Nobel Voices Video History Project, 2000-2001

Interviewee: Kary Mullis
Interviewer: Neil Hollander
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HOLLANDER:

Doctor, if you'd just introduce yourself to us.

MULLIS:

Kary Mullis. And what else do you want to know?

HOLLANDER:

What you do.

MULLIS:

What I do? As little as possible. Currently I'm the Vice President of Molecular Biology at a company called Burstein Technologies. That's my primary job. My secondary sort of ways to make money and things, job, I lecture a lot. I go around the country and the world giving lectures about various things. I used to be a laboratory person and I worked with my hands, and I did biochemical experiments, but that was when I had steadier hands and wasn't as old.

HOLLANDER:

What occupies your mind these days?

MULLIS:

The same kind of things that I always have, you know, the sort of three or four basic questions like how can I improve myself, how can I find out where I came from, what are we all about, that kind of stuff, I would say, you know.

HOLLANDER:

Let's try the second one first, where we came from, where you came from.

MULLIS:

Okay. That gets into the kind of things like just before I came down here I was reading an article about some rocks that somebody had dredged up from 3.26 billion years ago, and they said these little things here, these little filamentous things, were bacteria. They now are encased in granite and they're in a structure that seems to be from about 3.2 billion years ago, which is, what, way before what most people ten years ago even thought that life existed, that these things are clearly—they look like, at least—the fossils of bacteria that were here living in hot springs somewhere, you know, in the fiery early days of Earth. They were alive. And it seems that life probably started in a really hot place, very, very like hotter than we would be comfortable in and with a slightly different atmosphere.

But I mean, I was excited by that, just to know that, I mean, there's been a lot of discoveries like that recently, but nobody had found any really nice little fossils of thermophilic bacteria from 3.2 billion years ago, and so 3.2 is pushing it back to kind of when the planet formed, probably, 4 billion, maybe 5 billion, years ago. So that kind of stuff is what I mean, but you know, the development of that into something like us is a lot more interesting and how that works, you know.

HOLLANDER:

I don't want to go quite that far back, but go far enough back to find out how you got interested in science.

MULLIS:

You know, I don't think I got interested; I think I already was. And I'm not sure why. But if science means opening up an old washing machine and pulling out the solenoids, what I know are called solenoids now, but I didn't then, finding out how this thing managed to make the water come in at certain times. I mean, there was a little wheel in there, a little cam thing that turned on certain electrical circuits. Back then, you could actually understand how they worked. Now there's a little microprocessor in there, which, unfortunately, you can't figure out. But when I was a kid, you could.

So I'd say that was science. It was like I figured out how washing machines worked on my own just by experimenting, looking at them, trying to figure out how the devices worked, putting the little devices to use for other things, like making a door opener for my dog's house that I could electrically open his door in the early morning when it was cold, stuff like that. That's as far as back as I can remember. I can't ever not wondering how things worked.

HOLLANDER:

[inaudible]

MULLIS:

Oh, I got pretty sophisticated after a while. I developed—I discovered that you could melt potassium nitrate, which you could buy at a local drugstore. In fact, I convinced the druggist, which they weren't so frightened back then by children coming in asking for chemicals—I convinced him to buy potassium nitrate in larger quantities than he normally did. I discovered I could mix that with sugar and very carefully melt it, and when it ignited, it made a really good rocket fuel, because it converted solid into total gas. I figured that out by making little piles of it out on my driveway and figuring out what proportions of potassium nitrate and sugar gave you a complete change into a gas, which is what I figured that's what you want for a rocket, right? You want some very low-volume solid to turn into a very high-volume gas and go shooting out the back of it.

So I worked on that for a while, and I ended up making rockets that were probably four and a half, five feet tall, and was able to get like a frog, which we could catch in our yard easily, into a little film canister, which back then they were made out of metal, a 35-millimeter can, in the top of it, with a parachute, and send him up two miles and get him back alive. I knew it was two miles because a friend of mine's father—I thought it was close to that by just looking at it with a little like a tripod that had a protractor on the side of it so I could see what the angles were. I was taking geometry and I knew how to do that. A friend of mine's father didn't believe me, and he flew over in his airplane while we were launching one, which we were doing out of a sandpit. He said, "It went past me." He was about a mile up, and he thought he would be looking down on it when the parachute opened. But he said, "It went way on past me," and it was probably about two miles.

So I did that when I was about fourteen or fifteen, and I think it was pretty cool, because I designed the whole rocket myself, a very efficient design. I've talked to Dan Goldin of NASA about the design, and he thought, "Good," you know. That kind of thing usually works. It's like very simple. But that's the kind of stuff I did when I was a kid.

HOLLANDER:

I just have a theory that that kind of stuff would lead you into trouble.

MULLIS:

These days you'd get arrested, probably, just trying to buy the potassium nitrate at a drugstore. They'd say, "What are you going to do with this? You know that this stuff could explode if it was mixed with sulfur and charcoal?" you know." I said, "Yeah." No, these days, it would. Back then, it actually was kind of forgiven.

My mother never really—she was never comfortable when we would take the rocket and like turn it upside down in a pit in the backyard and fire it and watch what happened, to see how everything burned and stuff. I mean, that's when we learned how to make the rocket in a certain way. You can't just fill it up with this mixture. You have to have a structure inside so that the flame burns from the inside out, rather than from the bottom up, to make it really go. That's the kind of stuff we learned from doing experiments, basically, sticking—I didn't call them experiments, like setting off a rocket. My mother would get kind of upset when there'd be a lot of noise and a tremendous cloud of smoke in the backyard, although—

HOLLANDER:

You must have had a very forgiving chemist.

MULLIS:

A chemist. You mean a mother?

HOLLANDER:

No, no, I'm sorry. I mean at the pharmacy.

MULLIS:

Oh. Well, you know, listen, the hardware store sold us dynamite fuse, no questions asked, because that was the most efficient way to get the things to light. It was a good—you know, a dynamite fuse is a very dependable thing, so we knew that three feet of this will give us a chance to run about two hundred yards before this thing goes off, which sometimes it was important to not be there when that happened, because we had a couple of them blow up on us. You have like a steel pipe that just completely wraps around itself backwards, you know. You wouldn't have wanted to have been there when that happened.

HOLLANDER:

All of this led you to science.

MULLIS:

I think I was already into it, is what I'm saying. I don't really think I ever wasn't. I always just had an attitude that if you want to find something out, you do what I'd call these days "an experiment" with some sort of controls to figure out what actually happened there.

HOLLANDER:

Where did you from rockets?

MULLIS:

College, I guess. I mean, I probably—no, girls first, you know.

HOLLANDER:

Let's stay on girls for a while.

MULLIS:

You want to stay on that one? Well, I got on to girls probably around, you know, thirteen or fourteen. Probably earlier, but not seriously enough to draw me away from rockets. But it finally took its toll, but then I ended up, fortunately, going to college at Georgia Tech, and I didn't make any rockets there. I stayed with chemistry, though. I thought, "Hmm, that's what you're talented at, probably. I like it."

I think chemistry is one of those—if the study of chemistry puts you in a position to know when, like, there's a news report that some truck is overturned and there's white powder on the highway and everybody's freaking out, to say, like, what should you do in a situation like that, rather than panic or rather than assume it's poisonous or something. You know a lot of things that are important in your actual life. That's not that common an occurrence. But, you know, to know about all kind of pills that you could buy for various ailments, stuff like that.

If you're not a chemist, how can you know? I mean, I don't understand how people that are non-chemists deal with things like drugs that are available to the public, right? And they'll say something like a very long chemical name, 1-3-diametholprepanolamine [phonetic] or something like that, and what if you don't know what that means, you know? It's like I just can't believe it, because that's around you all the time, you know.

You talk about polypropylene. What the hell does a non—what does a non-chemist know about polypropylene, you know? You say, well, it feels good, or it doesn't feel good, actually. Polypropylene, I don't think feels very good. Polycarbonate, you know. All the different things that we're constantly using are all made out of chemicals that have fancy names like that, and they don't—if you don't understand what that is, to me, it just—I'd be kind of—I'd say, "Well, I don't feel comfortable here." [Laughs]

I feel comfortable here because, you know, I know pretty much what all these things are made out of and how the atoms are arranged in a way, and it sort of feels—I just feel better about it than I think I would if I didn't. I don't know what I'd be if I wasn't me.

HOLLANDER:
As you went on in chemistry, your focus began to narrow [inaudible]?

MULLIS:
It didn't happen to me that way. It really got—I didn't really—I was doing chemistry professionally. I knew that was going to be my career, but as has continued, I was just as interested in a lot of other things, like astronomy and astrophysics. My first paper that I ever published, actually, professionally, was while I was a second-year graduate student in Berkeley in biochemistry, and I published a paper in *Nature* called "The Cosmological Significance of Time Reversal," which was a particle physics and cosmology kind of a paper, which I still like it, you know. It took a little convincing to get Maddox to actually publish it, because he felt funny taking a paper on a subject like that from a biochemist. It just didn't fit the mold. But those things, I mean, I've always been interested pretty much in everything. You know, if it's interesting, I'm interested, and I don't care what they call it, exactly.

But I like mathematics, too, you know, just plain old simple pure math that doesn't seem to have much of an application anywhere. I like that also, because it's pretty, you know, and it's got—

HOLLANDER:

What led you to the Nobel [Prize], or what led the Nobel to you?

MULLIS:

Well, I got involved in nucleic acid chemistry at a very fortunate time for me, because it was at a time when it was extremely—it was like a frontier, still, like a young town, lots of things that needed to be done and lot of—they weren't—like today it's more industrialized. The people that are doing well at it are people that know how to organize a hundred technicians to do things.

But back then, it wasn't like that, and there were a lot of processes that needed to be developed, and I developed one of them. It's what I called the polymerase string reaction. It was a way that if you were curious about a particular part of a nucleic acid sequence in the presence of huge amounts of other nucleic acids, which is usually what you were confronted with, I mean, organisms have a lot of nucleic acid in them, and it's an extremely complex substance, the most complex substance in cells.

If you were interested in one little region of it, it was kind of tricky to obtain a sufficient amount of that region to do anything analytical with, and I came up with a method that made it simple, made it like a high school boy on an afternoon in June could do it. You really didn't need a lot of equipment. You needed some fairly sophisticated molecules, but those were all commercially available and you could buy them and you could mix them up in the right proportions, and then you'd do something very simple with it, which is you heat it and cool it and heat it and cool it. Every time you do, the sequence that you're interested in doubles, which means that after ten times, you have a thousand, and after twenty you have a million, and after thirty, you have a billion, and that's the way it goes. After a billion, you usually don't need any more.

HOLLANDER:

What do you use this for?

MULLIS:

We use this anytime we want to examine—if we want to examine DNA, meaning we want to know its sequence, usually, that's what we think of it as, is just sequence. It's like where are the As and the Ts and Cs and Gs, what's the order? Is it A, A, A, A, T, C, A, T, C, G, G, G, that kind of thing? If we want to know that, in order to find that out about DNA, you have to isolate it from all the rest of the DNA. It's like you're looking for a paragraph, kind of, in a book that's very large, usually.

If it's a human, it's like six hundred books that are a thousand pages long. That's what the genome will look like if you add it into letters. You're interested in one paragraph, and you're basically sometimes just interested in one letter in that paragraph. You know pretty much the context of it, what paragraph it's in, but they don't come out numbered. When you put human cells into a little blender and try to get the DNA out of them, it comes out in little fragments as though someone came into your library, ripped the books off the wall, and tore them all up into little pieces and left all these shredded pages, and you're interested in one paragraph in one book.

So PCR magically, really, it's got to do with the property of DNA of being able to find like sequences. Or little short pieces of DNA can always search out, sort of. They don't search. They just bang around until they find it, but they find a sequence that's what we call complementary, meaning it's sort of the backwards of it. And they stick to it.

This process said, if that happens, and you heat it and cool it over and over and subject it to these conditions, which are kind of complex, but they all just look like water in a little tube, basically, once you get them all put together. You do that over and over, every time it will duplicate. It will multiple by two the number, the sequences that have this particular kind of identifying sequences on the end of it.

It blew me away when I saw that. It really blew me. This was one night in Mendocino and driving at night when I thought of this. I pulled over and I made a few notes, but I knew in my heart, I said, "This is Nobel Prize work here. This, if this works—and I don't see why it wouldn't—this is going to get me the Nobel Prize." Ten years later, I got it. It did work and it made sense. It was a simple thing. It was just as simple as like making a hole down the middle of a rocket so that the fire could come all the way up there and burn from the inside out instead of having to burn slowly from the bottom. Made the same kind of sense. I said, "Here's something." If you do something that will double something every time that you do it, it accumulates in an incredible way, which is called exponential. But like you don't get thirty copies by doing it thirty times; you get a billion.

Those kind of processes, I think of as robust. Hard to step on something like that. It's hard for the sort of the vagaries of everything that's against you to hurt you when you're doubling every cycle. So the reaction that does that is a really powerful thing. So that means it works, in spite of the fact that sometimes some things go wrong. It's not like a string that's growing longer and longer. It's starting from one little thing, and it's becoming a huge amount of things. So anything else that happens is insignificant. That was the beauty of that particular reaction.

HOLLANDER:

[inaudible]?

MULLIS:

I told my sleeping girlfriend I was, and she told me just to take that—you know, she said, "Let's get home." [Laughs] She'd heard—well, she'd never heard that before, because I'd never said it before. I never realized. But I said, "This will—if this some for reason doesn't work, it's a tragedy. But if it does, I can't quite figure out why it hasn't been discovered already." That was one of my problems that night. I said, "If this works, why don't I know about it? Why isn't somebody doing it? Why aren't they doing it in Boston? Why aren't they doing it San Francisco? Why aren't they doing this all over the world? Because they will. If they hadn't heard about it yet, and it does work, they will, and sometimes they'll recognize who invented it, and I'll get a Nobel Prize for this, I'll bet you." That's what I thought.

And I couldn't convince myself in the next day or two that it wouldn't work. We didn't have an Internet back then, so I couldn't—

HOLLANDER:

How long did it take you to [inaudible]?

MULLIS:

Actually, it was six months before I actually got it to work. I was working with some stuff there I really wasn't very familiar with. I wasn't a protein chemist. I needed proteins for this. I needed to deal with them in a way that most molecular biologists didn't, either. I needed to deal with them in a stoichiometric way, meaning I've got to know how many molecules of the protein is there in order to produce a certain number of molecules of this DNA sequence. I have to know—there's a lot of things I had to know that had to do with times and temperatures and concentration. There was a whole lot of components had to be assembled, and they all had to be there in the right relative amounts or at least close. They, fortunately, didn't have to be exactly right, because it would have taken me forever to find out what now people know, this is the optimal set of conditions, right? It worked under the suboptimal set of conditions that I tried it, but I had to assemble a lot of things.

You know, I didn't work on it constantly once I got the idea. I had other things I was supposed to be doing. I was supposed to be synthesizing oligonuclides, and I had to deal with the fact that the methods for doing that were changing very rapidly, and I had like seven employees that depended on me for like analyzing, figuring things out, issuing commands. So I didn't have—and it's stupid that I didn't work on that constantly since I thought of it, because if someone else had come along in, say, August of 1983 and figured that out—and somebody would have eventually—then I wouldn't have gotten it. I wouldn't be sitting here, you know. I'd be sitting somewhere else, and they'd be sitting here. [Laughs]

But I didn't wait. It was Christmas, almost, before I got it work, and I'd thought of it in May.

HOLLANDER:

What is the significance of the Nobel?

MULLIS:

It's a really pleasant reward for people who have done something that generally is not—you know, a lot of times like when you do something like PCR, a lot of people have made millions and millions of dollars off of it, right? Well, I haven't. Scientists are sort of dumb when they're young, and they don't know how to capture the thing that they've done.

In the past, actually, back when Alfred [Nobel] was around, scientists were just—you know, they were thought of as kooks or weird. They did produce all kinds of interesting things, just Alfred made himself some really cool smokeless powder and all kind of stuff. And he knew how to capture the wealth from it. But generally scientists don't. They're specialized. They're just little children in the woods in a way, you know. They stumble on something or they intentionally make it, but they don't know about the processes of like trying to own it and all that stuff. I think he was saying, "Hey, at least we ought to give them something. Let's give them this, and let's give them the recognition that their peers will pay attention to so that they can organize some of their peers to continue their work."

I think that. I'm not sure what he had in mind. I know he was thinking along the lines sort of like that. But you know, he wasn't one of the sweetest guys. You know, there's not one in mathematics, is there? You know why? You know the story? Well, I think it was a mathematician that stole his girlfriend, is what I heard. I think that's what

[Michael] Sohlman told me, who's the director of the Foundation. There was some girl that Einstein had—I mean that Nobel had his eyes on, and it was a mathematician won her heart. He thought, "Well, if I allow mathematicians to get this, then that guy might some day," because he was a good mathematician. So that's why there is no Nobel in math, although math is kind of—it's sort of an art in addition to being a science. It probably belongs here, but for that reason, it's not here.

HOLLANDER:

What are you doing today? What are you—

MULLIS:

I'm still advancing the frontiers of science. What I'm doing is working in this company again. It's a little biotech startup, and this time I own a piece of it. So if what I do works, I won't need Alfred's fortune to reward me.

But if what we're doing works, it will have significant kind of effects. We're making a device that's basically going to look like an optical disc, like one of those little fan things about this big around. It'll have a little port in the middle of it, and you can inject a tiny sample of your own blood in there, yourself, at home, and stick it in the CD drive of your computer, and it will turn. It'll have software on there that the computer will read when it starts to read that CD, and it will turn your CD drive into a very sophisticated analytical machine that will tell you what the concentrations of many, maybe a hundred, maybe five hundred, substances of biological relevance in your blood are. It will analyze your blood for the same kind of thing that now they'll take like five milliliters of it, put it in a little truck, send it over to a laboratory, and do ten or fifteen of them, and charge you like $700 or something.

This will allow you to do that yourself from a tiny sample of blood and be in touch with a computer, sort of like your computer will call up an Internet site that knows about this thing. It will be like our company site or some other company that we'll have an alliance with that's into healthcare stuff, and there will be a dialogue between you and that site. It will replace, in a large—I mean, the people in my company don't like it when I start talking about replacing doctors, because they think, "Let's just don't make them mad yet. Let's don't get the AMA [American Medical Association] on our case here."

But, yeah, it will, because medicine, a lot of medicine, is very chemicalized now. If you have a device that can analyze lots of chemicals in your blood, and then hook it up to a computer network that can analyze it further, right, with like expert systems and all kinds of information databases and stuff, you can replace, to a large extent, the M.D. that you otherwise had to go to. And it's not out of the question that it could say, "Well, it looks to me like you've got syphilis. Would you like some penicillin? Push this button on your computer screen. Click on this, give us a credit card number, and it will be in the mail tomorrow by FedEx."

In some places in the world, that won't be terribly hard to establish, because there are places where there aren't too many M.D.'s working, you know. The streets—there's places like Brazil where anything would be better than what they have. They don't have the big building where you take the blood truck and analyze all the little tubes, for one thing, and they don't have the clinics. I mean, they have some of that, rudimentary, but there are places where it's even worse, and those places will be very—those places already are getting into the modern world through the Internet, because suddenly all you need is a computer and a little disk and you can suddenly talk to the rest of the world. You can get information from it. So they're really susceptible to that. It's like saying we can bring the technology of the western medical establishment to Pakistan, right, or to India.

HOLLANDER:

How close are you to doing this?

MULLIS:

It's working, but you know, scientific things, just like when PCR first started working, it was probably ten years before it was practically in the hands of a whole bunch of people who could do it easily. And I think this might happen quicker, because computer things generally do. But what we've discovered, see, is that you can make these specialized—our product is a disk itself. It's a special kind of a disk. It's got some of the regular kind of information on it that the thing reads, but it's got all kinds of little microfluid channels, places where the blood sample is divided into parts and taken into different little regions, and where chemical reactions happen and results are basically read by the laser that normally reads the disk.

It's a very complicated project. It takes a lot of different skills. I like it because I, like I said earlier, I've never really felt really—I feel like I'm a chemist, but I need—I have to define myself somehow to make a living, that I don't really feel like chemistry is the only thing that interests me. I've always liked electronics. I've always liked whatever it is. There's a whole bunch of stuff we have to deal with. There's physics in a way. It's chemistry. When you're dealing with the motion of fluids through tiny little channels under the influence of centrifugal force, it's a whole new area. Microfluidics is what they call it, but I like that stuff, you know. It's not the chemistry I learned at Georgia Tech.

HOLLANDER:

Do you consider yourself an inventor?

MULLIS:

Yeah. Yeah, an inventor is probably—but you know, I'm also a musician, too, so I'm not going to—I just don't really fit into a little box somewhere, because I'm also a philosopher, too, you know. I think in sometimes very grandiose terms about things. I cry sometimes, you know, in the presence of string theory or something like that, that I think is such an incredibly beautiful physical theory, you know. Inventors don't usually cry in the presence of string theory printouts, because you can't invent anything with that. You can just think about it as, well, that's the underlying theory of how things really work down at the bottom, but you can't make anything with it, you know. But I still like it.

HOLLANDER:

But you're inventing something [unclear].

MULLIS:

Oh, yeah. No, this is practical. This is meaningful to lots of people. It will be very, very neat for somebody to have this little disk that they will buy at a drugstore, probably.

HOLLANDER:

It's an invention.

MULLIS:

It's an invention. Yes, well, there's patents and stuff involved. It is an invention.

HOLLANDER:

What is your philosophy, in about six words?

MULLIS:

In six words, I can do that. I can do that. I would call myself a romantic positivist. Okay? That's two words, right? I really get off on things that can be tested, that have some connection to reality. I mean, nothing makes me happier than seeing some little material situation that I've designed work out either just like I thought it would or totally different from I thought it would, but to do it some kind of way that you can say, "Wow, that was a good experiment." It did show that you were wrong or that you were right.

Then I also like things that are more totally like what I was talking about, string theory and stuff, very mathematical stuff that really the only way you can know it's true is that it's beautiful, you know. I mean, that's really what it comes down to in those kind of highly symmetrical, very—you know, when you're talking about things that are ten to the minus-thirtieth of a meter wide, you're basically just talking. But if it's beautiful and it is a good possibility that things could work, then it makes you feel cool, I mean, about being here, if it's that—it's like it's just like it ought to be. It's extremely complicated. You never understand it completely. But here's a model. Here's a sort of a theory that kind of explains the general outline of it, and that's very nice. That's the romantic part of it, I guess.

HOLLANDER:

On the romantic side, what gives you pleasure in life?

MULLIS:

Well, in life right now, my wife, Nancy, is a real important part of my pleasure. My children are nice, too, but my wife is with me all the time, and she just makes my life a real pleasure. And I know the difference between that and the rest of my life, because it only happened about three years ago, and it made a big change. I would feel funny even saying that. Five years ago, I wouldn't have thought that it would make a difference, a person would make such a difference. But that's the truth, so there it is. Nancy is somehow responsible for my very high state. I'm very happy these days.

HOLLANDER:

[inaudible] isn't that a very lonely sort of thing?

MULLIS:

No, we have meetings all the time, and I get sick of them, actually. I'd prefer if it were a little lonelier. No, it's a company, you know, and there's sixty of us there. We all have to do this thing in a coordinated way because there's a lot of different aspects of it that have to do with different specialties. So I have to meet with all the different people all the time, you know. I mean, sometimes it's a little bothersome. It's nice to have Nancy to come home to after that.

If you're thinking of like lab work as being lonesome, I don't really find it all that lonely doing lab work by myself. I feel a kinship, kind of, with the stuff that I'm dealing with. I mean, that's a funny thing to say, but I mean, I feel quite comfortable with matter in all of its manifestations, and I like to play with it. So it's kind of like a friend in a way, you know. I mean, that's kind of strange to say, but I like the way it behaves. It can be predicted. It's not quite like humans, you know, but it does have its intricacies and its interesting kind of properties, and if you're patient and you're willing to really look at it, it provides an awful lot of pleasure.

HOLLANDER:

How do you look at science? What do you see happening to science?

MULLIS:

I'm actually pretty optimistic about it. I mean, people talk about globalization, and I think that's good, that the world is going to be smaller, but more people and much more in touch, and easier for anybody who's willing to make—or anybody above a certain level who's willing to make—I mean, economically, they can buy a computer, they can wire into it, they can all become part of the same community, that's an incredible thing. That's just happened, you know, just in the last ten years, and I think it's romantic. It's big. It's like extremely important for people all around the world to be turned into the same little button-pushing people that see the same screens if they want to and that. It probably will have—I mean, I think that's a real positive thing, right?

There will not be any more world wars. Too many people know too much to put up with anything like that anymore, right? They're just not going to be fooled by politicians, because they really can see the whole world. Then you have all the news channels and stuff like that, where you really know at least what somebody thinks is going on, but you're not really subject to the same kind of secrecy and stuff that there used to be. It used to be possible to fire up like this whole country once or twice, and that won't happen again. It won't happen anywhere where people are informed, I don't think, and I think that's a really important part of that.

I like being alive right now. And also we're right in on the edge of exploring space, and that's really cool. I mean, it's just going to be fun when we really do start wandering around on Mars and finding various life forms and stuff like that, you know. I mean, the big question will be if it's there and it tastes good, are we going to eat it? [Laughs]

HOLLANDER:

What are the implications of all this genetic engineering? Where is that going to lead us?

MULLIS:

Well, it's one of our more interesting sciences right now, and it's going to lead us to some nice things and some bad things, probably. I think I'm real optimistic about that, too, though. I think the bad things are very unlikely to seriously affect me. If somebody wants to make little strange clones out of their children or something and have them all be great tennis players or perfect marksmen or something, that'll happen, but I'm not going to do any of that, and I don't care if somebody else does, either, because that won't turn—you know, biological oddities don't usually have the robustness to survive. So you don't have to worry, I don't think, about the world being taken over by skilled marksmen clones. They will have their disadvantages somewhere.

You know, things that aren't natural have a tendency to be fragile. You introduce some kind of change into an organism as complex as us, and unless it's a minor thing like changing something that was there already and in this particular individual was broken, or you're just making them like the whole species was, that survives. But if you go altering too many things, my feeling is that you'll weaken the organism in some way or other. So you're not going to make a super race that we'll be scared of. I think that's almost the only fear that people have, isn't it?

HOLLANDER:

[inaudible]

MULLIS:

Yes, well, I think those will be weaker. I mean, we are already a super cool race, right? We have gone through some kind of weird thing 20,000, 100,000, I don't know, a million years ago, that caused us to be really interested—I mean, really, they call it sexual evolution, sometimes instead of survival oriented. It's like we just happen to like people with big brains, you know, that are clever, that can make us laugh and make us interested, and we have promoted those kind of people somehow for various reasons. They also were good providers, you know. We've just really blown our brains wide. We're very smart compared to the other primates. We've obviously got prettier hotels. We've got fun stuff going on. We're a pretty bizarre race already, so if they make that even weirder, I think it'll die. [Laughs] I think we've driven it almost to about as—we have as about as big—well, our heads are about—if it's any bigger than that, it won't come out of the birth canal, right? That's probably the limit.

So I'm not sure how we would—you know, there'll be some genes probably involved in regulating hormonal growth, and somebody will say, "Hey, you know, you trigger this one here, and play with this one here, the guy's going to be smart as hell, you know." Maybe so. Maybe he'll die of diarrhea or something, though, you know.

HOLLANDER:

[inaudible]

MULLIS:

Well, I think that sort of is kind of the way the planet has—you know, I've met some pretty smart women in my life. They've not always been encouraged. Most of these guys are also sixty or seventy, right? Things are changing in that regard in the sense like that of the scientists that I work with right now that are young people, about half of them are female. So I mean, biochemistry is fairly accessible to females. They're pretty good at it sometimes. They can think in those kind of ways, and they can pipette very carefully, which, when you're a young biochemist, you've got to be able to do some delicate things with your fingers. So that's an easy field for women to get into, I think. As soon as the doors were opened, they stormed right in. That's why half the people I work with are. But that's the biochemist ladies.

Now, the computer people were very different, total males, in our computer—in our what they call the IT department. There's not—well, there's one woman, actually, that they just hired recently, out of like twenty, and she's not that good. It might just be like it's one of these things—also, all these people are in their early twenties, not any old ones, you know. Because biochemists, I think, get smarter as they get older. We don't know that too much about computer people because it's such a young field, but it seems like you might pass through your computer max, you know, when you're about nineteen. That's when you can—somehow you figure it out then, better. Then your brain starts getting less agile, I don't know.

HOLLANDER:

[inaudible]

MULLIS:

You mean most of the socially relevant scientific issues? Is that what we're talking about now? Yeah, that's where I'm happy I'm a well-educated chemist, right? So when I hear that stuff, I don't just say, "Well, that must be true because they said it on television, you know." Things like the ozone hole, global warming, all that stuff, it doesn't bother me a bit, because, you know, I look back. I'm capable because I'm a little educated in these areas, and with the Internet anybody can be now, without even having a library down the street. You can go back and look at the actual facts, you know. If you're worried about global warming, the way to sort of keep yourself from being so worried is to go to the sites on the Internet that are there. The government has all the data. You want to look at what the temperature was in 1900 and what it is now, here, in Alaska, wherever. You know, if you look at all that and you say, "Well, what's the big deal? What are they worried about? I mean, why would they possibly think this is a trend?"

Then you look back into the history of the planet, you know, different sites, but I mean, different books you buy, and say, you know, twenty million years ago wasn't like it is right now. It wasn't because of us that it wasn't, because, in fact, twenty million years ago, we were up in the canopy of the African rainforest and we were about this tall, and we weren't even smoking cigarettes, you know. We weren't doing anything wrong, really, from the point of view that a lot of people take now. And yet the climate changed drastically, and it turned out it was in our favor when Africa dried up and turned into Savanna and we had to come down out of those trees, or those of us that are sitting here in B_____ right now did, and head north.

That stuff is the world. That's the planet. The changes, climatic changes, are part of the planet. They are not something that we are causing, nor are they something that we would really want to stop if we had a good feeling for ourselves, which I do. I like being here. I like being a part of the matter, and I like the way the matter has progressed. I wouldn't want to say, "Okay, from now on, it's always going to be 68 degrees in San Diego, and the humidity is going to be 15 percent, period. Anything else will not be tolerated." I would feel foolish doing that. I assume there's going to be global climatic change, and I assume it's going to be fun for the little ape that knows how to build a house and take care of himself regardless.

I don't assume that we did it, you know. It's happened too often in the past when we weren't there at all in terms of our capabilities today. It's happened too often to blame it on us. I mean, if somebody were to come down here and say, "You guys did it. You guys did it," I'd say, "Well, what happened sixty-five million years ago? Did we do that?" Now, that was an asteroid. What about the climate warming over and over? It's gone up and down and up and down in the last million, two million years, you know. We've had an Ice Age, then we have an interglacial, and then we have an Ice Age, and then we have interglacial. That actually works well for our species, because we're adaptive, you know.

HOLLANDER:

[inaudible]

MULLIS:

Well, I don't think my view of the ozone layer is unorthodox. I think the present view of the ozone layer by a few scientists who are leading public opinion, of course, but it's just a few scientists who have what I think is unorthodox views on it. My view of the ozone layer is it's pretty hard for me to imagine any way on an oxygen-based atmosphere, not based, but we got 20 percent, right, UV light hits oxygen and it turns it into ozone. That happens. You can't stop that. If there's less—once the ozone's formed, the UV light gets absorbed by it also and then re-radiated, so it only gets into a certain amount of oxygen and it turns it into ozone.

If you scraped all that off and just got rid of it one day, then the next layer of oxygen would have the same thing happen to it. You can't stop it. You can't stop like a tin can from rusting. Now, a tin can's not like an aluminum can. A tin can rusts all the way through. Oxygen doesn't rust all the way through. It only forms ozone outside, because the ozone stops further penetration of UV. It's like an aluminum can. It forms a layer of aluminum oxide on the outside, and it doesn't let air in anymore, so that an aluminum can stays there. The Earth is like that, and its oxygen is there. It will permit UV to get into it only to that depth that is required to extinguish the rest of the UV by ozone. Now, how are you going to interfere with that? How can you stop it?

HOLLANDER:

So there is no hole?

MULLIS:

No, there's waves. There's always, you know, since the thirties, it's been known that there are large waves up in the upper atmosphere that are caused by the solar wind blowing on the ionosphere, just like the wind blows on the ocean. The solar wind with the charged particles blows, and it has this friction and it makes waves. There are big five-mile-high waves. If you go up there and you want to find some holes, you'll probably find them if you look down the trough of the wave.

There also is this business of the seasonal decrease in ozone, you know, in the Arctic and Antarctic and stuff. So what? You know, I mean, show somebody that it didn't used to be like that and then talk about it as being a catastrophe, right? As long as you only have the data from the last few years, that there is slightly less ozone around Antarctica at certain times of the year than there is over L.A., you know, so what? I mean, that doesn't mean anything. It just says, "Well, that's the case, and it comes and it goes." It's like everything else in nature, there are cycles.

It's not actually getting any different, you know. The people that are in that field have a vested interest in making it look that way because they're being supported by you and me for the purpose of maybe warning us about some disaster that we're getting into. You have to take that into account when you look at their work. And if you look at the details of their work, you see, well, there's nothing to get upset about, you know. It's like getting upset about a bag of flour spilled on a freeway somewhere. They say, "There's a strange white powder on the freeway," and everybody comes there and gathers around it, you know, and finally somebody says, "It's flour." People like to have catastrophe, you know. It's kind of boring without a little catastrophe, you know.

HOLLANDER:

Is that similar to AIDS?

MULLIS:

That's a different story, but another one where people have been totally misinformed about something by a fairly large population of well-paid researchers that are living off of us by scaring us, and the evidence that there is a like a contagious organism at work in Africa, for instance, right now, doing the same thing as has been done in Africa for the last, you know, 50,000 years. People die of all kinds of diseases there. They still do. The population isn't decreasing. It's increasing, right? So what is all this talk about some kind of plague, you know? The population of these little towns that scientists, like ten scientists from America, doctors usually will take a vacation in like some little African country, and they'll study AIDS right there. They'll come back and they'll say, "Hey, that place is not even going to be there in two years, because everybody is dying of AIDS." Come back five years later, they're still there. That ought in itself say—

HOLLANDER:

A lot of them have HIV.

MULLIS:

Well, there are very few HIV tests done in Africa and HIV tests cross-react. This has been known for a long time. Those guys knew it, that the antibody tests for HIV cross-reacts with the antibody tests for like malaria. So it works in North America to detect a particular population that does seem to have some retrovirus, not necessarily the one they call HIV, just something that will react in that test. But in Africa, half the people there have all kind of parasitic infections that also test HIV-positive. I mean, they thought 75 percent of the people in Africa had HIV fifteen years ago. They should be dead by now, but they're not. That ought to tell somebody something.

The population in Africa is getting decimated by crazy people with AR-15s. It's not getting decimated by a virus, you know, and if you want to go over there and say, "Everybody that wasn't run over by a truck that died, died of AIDS, because we measured this antibody in a few people's blood at some point and estimated that 75 percent of the people in Africa had it," you can make that kind of a statement and a lot of people will go for it. But not me. I know where those people's bread is buttered, and it isn't in saving Africa from anything. It's got to do with sort of promoting their particular brand of science, which I think is not all that good.

HOLLANDER:

[inaudible]

MULLIS:

I'm not doing that. I'm just reflecting on that, you know. I see it. I mean, I'm one of them, and I know what we do for a living, you know. And a lot of times what we do for a living is perfectly reasonable for scientific principles to be obeyed, right? You don't have to break the rules in the development stages, particularly you don't. Like if you don't come up with an optical disk drive that will do what I'm telling you what it will do eventually, then, hey, I lose. If I do, it doesn't matter how I did it. You know, I could break some rules, in fact. I could believe sometimes in things that weren't true. If it comes out and works, it's all right.

When you're in another kind of a field, which is like in the doctor kind of area dealing with some very difficult-to-describe set of diseases that seem to be plaguing the whole world, but which don't really, if you look at it, you know, compared to other things that are, there, assumptions that you make had better be right, because you don't have a final product at the end. You know what? If those guys said, "You know what? Ten years ago we recognized that Africa was being plagued with an infection, an epidemic of this thing. We treated them drugs that would stop it, and now they're all well." Okay. If they did that, then I'd say, "Well, you know, I don't care whether your data was correct in the first place or your assumptions were right or not, because you produced something, so I have to accept that."

It's been twenty years, right, twenty-five years, since they said there is this little retrovirus, 9,400 base-pair virus that is causing all these twenty or thirty diseases, including uterine cancer, and we haven't been able to do a thing about that. Not a thing. Nobody will say, "Hey, you know what? We've really got it under control now. We've figured out how to cure this problem. It's not a problem anymore." If somebody after twenty-five years can't figure out how to deal with a 9,600 base-pair virus, they're on the wrong track, because we've dealt with much more complicated things back even in the thirties when biology was young. Now we've got more sophisticated things than we've ever had before. Somebody is telling me there's a 9,600 base-pair retrovirus on the loose that we can't stop?

HOLLANDER:

Why don't we stop it?

MULLIS:

We do. We stop it. It just doesn't happen to be the thing that causes the disease. See, AIDS is not caused by an organism called HIV, in spite of the fact that the name of the organism was assigned particularly to say that it did.

HOLLANDER:

[inaudible]

MULLIS:

Who knows? See, AIDS in Africa is not the same thing as AIDS in South America, it's not the same thing as AIDS in New York City, which is close to what they call AIDS in Holland, but it's not exactly the same. It's like AIDS is a sort of a social phenomenon that's extremely complex, and it probably has a lot of—see, when you're talking about thirty different diseases, but you need to have one of those in HIV to have AIDS, right, when you're talking about something that stupid, you're not really talking science. It's hard. How can you prove that it does or does not exist when it's every year there's another disease added to the list? How could they possibly have stuck uterine cancer in there? That's one of the things I wonder about. It got them some more women, because they didn't like the fact that if it's an infectious disease, it really shouldn't be male-specific. But it's always been 91 percent male. You know, there's something about whatever that is, whatever.

I think it's a very complicated—I've written a paper about my hypothesis, and I'm not going to bore your listeners here by describing it. But I have a much better hypothesis than the one that's generally accepted that's caused by a single organism. It's like it may be caused by a lot of complex behavior that has change. It might also have something to do—I mean, I specifically address those things in that article as to what I think might be doing it, but you know, I think it's more of a social thing than anything else. By that I mean the doctors are not dealing with a medical kind of phenomena; they're dealing with a society that's willing to say this and this and this and, "This all have to do with the same problem, and it basically goes back to homosexual promiscuity and, you know, sexual practices that we don't approve of." It's easy to make that sell in Kansas where people really don't have any other way to get out information. Now they do with the Internet. You look on the Internet. Look up "HIV, cause of AIDS" on the Internet, and you'll see a flurry of interesting papers that involve the fact that it's not shown. You won't find any interesting papers that say, "Here's why we think HIV causes it." Who would write such a paper? You would think somebody in the field would have written such a paper, you know, but they haven't. That's interesting.

A lot of people have written papers that say, "No, it doesn't. Here's why it doesn't. Here's the information that you could be able to assimilate and say it doesn't." There's no real evidence that it does. You can't really say that it doesn't, but you can't say that it does. You can say there's no evidence that it does, so why consider that it does? I mean, the nature of the scientific kind of thing is you can't ever really say something doesn't cause something else. You might turn out to be where like Newton would be right now.

HOLLANDER:

I read somewhere that you injected yourself? Would you inject yourself?

MULLIS:

With HIV?

HOLLANDER:

Yes.

MULLIS:

Not intentionally, no. I remember some maniac doing that, and I would consider such a person to be a maniac if they would. I mean, you have to really have the strength of your convictions to do that. Science is not a belief system, as far as I'm concerned anymore. I mean, you have to at some point in science say, "I do believe in the fact that if A implies B and B implies C, then A implies C." Right? And that's a belief. That is a structure of science. But you don't have to believe in any of the things that you think are true and that you think you have a lot of evidence for. If you do, you know, well, if you believed in Newtonian gravity these days, you'd look pretty stupid, wouldn't you? But you had all the evidence there. It looked right. It seemed logical. And it was, you know, a perfect little thing until suddenly there was a little wrinkle in it, and then there's quantum mechanics that came along and just screwed up the whole thing.

So you don't believe in scientific theories. You say, "The data that is currently available supports this with the probability of being wrong of something I can't always calculate with hopefully less than 5 percent." Then you say, "We're trusting that one for the time being." That's what you do in science. You don't even know anything absolutely, so you wouldn't take some unknown virus and stick in yourself just because you thought there was only a 5 percent probability that it was going to cause a disease. But you would stand on the 95 percent probability that it wouldn't in terms of scientific discourse, right, but you wouldn't do something dumb, because you have to realize it's a probabilistic business. It's always possible something's going to happen funny. In fact, that's one of the joys of it.

[End of interview]