

Paul Daugherty: Well, I am rolling right now. We are good. Anytime you're ready, you can go ahead and start chatting away.

Sonja Wolter: Well, first of all, tell us who you are.

Russ Schnell: Russ Schnell. I'm a scientist at NOAA [National Oceanic and Atmospheric Administration] Global Monitoring Division [GMD] in Boulder, Colorado.

SW: Very good. Let's start with your growing-up days. Tell us a bit about where and how you grew up.

RS: I grew up in Alberta, Canada, in a small village of less than nine hundred people two hundred miles from any city. The reason I was there was my grandparents and parents moved from Russia as a group. They were a group of Germans living on the Volga River, and when communism came in, they didn't appreciate that, so various ways, they managed to move the whole group of people in the village and the family piece-by-piece to Canada. They all settled down in a farming area – they're all farmers, fairly uneducated, just dirt farmers. In the area where we settled, or they settled, there was not much competition for land. Our group had about seventy square miles of hills and streams and fields, and we were all related. I had 283 direct relatives in that area. We were all family-oriented, and in this picture, you can see one of our family dinners we had. Every year, we would get all the people together who would come, and there'd be a hundred to two hundred people coming and were all relatives. A lot of them didn't make it because we had even more relatives. That was just on the paternal side. The maternal side was just as big.

SW: I just had a follow-up. Do you have any special stories from your childhood that indicate the scientists that you became today?

RS: Well, I don't know about the scientist part, but I grew up in this rural community, but we were the one family that lived in the town because my father and grandfather and brothers were designed to fix the farm machinery that everybody had. That was an incredibly great way to live because I knew everybody in town. We'd get up – before we even went to school, we'd go out and play. On the weekends, we'd get up in the morning. We may not come home until seven or eight at night. Parents didn't care. They didn't know because they knew you were at some relatives' place or some other place. Then, when I was a little older, I was in the Boy Scouts and then in the Royal Canadian Air Cadets. Sometimes, I would set up a trip, or we would have a trip. My father was very busy. In those days, you worked sixty hours a week. You worked all day Saturday and half a day Sunday because you just had to. There was no other way to keep all of the farm machinery running. My father, sometimes I wouldn't see him for three or four days. Sometimes, I'd go on a trip; I'd be gone a week, and my father would ask, "I haven't seen Russell around lately. Where is he?" My mother might say, "Oh, he's in Vancouver with an Air Cadet trip." That's how open it was because everybody took care of you, but you had very strong guidance from all of your relatives – your parents, your grandparents. Something my grandmother told me very young was you can earn a lot better in your life if you use a little bit of sugar than a lot of salt. But it was a great life as a child.

PD: You could try that quote one more time if you want to.

RS: My grandmother once told me that you could earn and be a much better person if you used a little bit of sugar than a lot of salt.

SW: Given your upbringing, it doesn't seem obvious that you would have ended up going to college. How did that come about?

RS: In our little isolated village, very few people ever went to college – schoolteachers occasionally, but it was very rare. I was told to go to college and become the village doctor because they were short on doctors. We were brought up to be very obedient and to work hard at school, so I was one of the top students in the school and in my group, so I was sent to college. But my parents didn't know what college was. We didn't have a vehicle to go over to college, so I hitchhiked two hundred miles to college. I got there, and I didn't really know what subjects – I thought it was all standard – you had to take. I didn't realize that you could choose things, so I just [chose] science topics because I liked science. I hated math, and I hated English, and I hated French, so I just loaded up with science topics. I also didn't know that you only had to take a certain number, so I took classes at night. I took classes on Saturday. So, I got a bachelor's degree, and I was one of the top in the whole university [of] ten thousand. I got my first degree [in] under three years of going to college, and then they gave me a second one after I took another year because I had so many hours. I didn't know any better. I was accepted to medical school. But one cold winter day, I went to see an uncle in the hospital who was dying of cancer, and it was quite a ways away from my residence. It was a very cold day, so when I was walking back – I wasn't dressed appropriately – I came by a government building, and the door was open, so I went in and sat down and tried to get warm. Then this uniformed man came up and said, "What are you doing here?" In a panic, I said, "Oh, I've come to apply for a job." He looked at me. A few minutes later, he brought me a piece of paper, told me to fill it out; I did, handed it in, thanked him, never thought about it again. A month later or two, I got a phone call – we didn't have a phone in the dorm, but they phoned the manager of the dorm, and the dorm found me and said, "Would you come for an interview?" I ended up working for something called Alberta Hail [Project] studies, which was a program where you chase hailstorms. I was given a vehicle and told to chase storms and plot them and mark them and stuff like that. It was the best job I ever had. So, I didn't quite go to med school. I put it off for a year. But then, I never went back because I got a bunch of scholarships and went to different universities in different places. I've been to six universities, but everybody paid me well to go, so I might as well.

SW: Did you want to say something else, too, about your Air Cadet stuff?

RS: In our small town, we had an organization that's something similar to the Civil Air Patrol, but it's ten times larger in proportion to the population as the Civil Air Patrol is in the US, and it's called the Royal Canadian Air Cadets. I call it a children's Air Force. So, I joined that as soon as I could. When I was sixteen or so, I was given a flying scholarship and became a licensed pilot. The following year, there was a competition for cadets to be selected to go to other countries for the summer. I applied and went to the different interviews, but it was kind of interesting because every other person there was a city kid because of course the city was ninety percent of the population; there was only ten percent or less that lived on little village farms like I did. I listened to some of the other guys giving their interview because I was outside, but I could hear them. They talked about going to the mall and all their friends and the music and stuff. When it came to me, I didn't know anything like that, so I just talked about my family. I knew how to weld, and I knew how to drive horses because, in the summer, I would rake hay with horses and things like that. They

asked me a lot of interesting questions. It was about what do you know about Alberta, what do you know about farming, what do you know about a lot of things like that. I thought I was doing kind of bad because I heard all these other people with all these big stories and stuff, so I didn't realize that this is what they were looking for. So, in the end, I was selected; out of all of Canada, two people were selected, myself and another one, to go to Israel to spend the summer with the Israeli Air Force. That was incredible because we got to see the whole country. We got flown around. We were dignitaries. We found out that they were actually working on making nuclear weapons because the soldiers at night who would take us out would get drunk and brag about what they knew and stuff like that. It was a fantastic – but that opened a lot of doors because when I came back then, on my resume, I could put I was a licensed pilot at sixteen. I had spent the summer with the Israeli Air Force at seventeen. So, of course, that helped me with scholarships and life in general after that.

SW: Was the pilot experience part of what got you the job with the Hail team?

RS: Yes, they wanted somebody to fly not into hail storms but to fly after hail storms and look at the damage. I just happened to have a farming background. I knew what hail looked like, I knew what farms looked like, and I could fly a plane, so there I was at eighteen, flying an airplane. Did they only know how little I knew how to handle it? [laughter]

SW: How did you end up going on to grad school after undergraduate?

RS: I took a couple of years off after my undergraduate and just tooled around and worked a little bit. Then I applied for a – I was working at an airbase, and I saw a Rotarians magazine; there's scholarships in there. So, I applied, again not even thinking I had a chance. But a few months later, I was called in for an interview, and then another month or two later, they said, "You can go to any university you want in the world. Where would you like to go?" Ding! The sexual revolution hadn't hit Canada yet, but it was in Sweden. I'm a very poor writer, and I wrote S-W and then a vowel da-da-da. When they took it to look at it, they couldn't figure out where I wanted to go. So, the only thing they could come up with was Swansea, S-W-A-N-S-E-A, same number of letters, same vowel organization. I ended up in Swansea, Wales, which is the most conservative, religious, you-don't-even-kiss-your-girlfriend-before-you-get-married type of place. So much for the sexual revolution. But it was a very great education. One of my roommates – we rented a little dumpy house – eventually went on to become a Queen's Counsel lawyer. When he would go for his official meetings, he'd wear short pants or pantaloons with red socks and a wig when he went to his court case. He eventually was a Queen's judge in Wales. I see him regularly. But a friend of mine who became a friend, a girl at the college, I took her home for dinner one night, and they met, and they really hit it off. She was American. She stayed and married him, and they've got five children, two of them doctors, one was a member of Parliament. She was from Nebraska. But I see them every couple of years. I go back, or they come here, too. I didn't learn much academically but had a great year.

SW: I'm trying to think how to transition here, but I guess that's what editing is for.

RS: You might want to know how I got to the US.

SW: Right.

RS: I was working at the airport on the hail studies, and the University of Wyoming aircrew was at the airbase studying hailstorms. So, of course, I worked with them. The head of the aircrew said, "I'm setting up a new department in Laramie, Wyoming on atmospheric science. Why don't you come be my first student?" I said, "Nah, I got to settle down and maybe go back and finally go to med school." He said, "Well, I'll pay you." I said, "Nah, I'm not interested." He said, "I'll pay you just like a faculty staff." I said, "You're crazy." He said, "No." He said, "I got a start a department. Your marks are perfect. You were the second-best student in the University of Alberta. You obviously know how to work. You can fly a plane. You don't care about getting hurt in hailstorms. Come be my student." So, I went. I thought all students were like that because I'd never been to the States before. I bought a new house and a new car, and I traveled a lot. I thought this was the way life was. But then I did a master's degree and a PhD there. But my thesis was interesting in that hailstorms have to start on a nucleus; a raindrop has to freeze. Water in a cloud does not freeze at zero centigrade or thirty-two Fahrenheit; it'll supercool [at] ten, twenty, thirty degrees. So, a hailstorm has to have a nucleus, and then that forms an ice crystal, and then it grows and comes down. One of the professors asked me, kind of jokingly, but [inaudible] seriously, "Where are those nuclei coming from?" I'd probably seen a hundred hailstorms over my work there and as being a farm kid watching the hail wipe out all our family's fortunes for a year. Before that, people had thought hailstorms' nuclei were from either dust coming in from meteors or from dust from deserts and stuff. But I said, "No, obviously, it's vegetation because the storms always start over vegetation, and they always move over vegetation. There's no dust out there like that." They laughed at it. So, I started some tests, and within about thirty days, I had found that the nuclei were biological products. The decayed vegetation was leaving. There was one type of nuclei made by the decayed vegetation, but as it was decaying, there was a bacteria. I accidentally found out – I was washing different plants with water to test their nuclei, and I left some of them decaying and went off to a party and didn't come back for a week or so. I came back; it was all milky. I tested the water, and it froze just about at minus one degree. That's about ten degrees warmer than ever seen before. It was a live bacteria. We eventually found out that the bacteria produced a little nuclei on its coat and that nuclei is released and it's involved in the cycle. I published two or three papers in *Nature* and stuff like that before I even graduated. But then it kind of died out because people thought it was so weird. But within the last five years, there's been about two-hundred papers confirming that these bacteria are producing it. Here's a picture of what the bacteria look like in an ice crystal. I shot some of these bacteria into a cloud chamber and then collected the ice crystal, and you can see the bacteria starting. But other scientists and another student in a different university worked with a company to take those bacteria and grow them in big concentrations and put them in ski area water. It's called Snomax, and it's a thirty-million-dollar a year business now. I didn't patent it, and he didn't patent it, but Kodak took it, and now it's run by another company. There's not a ski hill area in the world that makes snow that doesn't use this material because it cuts their costs by eighty percent because now instead of having to compress water and cool it, you just spray it out gently in a fan with this bacteria, and you've got beautiful snow. It makes better snow, and they can control the type of snow they can do now, so it's pretty interesting. The Canadian Olympics in Calgary were the first ones that used this stuff because there was no snow that year, so they made false snow on all their trails, and it was made with those bacteria; *Pseudomonas syringae* that's called.

SW: Local boy does good.

RS: Yes.

SW: Should we do Schnell's Laws?

RS: Sure.

SW: For just a little bit. In 1989, you were on a field campaign. Then you had some postdocs who were working with you who wrote this list of Schnell's laws.

RS: I had two postdocs, Pat Sheridan and (John Call?), and we were on a project a nuclear weapons project, where hundreds of thousands of tons of explosives were blown off in New Mexico at White Sands, and then we were predicting where that cloud would go in a couple of days. Then NASA [National Aeronautics and Space Administration] was going to bring a plane through it because the Army had buried different levels of materials under the ground like iridium and gold and silver and other stuff forty, fifty feet down. When the blast went off, they wanted to see where the cloud would go and how it dispersed, but they had no real way of predicting. But we had a program to predict that, but Pat and (John?) had to sit at a computer and adjust it. I was at the blast, and then I told him where it was going, and then they would adjust where they thought the cloud was going. They had hours and hours of sitting around [bored], so they started talking about things I kept saying to them. I never knew I had said these things. They put down about six or seven "laws," and this is what they looked like. They've put them on their doors, and we keep laughing about it. That's about twenty, thirty years old now, but they still are pretty applicable. The first one, I think, said, "If something is worth doing, it's worth doing quickly." The rest were kind of about finances because we were always trying to get money to do our research.

SW: That first one I have a question about, the "anything worth doing is worth doing quickly." There's a Latin proverb: "*Nomen est omen*," meaning "the name is a sign." Your last name is Schnell, which, as you know in German, means fast.

RS: Yes. *Mach schnell* [make it fast].

SW: I'm wondering if you have a story about "anything that's worth doing is worth doing quickly."

RS: Well, one that I can relate – it may be interesting. When I was in graduate school, the Rockefeller Foundation selected students from all over the US, one student from each country. They canvass and look and take them to Williamsburg, Virginia, for a week to tell them all about the US and to learn about our personalities. The CIA [Central Intelligence Agency] has a recruiter there. I was selected as the student in the US from Canada, and there were fifty-four different countries represented there, one student in each. There was one young lady from Singapore there, and we talked. I didn't meet her the first or second day, but on the third day, we met and talked. Then the next day, we had a bus trip, and we talked some more, and on the third day, we took a plane to Boston and agreed to get married. We didn't quite do it at that time because I had to finish my degree and she had to finish her work, but when she first came to visit me in Laramie – because she was living in St. Louis and working at Washington University. I was in [Laramie?]. We only dated three or four times. She came to visit me, and her passport was on my desk there. So, when she was gone, I looked at it, and I said, "Boy, is her mother ever going to be unhappy. She took her passport." Because I thought Oriental girls look much younger than you think. I thought she was ten or fifteen years younger than me. [It was] the other way around. [laughter] She's

not much older but older than me. But it worked out. We've been married for forty-seven years, I think.

SW: That's awesome.

RS: I had to buy her from the Singapore government because she was on a scholarship, and Singapore is a country that's run extremely efficiently and smartly. If the government pays for your first few degrees and the education and then she had another job – so they expect you to either come back and pay that off, or if you don't, you buy it. I had to pay thousands of dollars to pay off those loans, so I "bought" her more or less. It's a joke, but it wasn't cheap.

SW: I'm just going to hand this to you to take a quick look at Schnell's laws. Obviously, we have some projects of yours to talk about.

RS: Number three is very appropriate. "If it does not say I cannot do it, it means I can." That was many approaches I had during life. Do it and beg for forgiveness instead of going the other way around, and it has really worked out well in projects we've done and investments. When I was young, I met a guy, and he had a personality. We talked. We said, "It's better to try something and be bankrupt a few times than to not." So, we started investing with no money in real estate in the Boulder area, and it has really worked out well. We risked being bankrupt more than once. Once, we had bought an old apartment building, and just when – not the last recession but a couple of recessions before hit, so the mortgage company was coming out to see if we had enough people in the building because they thought we were going to go under. So, I went to the Salvation Army – I had an old truck – and I loaded up with furniture and clothing, and then I went to Pete's and bought twenty pizzas, went to a store and bought up piles of groceries, and we outfitted about – there were twenty units and fifteen of them were empty. We fixed all these units, put all this stuff in there – it was kind of junky looking – and they inspected a few of them, and they didn't pull our loan, so that was lucky. [laughter]

SW: How about "always get somebody else to pay for something you're already doing?"

RS: Well, that's the easiest way to make money. First of all, think of a project, and then do a little bit of work on it and get some results. Then project where the results will go and be pretty darn sure that they're going to work, so then you write the proposal and convince them. Sometimes, it's hard. I know in one program I had, I convinced the Army to give me fifteen thousand dollars, and then I went to another agency and said, "Well, the Army gave me fifteen. I only need fifteen more to do this project." "Oh, okay." About the eighth time around, we went to NASA, to NSF [National Science Foundation], and we had enough to do the project. That's because I knew what we could do. The same thing happened when – I came to Boulder as a postdoc. In my first postdoc year, I was working in Boulder here, and then I moved to NOAA, and NOAA wanted a person to go to Africa to see if it was feasible to set up a baseline station on top of Mount Kenya, so they asked me if I'd apply to the WMO [World Meteorological Organization] which I did. I actually got the job, but at that time, my wife was eight months pregnant, and they kind of said, "You got to take this job or not," and we dithered, so when she was eight months and about fifteen days before delivery, we decided to go to Africa. We flew to Geneva, where I had a meeting with the WMO, and she went into labor and then stopped. We should have stayed another day, but we didn't. So, we got on a plane that night and went to Africa. Then the next week, she delivered. My job in

the delivery – because we went to a native hospital, the lowest level hospital you could find because we didn't know any better. My job was to kill the flies and chase the birds out because the hospital was built by the British in colonial times, and British don't have screens on their windows in Britain. There's no screens. So, in Africa, there's no screens on the windows in British colonies, so the bugs would come through, and the birds would chase them. I would be killing them off – not the birds, just the bugs. But it worked out fine; the baby survived and grew up. But she never learned to cry because she was always with us, and we didn't have a bed for her, so we bought a big basket and put a blanket in there, and that was her bed. We always had it with us, and so she never had a reason to cry. We knew when she was hungry, and we knew when she was wet. Then I was working out in the bush with the natives, and my wife and the baby were there. The natives would always look [inaudible], and they would play with her. But when we went back ten years later – I took her back, and they said, "Oh, you're the baby that never cried." She just didn't cry; she had no reason to cry, and she never learned to cry, and she wasn't around any other kids that cried because we lived kind of an isolated life. It was kind of neat.

SW: What was the work that you were doing in Kenya?

RS: I was trying to see if Mount Kenya would be something like Mauna Loa Observatory on the mountain, so we studied the carbon dioxide concentrations and the aerosols and stuff. I went there myself. I was the head of the program, but we hired eventually about thirty local porters, and we would go up on the mountain and set up stations and then collect data for weeks at a time. It eventually was shown that it would be a good location, and a station was put in later on. Then, I came back to Boulder to work here. Then, my postdoc was running out, and about a couple of weeks before the end of the postdoc, I had no other options. I wanted to stay in Boulder, so I invented something called the Arctic Gas and Aerosol Sampling Program [AGASP]. At that date, there was a call that there was some P-3 hours free, so I applied to get P-3 hours and told them I would go to the Arctic and do profiles above the Barrow Observatory and show them where their aerosol was coming from. They gave me like a hundred and twenty-three hours because they have nothing to do. So, then we scrambled to do something because we had no equipment and stuff. So, again, I took that option; I went to a university guy, and I said, "If you come on this flight, I'll pay your airfare and all your flying if you just come. You pay your own salary and bring your instrument." Well, of course, the university – Why not? How can I get to the Arctic?" We did that for about thirty different people, and we've got an incredible amount of equipment. Then we had to convince the people with the NOAA P-3, which is an airplane that's used normally for hurricanes to put we put – we put thirty holes in their plane, thirty inlets, and here's one of the inlets. I'll show you that. We actually took out windows, and we had thirty inlets, for each instrument had its own inlet, so it wouldn't feedback. Then we went to the Arctic and flew for a month in the spring of '83, '86, repeated it, did it in '89, did it in '91, and we covered all the Arctic right from the Russian side right across to the pole and right over to Norway and back to Russia again. We found out that the Arctic haze was very pervasive. It was heavy. It was heavier pollution sometimes in the Arctic at the pole than it was in places like Los Angeles and London because all the European coal-burning industry in Russia with no controls was just all moving into the Arctic in the winter and spring. So, we published a huge number of papers from that. The whole group together, over the four periods we did, published 286 reviewed papers and four special editions. I'll show you them; they're here somewhere. There, there, there, and there. That was a great time. About that time, I developed a brain tumor near the end of that, and I figured I wasn't going to live very long, and if I was, I needed something to keep my family going, so I joined NOAA as the director

of the Mauna Loa Observatory and moved to Hawaii, where I lived for – directing it. But the operation was successful, and now I had a government job with insurance and everything, so I stayed with it. But at Mauna Loa, it was quite interesting. I changed the parameters of how the place worked. They just had a few buildings there, and they were very good buildings, but a lot of people would bring their instruments, and then NOAA would run them for nothing, and it was hard to keep all the people working and paying for all this, so we started charging. But then we started charging [and] we needed more buildings, so eventually, I arranged funding either through the military or through NOAA or something. We built seven new buildings up there over that ten-year period. The biggest one was about five times the size of the original one, and that was an accident. NOAA had some money left over the end of one year, and we found out about that and asked them – we said, “Look, we can build you a really new building in Mauna Loa if you just give us the money.” They said, “It’s got to be done quick,” and [we] said, “We’ll do it.” No idea how you’d do it. But they committed the money, and we managed to get a contract in. The observatory was not built on site. It was built in eleven pieces in Seattle, just tick, tick, tick, with all the wiring and plumbing in. They brought it over on a ship. We hauled them up and then made a foundation. There were rollers on there, just click, click, click – the whole building just clicked together in a couple of weeks, and it’s still operating; it’s a good [building]. It’s called the NDSC building, Network for Detection of Stratospheric Change building.

SW: Tell us about one or two of your most memorable projects.

RS: The most interesting, scary, fulfilling project was when myself and a colleague put together a program to go to Russia and use Russian military aircraft to do a project on their land because, for years, the military and security agencies occasionally were seeing big plumes coming out of this uninhabited island up towards the North Pole called Bennett Island. All of a sudden, there’d be a big plume [coming] out of the ocean and trail off for a couple of hundred miles. People had all kinds of different thoughts of what this might be from. “It’s nothing but methane leaking out of the ocean,” to “that’s where the Russians are dumping their old submarine reactors, they’re making steam.” So myself and Dr. Tony Hansen figured out that just when Russia was falling apart, probably we could pull off a program and go over there and see what those were. We never thought anybody ever would give us any funding for it or anything. To back up a little bit, Dr. Hansen and I were on something called the Working Group 8, which was a program between the US and Russia, where scientists would get together every year and exchange ideas. We’d both gone to Russia six or ten times before that, and he spoke and wrote Russian very well. He was from Britain, and his parents grew up during the Cold War [inaudible] he grew up, and they said, “You’ve got to learn Russian. It’s important because eventually, we’re all going to have to speak it,” because the fear was that the Russians were going to take over. He went to school and had to learn Russian. It worked well for him. He went to Berkeley and got a degree in nuclear physics or something. But we had a friend in high places in Russia, and we contacted him and said, “If we could bring instruments over and pay you a lot of money, could we get into Russia and fly up to Bennett Island?” He said, “Probably.” He said, “I’ll write you some letters,” which he did, and then we took those to Russian embassies. Right then, Russia fell apart. There were no rules, so we flew all our equipment to Nome, Alaska. We rented two two-engine planes and filled them up with all this equipment, and flew right across over to something called Provideniya. We landed there, and they didn’t really know what to do with us because there’s no rules. You didn’t need visas and things. That was kind of shaky, but we had arranged for a Russian plane to fly down from the High Arctic, a thousand miles farther north, and they met us, so we just transferred the equipment. But then we had a

problem because we had to pay for everything – the fuel, the people, the plane. So, I had a suitcase up there with forty-thousand dollars in small bills that we had been given by different agencies to do this project because they wanted to know what this plume was, and they'd spent a huge amount of time and effort and satellites trying to figure it out. We told them, "We'll go do it," and so they'd risk it. But they caught me with my case. They saw the money in the case, so they said, "You have to leave immediately. Get back on the plane." So, I went out, but I said, "Oh, I have to go." I indicated that – they didn't speak English much – I had to go back to the Russian plane to check something, so they let me. I dumped all the money on a seat and covered it up with maps so that Tony could pay the bills, and then I went off quite assured that he would make it. But they figured something was going wrong, but they never figured out what I did. They thought he had brought the money in, so they took all of his stuff apart and got down to just the last thing, and then they just couldn't find anything, so they left it. But in the last item he had, the little Petri dishes, he had a few tens of thousands in there, too. He'd still be in jail if they had caught [him]. Anyway, the plane went off there, and we flew every few days up to Bennett Island. It was a seven-hour flight around. I went back to Nome and operated a satellite system that the US government had set up. They put a new antenna up at Fairbanks to just look over the horizon, so when the satellite – there was one satellite that went up that area. Then, one day, *boom*, they saw the plume. I phoned Tony – we had a direct line, phone line, to Russia. Can you believe that? To a little village up on the North Slope. I called him, and he went out and got a plume, measured it, and it was nothing but cloud water. This little island, when a cold front came, the moisture would (hiccup?), and it would make a cloud that would just trail out. As long as the wind blew, it raised up this ice cloud. It would string out for hundreds of miles. [laughter] We laughed about it. But then, the local people were a little bit – I flew back to pick him up – a little bit hesitant about what we were doing, I guess, so we just abandoned all the equipment and just jumped on our plane. We left everything and came back. That was the most interesting and exciting. It was really exciting and profitable, too, because there was no accounting in those days. Back up. I was in Hawaii at the time, and the money for this project appeared in my bank account without me knowing it. Then they said, "Oh, the money's there," so I sent my secretary down to pick it up, and she picked up more than ten thousand dollars in cash, of course. About two hours later, there were DEA people at the door wanting to know why she had taken all this money out of the accounts; anything over ten thousand had to be reported. I had them call a number I had. They said, "Oh, okay." It was okay. We would never think of doing something like that now. But we were young and invincible, and why not. So, that's one of the rules there: do it first; worry about the details later.

SW: Any other favorite projects?

RS: Oh, a few years ago – it was about ten years ago – one of our staff at Barrow, the director there, had a sister working in Wyoming for the Department of air quality there. He said, "She saw some of this data, where there's really high ozone in a gas field in northern Wyoming, and people don't know what's causing this. They think it's stratospheric air come down." I said, "Well, have her send me the data. We'll look at it." She was able to do that, and we had a young student who had won a science fair, a NOAA science fair. He was in high school, and his award was to come and work in GMD for the summer. So, he came three days after we got this data. I had nothing to do for him, and I didn't know how to process the data. His name was Ryan Neely, and I told him, "Well, why don't you plot all this data up?" And he did. We could see that the ozone went up about an hour or two after the sun, and it went down after the sun went down. It was obviously driven by a

photochemical. Then we noticed that the colder it was, the more ozone was produced because what was happening is that the oil fields were putting out all of these pollutants from their drilling in their cars and stuff like that – I'll show you a picture of the oil fields right there. You can see it. That's a picture of where we did the work. We very quickly plotted this all up, and then we went around to other scientists who were [inaudible] in the field, and they all poo-pooed it. They said, "How can you possibly produce ozone at minus-fifteen to twenty C. It's never been modeled. It can't be modeled. It's never been seen. You guys obviously are wrong." So, we put it together and published it in *Nature*, and then other people eventually found out. Other people said, "If it's here, it's got to be other places." The same thing was in Utah – even worse. The ozone there, you could actually feel it when you were working. So, we did a project over there. We figured the layer wasn't very thick, so we devised a system where we had a balloon on a fishing pole, a motorized fishing pole – deep-sea fishing – and then we put a balloon on the end of it, and an ozonesonde and [imitates whirring] let it go up. It would get above the inversion layer, and you'd see no ozone. Bring it back down, all of a sudden, hundred, a hundred and fifty PPB [parts per billion], and it was just totally in this layer, proving – this was in a basin, so we took another ozonesonde, put it in a truck, and drove it around and up the side, and we just came right through the inversion, and the ozone went from a hundred and sixty to forty in about twenty feet, just like that, because it was the top of the inversion. So, obviously, it had to be coming from inside the basin and from the oil fields. We published that, too, also. That was very exciting to find that. We got a lot of publications out of that, too. But along the way, there was other stuff we – I ran a program for a while called the Special Operations Group. It was with NOAA, but we did measurements for different agencies anywhere in the world [that] they wanted something measured quickly and don't ask questions. We did projects for them all over the place. That was at the time when the Russians and the US were still having a lot of – I guess they were trying to outdo each other, and President [Ronald] Reagan was going to put in that Star Wars program. So, we did a lot of the measurements for the lasers that were going to be used to see if you shoot a laser if it would actually get out of space. We found that black carbon higher up was really affecting them, and they were going to put this down at White Sands Missile Range. We were working there one day, and we kept watching these jet planes come, and they'd come to a corner and turn. They couldn't fly over White Sands, but they had to fly around. We showed this to the project leaders, and they just about died because all of the jet exhaust would have completely destroyed this whole laser system they were going to have. So that program died about a year or two later. That was just pure serendipitous, just looking around.

SW: You've traveled to and/or done research in ninety-two countries.

RS: Ninety-two countries, yeah. Lucky, eh?

SW: Do you have a favorite?

RS: No real favorite. The favorite is the next one, wherever it might be. All the countries have a lot – but there's a few countries I'd never go back to, and one of them is Nigeria. It was so chaotic. The rules were made about everything as a person and a day went on. It was scary. But I had an interesting program before that, where I went to the Sahel of Africa alone for a month and collected vegetation samples because there was a big drought in Africa and the Sahel, and I theorized that all the overgrazing of the vegetation had removed all the vegetation, so it had removed the ice nuclei. I got money from some foundation, and I crisscrossed the Sahel by myself for a month, collecting all of these samples and testing them.

I had a little portable tester that I ran off dry ice. You say how can you get dry ice in the middle of the Sahel or the Sahara. If you take a cylinder of CO₂, turn it upside down, and open it up into a can, it makes dry ice. I would do the test that way. Where would I get the cylinder? Every country in the world, except a few Muslims, makes beer and soft drinks. To do that, you need compressed CO₂. So, you could get it. Even miles from a city, you could get a cylinder of CO₂ because they were either making beer or making soft drinks, carbonated drinks, and that proved out that the vegetation removal had removed the ice nuclei, but we were never able to prove that that did anything on the rain. But the basic premise was proven. That was quite interesting being alone in that – going across there. Now you couldn't do it. Boko Haram – that's where they're based and [where] those US soldiers a few years ago were killed – right through where I'd done sampling. I rented vehicles or walked a lot. Along the way, I met a Frenchman and his Arab girlfriend, whose vehicle had broken down. I took them with me, so we were able to – I would speak English to him. He would speak French or Arabic to the girl, and then the Arabic – she'd speak to the people we were working with. So, they thought we were some kind of great organization. We were just working by a shoestring. Luck again. It worked out. I managed to bring all of those samples out. Now earlier on – I didn't mention when I was studying in Britain, I was selected to go to Russia for a month, all expenses paid by the Russian Komsomol, a young communist group. So, I was with a group of English students, and we spent a whole month. They took us all over Russia. It was fantastic. So, then when I came back to the US, and I went to the University of Wyoming, I wanted to see – and I had found out that vegetation makes the nuclei, so I went back, and I took a trip right across Russia on a train. I started in Holland and went right across. Wherever the train stopped, I would collect samples. In certain places, I'd get off for a couple of days just to recover, but every place I went, there was always this impeccably dressed, either man or woman Russian, who could speak English and would love to talk to me. They were wondering what I was doing, but I managed to get a whole backpack of samples out of Russia. I did it three ways. I broke everything up into thirds because I figured I'd lose them. I had a student in Russia [who I] sent one collection of the samples, and then I myself went to another smaller village and mailed a sample, and then I put the third in my backpack. All of them got out, every one of them. The samples looked like – and I'll show you what they looked like. It proved that there were these ice nuclei and vegetation were everywhere you went in the world. After I got over to Siberia, I took a boat to Japan, and then moved down and came back across, went through Japan, through Thailand, Burma, somewhere else – another country in there – India, Nepal, Iran, and came back and collected samples. The best samples were always where the vegetation grew in cooler climates, not the tropical climates. I put that into my PhD thesis. I took off from Wyoming for half a year just to go traveling.

SW: That's awesome. I think we've covered this, but I'll ask it a different way. What from your life or career are you most proud of?

RS: Discovery of biological ice nuclei, the top of that, because it was so off the scale at first, and now it's so accepted. I also measured them in the oceans, and the oceans are producing a lot. In fact, the mosaic project, now up in the Arctic – there's two scientists up there working on these nuclei, and they're sieving them out of the water to see how they're affecting Arctic clouds. They're finding them in there. They're made by marine bacteria.

SW: I do have one more question that's general. Do you have anything else that you want to talk about?

RS: I think we've said quite a bit already. I'm proud of my hobbies. I do a lot of woodworking – back to my upbringing, as children, we had to know how to do woodworking. We had to know how to do farming. We had to know how to do welding. We had to know how to drive horses. We did this under the direction of our grandparents and parents. I never did much of this, but now that I still have the talents, in recent years, I started building trains for children. This is one I made a few weeks ago, but all the children in the neighborhood come over or used to come over on weekends and build trains. It would take them a month or so, and I'd just test them to make sure they had patience. But this is one I made. One of the little kids once came and said, "Oh, it looks like he's got eyes" because I'd make two of them the same. So, I said, "Well, why don't we make a face?" So recently, I took and made a face on there just for the heck of it. But the kids don't come by anymore because they've all got trains – all in a two or three [inaudible] block. And their friends would come. We've made about a hundred of these now. But also, as I grew up, there were a lot of virgin trees around the forest. You can hand me that cane in the corner, the wooden one. In the area, it's a very cold and harsh climate, and when willow trees grow, some of them get frost, and then it'll freeze in the skin, so the tree builds that kind of a callus around because the water goes up just under the skin. It goes up here around where the damage was. This is about a twelve-year piece of wood. I go out and collect them. I know there's a certain area where a lot of these are, and then you peel off the skin, sand it, and then, where the rot is underneath, it's all colorful. I make these canes. I make about one every three weeks or so. I've got piles of these. How do I get him here? I take a ski bag with me, and then when I come back, it's all skis. But it's all these trees in there. It's fun. I put a little turquoise in them, and then I give these away to people. So, when I retire, I will be building trains and building those little free libraries. You've heard of those? I make those out of reclaimed material. That's the rule. It has to be reclaimed material. I give them away. I've got them now on just about every continent except South America. I got them in Asia, Europe, and there's one on the way now to the South Pole; it'll go into the ARO [Atmospheric Research Observatory]. That's Antarctica. I've got them in Canada. Twenty-nine of them so far. It takes me about a month or two to build one of those, but they're made to be outside and wet. There's nine in Boulder ... As children, we had to learn a lot of handicrafts. Of course, my father, grandfather, and brothers had this large workshop, and I learned to do a little bit of woodworking there. But later in life, I really thought I would enjoy it. I like trains. I've taken a lot of train trips around the world. Here's one of the recent trains that I've built. You can see here it has a face on it because one of the neighborhood children when I made one – we made one for him, it just had two eyes, and he said, "Oh, that just looks like a face." So, I took this one and drilled holes and made an actual face out of this. But of these, we've made at least a hundred, and all the kids in the neighborhood have at least one of these, and some of them have six or eight. We make the coal car and the caboose and other things like that, but now they're all growing up, and there's no new people moving in, so we don't make so many of these. But we made about a hundred of these over six or eight years ... These willows grow in swampy areas. Sometimes they get frost in them, and it causes a lesion, so the tree produces scar tissue and a callus. The water goes up this outer area here around where the dead tissue is, and they just keep growing. So, if you take this and then scrape off all of the bark and clean out the calluses, they're all brown inside, and then you can just cover it and put on some different types of varnish on it. It makes a beautiful walking stick, and it's a piece of art. This particular one, I put some little turquoise in a crack to fill the crack. It's really rewarding. You can get these – they're hard to find really good like this. You might spend three or four hours to find one looking through a very large area, but when you do, usually there's five or six on that same tree because they've all been subjected to the same stress.

SW: I was just also noticing your collection of hats. I'm wondering if we should – I know there are at least a couple of stories related to hats ...

RS: Every time I went to Russia – and I've been to Russia more than ten times, probably less than twenty. I never kept track. But one time, in Russia, my friend Tony Hansen was at Chersky, and he asked somebody he met, "Could you go buy me one of the hats" that he liked in Russia. So, this guy went, and the next day he came back with three different colored hats. Tony paid him some money and thanked him. He'll tell you more of this story. But when he was leaving, the guy said, "Oh, you know how I got them?" "No." "I went down to the officer's club, and they were all having a party, and I picked up the hats off the ..." [laughter] The implication was you better get out of the country quick, so he gave me this one. But another story is I first went to Russia in 1968, and most recently probably [2008], so that's over thirty years. When I was earlier on in Russia, I met different people; we've kept in contact because we [tended] to move with fairly well-educated military people. They were wondering what we were doing, and we were wondering what they were doing, but there was one particular man I hit [it] off [with], and whenever I went to Russia, we'd try to get together and get drunk. One of the last times I was there, I took a very nice bottle of whiskey, and I gave it to him. I said, "When you retire, I want your last command hat." [Imitates Russian accent] "Oh yeah. Sure. (Swell?). Ha, ha, ha." I thought he'd forgotten about it. I'd forgotten about it. He was a submariner, and he eventually became the captain of a nuclear sub. Years later, somebody knocked at my office door and said, "Schnell?" I said, "Yeah," and he handed me a bag. It was from a Russian store. The bag was like the equivalent of a Walgreens bag, just a plastic bag. He didn't say anything else, gave me this, he said, "I was asked to give you this," and it was the last command hat of my buddy in Russia. He's obviously retired. The hat has, I don't think, ever been used; it must have been a new one he bought just to give me. It fits my head just right. He's obviously retired. I haven't seen him or had any contact since, but that's the story of this particular hat. You'll notice that after Russia changed, the head emblems are different. This is the old communist one, and this is the new Russia. There's the submariner's anchor and stuff, and this means something about it. But that collection of hats are the different times I went to Russia ... You'll see the emblems. The one in the green hat is the old Communist regime that lasted about sixty, seventy years. The one on the right is the new Russia with a different emblem, and this particular hat is a Navy hat as you can see the anchors and the gold braid, of course, too, signifying a fairly high-level officer in there. Someday I might go back to see him, but I don't think I'll travel anywhere near as much as I used to. This is a well-used hat.

SW: Yes, [laughter] the one that was stolen.

RS: This is just a story. You don't really have to record it, or you might. We went back to Chersky some years later, and we took the head of the NOAA AOC [Aircraft Operations Center], Admiral [Michael] Moran and his entourage and others to show him that you could do flying in the Arctic in Russia, and they were still kind of – there was a second kind of revolution in Russia where things fell apart again, so we were able to do this. While we were there in this area, the local people who were not Russians – they're reindeer herders and stuff – had never seen anybody other than a Russian, so they invited us to their communal house and put on a whole night of entertainment with their best clothes and food. It was incredible. I just found today the forty-five-year-old video of that. It's in an old VHS format, and I'm going to try to get that next week downloaded, then you'll see it. But they did dancing for us. There was a fire in the middle of the place we were, and we had to jump over the fire. It

lasted six hours, but at this meal, myself and Tony and a couple of others had to go and try to make some arrangements to fly back into the US because we were going to take a Russian plane right to Anchorage, fly everybody back, and the rest of the party were there, and they brought out a special meal. It turned out to be a mastodon that they had found frozen solid, and they eat those things because they've been ice frozen – only when there's a big party, but the bones were huge. We didn't eat it, but most of the [inaudible] got violently sick the next few days. My sister, who'd come along on the trip, was very sick, and other people were. They didn't tell us – they couldn't really tell us what it was, but we figured out – from the bones, we knew what it was later. I hope they didn't eat much, but we ate reindeer and fish and seal and stuff like that. So, we'll put some of this into this if we can get the – it was really nice. They sang and verbalized. Really, a nice time.

SW: Paul, do you have any questions that you would ask?

RS: We didn't talk much about NOAA Science. [laughter]

PD: Now that you're retiring, do you think that there's your impression of why you think you're going to be remembered most and why everyone here is going to remember you most?

RS: My impressions of what I'll be remembered for? I don't know. As being relaxed and smiley and telling interesting stories at times. I should be remembered, I hope, for the discovery of biological ice nuclei, that I think. But what's happening now – a lot of papers were coming out that never referenced the earlier work because – well, a lot of it was done before it was ever put into electronic databases. It was all done in the early '60s. There was a whole flurry, and then I moved on, and there was no more interest in this field for twenty years. So, I read papers in *Nature* that talk about the discovery of these biological nuclei, and we just figured this out – da, da, da, da, da – and no reference to our work because they don't know about it or they're ignoring it. I don't know. But one particularly egregious paper came out in *Nature*, where they had talked to me for months and got all my papers, and then never mentioned it, that they had discovered these nuclei in the ocean. I was very unhappy, and I wrote to the editors of *Nature*. So, when the paper comes out electronically now, there's a three-page rebuttal, showing where all of the graphs that they have just match exactly the ones that I had shown them. That's the only time I've ever done it. The rest, I just feel that they probably didn't know about this stuff.

PD: Former medical student turned hail-chaser. Regrets?

RS: Yes. Many times, I regret that I didn't go to medical school and go into the Air Force. Because the guy I was with in Israel became a general in the Canadian Air Force. He was the number two man in the Canadian Air Force. I was quite a bit smarter than him and older. I'd have been two years ahead of him. I might have been his boss, maybe. But that's water under the bridge. So, out of my guilt complex, I pay for any student from my little village who goes to medical school. I'll even pay their undergraduate [tuition] if they're smart. We're working on the third one now. But the first ones never came back. The first one became a specialist [of the] brain, and that's not working in a village. He married a lady who would never move out of a city. The second one – undetermined. The third one is about to start.

PD: New lease on life? A tumor gets you into NOAA. Can you be grateful for something like that?

RS: Oh, yes. I'm grateful all the way. There's so many different ways a person can go. I've never really worked in my life. I consider my job a privilege, and it gives me travel and meet neat people and write papers and stuff. When it's a snow day, I come in – "Wow, I get to work today with no phone calls." At night, I do the same thing – I work – and on the weekends because there's so much interesting stuff going on, and your whole life is like that. It should be. People say, "Oh god, I just can't wait to retire." I'm retiring so that my salary can be used to save young people's jobs because our budget is stable. So, if a person retires of my age and level, and I'm way beyond a normal retirement age, I can save two or three jobs. So, why not? I don't need the money. That guy I met when I was just out of school, we invested wisely. We own apartments and other things. That's better than the government income, so why not?

SW: What do you think has given you this lifelong good humor and can-do spirit?

RS: It must be genetics. I think our upbringing. I can never remember having a spanking. I can only remember once my mother really reprimanding me, and that was when I was about four years old in the village in a creek that was going by. Some kid started a fire, and it started burning the whole valley. I ran over to watch it. I didn't know much about – and she missed me after a while. She panicked. She went over, and she saw me standing there beside the flames, looking at things going by. I remember her reprimanding me. But you were brought up by the community. I never touched alcohol, never thought of it until I was over twenty-one. Because you said you don't drink alcohol and you don't smoke. Okay. And you don't have sex until you're married. Okay. That's just the way it was. You were told to be a good student. But then, when we left the colony, things changed. I married a Chinese [woman]. Another one of my cousins married a full-blooded Indian. Another one married a Palestinian. We'd never seen anybody other than a white, blue-eyed person. Blonde-haired women, that's all we ever saw. The exotic was just incredible. I still go back twice a year. We get together with – I still have cousins and children of cousins of children and aunts and uncles. I've probably got thirty or forty cousins I've never met because the families – each of my grandparents had ten or eleven kids spread over twenty years. I was in the older group, so the younger ones never even were married or were very young when I left. Then, they got married, and they moved away. So, they have kids that I know about but I have never met.

SW: Got anything else?

PD: If you were to do a documentary like Carl Sagan did, *Cosmos*, and it was a personal journey, what do you think would be yours?

SW: Well, let's make it a scientific journey. I would think that I would be an advocate for people to look at the data of how we are changing the atmosphere. We are changing it so dramatically, and it's hard to believe, and as we change the atmosphere, we're changing the climate, and it's such a simple equation because the atmosphere is driven – the temperature in the atmosphere is driven by a couple of molecules. For hundreds of thousands of years, these molecules were in a constant concentration, so the sunlight comes through, and the atmosphere is not warmed from above; it's warmed from below. So, the sunlight comes through the atmosphere, hits the ground of the ocean, radiates back up, and this blanket of gas – CO₂ and methane molecules – are just like feathers in a feather bed, and they hold the heat. With an analogy – if you're in a house and it's cold, and you want to be warm at night, you put on an extra comforter of feathers, and in a few minutes, you're warm. It's not because

the blanket warmed you; it's because you warmed the blanket, and the heat is held. It's exactly the same thing in the atmosphere. The atmosphere has these little feathers, these eiderdown feathers of CO2 and methane. We have essentially added fifty percent more of these feathers to the atmosphere in the last hundred years. Before, it was in stable condition, the heat coming in, and now we've added this extra blanket. There's just no discussion; climate change is coming, and we've put so many feathers out there; we can't go catch them up. So, we are into climate change. We've got to either stop putting out so much or adapt or both, and I think we have that choice. But it's such a simple thing. You can't argue physics. You can argue religion, politics, finance, relationships, but you cannot argue with basic physics, and the basic physics is sunlight comes in, it warms up the Earth and the ocean, the radiation is out, the atmosphere holds it, and we've doubled the blanket or added fifty percent. The heat is there. It's all been going back into the ocean for the most part, but eventually, it comes out because it doesn't go away. If it goes into the ocean, it'll come back out somewhere. When it does, it's really going to warm up. Then, when you really warm-up, all of the peat and all of the permafrost are going to melt. There's as much CO2 and methane in the permafrost as there is under the ground in oil and gas. So, now we're going back to tropical. Someday, there's going to be big, tropical trees growing right here in a permanently warm climate. So, man's effect on Earth – you can see it. Let's just do an analogy. All of the prairies that were once wild grasses and animals, we've turned into farms. We've changed the whole structure of that. We've done that land. Oceans, we've overfished them; we've polluted them. We've done it to that. Now we're doing it to the air. We are a species that's growing too fast, consuming too much, and eventually, we're gone too. It might be thousands of years. It may be less. It may be more. But you can see we can't just continue doing this. It's a constant evolution. On the evolution of the Earth, we're just a speck on the large spectrum.

PD: I think we have a lot of good material here.

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Reviewed by Molly Graham 2/23/2022