think there's still that kind of perception that we should be the people who are going to be the arbiters by bringing the best science to bear on these questions and not frame it more broadly. So it's our goal to slowly get them educated to see that it's actually in the best interest of industry and everything else to not sort of just tell everybody, just listen to us, we know the answers. So it's a fine line of trying to educate and not alienate. So that would be my nightmare is that we wind up alienating people who really could benefit from what we're doing.

[*A.W.*]: And if there was one thing that you wanted those people to know, the public at large to know about genetic engineering and/or the Center, what would it be?

[*F.G.*]: [*pause*] Well I think we had this very interesting, discussion in our colloquium. And we talked to all of the people who were in the colloquium and came up with a lot of different answers. And I think one of them was that we are not one voice. And another is that we're working hard to understand this and it's not that easy to understand, so we're

not being arrogant in that. And there were some other things. Do you remember some of the other things that came out of that conversation?

[*J.K.*]: Yeah, what I think, if anything, I would like them to know that as collectively as a unit our intentions are--I think good--in really trying to parcel out the issues in ways that are balanced and maybe not individually any one of us could do that--but to try and develop processes so which--by which that can be done. Which things can be explored or vetted in ways that get closer to the truth than any individual one of us can. And so I think just to know, I think, that the intention of the Center is, it's not some deep hidden motivation or some...it really is kind of a transparent place. I mean, what you see is what you get pretty much. And I, because often when you think of a group, you think what are they really try to do? Or what is their hidden agenda? And I think, I don't think we really have a hidden agenda.

[*F.G.*]: [*laughs*]

[*J.K.*]: The question is, do we have an agenda!? [*laughs*]

[*F.G.*]: And I think that that's really interesting, because I think that, you know, we have folks in our Center who are being funded by Monsanto, right? And they know exactly where they want to go with that funding. So it's not as if we are saying, you can't be in our Center if you're funded by Monsanto, but we are saying that our Center itself will not take funding from any organization that does have some kind of ulterior--you know--have...I don't know what the word would be--a bias or, you know, that they have something where they want to get to--

[*J.K.*]: A personal interest, or--

[*F.G.*]: Yeah, yeah. So trying to keep the...we're not--we have scientists who are very interested in seeing what they built out there to help the world. And there are other people who are more skeptical. And we try to get along. And sometimes we don't. And that's, that's not an easy place to be all the time, that way.

1:24:21

[*J.K.*]: But if I look back at some of the most successful university centers, and what have they accomplished and what have they done, I think in some cases they've developed new tools of assessment of technology and upstream technology assessment. They've envisioned different exercises to engage the public. And so I would like for us to do things along those lines as--in five to ten years--have some tools and resources that we've developed that maybe will live on. Or to have several different people look back and say, "Hey, that workshop you hosted was really great, I really changed my perspective or I really started to understand x better." But I think with any university center these things don't come in like, big leaps. They come in little nudges in that, you know, you might do several things over time that influence the discussions in society, but there's not any one big place where you're called to testify in front of the

congressional committee. I don't know, we might be someday. Or the president calls us in and says, "Hey Fred great job on that Center, you really changed my thinking on genetic engineering."

[*F.G.*]: I expect that [*laughs*].

[*J.K.*]: [*laughs*] But I think they're going to come from more little nudges in the community, well in NCSU, but then also in the Triangle area and then also in the different communities in which we engage, or the people that we call in. But I'd like to see us develop some useful tools, some useful resources for people to draw upon, and some useful spaces for conversation and education and bidirectional understanding.

[*F.G.*]: Yeah, there's a lot to do.

[*J.K.*]: Yeah, there's a lot to do.

1:26:10

[*M.B.*]: Brad have you got a follow up that you wanted to ask or a question that's on this list that we were going to ask?

[*B.H.*]: Well, I mean I want to be respectful of your time too, I mean it is 3:42, but I think there's a couple things. So one is, thinking about the website. If there are nuggets of this conversation that we can put on the website for the public. Is there something that you think that's appropriate for that or, you know, thinking the big objective here is historical archiving of the field, but I think part of my other job is to find little pieces that we can turn into short clips. Well, I guess one thing I wanted to say or to ask you is just, if you could talk for a minute about why it matters, why does this technology matter? Why should, why should this field move forward or why should people care about whether this field moves forward or not? I think that's something that people will look at. Not just your graduate students who want to come here. I'm thinking about the public. Why it matters big picture.

[*F.G.*]: Well I think I'd go back to this question of what's the world going to look like in the next century, right? People are having children and their children are going to grow up in that world. And that world is going to be impacted by this, you know, more than the creation of a microwave oven! You know, that's going to be part of their life is going to be living with organisms like this. And I often come back to this issue of the person who goes for a walk in the tropical rainforest and sees all these wonderful frogs and things like that, and it's just incredible. And they come back to the lodge and they find out that the only reason those frogs exist is because they've been genetically engineered to be resistant to a fungus. Right, our world is not natural now, you know, in that sort of sense of pristine, but in the future, you know, some of what's supporting the infrastructure of society may be that we have this genetic engineering. So I think it's going to effect--the public is going to be interacting with genetic engineering very directly.

1:28:21

[*J.K.*]: And I think back to the synthetic chemicals and the chemical industry essentially started in the late 1800s or so when we had kind of the boost in synthetic chemicals and--so that was about 100 years ago, 130 or so. If you think 100 years from now, and people are; oh, going back to the chemicals, people are faced with daily decisions: do I buy this chemical? Do I eat this chemical? Do I wash my skin with this chemical? Do I... you know all these decisions regarding chemicals. I think the same thing is going to be true for genetic engineering in 100 years. Do I buy this organism to put into my lawn? Do I eat this organism? Do I put it on my skin? Seriously! There's going to be a lot--there's going to be a lot of different products out there that you can come in contact with and I think so--even at an individual decision-making level, I think it's important people know about it for their own decisions. Do I want this drug, this synthetic microorganism? Do I want to eat it and cure my ulcer or not? So they're going to have to have some sort of awareness of these products for their own individual decisions as well.

[*F.G.*]: Yeah, this goes back to your thing about the art and stuff like that.

[*J.K.*]: Yeah

[*F.G.*]: Trying to envision what that's going to be like. Are you going to pick up a package of Cheerios and on the ingredients it's not going to just have all the chemicals and all of that, it's going to have weird bacteria or something like that that's going to help you live until you're 120.

[*J.K.*]: There you go.

1:29:47

[*B.H.*]: So, but how do we get past this fear that's out in the community right now about genetically modified foods? And I think that's where everybody is going to go back to when they think about this. There's a great article in the New York Times a month or so ago about this guy in Hawaii who really had to do his own research to kind of, like, how do we battle that now in thinking about how to get this, you know---the public's going to already turn on it--

[*F.G.*]: Yeah, but I--I--take a little issue with your thing of how do we get the public over this fear of genetic engineering, right?

[*J.K.*]: Right, yeah.

[*F.G.*]: I think we both say wait, that's maybe the wrong question.

[*B.H.*]: Okay.

[*F.G.*]: Alright?

1:30:26

[*F.G.*]: How do we--

[*J.K.*]: We think we want to battle it, don't battle it. I mean you can't battle that.

[*F.G.*]: Yeah.

[*J.K.*]: I think it's *listen* to that--

[*F.G.*]: Yeah!

[*J.K.*]: Go ahead...

[*F.G.*]: I think we agree on this is that the question is more to...how do you elevate the conversation? Right? Is that fear justified or is that fear not justified? Is it the wrong fear?

[*J.K.*]: Yeah.

[*F.G.*]: You're worrying about your food because you've maybe got this kind of input about it, but maybe what's behind that is some other fear of, I didn't--"Companies told me that DDT would be good and now they're telling me that this is good...why should I trust them?" So is what we could do is help people to accept that there's a reason why they're distrustful and maybe how do we gain more trust and how do we take control of this as opposed to it being put on us, you know. In that same way with cigarettes. You decide if you want to take the risk and smoke that cigarette. Nobody's putting it in your mouth. So I think if you know more about it you can then gain more control...you might want to talk more.

[*J.K.*]: No, I think that's good. I think it's listening to exactly what they're concerned about. I mean if it's a fear like, I'm going to eat this Bt corn and I'm going to turn into the bacteria...I mean there's clearly some things where the science is going to say no… there are some fears that you can say, "No. That's not going to happen." However, like you said, getting to the root of that fear, "Well has it been tested well enough, has it been--do I trust the organizations that are looking at it? Do I think that who is profiting from it should be the people who profit from it? Do I think that the applications they're working on the right ones or would I rather have them using my tax dollars to work on something else?" I think that's the kind of conversation we would want to take it past the "I'm going to turn into the bacteria" if they're not... and then move it to more kind of questions that, are more, might be more important and more relevant.

[*pause*]

1:32:32

[*M.B.*]: At the core of many people's concerns about genetically modified foods, it seems to me that there are assumptions that GM foods are unnatural. That they are the technological product of human innovation. And, by implication, that conventionally bred foods are natural. So there's a natural thing and an unnatural thing. Whenever you get a newly extra unnatural thing, you get to make the thing that you have already a bit more natural. And so I wonder if, if the Center has any ideas about that? I mean you both talked about your own, you in particular Fred, about this obsession you had with natural. And you grimaced a little bit when you said that, but our notions perhaps of what is natural have changed a bit over time.

[*J.K.*]: Oh yeah, I think so.

[*M.B.*]: Is there some role for the Center in that? Or is that part of how you think about this? That is, making...is in fact, genetic engineering...do you now think of that as unnatural in your own work?

[*J.K.*]: Well that's a... I do...I mean, because that's where my definition of natural sort of...in conventionally bred crops they can cross pollinate, you know, in the wild, most of the time, some not, but it can happen. So my definition of "natural" pretty much goes back, you know. Could it have happened about 100 years ago? [*laughs*] But, I think the next generation may look at, I'm not sure in 100 years, they may look at genetic engineering as natural. I think our definition of nature changes over time. And who knows what the next generation is going to consider natural. They may consider a cell phone perfectly natural. It's part of their body almost.

[*F.G.*]: [*laughs*].

[*J.K.*]: It's attached to them, it's something they consult every day. Or maybe the Google Glasses will be natural in the future. So I think the definition of natural is very generation-dependent.

[*F.G.*]: Well here's the thing, Jennifer and I both have glofish in our--

[*J.K.*]: Yeah we do.

[*F.G.*]: [*laughs*]

[*J.K.*]: We already faced the decision of whether to buy them at Petco and we did.

1:34:37

[*F.G.*]: But I do want to comment on your thing because I just came back from Mexico, right? And there's this whole issue about maize in Mexico and transgenics. And I've been struggling with that to understand it better and it was really interesting to be in Mexico. And you were in Mexico, too, a few months ago. But to be this time, with the peasant farmers who were working on this, you know, dealing with their crops. And

these farmers are really against Monsanto. And part of it is a social thing and a cultural thing. But, they've had companies come down there and hurt them in the past, right? And some with the insecticide, some with other things. But they feel that multi-nationals, U.S., is a whole bunch of things with imperialism and stuff. So what I have seen there is that they really do feel that those are alien genes. And in some sense, I have to use the strong language, they feel like Monsanto is raping their corn. You know, to come down here. And we've had this thing that we have created. This is our culture. And you're coming in here with your money and your thing and you're going to stick this in our crop? Who are you? Just get out of my world. Even if it would make their life easier. So I think that there's, you know, when you ask what is "natural," there's also sort of a cultural battle about this. And you don't hear, you know, in the EU--we've looked at a lot of websites in the U.S. and Europe and it's all about health and is this going to be a problem? But if you go to Peru or you go to other countries--

[*J.K.*]: To northern Minnesota! With the wild rice issue.

[*F.G.*]: Or Hawaii with the, you know, where there's a cultural thing and there's also a history of imperialism. You get a different answer. So I think there's both that natural thing, but there's also something else. And we shouldn't avoid that.

[*B.H.*]: And I think that goes back to the question that I don't think you ever answered, which is why the "S" in GES?

[*J.K.*]: Oh! We didn't answer that?

[*B.H.*]: Maybe, I mean maybe you did [*everyone laughs*].

[*J.K.*]: Maybe not explicitly.

[*F.G.*]: Well, we just thought that a center called the GE Center would sound too much like General Electric, so--

[*J.K.*]: Well I think it's--[*everyone laughs*]--Yeah, there you go. I think it's because we gave examples of how the societal part is so important. That, the technology itself cannot make decisions on its own. And even the technologists. So if we were to end it with just the "E" it sounds like, one, that we're promoting genetic engineering in every possible shape, way, and form, regardless of what it does to society. And that we're ignoring the context of the work, which...the technology wouldn't exist without society, because the society conducts it, and funds it, and develops it. And it wouldn't have any place to go without society.

[*B.H.*]: And I don't know...I didn't mean you didn't answer--

[*J.K.*]: I know! Just not explicitly!

[*B.H.*]: You answered it!

[*J.K.*]: You wanted an explicit, two sentence answer.

[*F.G.*]: But an interesting thing--we actually, in the end, struggled a little bit with the name--

[*J.K.*]: Yeah.

[*F.G.*]: And it was going to be Center for--

[*J.K.*]: That's why I tripped up--

[*F.G.*]: Center *for* Genetic Engineering and Society. Well that *for* makes it sound odd, you know, then we change it and we got it to be a pretty long sentence, like the Center for the Study of Genetic Engineering and Society...so this was [*laughs*]. Alison is shaking her head.

[*J.K.*]: We're not changing the name again! I just did the logo [*everyone laughs*]!

[*A.W.*]: We're not changing the name.

[*B.H.*]: The Center for Nanotechnology in Society or is it *and* society?

[*F.G.*]: In society?

[*B.H.*]: Is it *in* or is it *and* society--

[*J.K.*]: What is it? Center for Nano *in* society?

[*B.H.*]: I think it's *and* society.

[*J.K.*]: *And* society.

[*B.H.*]: Yeah, but I can never remember...

[*J.K.*]: But it's still *for* they didn't think about it, we thought about it--

[*B.H.*]: And then--

[*J.K.*]: We're a step ahead of them!

[*F.G.*]: [*laughs*]

[*B.H.*]: The other question I think which would be kind of cool to look back historically at why NC State was chosen. One of the things I remember from Fred Gill's interview was the reason why you guys were able to lure him over from UNC was really--if I remember correctly--I mean, the genetics program here at NC State was one of the top in the

country and it just made sense that this is where this Center lives. Is that part of that or is--am I misremembering?

[*F.G.*]: No, I don't think so. I think he may have come out over here because of Trudy MacKay and some other things that were going on in terms of the cutting edge of quantitative genetics. He and Trudy were doing somewhat parallel kinds of work--

[*B.H.*]: But is it true that the genetics here--

[*F.G.*]: The genetics here is excellent. Yeah. But I don't think that's why the Center's here. I think the center's here more because of crop science and entomology. That's what it grew out of. It grew out of people working on these genetically modified crops, whereas the genetics program--and even some of crop science was just quantitative genetics--wasn't as involved as the applied fields. And that is what led us to the problems and I would say also in that was the...administration was pretty tolerant of us not just going along with the companies early on with those kind of things. So no, I wouldn't put...

1:39:53

[*J.K.*]: But from an outsider's perspective I think NC State is also a good choice because I've known NC State's role in the crop science, entomology, food science areas well and this land grant, you know, mission and the good agricultural, biological engineering. So there's a lot of departments of NCSU that are very strong. Plus, then you situate that with the Triangle and all the biotech companies, it also makes sense. Makes a lot of sense. And then agriculture in NCSU--or in North Carolina from what I understand--is a bit different than Midwest agriculture with these large fields and it's a little more smaller farms, varied. And it seems as if that also might be a factor in that the agricultural landscape is different.

[*F.G.*]: Yeah, so I think--I would think it's an appropriate place for it, but I'd have to say it's more like our careers. That it didn't happen because it's appropriate. It happened because--

[*J.K.*]: Because Fred did a cluster hire, did an IGERT--

[*F.G.*]: --Yeah, and it wasn't a direct path that led us to this as opposed to something else. And there are a lot of other universities where that did--obviously didn't happen, but it was a confluence of things coming together. And I have to say that actually when we did the cluster hire, if we didn't get Jennifer, we wouldn't be in the place we are now--

[*J.K.*]: Oh that's ridiculous.

[*F.G.*]: And it's really actually true. She's going to deny this, but I do have to say that we really tried hard to get Jennifer because the connection made so much sense, because

Jennifer had been working on this kind of stuff and especially thinking into the future of where this was going to go and also had a great reputation for working in other Centers, she had an IGERT that she was working on that just fit together. So there's been this confluence, we've been very lucky actually.

[*J.K.*]: Now that they have me they're ready to kick me out--

[*F.G.*]: [*laughs*] Right... right.

[*J.K.*]: [*laughs*]

[*F.G.*]: Just spend a couple of million dollars and then you can go.

[*B.H.*]: And I'd say part of that is also you too.

[*J.K.*]: Oh absolutely.

[*F.G.*]: Yeah, yeah! Yeah...

[*J.K.*]: Absolutely...I mean if this--none of this would have happened without Fred. And he was the one who had the vision for this from the beginning--

[*F.G.*]: Yeah, yeah, yeah.

[*J.K.*]: With the cluster hire proposal--

[*F.G.*]: But then you have to--

[*J.K.*]: This would not, yeah--

[*F.G.*]: I mean, as I said, when I came here and had a toxicologist and a biocontrol person talking to each other and sharing a cabin, that's what happened when I--you know--it was; in other universities, I couldn't have gone across to go talk to history, or *instead* had the history people show up in my office? Matthew showed up in my office and said "hey"--

[*J.K.*]: Cool!

[*F.G.*]: Yeah! Remember that?

[*M.B.*]: No.

[*everyone laughs*]

[*F.G.*]: Come on!

[*M.B.*]: I'm a historian and I can't remember anything.

[*F.G.*]: Yeah... that's right I forgot about that problem. But you know, there has been, the walls were not as high as they could have been.

[*J.K.*]: Yeah.

[*F.G.*]: And at other universities, I think the walls would have been higher. You know, everybody in their own little thing. Worrying that if they don't get that next grant--don't get that next grant, you know, and if they talk to somebody who's ten minutes out of their life, everything will fall apart. So it's more of a relaxed and more collaborative environment.

[*J.K.*]: I'm still waiting to meet the person with the cabin though.

[*F.G.*]: [*laughs*]

[*J.K.*]: Anyone? Because I'm renting one this weekend.

[*B.H.*]: One more if I can. So one of the really cool things that I heard from my early interviews with you guys was someone who said, you know, an NSF or U-panel said, this is absolutely the first proposal I've ever seen that has a rhetorician, a geneticist, a historian, a mathematician, a biologist, to have all those people, and I think, can you talk about what it means to be the first Center of this kind for this field...are you the first Center of this or is that--am I--

[*F.G.*]: I don't know.

[*J.K.*]: I think for this particular subject matter in the U.S., yeah!

[*F.G.*]: Yeah, that same, you know, the reviewer--the strong--we've been to this three times. The strongest supporter for this on the last go around that we got it was also critical of it. Because saying, look this could be the most impressive connection of true, broad interdisciplinarity or it could degenerate into a polyglot of independent, useless things, more or less he said that. And that was part of a review that was the strongest one to get us over the--you know, but recognizing that we're trying to do something that isn't easy. And there have been many times there was that kind of thing. The day you get your grant you feel great. The day after you say, “Oh my God.” Our Center doesn't do that. That's why the cluster hire really saved us in a way. Anybody who's getting kind of burned out in terms of, they had 100% work, plus helping with all of this. So having Jennifer and the other people in the cluster hire who actually had a portion of their time, you know, allotted to this, has helped tremendously.

[*J.K.*]: And I think we're still trying to figure out--we are multidisciplinary and we have projects that are interdisciplinary, but I think we are still trying to figure out how to do *really* interdisciplinary research. Where theory from biology is used in a policy study

or policy or network theory is used in a bi--you know, really that integrated kind of-- I think everybody is still trying to figure out really how to do that inter-trans-disciplinary work. So I think we have some projects that may be going in that direction.

[*F.G.*]: So the dream is that that works.

[*J.K.*]: Yeah.

[*F.G.*]: But we're not sure yet.

[*B.H.*]: There's only one way to find out.

[*J.K.*]: Can I stand up? My back is--

[*M.B.*]: Let's stop for a minute--

1:45:34

END OF INTERVIEW PART I

PART 2

[*Brad Herring*]: It will be good to go back to the transcript and look at it.

[*Jennifer Kuzma*]: Yeah.

[*Matthew Booker*]: For the archival purposes, one thing we did not do that's essential, as standard operating procedure, is that we were supposed to introduce ourselves on camera, or at least be audible, because the other voices in the room are required for archiving purposes.

[*B.H.*]: So I'm recording, so I'm Brad Herring, videographer.

[*M.B.*]: I'm Matthew Booker, Associate Professor of History at North Carolina State.

[*Alison Wynn*]: I'm Alison Wynn, I'm the Deputy Director of the GES Center.

[*M.B.*]: And today is May 20, 2014.

[*B.H.*]: At the Hunt Library, NC State.

1:46:11

[*M.B.*]: So I have one, well, two questions to ask. And they are variations of the same question. And they are--are there any questions you expected us to ask that we did not? Or, what question should we have asked that we did not?

[*Fred Gould*]: Hmmm...

[*J.K.*]: Well I don't know--did...maybe what was your involvement with the history of genetically engineered organisms? We did get to it, but I wonder--and I knew that in different survey and focus group methodologies you don't ask that directly, but—

[*M.B.*]: What was your involvement with the—

[*J.K.*]: I think we got to it, you know, we got to it, we got to it through the NAS Report and through the--but I know you've also said on the SAB of EPA for a while and developed the resistance management that people use in the field. I'm not sure if that came out.

[*F.G.*]: Yeah.

1:47:14

[*M.B.*]: What was your involvement with the history--[*everyone laughs*]--in genetic engineering, Fred and Jennifer?

[*F.G.*]: So I've had a long history with it, as I said. I was in some ways pre-adapted to getting involved in this thing because I had been working on insect adaptation to conventional crops. So when this whole thing happened, I was ready. So I have been involved in this thing...since 1986, was the first conference I went to on this kind of thing. And then we were probably the first people to field test genetically engineered tobacco that had Bt in it. And North Caroli--again, North Carolina tobacco, when you want to do a field test of tobacco, where do you go? North Carolina. Because the companies were considering genetically engineered tobacco. And it was great! I mean, in terms of controlling the pest species on tobacco without insecticide. And then in the end, the way I heard it was that R.J. Reynolds pulled the plug because they thought that tobacco smokers would be worried about having Bt in their tobacco. Anyway, that's how we started out. We just kept doing these--we were able to get to do a lot of field experiments with those tobaccos and look at how they interacted with natural enemies and stuff like that. So, I had a long empirical and theoretical research program from around 1986 up until now, looking at ecological and evolutionary impacts of these crops. Looking at gene frequencies, lots of publications on that, lots of students, post docs. And one of the interesting things is that quite a few of our students are now working for

the industry in positions about resistance management. And I have even been on EPA advisory committees where I have showed up there and I'm on the science side. We're supposed to be carefully examining the industry positions. And I have my own students who are presenting the industry opinions, and it's kind of interesting to be dueling with them a little bit. So we've had a long history of that going on. And being on EPA advisory committees, USDA committees, so a big part of the work I've done has involved that kind of thing. And making people aware of it.

1:49:42

[*M.B.*]: Jennifer, what about you? Is there more you would like to say about your own involvement in—

[*J.K.*]: Well maybe—

[*M.B.*]: --the history of—

[*J.K.*]: I think there might have been a few things that I didn't mention and... So my undergraduate was the time where I got interested in genetically engineered organisms and then my graduate work was on plant biochemistry and molecular biology and that was actually a time when, just shortly after the first plants were transformed and developed in the mid-80s, so this was the early 90s, 90-95. So I worked on isoprene production from plants, which tried to clone the gene and try to figure out what gene was responsible for isoprene production. And then my post doc was on the molecular biology and biochemistry of drought and salinity, so I worked with transgenic plants then. Arabidopsis was the model for making the transgenic plants and studying them by using reporter genes to try and figure out signal transduction pathways in plants. And then after that I went to the Department of Agriculture and I was doing risk assessment. And that's where I got policy and science were starting to come together in regulatory policy and learning how to do risk analysis and environmental risk analysis. Most of my work was on food and microbes, microbial pathogens, but I did dabble a little bit in the transgenic plant risk analysis world there while I was at USDA, and then moved on to the National Academy where I was study director for one of the key reports on genetically modified plants. And I was also program director for the Standing Committee on Agricultural Biotechnology in the late 1990s and early 2000s up until 2003 at the National Academy of Sciences, where many reports were done under that committee, the Standing Committee, about four or five different reports on animal biotech, on bio- confinement, on environmental effects, the second crop study. So I kind of oversaw the development and the agencies that would sponsor those studies would come to us and then I would help the study director get those off the ground. And then I think...what did I do...and then I was in academics [*F.G. laughs*]. You know all about that.

1:51:54

[*F.G.*]: So I just thought of a question you didn't ask. You asked us what were our dreams and nightmares about the Genetic Engineering and Society Center. So what are your dreams and nightmares, you know, why am I afraid of genetically engineered crops?

[*J.K.*]: Yeah, what are your dreams and nightmares about genetic engineering?

[*F.G.*]: Yeah.

[*J.K.*]: Yeah.

[*F.G.*]: So I would say specifically about genetically engineered crops, my concern is about secondary impacts of this whole thing happening. So the dream of course would be that we have better soil conservation, we have better biocontrol because we developed these systems that are actually just more consistent with natural environments, however we define those, biological environments, and we have more natural control and more efficiency and everything. The thing I worry about is that we are seeing all of this gene patenting, and I guess that thing that concerns me, and it's reasonable for people to get a patent on a gene that they have synthesized and put into a crop, but once you've put that gene in that plant, that whole variety is patented. And that means that nobody, and when that's sold, nobody can do anything with that other than plant it and use it as, you know, for production. You can--so a researcher can't investigate anything about it. And there was a whole letter to the New York Times by a bunch of entomologists in the Midwest about how they weren't being able--allowed to use these kind of things. So it becomes locked up. And actually we're getting to a point now, you know, a number of people have been arguing lately that transgenics haven't really given what they've promised. That we really don't have this great, new things that have new ways of photosynthesizing and better health and all of that. We just get these two traits, one for herbicide tolerance and one for insect resistance, right? And in a sense, I think those are pretty good traits, but we're getting to a point right now where if those traits weren't necessary--so let's say all of a sudden you weren't using that herbicide because all of the weeds had become resistant and all of the insects had become resistant to that, so these were anachronisms, whatever you would call them, right? Farmers still couldn't afford to not buy the transgenic crop, because they've patented it, but they are continuing to breed these things and they have ex--they hire all our best students, right? And they're breeding these things for higher yield, higher drought tolerance and stuff like that. So in a way you wind up--yes, you don't have to buy this, nobody is forcing you to buy a genetically engineered crop, but you can't stay in business as a commercial--in conventional agriculture--if you don’t, aren't farming those things. So it's a way of locking up the germplasm. Now hybrid corn did something similar but not completely, because once those hybrids were out there, people could take those; there were Breeders’ rights, so you couldn't just use that, but you could improve that, so if you could use it for research and improve it, and then you would get Breeders’ rights for the next thing. This stops that. So if you think about the direction,

they have just really invested a lot in research. And we've had some of our crop scientists who are great breeders, great quantitative geneticists here, who realize that they don't have the funds to do the high powered breeding because it requires you to do huge genomic inventories in order to be able to make predictions about what the next step will be, so you have to put this big investment in. So what it does is it puts a shield around the stuff and only really, like, three companies right now, globally, can do some of this breeding to make these advances in performance where you had the Norman Borlaugs and all of that stuff. We just were in Mexico where SIMID is, the place where Normal Borlaug worked on corn, and we heard from one of their scientists that they think that they're playing in a game where they're not the big dogs anymore. They can try to compete and come up with new crop varieties that would be better than the companies, but they're not going to do it. And so where are we in 2100, you know? Are we going to get to a point where the germplasm bank gets smaller, it's run by these companies, and the thing I worry about is that if you go after the short-term kind of thing, the stockholders, and you have a smaller genetic diversity, I'm not too worried about that, but you're going after high yield in a certain way, what happens if you're building a racehorse and it breaks a leg, something happens and we have a huge population? Are we in trouble? You know, talk about unintended consequences. All the best intentions, let's feed the world, that's what I said earlier. Maybe the geneticists should say, "No we aren't playing the game anymore." But we are playing the game. And we're going to have all the--and there was a recent article in *Science Magazine* or *Nature* where you have a narrower and narrower spacing between the rows and that is good for productivity, but it gives the crops more chanced to have stress problems because of using up every bit of water. Anyway, all I want to get at is that maybe the coefficient of variation in yield, you know the variation which is so important to a subsistence farmer, may go up as we're doing it. And in the end, you know, who is gonna, you know, with chickens, chicken farmers don't own their chickens anymore. They're leased to them. Are we going to wind up in a world where farmers don't own their corn seed, they just lease the corn seed? I don't know where we're going to go, but when you asked that question about where we're going to go, that's my kind of worry and I want to make sure that we don't wind up down that trail. So that's my fear.

1:57:50

[*J.K.*]: I have to get my phone.

[*M.B.*]: Yeah mine is doing that too.

[*J.K.*]: I'm pretty sure that's mine.

1:57:54

[*M.B.*]: Just to, just to kind of point something out here. What you're describing, of course Fred, is not a characteristic of the technology, and in particular not of the science, but rather of the society.

[*F.G.*]: Yes, yeah.

[*M.B.*]: It's the legal—

[*F.G.*]: Oh that's why it's called GES!

[*M.B.*]: It's the legal structures, which don't necessarily, don't necessarily have anything to do with genetic engineering but which, in fact, as you pointed out, are in fact correlated with these changes in science and in technology. That is, it may have been the same with conventional breeding, had GE never been invented, but in fact, the two are closely linked. And it's an observation, but I see the same thing from the people I know who are intelligent critics of genetic engineering. This is where they all end up. They all end up with the "I hate Monsanto because they own everything." It's actually not a criticism of the technology.

[*F.G.*]: And it's not a criticism of Monsanto in a certain way.

[*M.B.*]: Exactly. It's not even about--and so that's the problem is that you can't fix that by locking down genetic engineering. But you also, you can't really address this problem by addressing the technology—

[*F.G.*]: Well, I'm not sure that—

[*M.B.*]: It's a social problem.

[*F.G.*]: I totally agree with that—

[*M.B.*]: Then yes, tell me.

[*F.G.*]: Okay, so if we never had genetic engineering, where would the companies by going, where would everybody else be going? Would we be as far down that track, or would the plant breeders have more say? Would those companies that we're doing, like Pioneer, wouldn't have been bought out by even larger companies. Would we be seeing--you know, maybe you're right. Maybe, over the long haul, everything is leading to bigger and bigger companies, fewer and fewer, bigger and bigger companies or something like that being in control. And again, I don't want to say that that's bad. We're moving--it's because we have those big companies that we can move ahead and have higher yields and maybe because they're bigger companies they're more accountable. I don't want to say that it's all bad that way, but I do think that the genetic engineering in that patenting situation, somehow I feel like that has changed the rate and maybe even just the process, so, again. I don't know what you say. It's not the technology of the gene, but it's the patenting of the gene, so I'm not sure which way that goes. But if you

didn't have the technology, you wouldn't have had those patents and you wouldn't have had maybe the accumulation...enough [*F.G laughs*]. That's why we need the new technologies course.

2:00:32:

[*B.H.*]: Okay, we can stop recording.

[*M.B.*]: Jennifer, did you have something you wanted to say about the nightmares?

[*J.K.*]: I was just going to do two words: utopia and dystopia.

[*M.B.*]: [*laughs*]

[*A.W.*]: Well it almost seems like the way you're describing this, that plants are going to where it's more and more narrow as to what you're going to be able to do, whereas SynBio [Synthetic Biology] it's like anybody can get in on it. It's almost sort of like, in my mind, closed software, like a closed system like Apple, where you can't do anything with Apple if you're not a part of Apple, versus something that's really open source like Linux, where everybody can go in and change and have little pieces of code and make things happen.

[*F.G.*]: That's a very good point. I think that there is something to that. Except there's going to be a part of SynBio that will—

[*J.K.*]: --I think that is a good thing about it. Go ahead I'm sorry—

[*F.G.*]: The Syn--some parts of SynBio that will be very much as closed as the genetic engineering of crops, but there will be other parts that won't be. But, you know, we'll just make our own vegetable soon in the back yard, right?

[*J.K.*]: Sad.

[*F.G.*]: We're going to cross squash and cucumbers and come up with some new food, right?

[*J.K.*]: Yeah.

[*F.G.*]: Yeah! But I do agree, that's an interesting point, very interesting.

2:01:46
END OF TRANSCRIPT