Vaccine Research Center
National Institutes of Health
Oral History Project
Interview with Dr. Richard Koup
Conducted on November 15, 2022, by Holly Werner-Thomas for
History Associates, Inc., Rockville, MD

HWT: My name is Holly Werner-Thomas, and I'm an oral historian at History Associates, Inc., in Rockville, Maryland. Today's date is Tuesday, November 15, 2022, and I am speaking with Dr. Richard Koup for the Vaccine Research Center with the National Institute of Allergies and Infectious Diseases, NIAID, which is part of the National Institutes of Health, or NIH. The NIH is undertaking this oral history project as part of an effort to gain an understanding of the Vaccine Research Center's work. This is a virtual interview over Zoom. I am at my home in Los Angeles while Dr. Koup is in, are you in Bethesda?

RK: I am in Bethesda in my office, yes.

HWT: Okay. Bethesda, Maryland. Before we get started, could you please state your full name and also spell it?

RK: Yes. It's Richard Koup, K-O-U-P. [pronounced COWP]

HWT: I'm sorry.

RK: I should have let you know how to pronounce it beforehand.

HWT: I apologize. Richard Koup, okay. Dr. Richard Koup has been acting director of the Vaccine Research Center since March this year, where he previously served as deputy director. He is also chief of the immunology laboratory and immunology section. Dr. Koup received his BS in biophysics in 1978 and his MS in biochemistry in 1979 from the University of Connecticut. He attended the Johns Hopkins University School of Medicine, where he obtained his MD in 1982. Dr. Koup served an internship and residency in internal medicine with the Rhode Island Hospital, Brown University Medical School, Providence, Rhode Island, from 1982 to 1985. He served in a clinical fellowship in infectious diseases at the Worcester Memorial Hospital, and as a research fellow in viral immunology at UMass Medical Center, Worcester. Dr. Koup is board-certified in both internal medicine and infectious diseases. He previously held several academic appointments at University of Texas Southwestern Medical Center that include chief, Division of Infectious Disease, professor of internal medicine, professor of microbiology, and the JP Stanford professor in infectious diseases. Does that all sound about right?

RK: That all sounds about right.

HWT: Okay. Good. Obviously we're going to be talking quite a bit about COVID. However, we wanted to begin by asking you more generally of course about your own career, and also about the Vaccine Research Center. I'd like to start a little bit further back, and I'm sure you've seen the questions. But can you describe your background a little bit in relation to your career path? So, for example, did you have people that influenced you? Did you have any mentors? What support did you have at home or at school?

RK: I had a very different path from many individuals in that there was no one in my family who was a physician or a scientist. My father was an engineer and had worked for Sikorsky Aircraft in the defense industry for years. My brother became an engineer. My sister went to college in early childhood education, and I really didn't know what I wanted to do. I didn't have any physicians or scientists as mentors. Probably the closest I came is in high school I needed to earn money, so I worked at a drugstore. I was the delivery boy for a drugstore, and the pharmacists had their own little businesses and were running the drugstore. I said, this looks pretty good. When it came time to apply to college, I applied to the University of Connecticut only because that is where my brother and my sister both went. And I applied to the pharmacy school because I wanted to run my own little business. I thought that was great.

After I got accepted, one of the pharmacists looked at me and said, "You're too smart to become a pharmacist. You should be a doctor. Why don't you change your undergraduate degree to premed?" And I said, "Oh, okay. I'll do that."

I showed up at University of Connecticut the first day and said, "Can I change my major?" They said, "Sure," and so that started me on my path to medicine, but I was totally clueless about what medicine meant when I started that journey, but it all ended up working out quite fine, I think.

HWT: This question is going to be quite a jump, then. Because here you're an undergrad and you just expressed that it was somewhat accidental as well; how then did you choose to focus on infectious diseases and viral immunology?

RK: I ultimately got accepted to Johns Hopkins [University, Baltimore], which you know is a very research-oriented, even as you're in medical school, it's very research-oriented, and they try and push everyone towards academic medicine, not primary care. And while, so I was at, doing my internship or my sub-internship, so I'm still a medical student, but taking care of patients on the wards on the Osler service in Johns Hopkins in 1981. That was right when the first cases of AIDS were showing up, and I remember seeing a young lady, IV [intravenous] drug user, who came in with two opportunistic infections. CMV [cytomegalovirus] of the lung. thrush, etcetera. This was her second episode, and I remember the ID doctors saying, "You'll never see another case like this. I mean, she must have an occult malignancy or something. I mean, this is so bizarre, you'll never see anything like this again."

Within about a month after that, the initial reports came out of gay men with pneumocystis carinii pneumonia. Basically, what I'm saying is, as I was in my formative years, AIDS was showing up. It was the most interesting, it was the most challenging thing, out there. That, coupled with the fact that in most specialties, you deal with chronic diseases. Chronic heart disease, chronic lung disease, etcetera. Infectious disease was always something where you could see patients, you could treat them, you could cure

them. That always felt great. So, infectious diseases always sounded like a great thing to specialize in.

And of course, that's not true with AIDS. That became a chronic disease to deal with, but it was new; it was interesting; it was unknown. That all drove me into infectious diseases. Once I got into that, then viral immunology became a clear area to focus on.

HWT: And just one quick follow-up question: can you define both infectious diseases and viral immunology in terms of your own work?

RK: Infectious disease is the study of any infection. So, it could be tuberculosis; it could be strep throat. It could be, you had a skin infection, you give antibiotics, etcetera. Viruses are one class of infectious agents that cause infectious diseases. Viruses are like measles, mumps, rubella, etcetera. A lot of pneumonias are caused by bacteria: staph, strep, etcetera. You have these different classes of infections. Antibiotics only treat bacteria. They don't treat viruses. For years, when I was in training, there really weren't any agents you could give to treat viruses. They were just then starting to come up with what you could use to treat things like herpes. So, the way that we treated viruses is to make vaccines against them, and that's where you give the antigen to that virus ahead of time. The body develops an immune response against it. Then when you see that virus in the future, you can clear it with your own immune system. That's what viral immunology is all about. Trying to understand how the immune system interacts with viruses, to clear them, protect yourself from them, etcetera.

HWT: Thank you for that. One other follow-up question, before we move on, just in terms of your own personal trajectory, so, you went from pharmacy to premed to Johns Hopkins. Can you talk a little bit more about that process for you? You obviously felt that that, you fell into premed. You were encouraged to go in that direction, and it turned out to be a very good direction for you. Can you expand a little bit on that and your sort of thinking at the time?

RK: That was a long time ago. I just remember being, in college, the college courses I liked the most were the science courses. Actually, when I was at the University of Connecticut, I had the opportunity to join a program called the University Scholar Program, which allowed me to do both my bachelor's and my master's [degrees] at the same time. So, I went summers to get both degrees in, well, just over four years. As part of getting my master's, I went into a laboratory and started doing experiments on, it happened to be on protein degradation. Nothing to do with viruses, but it sort of lit the fire in me that you could actually learn things by doing controlled experiments. I think that sent me down sort of the academic pathway of I – I wasn't happy just going on rounds, being a doctor, and saying, "Oh, this is the treatment that worked best." I wanted to know what's the evidence, how would you actually investigate and find out that this was a better treatment than that, how would you know to attack a certain enzyme somewhere to help overcome a problem? I think that's what instilled in me the desire to become a researcher more than a bedside clinician.

HWT: Thank you for that. I'm glad I asked. Then what brought you to NIH and what were your initial goals?

RK: Ah, so what brought me to the NIH is, it's actually a long story. Because I was at the Aaron Diamond AIDS Research Center at Rockefeller University[1] doing AIDS research after I'd finished up at the University of Massachusetts. Then I got recruited to be the chief of ID [infectious diseases] at UT [University of Texas] Southwestern Medical Center in Dallas. And no, it was a great place, Dallas. I built what I think was a really nice department. Quite honestly, I'm from the Northeast. My wife is from the Northeast and just never, never felt that Texas was the right place for me. I wanted to get back to the Northeast.

Soon after I arrived in Texas; they had started building the Vaccine Research Center. I knew about it in the background but hadn't really given it much thought. About two years into my tenure at UT Southwestern, I got a call from Bill Paul, who was the head of the search committee.[2] Very, very-well-known immunologist asking me whether I'd be at all interested in heading up immunology at the new Vaccine Research Center. I said, "Geez, I hadn't really thought about that, but that sounds like a great opportunity." And so, I interviewed; it looked like a great opportunity. The nice thing about, I didn't know this when I joined the Vaccine Research Center, but what's really great about this place is that you can take basic research and you can translate it into actual vaccines and actual treatments. Usually when you're in academic research, you're doing bedside, either

[1] The AIDS Research Center is now located at Columbia University.
[2] Dr. William Paul was named the director of the NIH Office of AIDS Research in 1993.

bedside or bench research. You have these great ideas. You take them through to a certain point. But you can't actually then take it and manufacture a product, give it to humans, see how it works and potentially have some pharmaceutical company come along and say, "Yes, we'd like to license this from you." At the Vaccine Research Center, we have that ability to actually take our ideas and take them all the way through to first-in-human clinical studies. It's really been transformative in terms of the research we've been able to do here.

HWT: Of course, the Vaccine Research Center has changed quite a bit over time. Founded by executive order, 1997. The idea was to create a vaccine, you know, to combat HIV. And it's expanded over and over again since, you know, to focus on many diseases, including Ebola, SARS. Can you describe the Vaccine Research Center when you first arrived and how it has changed over the last twenty-plus years?

RK: Yeah, there's so many changes. When I arrived, it was a brand-new building. We had brand-new groups of young investigators, and we actually had lots of empty bench space. A lot of what we did was try to protect that bench space from other investigators trying to come into the building and use our new bench space. It's a good thing we did because after about probably three or four years, we were full. We had recruited in so many people that we became one of the most dense person-to-bench-space buildings on campus. So, aside from just sort of the mass of people, there was also at the Vaccine Research Center, it has always been a very collaborative family of researchers all working together towards a common goal. The people I work with throughout my

twenty-some years here have been the people that I also socialize with and see afterwards and call if I have any issues that I need to talk through.

In terms of the science, it started under Gary Nabel [the founding director of the VRC]. From the beginning, we've been very interested, and we see it as a mandate, to develop an HIV vaccine. That's been a 30-year project. We've been working on it for over 20 years, and we still don't have a vaccine that works. There has been just slow, slogging through the HIV vaccine, figuring out what works, what doesn't. Changing direction after we figured out that our first vaccine that we developed didn't work. Changing direction and trying to learn new things and direct our efforts in other directions. At the same time, we've had very strong programs in flu vaccines. We've had very strong programs in Ebola virus vaccines. We've developed multiple other vaccines along the way. We've figured out that monoclonal antibodies are very important treatments for many different infections. Then most recently, of course, COVID vaccines. So, sort of the trajectory has been always keep working on HIV. Quite honestly, a lot of the things that we learned through our work on HIV we're able to apply to RSV, to COVID, to Ebola, etcetera. So, the knowledge base that we built has helped us develop multiple different vaccines, so the different efforts have fed off of each other, I guess is the way to put it.

HWT: Can you just describe a little bit more the process of expanding from a focus on HIV, even as you continue that focus, to these other diseases, of course, as they arose. So of course, the coronavirus family, since about 20 years ago, and SARS and then MERS, Ebola, what was the thinking along the way to even focus on these diseases?

RK: It's multifactorial. Part of it was the individuals who were recruited. Nancy Sullivan [Chief of the Biodefense Research Section, NIAID] was recruited. She was an Ebola specialist, and she actually was a postdoctoral fellow with Gary Nabel and was working on Ebola, so she continued working on Ebola. Barney Graham [former Deputy Directory of the VRC] was a specialist in RSV and influenza. He was also a specialist in HIV. While he was recruited here to work on HIV, he also continued his work on these other viruses, etc.

I think part of what linked everything together was structure-based vaccine design. So, we have structural biologists, so Peter Kwong [Chief, Structural Biology Section, NIAID], who looks at different protein molecules, mostly within viruses, and can look at the 3-D structure of those proteins, figure out how to stabilize them, how to best make them into an antigen that the immune system is going to see, and that isn't going to break down the minute you inject it into your arm. The work that he did in conjunction with Barney Graham allowed us to realize that for a lot of different viruses, if we could stabilize the envelope glycoprotein, we could get the immune system to generate the right kind of antibodies. So that's what they did for RSV. That has now been applied to HIV and is really part of the next generation of HIV vaccines that we're working on. It was absolutely critical in the development of the SARS coronavirus vaccines.

Along with all this work that was going on, the investigators here were constantly in touch with what was happening in the world so that when there was the first SARS

outbreak and the first MERS outbreak, everyone sort of jumped on that and said, well, what are these coronaviruses? How can we help there? Is there a way that we can apply our knowledge to those? We were able to learn how to stabilize the envelope glycoprotein of SARS 1 and MERS, so that when SARS CoV-2 came along, it was very easy to just apply what we already knew to that virus, which is why we're able to act so quickly.

HWT: This is an aside. It seems to be in a general sense in American society a misunderstanding, you know, there's this mistrust around this all happened so quickly, and people don't seem to understand it's actually decades' worth of research behind it.

RK: That's actually an incredibly good point. We like to say that the COVID vaccine was developed in less than a year. From the time we got the sequence until it was given emergency use authorization by the FDA was less than a year for Moderna and for Pfizer. But the fact is that had it not been for let's say five or six years on MERS before that, 20 years of work on mRNA vaccines before that, 15 years of work on crystal structure and stabilization of proteins before that, none of this would have happened. A colleague of mine and former deputy director here, Barney Graham, likes to show this slide of yeah, it took us one year to develop the vaccine, but you could say it was actually a five-year journey, or it was a ten-year journey, or it was a 20-year journey, or it was a 40-year journey. That's absolutely right. We probably didn't do ourselves any great service by talking about how quickly we developed the SARS CoV-2 vaccine. We should have

emphasized all of the work that had gone on for years beforehand that was instrumental in that discovery.

HWT: Interesting. Yeah. It's hard to communicate these things in a crisis as well. So, let's talk about the mission of the immunology laboratory and specifically your own role there as chief of the immunology laboratory and section. So, can you describe what your initial goals were in that position or those positions, and how they evolved?

RK: Yeah, it's a story of utter failure, I'm afraid. (*laughs*) When I came to the Vaccine Research Center, once again, the main goal was to develop a vaccine against HIV. Several vaccines against HIV had been tried that generated antibodies and had failed. At that point, about the time I was coming to the Vaccine Research Center, the concept was what we need is a T-cell-based vaccine. So not a vaccine that develops antibodies that neutralize the virus, because the virus is just too able to escape those types of antibodies. What we need is to develop T cells. So T cells basically recognize bits of the virus that are produced from infected cells, virally infected cells, and then recognizes that virally infected cell and kills them. So the thought was, HIV would infect someone and before it could produce any virus, that virally infected cell would be recognized and killed by these T cells that we would stimulate with the vaccine. And I was a T cell specialist. So, I, my expertise was in T cell immunology.

That's what we worked on for the first several years that I was here at the Vaccine Research Center. We had an adenovirus-based vaccine. So this was a vaccine that would

stimulate T cell responses. It took a long time to get that into people, but we did a clinical trial with that vaccine, and it didn't work. And now we're back to trying to stimulate neutralizing antibodies. But you know, I still continued for many years to study T cells. But I switched much more now to antibody-based immunology.

HWT: One of the questions I like to ask is not just about people's biggest successes but also about setbacks, because they tend to be learning experiences. So is there anything that you want to add in terms of you know, obviously you me mentioned what you learned in a specific way. But more generally, when did you know to move on? That kind of thing.

RK: Well, I think you know when to move on when you start realizing that the ideas that you have aren't really going to advance the field. When you're working in a highly stimulating environment like the Vaccine Research Center, you're constantly seeing what's working, what's interesting, and you sort of gravitate to those new ideas. And so, I wouldn't call it opportunism. I would call it just sort of following the obvious pathway. And you know, you work with the other scientists, and you start to come up with collaborative ways of working together. One of the other nice things that happens here at the VRC is that in many places, you sort of have to lay out okay, you're going to work on this, and you're going to work on this and you're going to work on this, and this is your area, this is your area, and this is your area; and don't overlap and don't cause tension. Basically, at the VRC, it just organically – people would work together, and attack different problems in a collaborative manner with the goal of being that we need to come up with the best science and the best answer, and we'll all get credit in the end.

HWT: What do you attribute that cooperative spirit to?

RK: Part of it was very good recruiting. I give a lot of credit to Gary Nabel, who was our first director, and the search committees. One of the things that he basically set as a top criteria for the recruiting of the scientists is that they would be collaborative and would work together, and so he specifically sought out people who would want to work as a team, not as, you know, he didn't want people who were here to build empires.

HWT: Very interesting. I've also spoken to people who say there's really no such thing as failure because you are learning all along the way, you know, as part of the process. How would you respond to that?

RK: Yeah. (*laughs*) It is true you always learn from failure. But you know, there are times when the results are just, they're just not helpful. That doesn't happen all that often. And certainly, I can't, although there have been sometimes when projects I've been working on just sort of went nowhere and I just had to say, well this just isn't working, time to just give up. I'm not sure what I really learned from that other than don't ever do that again. But yeah. I mean, a lot of times you have a hypothesis. You test it; it doesn't work. That starts you thinking well, if that didn't work, why didn't it work? Oh, well, maybe it's this other possibility that I had discounted earlier. And you follow up on that and that ends up being the real answer. So, yeah. I mean, a lot of times failure does lead to other discoveries.

You know, a lot of what we've learned about mRNA and mRNA editing, you know, the scientists who were working on mRNA kept coming up with these negative results and couldn't figure out why. And everyone told them to drop it. And ultimately it ended up, mRNA editing and CRSPR Cas9, none of those would have been discovered if the scientists behind that didn't just keep slogging away at it. So sometimes persistence in the face of failure is also important.

HWT: That sort of leads into my next question. If you could take just a moment to talk a little bit about technology. So specifically what technologies from genomics to single particle cryogenic electron microscopy, even computing, have influenced your fields and enabled you to do what you do, and how?

RK: Yeah. So, I remember, I'll go way back. I was one of the people who discovered the 32-base pair deletion in CCR5 that led to the resistance of people, people who are homozygous for this deletion in CCR5, which is a co-receptor for HIV, can't get infected. Back when I was doing that work, trying to figure out what CCR5 was, going into individuals who had been multiply exposed and hadn't been infected and whose cells we couldn't infect, and cloning out the CCRR5 gene and sequencing it took months. Now, just like that, you could just go in and get that information within a matter of a day or two. And the technology advancements are just incredible.

Crystallography. So, I said that we use a lot of structure-based antigen design. When I first came here, Peter Kwong would, in order to get the 3D structure of a protein, let's say it's the HIV envelope, he would have to figure out some way of getting that protein to form a crystal. What you would do is you would produce the protein and then you would set up hundreds of different wells with different – maybe you'd put antibodies in there that would bind, that would help stabilize and help that protein form a crystal. You'd put into different sorts of buffers that might allow it to form crystals. So, you would have hundreds of different conditions. Then you would put these in an incubator, and you'd go back over weeks and see if you were actually growing crystals. Because it was only if you got really good crystals where these proteins were all in a lattice, exactly perfectly arranged, that you could then figure out the three-dimensional structure. Once you got a crystal that looked good, then you'd go to a cyclotron somewhere and you'd shine lasers on this, and you'd get this pattern off of that that would tell you whether you had a good crystal. Then you'd spend a month trying to figure out what that crystal structure really was.

Nowadays, we have electron microscopes. You basically freeze the protein. You put it under the electron microscope. You put it into this program, and it aligns everything that's in solution. It takes all these pictures, and it says, "Oh, I'm looking at that on the side, I'm looking at this on the top, I'm looking at this on the back side." It just bioinformatically arranges everything and tells you what that protein looks like. You get almost as good resolution as you did with the other thing. Nowadays, we are just routinely, we have a monoclonal antibody that's binding to a protein. We say well, is this

different from this other monoclonal antibody? We can put them both together. We can send them off to the cryo-EM [cryogenic electron microscope] and the next week we say, oh, look at that, they're binding slightly differently, and it's this amino acid and this monoclonal antibody that's different. Now we know how to make that monoclonal antibody better, etcetera. I mean, I could give you ten, 20 different examples of this. But where things used to take months, they now take days. Where things used to take years, they now take weeks. I mean things are just moving so fast.

HWT: It really is astonishing. Looking forward, what are the most promising technologies for your field and why? I don't know if that's easy to narrow down. But if you want to answer that one.

RK: Well certainly for vaccinology, I don't think anyone would argue that mRNA technology hasn't been transformative. So, you look at the COVID vaccines, in the U.S., almost everyone gets an mRNA vaccine. That's because those were able to be developed so much faster than the protein vaccines. The protein vaccines, like from Novavax, etc,, are just sort of getting approvals now. If we are looking at let's say an HIV vaccine that we're trying to develop and we say, well, we want to change this antigen, we want to try this slightly different antigen. If we needed to make each one of those new antigens as a protein, purify the protein, make sure that we had gotten rid of all of the non-important things that were in the process of making that protein, make sure it was pure, make sure it maintained its structure and that the FDA would allow it to go into humans and then gave it to humans, it would take, it takes about a year and a half, maybe two years for each

new protein. For mRNA, it's a matter of a few months. Because we can make the mRNA, we can show that it produces the protein we want. It's a platform that we can very quickly move. So, what we are doing and what so many different companies and academic groups are now doing is gearing up for mRNA technology so we can make our own mRNA vaccines and test them in small batches, both in preclinical and in clinical studies. So, we hope that the iterative process which is inherent in vaccine development can be really shortened so that every new product doesn't take several years to be tested. That it may only take several months.

HWT: So previously we talked a little bit about, say setbacks, potentially failures. How would you describe your biggest success or successes? And what made them so?

RK: I think my biggest success was actually before I came here to the Vaccine Research Center. As I mentioned, this happened at the Aaron Diamond AIDS Research Center. I was very young. I was in my first real big job out of my training, and I had a young postdoctoral fellow who, I was a T cell immunologist. He wanted to study individuals who were exposed to HIV but had not become infected. These were called exposed, uninfected individuals. We wanted to figure out why they didn't become infected, and the going thought back then was that they had a cellular immune response that was clearing the virus and keeping the virus from infecting them.

This was in New York. He, this young postdoc was Bill Paxton, identified a few individuals in New York by calling up just the local physicians and saying, do you have

any individuals who are part of the gay community but have not become infected? And we studied some of them. And we found that there were two individuals in particular who we could take their CD4 T cells, and we could try to infect those T cells in the laboratory with HIV and we could not. We could not infect their cells.

That was right at the time when the concept that there has to be a co-receptor along with CD4 for HIV. People here at the NIH, like Dr. Berger, had figured out that one of those co-receptors was CXCR4.[3] Everyone started looking for the other co-receptor, which turned out to be CCR5. We very rapidly, as I mentioned, then figured out that these individuals had a genetic defect within their CCR5 gene such that they didn't produce a functional CCR5. The number of people who are uninfected because they're homozygous for this defect is pretty small within the world. I mean, it's a very rare mutation. And so, you could say well, you discovered this, but it really didn't change all that many people's lives. That was true until the Berlin patient and the London patient.[4] The fact that we had discovered this 32-base pair deletion protected CD4 T cells from HIV meant that when individuals for some other reason needed a bone marrow transplant, if a donor could be found that was an HLA [Human Leucocyte Antigen] match with them but was also homozygous for this 32-base pair deletion, that they could basically repopulate all their

[3] In 1987, Dr. Edward Berger joined the NIAID Laboratory of Viral Diseases as an expert on how biological chemicals pass through cell membranes and how the membranes control interactions between cells.
[4] In 2007, doctors reported the first patient cured of HIV, after Timothy Ray Brown, also known as the "Berlin patient," underwent a transplant of stem cells derived from another person's bone marrow and remained free of infection thereafter. In 2019, it was reported that the "London Patient," who remains anonymous, also received a bone marrow transplant, in his case for Hodgkin's lymphoma. He had been diagnosed with HIV in 2003, and 18 months after the bone marrow transplant, the HIV he had had was undetectable. Significantly, his doctors chose donor bone marrow that they knew had a mutation in the CCR5 receptor called "delta 32," which prevented CCR5 from being produced altogether.

CD4 T cells with resistant CD4 T cells. That led basically to the only cases of cure of HIV, all basically stemmed from the discovery of the 32-base pair deletion. Even though I wasn't involved in any of that further work, I think just knowing that that discovery ultimately many, many, many years later and after tons of work by lots of other very important and talented people led to the cure of HIV, I think. Just, yeah, it makes me feel very good.

HWT: I'm so glad I asked. What a story. So, you've won many awards, obviously, throughout your career. I could list a few here. The Max Finland Research Award, Massachusetts Infectious Disease Society in 1988, two NIH Director's Awards, etcetera. But I want to know from you, and I always ask this and don't know if it's quite fair for people to narrow down, but what are the major awards and honors that have been the most meaningful to you personally, if that is a thing.

RK: You know, I think it's always good to get recognition from your peers, but I've never felt that, I guess I've always lived by the mantra that don't expect too much. Don't expect special treatment and you'll never be disappointed. So, I never do expect to get any award. I don't expect special treatment. And so, when I don't get that award, I'm not disappointed. So you know, I look back at some of those awards and I think yeah, that was nice. But it's not what drives me, never has, and hopefully never will.

HWT: Do you want to take a moment to talk more generally about what drives you?

RK: I think intellectual curiosity. For years, it's been just really fun to come in and come to work and talk mostly to young scientists. There's nothing more fun than going into the lab and talking to young scientists and talking about their projects and seeing—there's nothing more fun than when they come in with their data that they really want to show you because they've found something really nice. I think that was the hardest thing about the COVID epidemic is when, all of a sudden, that personal contact, that being right there; holding lab meetings virtually. Not being in the same room with people. Being at home and trying to direct a lab but not walking in and seeing the people. And having the people who were doing the lab work actually have to do it in shifts because we could only have two or three people in the lab at the same time. You couldn't have 12 people in the lab. These three people would have to come in and work for this shift, and then they would leave, and the next three people would come in. That's not how you maintain interest and excitement in science. Most of the great discoveries occur over lunch when people have been doing their work and then they sit down to lunch, and they start talking to their friend about it. That person says, "You know, that sounds like what so and so up there was talking about the other day. Have you heard his or her results?" COVID just destroyed that. We're getting over it now. People are back in the lab, etcetera. But here at the NIH, we were more cautious than most academic institutions. So, it was a good year, year and a half of just not having the type of interaction that I think is really required for science to grow.

HWT: You've anticipated a question of mine on COVID, which I want to turn to now. But before we do, I want to make sure, if there's anything else you want to add specific to

your time at the Vaccine Research Center or your career in general before COVID? Anything at all.

RK: No, I think, I don't think there's anything else that anyone else would want to hear about my career. Thank you.

HWT: I do want to ask you what you see in terms of the future of the Vaccine Research Center. But let's wait for that toward the end. Because I do want to get to some of these COVID questions. As I said, you've anticipated one. A very important aspect, which is you know, how was the work affected itself by the pandemic? But how did you learn about the outbreak in Wuhan, China? And what was the Vaccine Research Center, its initial response, your own response? And can you describe the first month of shutdown, which was, started basically mid-March 2020?

RK: Yeah. So, well, so the Vaccine Research Center had been involved in research in coronavirus vaccines after the first SARS outbreak and MERS. When the first reports came out of Wuhan of this very bad pneumonia, we all basically said, this sounds like another coronavirus. So we were right there. And Barney Graham was really leading that at the time. But we were all in contact with them. So, yeah, there was no – we knew about it very early, so we weren't surprised when they isolated the SARS-CoV-2 and the sequence became available. So that actually we knew about that very early in January of 2020, and actually, my wife and I were traveling to Southeast Asia on vacation then. So, we actually went, as they had shut down the border between China and Vietnam, Charla,

my wife, and I went to Vietnam and Cambodia. She had worked a lot in Cambodia but always was there as part of her work. We had both wanted to see some of the sights. So, we went there and spent a couple of weeks in Vietnam and Cambodia as everything was shutting down and managed to get home and be just fine, but that was our last travel until sometime last year.

When we came back, the Vaccine Research Center had started to really gear up in collaboration with Moderna for making the coronavirus vaccine. And really, that's when, in March—there's one other story to tell you before we get there. (*laughs*) So I helped organize this meeting called CROI, which is the Conference on Retroviruses and Opportunistic Infections. It's one of the biggest AIDS meetings each year, and it was held in early March in Boston. There was a meeting of Biogen that happened the week before. And the week before the meeting, reports started coming out that there were a couple of people at this Biogen meeting had come down with COVID. We had to make the decision, do we go forward with this meeting or not? And 48 hours before CROI 2020 was to happen in Boston, we decided to shut it down. Well, not shut it down, but to switch it to virtual. In 48 hours, we notified everybody. People were on planes coming from Europe. They arrived at the hotels and were told basically, sorry, it's going to be virtual. But we're so glad we did because the Biogen meeting ended up being a super spreader event and having an infectious disease meeting be a super spreader event would have been terrible.

But came back from that. And that's basically, within a couple of weeks, everything shut down. So that was right at the cusp of when everything was happening. The first part of that, let's say the second half of March, was terrible. You're sitting at home; you're trying to do work. I mean, the first concept was oh, this will be for a month or two and then we'll be back to normal, and I'll be able to write a lot of papers, etcetera. Then it became clear that that wasn't going to be what was going to happen.

That was also, at this point John Mascola was the director here. He was working with Tony Fauci and people at BARDA [the Biomedical Advanced Research and Development Authority] and the White House to establish what was then called Operation Warp Speed, which was the government group to help coordinate the development of six different vaccines, or support six different vaccines against COVID, under the auspices of the U.S. government. And so, sort of soon into March, early April, John Mascola called me and said, "One of the things we're going to have to do for Operation Warp Speed is figure out the immune correlate from the vaccines." So, we vaccinate with these different vaccines. We measure immune responses. We then in our big phase 3 clinical trials, all of which we're going to start that summer, we'll be able to measure whether there was efficacy. What we want to know is, are there any immune markers that we can measure that are correlated with the protection? Because if there are, then well, when you need to move to a pediatric population, all you need to do is show oh, you've stimulated that same immune response. You don't have to do an entirely new, 30,000-person pediatric trial. Basically, he recruited me to be one of the co-leads of that group. So since then, my life has been tied up in identifying the right assays, getting those

all validated, working with the FDA, etcetera. And working with all these government agencies on vaccine policy, on vaccine rollout. So, it's been a complete career-changing effect on me, because I went from running a lab to being part of the major public health enterprise, let's say.

HWT: So once again you kind of anticipated a question. And you've answered some of it quite a lot. But I'm going to ask anyway and see if there's anything there that you can elaborate on. So, as you mentioned, your role has completely changed because of COVID. I know starting in, I believe, 2020, you were cochair of the Immune Assays Working Group, Operation Warp Speed. That was under the Trump administration, so-called Operation Warp Speed. And then from this year, the cochair of the vaccine development team, or H-CORE, which was formerly Operation Warp Speed. You were also a member of the H-CORE leadership group. So, you've been very much integral to the U.S. government's COVID response through these various leadership positions. I was going to ask you to talk about those roles and your leadership, which you have to some degree, how they were decided upon and how they evolved. And what your goals were and are.

RK: All right. So, when I, as you say, when I first got into it, it was we need to, I was cochair of the Immune Assays Working Group. And that was to figure out what assays we should be doing and come up with an immune correlate. Very rapidly, we knew that there were these clinical trials coming up. Big phase 3 clinical trials of efficacy. We needed to have the assays worked out, we needed to have them validated, etcetera. I remember those first couple of meetings; I just, I knew what assays I thought needed to be done. I knew

from HIV, once again, HIV, all the experience with developing assays for HIV was so integral to what we did for SARS that I basically said, okay, on this meeting, I want to have the following people present. I basically said, all right, my best person for HIV neutralizing antibodies is also working on SARS-CoV-2 neutralizing antibodies. I want you, within a week, to go out, evaluate all the neutralizing antibody assays that everyone is doing out there, come back and report to us what's the best neutralizing antibody assay and tell us who should be doing it. This other person, you're my person for binding antibodies. What are – same thing: Go out there in the next week, evaluate all the binding body assays. Come back, report to us. And you, you're the T cell person. I need you to do all the same thing for all the T cells. So that within a week we got reports back saying, okay, here's everything, here's my recommendation for what assays should be done. And we just went right to work. And we said, Okay, those are going to be the core assays that we're going to work on. You need to start getting those up and running. We need to see how they perform. We need to get them standardized. We need to establish a system to communicate all the results to the FDA so that they can say no this assay isn't performing appropriately, we'll never license a vaccine based upon this. You need to clean up this or that within the assay. We need to get contract research organizations. Once you have these assays going, you're not going to run these assays for companies for the rest of your life. We need contract research organizations who can transfer these assays in and take them on for the rest of the epidemic.

That's basically what I spent a year doing. And during that time, John Mascola was heading the entire vaccine development team, and was in sort of that leadership role and

advising all the higher ups. Then about February, March of 2021, so like a year later, he decided to retire from government service and move on. Somehow, they thought that maybe I would be a good person to step into all those other roles. I started moving up the chain of advising higher and higher people. I have to say that John Mascola was incredible in terms of his insight and his ability to perceive what needed to be done and what the right advice was. I don't think I've been nearly as good, but I've done the best that I can behind these higher roles.

HWT: So, let me ask you a little bit further. So, if you can elaborate on what you're, you know, you talked about because John Mascola left, and you've been promoted and you've taken on roles throughout this process because of the pandemic that have completely shifted what you do. Can you talk about, you know, in terms of goals, if that makes sense, and I imagine it changes because COVID keeps changing as well. Is there anything you want to share?

RK: Well, there's several different goals I could talk about. I now have to look at more the public health goals, so I'm asked much more frequently about things that have to do with public health decisions and messaging. We have these vaccines that work very well, but people aren't taking them. Why aren't they taking them? If we could – we have a new variant coming out. Should we tell people to take the vaccine now, or should we tell them to wait for the bivalent vaccine? How will that be perceived? So, it has sort of changed how I look at things. I do feel good that I'm at least, when you're a basic researcher in a lab, you feel that nothing that you're doing really has any impact on people. Now I feel as

though maybe my advice is having some real impact, but it's quite foreign to me. I'm getting quite comfortable with it. But I think you'll find most basic lab researchers feel very comfortable doing their mouse experiments or their test tube experiments. But don't ask them to make life and death decisions for large groups of people. So, it's been a life-changing experience. In some ways, it feels good. I hope I haven't given the wrong advice, but I know that there's many different people who are giving advice. Hopefully if I give stupid advice, the people I'm advising understand that I don't know what I'm talking about, and they shouldn't listen to that.

In terms of personal goals, it has pulled me away from the lab, and that's been hard. I feel like I have been neglecting my lab. That's been hard. I really want to get back to the lab. But once you move out of the lab, it's very hard to get back. So I'm trying. By the same token, I do feel that I am 66 years old now. I got my MD 40 years ago or so. I think there are younger people who are newer in their training, have more energy than I do. They might not have the historical perspective that I have, but do you really need some of that historical perspective? I do feel there comes a time when you should turn over the laboratories to the younger people. My wife often tells me that when I start being that doddering old professor walking around the halls where everyone is pointing at them saying, "Why is that person still here?" That it's time for me to leave.

And so, part of what I am doing is evaluating how much longer am I going to do this? It's been a long and wonderful career. As you're aware, the Vaccine Research Center is currently in the process of trying to identify a new director. John Mascola left about

seven, eight months ago now. Because of what I just told you, I let it be known that I was not going to apply for that position of the permanent director. So, a lot of my goals are that I want to get a new director in, I want to make sure that there's a smooth transition to that new leadership. We're building new laboratories, a new tower here at the Vaccine Research Center. I want to help recruit in the people who will fill that tower, the new young investigators. I want to see the Vaccine Research Center set on a firm foundation for the next 20 years of success. And then it will be time for me to retire. So that's my current personal goal.

HWT: And getting back to the lab, it sounds like a difficult possibility.

RK: Yeah. Yeah.

HWT: So, let me ask you a few more questions with regard to COVID. Obviously, it's so important. A year ago this month, in November 2021, you co-published in *Science,* "Immune Correlates Analysis of the mRNA-1273 COVID 19 Vaccine Efficacy Clinical Trial." So, what aspects of your research informed the findings of this article?

RK: Well so that was the first culmination of all the work that I told you about for identifying a correlate. So this is – so we identified the neutralizing antibody and the binding body as the assays that we said we think these are going to be the correlates. And we got those all stood up. We got them validated. I say "we." It was Adrian McDermott's group and

David Montefiori's group and all of their excellent teams that did this.[5] And then those were applied to the Moderna vaccine trial. It turned out that we were right. Neutralizing, the pseudovirus neutralizing antibody assay and the binding assays did correlate. So, the higher your antibody response, the more likely you were to be protected. That was the first. We've subsequently published similar results for the Johnson & Johnson trial. And we have other publications that will be coming out for the ChAdOx1, the Oxford adenovirus vaccine, and for the Novavax vaccines. So this is what I did.

Now I have to say, it wasn't my laboratory that did these assays. But you know, it was people that I knew and respected and I knew could do the work that did it. So I feel that I made the right choice. Let me put it that way. Even though I personally didn't do the research, I knew that these were the people who could get it done.

HWT: And then relatedly, potentially, I was going to ask you if you could elaborate on the United States government's efforts to identify a correlate of protection for COVID 19 vaccines and how that relates to vaccine efficacy. Further, what does biomarker validation require? And how does validating a biomarker that reliably predicts vaccine efficacy support approval of vaccines in lieu of largescale efficacy studies, as you and your coauthors wrote last year in a government-led effort to identify correlates of protection for COVID 19 vaccines. And this was in *Nature Medicine.* So, there's a lot

[5] Adrian McDermott is the former Chief of the Vaccine Immunology Program, Vaccine Research Center and current Global Head of Immunology, Research and Development, Sanofi Vaccines. David Montefiori is Professor and Director of the Laboratory for AIDS Vaccine Research and Development in the Department of Surgery, Division of Surgical Sciences, Duke University Medical Center.

there, I realize that, so we can break that down a little. So just beginning with the original questions in terms of the government's efforts to identify a correlate or protection for COVID 19 vaccines and how that relates to vaccine efficacy.

RK: Yeah. As I mentioned, we identified these assays that ended up correlating with vaccine efficacy. So, we could actually say within a population, that population that had a neutralization titre of 100, they were protected, say, 90 percent versus the placebo. If their neutralization titre was 1,000, they were 98 percent protected. So we were able to show that this biomarker, this assay, that we had gone through the validation of, could predict protection.

Take you back to influenza vaccine. Every year they come up with a new influenza vaccine. They say these three components that are in this year's influenza vaccine; that's what's going to be in the vaccine, and we know it's going to be protective against the strains that are circulating. Well, how do they do that? They don't develop these vaccines and then do an efficacy trial with 30,000 people. There's a biomarker, which is called the hemagglutination inhibition assay that the FDA accepts as a biomarker for vaccine efficacy. All they have to do is make these vaccines. They need to give them to a few people, show that they get an HAI, hemagglutination inhibition titre bump of four-fold, and the FDA says, yes, that's good. That's what we're pushing for and hope to get at some point for SARS coronavirus vaccines. We're not there yet. But we're partway there.

For the Moderna vaccine, when they said, okay, I need to go in and test that vaccine in children, so I need to see if the vaccine's going to work in children, the FDA did not make them go do an efficacy trial in children. They said, show us that your vaccine at the dose you're going to give in children is safe. That's the most important thing, that it's safe. But also, it stimulates the same or better neutralizing antibody titers than it did in the adults. And why did they ask Moderna to look at neutralizing antibody titers? Because we had shown that neutralizing antibody titers correlated with protection. And so that's what Moderna did. So that in a matter of a couple of months, they could generate the data, present it to the FDA, and the FDA could authorize them to use the vaccine in children.

Now that's good for mRNA, but what we want to do is get to the point where across any different vaccines. So, if it's a protein vaccine, if it's an mRNA vaccine, if it's an adenovirus vaccine, that there's some biomarker that the FDA will be able to say okay, just show us the immunogenicity and that will be adequate for licensure.

HWT: And I understand that some Vaccine Research Center work on COVID has impacted U.S. COVID policies and best practices. Is that accurate to say, and can you elaborate?

RK: Hit me with that one again.

HWT: So, I understand that some VRC work on COVID has impacted or supported U.S. COVID policies best practices. Can you elaborate?

RK: U.S. COVID best practices. Yeah, I'm not sure I know what you're actually referring to there. So no, I hate to be ignorant, but on this one I have to claim ignorance.

HWT: To be honest, I'm not sure any longer, either. I first put this question set together in August, and I don't know where I came across that, since I don't have a footnote. So, let's move on. Describe some of the other COVID work that has been going on at the Vaccine Research Center. I'm thinking of nanoparticle research, monoclonal antibodies for both therapeutics and vaccines, and different types of vaccines in general.

RK: Yeah, so there's a lot that's going on. So let me try and break it down in different areas. So, one is sort of new variant research. As you know, there are new variants popping up all the time. And we're never sure which ones are going to be problematic or not. So there's a group called the SAVE group that's constantly monitoring. The different variants that are showing up around the world. Once we identify something that looks like it's going to be what we call a variant of concern, a new SARS strain that looks like it's actually going to spread and take over, there's a lot of things that get done. We get those into the pseudovirus neutralization assay. There's people at the VRC and labs around the world that make the pseudoviruses so we can see people's sera, how well do they neutralize these new variants? Because we know neutralization is important.

We actually get that virus. We get it growing in the lab and we try and make a virus stock that we can use in animal model studies so that we can actually test vaccines in

animals and see how well the vaccine, either our current vaccine or a new vaccine based upon the new strain, protects against that new virus. So we need to have that virus in a form that we can infect animals with. So those are some of the things that go on there.

In addition, we're looking, as you said, for newer vaccines, so trying to put together vaccines that give longer-term protection. One of the problems with mRNA appears to be that the titers come down fairly quickly. We think that proteins and protein nanoparticles may get around that issue, so we have several efforts to put SARS onto spike proteins onto different nanoparticles in different ways to try and stimulate longer-term immunity. In addition, we want to cover all the different variants. Not only the variants that are around today, but the variants that we think may be here in six months, a year, two years. We're doing types of research that are necessary to try and predict what might be coming and put some of those newer spike proteins into these nanoparticles such that we'll stimulate immunity not just against today's viruses but hopefully tomorrow's viruses.

Then the last part is immunity in the nose. We know that the vaccines are very good at protecting us against severe disease, infection in the lungs, but as we're all aware from the recent waves of Omicron and Delta, and BA45, that people are still getting it. Even though they've been vaccinated, they're still getting infected. What happens is, they're getting infected in the nose, their upper respiratory tract. But they're not getting the severe complications in the lung. So, what our feeling is is that we need to stimulate better nasal mucosal immunity. We're looking at different delivery methods, different formulations of the vaccine that might stimulate nasal mucosal immunology. We have

different groups working on these different ways of stimulating hopefully better and longer-lasting immunity.

HWT: So once again, you anticipated a question. I was going to ask you about the SAVE program, or the SARS Assessment of Viral Evolution program. However, I do have one follow-up question in terms of are there VRC initiatives to address long COVID?

RK: Yeah, that's a good question, and we actually are not there. There are obviously a lot of different studies that are ongoing that are looking at long COVID. The Vaccine Research Center is not really all that actively involved in any of those at this point. That's not been a major focus of the Vaccine Research Center. Though within NIAID in general, yes, it's a very high priority.

HWT: And so new. So difficult. So, throughout our conversation you have talked about, you've sort of mentioned the idea of the pan-coronavirus vaccine. Obviously, we've talked about mRNA vaccines and vaccination in general. Can you talk about the future of vaccines that the Vaccine Research Center is working on, including with these?

RK: What we're starting to do, well, we've been doing for a few years now, is what we call the prototype pathogen approach to pandemic preparedness. A lot of Ps. So, what we know is that every few years some new viral strain pops out of animals and infects humans, and we're usually unprepared for that. What we've been able to do, this isn't just the Vaccine Research Group, but you know, multiple academic groups and scientists

around the world have been able to identify let's say 26 or so different families of viruses, which are all related in terms of their genetics, etcetera. And what we're trying to do, there are some that we consider low-hanging fruit. You know, we know RSV. We know how to stabilize an envelope protein of that and make a vaccine. We now know for SARS how to do that, but there are others that we don't know. So, we're working on Nipah virus. We're working on noroviruses. What we're trying to do is figure out how do you make vaccines against at least one of the strains of each one of these 26 different families? And then that should give us the information. If a new virus within that family comes along, we'll have the information to know, oh, all we need to do is to change this to match that new virus within that family. We'll put it into the same platform of a vaccine that we already know works, and we'll be ready to go. So, we'll be much faster. And that's basically what we did for SARS CoV-2. We knew how to stabilize the protein based upon what we did for SARS CoV-1 and MERS. We had everything ready, and so we were ready to go. There's lots of other virus families out there where we don't have that information. So that's where we're working right now.

HWT: So of course, throughout our conversation we've talked about your work with HIV and on HIV over decades. And of course, now there's talk about the impact of COVID 19 on HIV treatment and research, especially with regard to mRNA technology. Can you address that from your point of view? For example, could the coronavirus bring us closer to an HIV vaccine?

RK: Yeah, I'm often asked will mRNA technology revolutionize the HIV vaccine field. I like to say it won't revolutionize it, but it will accelerate it. So, as I've mentioned, every new protein that we use to make for a vaccine component of an HIV vaccine would take years. Now we can do it in months. That just allows us to accelerate the process of going from something in someone's head to the laboratory bench to something that goes in the arm of a person in a first in human phase one trial. The more we can shorten that time between what's in your head and what's in somebody's arm, the faster we can figure out what works and what doesn't work. This is what we call the iterative design cycle. Shortening that cycle means you can test many more ideas. That's really what's been hampering the field is that there's no lack of ideas; it's just the time that it takes to test each one of those ideas forces you to make choices. When you say, you know, it's just going to take too long and too much money to test these five ideas. I think this one idea is what we should invest in. So you spend five, six years and find no, that idea didn't work. Well, now you have to go back. So if you can be testing five ideas at the same time and get them all tested very quickly, you can figure out what works and what doesn't much more rapidly.

HWT: So I was going to ask you also, you answered that question, how your own research was disrupted by the focus on COVID 19. Is there anything you wanted to add in terms of the work of your staff and how it's been affected, or anything at all? I know we have spoken about it, but just want to be thorough.

RK: Yeah, I do have to say that no one in my lab was doing COVID work when the outbreak occurred. Actually, within the VRC, there weren't that many. There were a couple of labs that were working on coronaviruses. The labs shut down and people were writing papers, etcetera. Then it became clear that we had to be putting in a big effort on coronaviruses. This was a major public health calamity, and this is what the Vaccine Research Center does. I mean, if there's a new infection out there by a virus, we need to be helping to develop a vaccine.

We went to the staff and said, you know, "Who wants to work on SARS CoV-2?" Almost all of them wanted to. I mean, it was just like, sign me up. It was just incredible. Everyone wanted to help out. It was really very inspiring.

You have to understand, you might say, well, of course, it was what's new and what's hot. But what you have to understand is that a lot of these people, they're in a timeframe that they have to get something done within a certain timeframe. So, whether it's a graduate student, you know, I'm working on my thesis. This is my thesis project. I need to finish that thesis project on HIV in order to graduate. I'm doing my postdoc. I need to finish the project I started two years ago in order to get the paper so that I can get my academic position. And to basically drop what you're doing and take on something new when your career is based upon: I need to finish this that I started. I mean, it's a big thing to make those kind of changes. But everyone, basically said, I know it's going to set back my PhD, I know it's going to set back my postdoctoral fellowship, but I want to do this, I want to be part of the solution. So, it was inspiring.

HWT: Well, I just have a handful of other questions. And I want to respect your time. I know we need to wrap up soon. Do you have a few more minutes?

RK: Yeah, I have a few more minutes.

HWT: Okay. So, is there anything else on COVID, specifically the Vaccine Research Center response, your own work, and the research that you've done over decades leading up to it, or HIV and your own research and laboratory otherwise, that we haven't covered you think is important to add right now?

RK: No. I think, I think we've covered most everything. (*laughs*) Thank you.

HWT: That is good. So, I wanted to ask you a little bit about health equity. Because both HIV and COVID-19 have had a disproportionate impact on marginalized communities. Can you take a moment to talk about health equity?

RK: I can talk about how important it is and what I've learned about it in the last couple of years. I mean, through Operation Warp Speed, when the vaccines were starting to be rolled out and the companies were setting up their clinical trials, what became clear is that a lot of those companies wanted to get their vaccines tested as quickly as possible. They had these research organizations, clinical trials organizations, that would test, they had sites in these different places, they could get people enrolled very quickly. But that

wasn't going to get them the diversity of individuals that they needed. So, it was going to be, let's face it, it was going to be mostly white, middle-aged people. What they needed was older people; they needed minorities; they needed underprivileged people. Because those are the people that are going to need to get the vaccine. If you don't know what the immunogenicity is in those groups, then what good is your vaccine? Oh, I've got a vaccine that I know gives a good immune response and is very protective in people with great nutrition and good healthcare. That's not really helping the overall public health response.

There was a huge effort that we put forward to try and get more and more diverse populations enrolled, and I think we were quite successful in that. Such that we at least generated the data that we needed. Now the next part of that has been even more difficult, and it's not something that I specifically deal with. But just because you have a vaccine and you have shown now that it's efficacious in this population but also this population and that population and those populations, how do you actually get those populations to use the vaccine? And that's, you know, the Vaccine Research Center is really a basic research and development organization. We don't have expertise in that second aspect of how do you get vaccines in arms, how do you influence people's acceptance of vaccines and get them lined up to take vaccines? But as we often say, a vaccine in a vial is of no use. A vaccine in an arm can be very helpful.

HWT: And you know, we're in an age of misinformation as well. So it's very, very difficult, I can imagine, to address that.

RK: Yeah, it's [overtalking].

HWT: I'm going to ask you just a couple more questions. One is about, within the Vaccine Research Center, building on the idea of health equity, how should inclusion, diversity and equity be defined and operationalized in the VRC more generally?

RK: We, you know, I think we really, we have a fairly diverse group of young people. Our leadership is fairly old and white, and we're hoping to change that as we bring in new people. As you probably know, Kizzmekia Corbett, who is one of the developers, worked with Barney Graham, one of the developers of the Moderna, or the stabilization process for the SARS spike, an African-American woman. Incredibly bright, driven, wonderful and certainly someone we tried to keep here, but she got a lot of wonderful offers, obviously so we weren't able to keep her. We do feel that it's extremely important to have diverse ideas within the scientific community that's working here at the VRC, and we put a lot of effort into recruiting young and minority individuals. We have trainees who come in and work with us. We've had several real successes, but we continue to work on making more strides into recruiting the right individuals into the center.

HWT: And building on that a little bit, what is the role of mentoring in your organization and in general in terms of the scientific community?

RK: I don't think there's any way to underestimate the role of mentoring. I don't really know how to explain it other than to say that we are all influenced by the people we work for, and we all pick up, we learn from those individuals. I've seen people come out of laboratories where it is well known that the mentor is an SOB. Those people who come out of those labs tend to run their labs in the same way, and it's really terrible to see. But you look at the individual and you say, Oh, they trained in so and so's lab? Oh. Now I understand why they are like they are. Then you look at people who come out of, let's say, Barney Graham's lab, who was one of the greatest mentors in the world. Every one of the people who comes out of his lab is just a wonderful, caring, dedicated scientist. So, I hope I haven't oversold Barney Graham, but he's just a wonderful example of what I think we all should be, and what I certainly strive to be in my mentoring.

HWT: So, my last question is what I wanted to ask before, I thought we would come back around to it. It's what you see for the future of the Vaccine Research Center in general.

RK: In general? I don't know. What I have to do over the next couple of years is to let a new director take the Vaccine Research Center in the direction that he or she decides is the correct direction. I will try to influence that. I think that what we've been able to accomplish here is to actually get vaccines, get them licensed, get monoclonal antibodies, get them licensed, get them into arms. I do think that I want to continue to see that. I don't want the Vaccine Research Center to become just another place that publishes good science but doesn't actually have a health impact, or a public health impact. So, I think that the wave of the future is going to be the pandemic preparedness, and I do think that I

would like to see the Vaccine Research Center be one of the leaders in prototype pathogen vaccine design. Continuing to use our tools of structure-based antigen design to develop the next generation of vaccines against what may never prove to be a public health threat. But if one of these potential pathogens does come into the human population, I would like to be able to say the Vaccine Research Center had done some of the basic work that helped us respond as quickly as possible.

[End Interview.]