Archiving Agricultural Genetic Engineering and Society
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[00:00]

[*Alison Wynn*]: Okay! So please tell us your names, institution, and what your role is.

[*Pamela Ronald*] My name is, and look at the camera, or look at you, or…?

[Brad Herring] You know, I think you can do both, you can look at either her or just kind of like right here is fine.

[P.R.] Ok, yeah, alright. I'll look at her. My name is Pamela Ronald, I'm a professor of Plant Pathology, and well, I'll start again, actually this is a different way of saying it. Hello, my name is Pamela Ronald, I'm a professor in the Department of Plant Pathology and the Genome Center at the University at California, Davis and I study the role that genes play in the plant's response to environmental stress and disease.

[*Raoul Adamchak*]: I'm Raoul Adamchak. I'm the market garden coordinator at the UC Davis Student Farm. I don't know how much more you want, but--

[*A.W*]: As much as you want to share, because the next question is really describe what you do, so you can sort of describe, you know, what you do.

[*R.A.*]: Okay...I've been an organic farmer for the last 25 years. And at the Student Farm I both teach students the principles of and practices of organic farming as well as generate income for the farm. The farm is a place for UC Davis students to come to get hands on experience in agriculture because these days most students don't come from the farm, and what they learn on the farm very much compliments the information that they're getting in the class. So my role is to teach and to farm and it's very enjoyable.

[*A.W*]: Wonderful. And so how did you get interested in organic farming and teaching and sort of combining those two passions?

[*P.R*]: I'm going to let you do him first.

[*A.W*]: Okay.

[*P.R*]: He's fascinating, but we have heard each other speak about a thousand times.

[*A.W*]: Oh okay. Can we ask you some questions together though?

[*P.R*]: Oh yeah!

[*A.W*]: I would love to get some synergy between the two of you--

[*P.R*]: Oh yeah, sure!

[*A.W*]: Because it was really great. The chemistry on stage yesterday was really great.

[*P.R*]: Just tell me when you want me to come back in.

[*A.W*]: Okay.

[*B.H*.]: Do you want to switch seats with her or... Yeah, or actually if you could just sit over there that would be great and you can look at her.

[*R.A.*]: Okay.

[02:32]

[*A.W*]: Okay so I think the question was how you got interested in this and how you came about being in this position and combining those two passions.

[*R.A.*]: Oh, it took a long time. My career in agriculture started when I was in an International Development Master's Program at Clark University that required an internship. And I looked around the country and I found one in Santa Barbara, California that was going to teach us small-scale agriculture and Spanish and send us to work in Central America. And that started my love, I guess is the best word, for agriculture that I continue to have to this day. What I learned in Santa Barbara were the basic principles of organic agriculture and interestingly enough, in hindsight, the next year after I took the class I helped teach the class. And so that was also my introduction to teaching and it's ironic that 30 years later, I'm essentially doing the same thing. I don't know if that's a lack of progress or what, but it's still enjoyable. But, I realized after that class that I didn't have enough knowledge to be that useful as an agricultural teacher, so I did go to UC Davis and complete a Master's in International Agricultural Development. After that, I started farming in the area and I farmed for about ten years on a 175-acre vegetable and nut farm nearby the university and then after phasing out there I came to work at the university. So I think one of the reasons that when Pam and I came together that we shared a similar view about agriculture, was that while I knew a lot about organic agriculture, I had also studied science a great deal at the university as well so when Pam talked about genetic concepts and plant breeding I had an understanding of that. And so since we both had the same goal of a more sustainable agriculture, looked at from different points of view, we could combine our ideas to come up with a concept of

sustainable agriculture that included both organic and genetically engineered plants to achieve the same goals.

[*A.W*]: Excellent. So, what do you think the most contro--important contribution you've made to organic farming or to teaching students, mentoring students in your field?

[*R.A.*]: Well there, it depends how you want to view it. We have had a lot of students go through our program who have gone on to do wonderful things in the world whether it's farming or working for the World Health Organization, or working for Catholic Relief Services, or becoming agricultural extension Agents in Arizona, starting urban--urban gardens, teaching children, you know the list goes on and on. I'm--I'm proud of all those students and all they've--I'm proud of all those students and what they did. And you know that's part of someone's accomplishments that you can't really quantify, but it's the part that maybe has made the biggest difference in the world. It's also been exciting to be part of this--this process of writing our book, *Tomorrow's Table: Organic Farming, Genetic Engineering, and the Future of Food*, because it has brought us both into a national dialogue about a controversial subject and it's very satisfying to contribute to that dialogue and bring other people into our ideas and the information that provides a--we hope a more balanced view of this important issue.

[07:31]

[*A.W*]: Excellent. What did you want to do when you were younger? What did you want to do when you grew up?

[*R.A.*]: [laughs]

[*A.W*]: Is this where you saw yourself?

[*R.A.*]: No, not at all. Not at all, I...I'd have to say that I was--I didn't have a lot of direction in junior high or high school. And I don't, I enjoyed the outdoors, I enjoyed doing things with my hands, building things, and in some ways just in that description right there, I enjoyed the outdoors and I enjoyed doing things with my hands. Those are actually basic farmer skills. So I didn't really have the, the concept of being a farmer or even a sense of growing things, but I had some of the important skill sets to be a farmer and so when I finally came in contact with plants and the process of growing plants, it really clicked.

[*A.W*]: So what roads did you not take? So--

[*R.A.*]: Ah, yes. Well, being at the university there is a subtle pressure to be at the university more. You're around bright people doing wonderful things and I actually started a PhD program in entomology because I was interested in entomology and it seemed like there was a lot going on and I, I started, I took all my classes and I started doing research and I found myself in the lab a lot with a microscope, counting aphids on a slide. And I just started thinking to myself, this isn't going to work for me. That I really

am a person who needs to be outside and moving around and working with plants. And so about midway through that I had a change in course and fairly abruptly stopped going to graduate school and decided to find work to raise some money so I could farm. I spent a couple years working and right after that was able to invest in a farm partnership and start to farm.

[*A.W*]: Great!

[*R.A.*]: Well, it was what it was. Yeah...

[10:15]

[*A.W*]: So why are you more interested in organic farming than other types of farming, like more genetic engineered farming.?

[*R.A.*]: Well, I started off that was my training, organic farming, and one of the rules of organic farming is that you're not allowed to use genetically engineered crops or any genetic engineered products in organic farming. So I was farming for, how many years...I don't know, eight years before I even met Pam. And so I hadn't really given a lot of thought to genetically engineered crops. Also, I'm a vegetable grower and the genetically engineered crops that had been developed were corn and soybeans and canola at the time. They weren't things that I grew and the traits--the herbicide tolerant traits aren't really useful to an organic grower at all. So until I met Pam and we started talking about these issues and our view of farming I honestly didn't give it a lot of thought.

[11:43]

[*B.H.*]: Can I ask you a follow up question? You can certainly answer her. But when you see or hear people say "well we've been genetically modifying food for thousands of years. If you look at a picture of corn prior to that it was this big and if you look at it now. So how is it--what is the difference between genetic engineering food and saving corn that we have that's organic but it's still engineered to be what it is today, right? Or is that...

[*R.A.*]: Well there is a... a spectrum of plant breeding starting from the basic level of starting to select plants that you think will be more appropriate to your needs of eating. So our ancient ancestors selected wild grasses and started to grow them--they saved the seed and started to grow them in more concise areas...compact areas. And each year as the seasons went by they made continued selections for yield and taste and utility. And then it took thousands of years until the 1850s and Gregor Mendel came up with the concept of genetics, really, that genes can be inherited from generation to generation and that you can, as a plant breeder, work with those concepts to develop traits in plants that are a value to you. So it's only been 150 years or so that people have had that knowledge that they can influence the direction of evolution to meet their needs. So, in that period people did many crosses in a traditional plant breeding sense

to develop new varieties and then in the early 1900s the concept of hybrid plants was developed where plant breeders would grow two parent lines that would be inbred over the years and then they would make crosses between those two parent lines and the offspring would have something called hybrid vigor where the plants yielded more often, were germinated better, had better health. And as a consequence of that yields started to increase first in corn and then that hybrid concept was used in tomatoes and melons and broccoli and many other plants. So organic farmers benefitted from all this development of crop improvement over the years and these days, organic growers really depend on seed varieties that have had traits bred into them like disease resistance or nematode resistance, hybrid vigor, all of the things that have benefitted agriculture as a whole actually on some level benefit organic growers more because they have fewer opportunities to use fungicides or nematocides or other chemicals to help control those pests.

[15:43]

[*A.W*]: So, sort of changing the subject a little bit. Have you--what ethical issues have you encountered either from organic farming or the book? Or have you?

[*R.A.*]: [long pause] Hmmm...so this is the issue of using genetically engineered plants is a controversial one, but our vision of integrating genetically engineered plants with more ecologically based farming practices seems like a very good ethical choice because it is really focused on sustainable agriculture, on protecting the environment, on feeding the world. And so ethically, I feel very good about it. Even though many other people don't. And there are a lot of nuances that make it a little more challenging than many subjects. I feel like if we completely did away with genetically engineered plants, we wouldn't get rid of all the problems of agriculture and we would also get rid of a lot of opportunities to increase the food supply, reduce pesticide use, reduce soil erosion. So, the thought that this technology is harmful...doesn’t really make sense in the bigger picture when you see all the opportunities that are associated with it. At the same time, if the genetically engineered seeds are used in a bad farming system, that really doesn't help the situation either. So...

[*A.W*]: What do you mean about a bad farming--can you explain a bad farming system?

[*R.A.*]: Well, yeah...the idea of a sustainable agricultural system is one where you use integrated control strategies to help solve your pest problems. So an example is, with herbicide tolerant crops, if they're used repetitively year after year, you're going to develop resistance to the herbicide. So that is not a sustainable strategy. Whereas, if you had a system of ecologically based, integrated controls of crop rotation, different weed management practices, you end up with a sustainable strategy and herbicide tolerant plants could be part of the strategy, but they can't be the whole ball of wax. So in advocating for an integrated system of ecological farming practices along with these genetically engineered crops with beneficial traits, it seems like you get the best of both worlds.

[19:41]

[*A.W*]: Brad do you have any more questions?

[*B.H*.]: I just have one. In your mind, what is the future of farming?

[*R.A.*]: Well, the future of farming is very challenging because the world's population is going to be increasing, demographers predict by 2 billion people and that's a--in the next 50 years and that's a huge challenge. At the same time, we're starting to feel the effects of global warming: increased droughts, increased flooding, variable weather. That's a real strain on agriculture. That's when you have large areas of crop loss because there's just not enough water, there's too much water, there's an early frost or a late frost. If ocean levels rise and there's more salinity that comes into the coastal groundwater, that impacts agriculture as well. So, the future of agriculture is one of challenges and that's also exactly why we may need new technologies to meet those challenges. Things like salt tolerance, drought tolerance, flood tolerance, temperature tolerance, they are going to become huge. And you know, we've been a very adaptive species and a very creative species and have developed new technologies very quickly over the last 200 years and I think we have to continue to do so. And, you know, it's not just agricultural technology that's going to end up feeding everyone. You need government policies, and you need a world with a lot fewer conflicts, and you need an equal distribution--a more equal distribution of income. I mean, there are all these factors involved, but it doesn't hurt if you have at least the ability, theoretically, to address some of the problems that you're going to have in the future.

[*B.H*.]: That's a tough one.

[*R.A.*]: That's a tough one! Yeah.

[*A.W*]: Are we ready to go to Pam do you think?

[*R.A.*]: Sure.

[*B.H*.]: Sure.

[*A.W*]: Do you want me to do it?

[*R.A.*]: I don't know where she is, but...

[22:15]

[*A.W*]: So, you've answered a lot of questions about, so far, well I guess yesterday, that we don't have about how you met and the fact that you have the same goals for sustainability. Could you talk a little bit about how you came to the conclusion? What was the impetus for you to write *Tomorrow's Table* together?

[*P.R*]: Well, many of our friends, family, and colleagues had asked us about genetic engineering and organic farming, wondering if organic farming had solved all the issues of agriculture and if genetically engineered crops were safe to eat, and we felt that there was a role for a scientist and farmer to talk about these issues and I think we were familiar with news stories that weren't completely accurate. So we thought we could write this book together and describe our experiences.

[*R.A.*]: We also had an editor from Oxford University Press who--I'm not sure if pester is the right word--but approached Pam several times to write a book about genetics and society and Pam eventually caved in and said she would write a book and then started thinking, "well it might be interesting if my husband and I wrote the book together." And so she had to--we had to talk about that for quite a while before we came to an agreement that we would write the book together.

[*P.R*]: And it was about that time when there was a lot of misinformation I felt from leading newspapers about the situation in Iraq and the Weapons of Mass Destruction and the need to invade Iraq and it really bothered me a lot. I felt that citizens were not always using their critical thinking skills and our politicians were not always reflecting the voices of experts in the world and there was really not much that one could do about that as a scientist but at the same time we were seeing a lot of misinformation about farming and plant genetics and felt that we could contribute to society and critical thinking in that way.

[25:06]

[*A.W*]: So what was it in the book that you wanted in the book? Was there something in the book that you wanted to cover or wanted to cover more in depth that you weren't able to or after, you know, it went to press you're like "oh wow I just really wish we would've added this to the book."

[*R.A.*]: Well, after the book was done, for a long time I don't think we had any of those sorts of thoughts. Recently, the--we had talked to the publisher about updating the book and doing a new edition and we think we're planning on adding chapters on organic nutrients and probably labeling as well as updating some of the temporal facts that are in the book.

[26:01]

[*A.W*]: So what are your views on labeling since you brought up labeling?

[*R.A.*]: She's going to write that chapter [laughs].

[*P.R*]: I think labels should be informative. And I think there's an interest and a need on the part of the consumers to have more information about what they're eating and how it was grown, whether it was grown in a sustainable manner, perhaps how the plant breeding was done. And so I really hope that we can develop a certified sustainable

label that provides that information to the consumer: how much land, how much water, what types of compounds were used to control pests and disease? And come up with some best practices for particular crops. And that this certified, sustainable label would also be barcoded so the consumer can go to the computer and have a better understanding, for example, what is Bt corn? So that they can then understand that it's the Bt corn expresses the same compound that organic farmers use and it's considered to be non-toxic to humans and that it's resulted in a large decrease in the amount of insecticides. And that kind of really basic information. So I don't think a GMO label will help, because everything has been genetically modified in some manner so we need to be very specific as to what the, what plant breeding was used and what is the result in terms of sustainable agricultural practices.

[27:41]

[*A.W*]: And so if I'm understanding you correctly, so you're talking sort of like a database of it being sort of a barcode you'd put in your thing and you'd get sort of a database of what is in your product. Like what product you're buying and sort of what its history is.

[*P.R*]: Yeah! And so it could be for those people that don't care about the details it would be some consensus about what certified sustainable would be for a particular crop, strawberries for example. And of course that's not going to be easy because there is a lot of vested interest about what they would like to see. And then perhaps even more importantly, this barcoding system that consumers can get all the information about it.

[28:26]

[*A.W*]: Interesting. What are you most proud of about the book? I'm going to change subjects here, but what are you most proud of about the book?

[*P.R*]: I think I was proud that it was readable, that was really gratifying to hear today that one reason it was selected was that they thought students would read it. I think, for me, that is very exciting.

[*R.A.*]: And it's also been the basis for what seems to be a reasonable conversation about the issues and expanding the concept of a sustainable agriculture and the principles of sustainable agriculture perhaps being more important than issues of organic farming and genetic engineering on their own.

[29:17]

[*A.W*]: Okay. I read the book. On page 129 you talk about Monsanto buying up hybrid seeds. What's your opinion about large corporations buying up seeds and seed companies?

[*P.R*]: They're not buying hybrid seeds. What they do is they develop hybrid seeds and that's what most large seed companies do. So they, hybridization, the companies

develop these very carefully selected lines and then they do cross pollination in their fields and then they sell the hybrid seed, so just to clarify that. Hybrids [seeds] are popular with farmers in the United States, whether they are conventional growers or organic growers- they are very popular with growers because they have what's called hybrid vigor, they are resistant to a number of diseases and pests. That's why they're in demand. And so I think there's an important role for seed companies. Obviously, small, most farmers are not in the seed production business so they need to get their seed from some place and I think there's a role obviously for seed companies, just as there's a role for computer companies to make our iPhones, a very good product, and we go to large corporations to buy those tools that are very useful. So, certainly a role for seed companies, and I would like to see that we can cultivate and support young entrepreneurs to start their own companies, and I think certainly they can do that now. One of the issues is that the large seed companies tend to buy off a very successful, young seed company; is often subsumed by one of the larger companies. And so that's a very interesting sort of issue that I think that it's worthwhile. The department of justice looks into that because we don't want a monopoly in any type of manufacturing company or seed company because the more diversity you have the better it is for everybody.

[*R.A.*]: Yeah, the consolidation of the seed industry doesn't really benefit the farmer, it doesn't benefit the consumer, because it reduces diversity, increases prices. And while this has been the trend in the U.S. in a number of sectors, the consolidation into a few big players, it isn't something that is working that well for the seed industry and hopefully over time forces will develop to help break up the seed industry a bit and increase competition.

[32:16]

[*A.W*]: What do you see the future there? How do you think that's going to go in the future?

[*P.R*]: We're not experts on--

[*R.A.*]: We're not experts--

[*P.R*]: Maybe that's not the best question for us.

[*B.H.*]: Can I ask, are terminal seeds and hybrid seeds kind of the same thing? I hear the term terminal seeds used by companies like Monsanto. Is that kind of the same? In other words, you can't harvest the seed to make another plant?

[*P.R*]: So--

[*R.A.*]: It's a very different concept--

[*P.R*]: Yeah. Hybrids were developed in the 1920s, completely independent of genetic engineering. And, the farmer can collect the seed but they don't replant the seed because all the offspring are different. And so that's why the farmer goes back every year to the seed company, because they like the hybrids and they don't have the resources to produce the hybrids and they haven't developed the parents. And so, that's actually what has created the seed industry, is development of hybrids that organic farmers and other farmers will want to buy. There is an old technology called terminator seed that was developed in response to the concern about pollen flow that was never commercialized. So that doesn't even exist. So when people talk about not being able to grow their own seed, usually they're talking about hybrid seed, which is separate from genetic engineering

[*B.H.*]: Okay, thanks.

[33:43]

[*A.W*]: You also had a chapter about patenting of genes. Can you go into that a little bit? Can you talk a little bit about the patenting of genes?

[*P.R*]: Well there's a couple different ways that breeders protect their intellectual properties. Breeders can do plant variety protection on their seeds, so if they develop some interesting new breeding line, they can have a plant variety protection that gives them some rights so they are able to establish a seed business and sell their seed. And there's also patents on particular lines so those are--or even a particular gene--so those are the common ways that breeders protect their intellectual property.

[*R.A.*]: So the plant variety protection, PVP, it allows growers to save the seed, if they want to, and actually grow the seed, but it doesn't allow other companies to save the seed, bulk it up, and resell it to farmers. So it protects the seed company that has the PVP, but it still gives some flexibility to the grower. Whereas the seed that's patented not only can, is it prohibited for farmers to use that seed, it's prohibited for other companies to take that seed and reproduce it and sell it to growers as well. So the patent is a much stronger protection for seed. It's also more expensive to obtain. But it's also used, well it's used for genetically engineered traits in crops. It's also used for a number of varieties that are not genetically engineered where the parent lines are patented or most of the strawberry varieties are patented as well. So usually any variety that has a lot of work that's been done on it and the company thinks they can make money on it, they'll patent these days. So it's not a genetic engineering issue, per say, although the genetically engineered crops are certainly patented.

[36:13]

[*A.W*]: And that's probably because it costs a lot more to develop those?

[*R.A.*]: It costs more to develop them, yes.

[*P.R*]: Well, creating a genetically engineered crop actually is not costly itself. The breeding and the science; what's costly is the regulatory approvals because any variety that you develop using any genetic method does not have to go through any regulatory approvals. It's only if it's genetically engineered, so that's where the cost comes in.

[*A.W*]: Okay, and why is that?

[*P.R*]: Well, so there's some old techniques that have been used for, I don't know, nearly 50 years now, that induce a lot of genetic changes. It's called mutagenesis and it actually creates many more genetic changes than genetic engineering and is considered by the National Academy of Sciences to be much more risky in terms of unintended consequences than genetic engineering because with genetic engineering you just bring in one or two well-characterized genes. But, it's really sort of a historical issue that mutagenesis was developed so long ago before anybody, before there were many regulations. And when genetic engineering developed in the '70s, the scientific community wanted to look at it very carefully because it was very clear you could move genes between different species and so it was highly regulated for medicine and, of course, we ended up with genetically engineered insulin, which has been very, very important for patients with diabetes. And over time there's been great acceptance of genetic engineering in medicine. However, with genetic engineering in crops, it was the regulations actually were put in place because it was considered to be something different and the regulations probably are not keeping up with scientific knowledge, so that's why it's still very costly.

[38:36]

[*A.W*]: Okay, thanks. Why do you think that there is such a controversy in genetically engineered plants?

[*P.R*]: Well I think one problem is the term "GMO." People tend to think...well first of all it rhymes with "UFO" so it's kind of scary but it really is meaningless, the term GMO. So when you have discussions about GMOs you can't get anywhere, because everything is genetically modified somehow. And so, you know, it's better to talk about a particular crop, so certified organic rice has been developed with mutagenesis. So you can have a discussion about genetic alterations and whether that should be certified organic or not. It is certified organic. Then you can talk about genetically engineered papaya and have a specific conversation about that because papaya is genetically engineered with a snippet of a mild strain of a virus and it's completely resistant to viral infection. And that can be compared to organic papaya, which is infected with the virus and multiplies and has a lot of the virus in it. And to have a deeper discussion about these issues, so, in either case is there any danger to human beings because it's not a human virus, it's a plant pathogen. But to group all GMOs together is sort of a very scary thing for people and so I think it's really--I think the discussion has gotten so sort of stuck is because consumers and politicians are not thinking about individual crops and they're not thinking about sustainable agriculture. And so Raoul and I believe that we really--to advance sustainable agriculture--we need to think about the economic-social and

economic-aspects of agriculture. And instead of getting distracted by how a seed variety was made, we need to consider how we can provide safe and nutritious food, how farmers can make a profit, can consumers afford to buy the food, how can we foster self-fertility, how can we reduce toxic inputs, and how to conserve land and water. So these are really the important issues, and unfortunately with this whole sort of language issues using the term GMOs, we're not even discussing the greatest challenges of our time.

[41:15]

[*B.H.*]: Can I piggy-back on that? So, Neil deGrasse Tyson just made that exact point about a week and a half ago, so we need to stop with this big umbrella of GMOs, right? But he's an astrophysicist, so he's catching a lot of grief that why all of a sudden is an astrophysicist now a genetic scientist and how does he know everything? So I guess my question is around genetic literacy. You've stated the problems but how do we get this message out to people? How do we make a more literate public or publics if you will? How do we do that? I mean a book is a good start, there are good conversations that we can start, but what else do we need to do?

[*R.A.*]: So, just out of curiosity, why would the public ask Mr. Tyson how he can have an opinion as a physicist and not ask Vandana Shiva for example, why she could have an opinion as a philosopher? You know, it's the same sort of thing. People are applying their expertise and their knowledge to the field and sometimes it's appropriate I guess and sometimes not.

[*P.R*]: Well I would argue that Neil deGrasse Tyson is a very esteemed scientist so he understands the scientific process. So he's not saying, "I've looked at the matter and I have done my experiments and I've decided the crops are safe to eat." He's looking at the scientific process. He understands what the National Academy of Sciences is. He understands what the World Health Organization is. He understands peer-reviewed literature. He understands the consensus on the safety of genetically engineered crops is greater than the consensus that human climate change, human actions are contributing to climate change. He understands this concept of scientific consensus. So I think that he is able to grasp that and he's also an incredible communicator. So he can grasp the scientific information and the scientific consensus and convey that. Whereas, if you have vested interests--non-scientists that have some vested interests and are trying to sell you something when they have a conflict of interest--that's problematic. So I think we have to start at the very basic: explain scientific consensus, explain conflict of interest, and really get that information out or else we're just going to be stuck having these debates about whether we should vaccinate our children or not or whether global climate change is a problem or whether plant genetics is important, so...

[*A.W*]: And that's actually exactly what he said. He pretty much said, "The scientific consensus is that these are not harmful. The plants are not harmful for you." Exactly how you said it. He didn't say, "Hey, I was in a lab or I was doing this." He basically

said, "The scientific consensus is this, and this is what it is, and it has been reviewed, and reviewed, and reviewed"--

[*P.R*]: Yeah! 30 years now.

[44:27]

[*A.W*]: Yeah! So why do you think the general public doesn't really...that knowledge hasn't really transcended to the general public? Because there's a lot of people who that that GMOs...we were talking at lunch today...people sort of compile them, a lot of things under GMOs like processed food, generally processed food they somehow associate completely with GMOs. There may be some GMOs in processed food, but it's not GMOs themselves. Why do you think that is?

[*P.R*]: Well if you extract sugar from a genetically engineered sugar beet or sugar from a conventional sugar beet or sugar from an organic sugar beet, they're chemically identical. And so it...I think that unfortunately--and this is the fault of scientists--some consumers feel that scientific information is not accessible. I mean, I actually disagree with that because most of our nonprofit, professional scientific organizations and government agencies have a lot of information for the public on their websites that's science-based and fairly easily digestible. The USDA had a really great report out and even just the summary can be read. But unfortunately, we've done a poor job of making that information available. Directing them to the websites. I think our government agencies are so worried about...they do terse reports they don't really get out in the public very often. And politicians are often afraid to tackle scientific issues, most politicians are not scientists. So I think we have to do a much better job at getting that science-based information out there.

[*R.A.*]: And in the public and in nonprofit activist groups, there has been a fear of new technology, there has been a fear of corporations that, you know, it's a spreading fear and doubt is a very effective tool for influencing people. And it seems like it's easier to spread fear and doubt than it is to spread information and knowledge. So, it's a tough battle there.

[*A.W*]: Thanks.

[*P.R*]: And it's really basic information. If you take genetically engineered corn, there's a report out by the USDA, the use of genetically engineered corn has reduced insecticide use ten-fold over the last 15 years. And that little bit of information I don't think is getting out to the public. But that was the goal of genetically engineering corn with this organic pest control. And I think the USDA should do a better job of getting that information out, for example.

[*B.H.*]: I've got a quote from Fred [Gould] saying that we're combating biodiversity issues with genetic engineering. It’s kind of like knocking heads, it doesn't make sense, but it does. Intuitively it doesn't sound right, but it is.

[*P.R*]: Yeah! Because you spray fewer broad-spectrum insecticides and you have a hugely more diverse insect population.

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[50:07]

[*A.W*]: So do you have any more questions for them together?

[*B.H*.]: Maybe one more. Is there a role for genetic engineered crops in the future for say subsistence farmers and developing countries? I mean, I was in the Peace Corps and I served in Panama and worked with a lot of farmers who were subsistence farmers. Is there a role for that or...

[*R.A*.]: So, the subsistence farmers and the crops they grow in many parts of the world are some of the least serviced crops and farmers in the world when it comes to plant breeding. So they're growing crops that aren't the major crops like corn and soy beans. They're growing millet, or amaranth, or bananas, or cassava. And there hasn't been much work done in terms of plant breeding on these crops at all. So they could be the biggest beneficiaries of genetic engineering. Also some of these crops are difficult to breed. Bananas these days are propagated vegetatively and breeding them using traditional plant breeding is slow and challenging. But it's a crop that many people in Africa and really around the world eat. And there is a blight disease that reduces yield by 15 or 20 percent these days. So to be able to use genetic engineering on those unimproved crops would benefit subsistence farmers everywhere and really contribute to improving their diets, cassava is a good source of Vitamin A, increases in yields make for healthier people. So yeah there's a big role to play. Chances are the private sector isn't going to make those improvements so it's up to either publicly funded projects or NGOs to fund those plant breeders to get those improvements made in those local crops.

[*P.R*]: Well, you know, cotton, genetically engineered cotton is grown by more farmers in the developing world than it is in the developed world, millions and millions of farmers. So they have, there's many studies showing an acid reduction in insecticide. Cotton growers in China and India, they're using Bt cotton. It's very popular. So it's already being used in less-developed countries. Rice is the staple food crop, of course, for half the world's people. And rice is very well studied and there are many groups working on genetically engineered rice. [Removed by request of interviewee: timestamp 53:15 – 53:39]. And then recently the USDA, USAID has released a Bt eggplant. Now, Bt is this organic pest control I mentioned, so the eggplant expresses the Bt protein and that was developed through a nonprofit consortium. And eggplant is the most important vegetable in Bangladesh and India, so it was actually a really exciting breakthrough for Bangladeshi farmers that the government allowed it to be cultivated, because they can massively reduce insecticide usage. In less developed countries, many insecticides, not only are they very toxic, but they can be used without any safety, so you have small children spraying these insecticides. It's really heartbreaking to see those pictures, so

for the farmers to be able to use Bt eggplant and reduce the use of their insecticide should have a huge impact on their livelihood, their productivity, and reducing harmful inputs. And there's reports for Bt cotton that farming families have reduced their insecticide poisoning 75 percent in areas where they're growing these Bt traits. Unfortunately, countries like India have still not accepted Bt eggplant because of the political issues. And so they continue to use insecticides.

[*A.W*]: Okay thanks.

[*P.R*]: Oh! And golden rice, of course, right. I should have mentioned golden rice. I mean that is the most important crop for subsistence farmers is golden rice, with high amounts of beta carotenoids. And these are areas where there are something like 500,000 children die every year from lack of this essential nutrient. And that is also ready, has been ready to be released for many years. [Removed by request of interviewee: timestamp 55:53 – 57:15]

[*A.W*]: Okay.

[*R.A.*]: Okay, you're on your own now.

[*P.R*]: Oh! Oh, oh dear, okay.

[*B.H.*]: If you want to come back in the door locks...

[*R.A.*]: Okay.

[*R.A..* leaves the room]

[57:39]

[*A.W*]: So what did you want to be when you grew up when you were younger?

[*P.R*]: You know it's hard to remember back that long ago. I mean, I certainly remember we spent a lot of time in the wilderness my brothers and I. Backpacking, we had a 500 square foot cabin in the Sierra Nevada Mountains and so we spent summers up there wandering around with our little rain fly and hiding from lightning storms. And once we were hiking, it was really hot, I remember climbing to a ridge and there was a man and woman sitting there with a book open and they were identifying flowers, they were botanizing. And that was the first time I think I had this idea of, "Oh! There is such a thing as a career and there is such a thing as a career where you can be in the mountains and then you could get paid for it." I was really fascinated. So I think I was drawn to plant biology very early, but I was also interested in French and Math. I thought I was going to be mathematician for a while. And then you have life experiences where some things don't go so well, some of the things go better, and it sort of shapes your path.

[58:57]

[*A.W*]: Why rice?

[*P.R*]: Well I thought when I finished my graduate work--so I did my graduate work on peppers and tomatoes which are very tasty and very important, but I really wanted to work on something that would interest me my entire life and my father's an immigrant so I think we always had that calling for doing something for the world. And so rice really appealed to me because I could be working on supper instead of salad, right? Working on something that feeds half the world's people. If you could even make small changes, small genetic improvements, you can affect the lives of millions of people. And it was also a very good genetic system so you could make a lot of basic research progress and that was important to me because, you know, scientists are often, usually, intellectually drawn to the science and the sense of discovery, so you want to make forward motion in an attractable organism. But I also really wanted to work on a crop that would be meaningful for people's lives. So that's really what drew me to rice.

[1:00:09]

[*A.W*]: Did you have any major influencers? First to get you into genetic engineering and then rice? Was there somebody who really influenced you or a group of people?

[*P.R*]: So one thing to be clear, is people don't really go into genetic engineering. That's not what, sort of what, science the way it works. You go into a field, for example, of plant genetics or plant breeding and genetic engineering is just one small tool in a whole toolbox and virtually all plant geneticists will use plant genetic engineering as a tool sometime in their career. And so I think I was, of course, influenced by my many advisors and I have a wonderful colleague when I was first looking into doing a postdoc and I wanted to work on rice, Jan Leach who is now at Colorado State University, provided me a lot of my initial stalks and advice and then I had a really wonderful colleague named Gurdev Khush who provided me the first seed packet of rice and explained to me a lot about this, Oryza longistaminata, wild species and the resistance gene that I became very interested in and I spent my career working on. I've had a wonderful collaboration with David Mackill who was at UC Davis, actually we met at Cornell and then at UC Davis and then he was at the International Rice Research Institute on submergence-tolerance rice. And so we collaborated for many years and he educated me a lot about the needs of subsistence farmers. And so I've been lucky to have a lot of good colleagues in my career.

[1:02:02]

[*A.W*]: Excellent. And what are your current research goals?

[*P.R*]: So we continue to work on understanding disease resistance in rice, mediated by the Xa21 resistance gene. We continue to work on drought toler--actually I should say flood tolerance in rice, mediated by the SUB1A transcription factor. And we're also

spending some time looking at drought tolerance and soil biosynthesis. We have a large program of microbial biology, tying to understand the interaction between plants and microbes.

[1:02:39]

[*A.W*]: What do you think is important about the technology? What's important about genetic engineering?

[*P.R*]: Well, that's maybe too general to answer that one. I'll skip that one.

[1:02:58]

[*A.W*]: What do you think your most important contribution is to the field?

[*P.R*]: Well I think probably my work on rice is...I think it has been important and worthwhile. So primarily my lab is known for isolation of the Xa21 resistance gene and the SUB1A transcription factor, and I hope I've had a hand in educating a lot of young people setting up their own labs. And I've had wonderful collaborations with scientists from Asia. And so it's really a global community and we all help each other and exchange ideas.

[1:03:46]

[*A.W*]: Excellent. So what gets you out of bed in the morning? What motivates you?

[*P.R*]: Well, I think as a scientist you're very interested in discovery. You're constantly thinking about experiments, what you could do next, what worked, what didn't work, and you're really driven by the experiments. So we're very excited about many of the experiments in the lab right now and the teamwork is just phenomenal. This has been a really wonderful year for my lab in terms of teamwork and I have such high respect for my laboratory group. So it's, it's been a good year.

[*A.W*]: [long pause] Do you have any questions Brad?

[*B.H*.]: We only have about ten minutes left.

[*P.R*]: You know, maybe I could say, I don't know if, well I'll just skip it.

[1:04:40]

[*B.H*.]: Well one of the questions that I always ask is, is there anything that we haven't asked that you would like to say?

[*A.W*]: I did want to mention one thing, just about the retracted papers. Basically in more in how you handled it. I mean you've written really openly about it; you wrote this really

great article about it. What was the impetus, a lot of people would have sort of run for cover, but you sort of stood up and said "We did make a couple of mistakes" and you wrote a very instructive article. So could you talk about the articles a little bit? What the motivation was to be, to do the right thing basically?

[1:05:27]

[*P.R*]: Yeah, well thanks. So when you're a scientist you follow the scientific method and you want to reproduce your research, and use proper statistics, and have independent people do the experiments, submit it for peer review, have your peers read it, correct...take their suggestions, do additional experiments. So we went through this whole process and were very excited about this particular result that was published in *Science.* And then, in my lab we build on our own research. That's what we like to do to go deeper, and deeper, and deeper into a biological question. And we started finding some discrepancies. Some people had left the lab and new people came to the lab and it takes quite a while to understand, "well, you know we just aren't doing the experiments exactly right, or are we forgetting something?" And you repeat, and you repeat, and finally we came to the conclusion that there were some mistakes in the paper we published. And that's not something any scientist ever wants to happen, because you're supposed to catch your mistakes before you publish the paper. So it was really very devastating to us, but we, our main concern was we didn't want to waste other scientists' time who wanted to build on our results if they weren't correct. So I did notify the editors and we did about 18 months of additional experiments. Because even when you publish a retraction, then you need to be sure your retraction is correct or you run into more problems. And so that's the way we decided to handle it and, you know, I think most scientists would like to retract a paper if they had made mistakes and I think some scientists don't have the...maybe they don't know they made a mistake. Maybe they move on to a different problem or maybe they don't have people in the lab who have time to address the problems. I'm not really sure what happens at other labs, but in our situation the path was very, very clear that we didn't want to have incorrect information in the literature.

[*A.W*]: Thanks. I think it...I just wondered if I read that. I'm a social scientist, I'm not a science scientist. But as I read it, your article, I was just thinking how many people would be so ethical as to sort of come forward when they found something. I'm thinking, my thoughts were probably not as many would and I thought that it was very impressive that you did the right thing and that you wrote that really very--

[*P.R*]: Well thank you--

[*A.W*]: Very instructive article.

[*P.R*]: Yeah, it means a lot to me. It was a really hard time. And the poor postdocs, they had come to the lab to work on this! So we had a lot of discussions about...we had to reframe their career trajectories and did they want to stay in the lab or did they want to leave? And of course I was going to support them. It wasn't their fault. They all stuck

with the lab and that really meant a lot to me. And not only stuck with the lab, but we have some really exciting results that we hope to write up very soon. And so it's been a really good year.

[*A.W*]: Excellent.

[*B.H*.]: Part of probably who you are...they stayed and let you retract it rather than send it back**.** But it's also a part of science; is making mistakes and learning from those, so...

[*P.R*]: Yeah. I hope other people don't have to make such severe mistakes, but I'm sure it will happen again and again. And so I'm glad to at least provide some model of how to handle it because you do need to talk to colleagues when you have mistakes. I'm happy to talk to people about it. Hopefully I can be useful in that way. Something good hopefully will come out of this [laughs]!

[*A.W*]: So I thought it was a very impressive article.

[*P.R*]: Well thank you.

[1:09:27]

[*A.W*]: I really did. [Removed by request of interviewee: timestamp 1:09:28-1:09:44] Do you have any opponents whom you especially admire or respect? Which I know is hard, but people who look at things maybe in a different way, but have some basis in it? Not the ones that are obviously like the example you gave before, that are stopping the distribution of golden rice, but maybe somebody who differs from you--other than your husband--to some degree and his approach, that you greatly respect and admire?

[*P.R*]: Yeah! I respect and admire many, many people. And I think the issue for me is you really can't have a dialogue if somebody is talking about GMOs. When they talk about GMOs as sort of this monolithic entity, usually means they're not familiar with genetics or farming or some aspects. So when you break it down you can have many interesting discussions. I mean, you know, there is a valid discussion to be had about whether we want five major seed companies in the world producing most of the seed. That's a really important discussion. I think it's very clear we know that if you spray a lot of herbicides, you're going to get herbicide tolerant weeds. I don't think there's not, again, there's not much disagreement about that. And there's discussions in that sense about the herbicide tolerant varieties. There's pros and cons about those varieties. These herbicide tolerant varieties are the varieties that can be planted and then you can spray glyphosate, which is considered to be a non-toxic herbicide. It's actually less toxic than Bt sprayed by organic farmers. So it's good for farm workers and it's good for growers because they can manage their weeds more efficiently. It's good for the environment because they don't have to till their fields so often. And it reduces carbon emissions, reduces use of fuel for the tractors. There's actually a lot of good, but it's so powerful that too many farmers are using it over and over and over and not paying

attention to other really important aspects of farming, which is integrated management approaches. So I think there's many important discussions to be had about that.

[1:12:06]

[*A.W*]: Thank you. So yeah, so as we wind up is there anything that you wanted us to ask you that we didn't? Something you know you want in the archive?

[*P.R*]: No, I think.

[*A.W*]: People who are looking 300 years from now.

[*P.R*]: Oh my goodness. Yeah, it's hard to imagine.

[1:12:30]

[*A.W*]: I have a question. What do you think the future of genetic engineering is? Where do you see it, say in 20 years?

[*P.R*]: Well 20 years ago I would say it is widely accepted all over the world and I would have been wrong! But we are seeing incredible advances in plant genetics. In the year 2000 it cost something like 70 million dollars and 500 people to sequence the *Arabidopsis* genome, which is just this model plant that can be grown in a Petri dish. The same project can be carried out this year in 2-3 minutes and cost 70 dollars. So 300 years from now, there is going to be incredible technologies and I'm sure many important methods for food production that are enhanced sustainable agriculture. So hopefully in 300 years, we won't have so much poverty and malnutrition and starvation and war. I wish I could be around to see that.

[*A.W*]: Thanks.

[*B.H*.]: Yeah.

[*P.R*]: Yeah.

[*A.W*]: Thank you so much for your time.

[*P.R*]: Sure!

[1:13:42]

END OF TRANSCRIPTION