TJ Higgins:	00:01	I'm TJ Higgins and I'm interviewing Professor Susanne von Caemmerer on this date, 27th of April 2022 for the Australian Academy of Science. It's part of Conversations with Australian Scientists program.
TJ Higgins:	00:20	Susanne, it's a great pleasure to interview you. I'd like to start by asking you where you were born?
Susanne von Cae...:	00:29	So I'm German, and I was born in Freiburg im Breisgau, which is a town at the edge of the Black Forest. It's a beautiful city, very old.
TJ Higgins:	00:39	I've been there.
Susanne von Cae...:	00:42	I went to school there. I finished my high school there, everything. It was a very pleasant life there. I went to the public schools and got, I think, a very good education.
TJ Higgins:	00:56	You were very impressed with pure maths?
Susanne von Cae...:	00:59	I loved mathematics, yes. I always did. Even at school. I think when I was 13, I had decided that I would like to study mathematics, and especially pure mathematics.
TJ Higgins:	01:10	So what influenced you?
Susanne von Cae...:	01:13	Well, I guess my aunt and uncle were both mathematicians, so I had mathematicians around me.
TJ Higgins:	01:19	Yes. The Neumann's [Hanna and Bernhard]
Susanne von Cae...:	01:22	So that sort of gave me... Also, I was good at it, and I was dyslexic. I couldn't read or write very well. So, mathematics was a real easy thing to do.
TJ Higgins:	01:33	So you wanted to study mathematics in university, if possible, but you couldn't for some reason?
Susanne von Cae...:	01:39	Well, I could have. In Germany, I would've had to study mathematics with either physics or with economics. None of those two really excited me that much. I really had always wanted to do mathematics together with biology or plant biology, but that wasn't really fashionable at the time. People

hadn't really been thinking about it. I mean, bioinformatics didn't really exist yet, and so on.

TJ Higgins: 02:07 Yeah. You were very lucky, I think, to take a gap year?

Susanne von Cae...: 02:09 I think I was very, very lucky. Yes.

TJ Higgins: 02:12 It was a wonderful idea. Especially with your relatives.

Susanne von Cae...: 02:18 Yes.

TJ Higgins: 02:18 Here in Canberra, who were also Fellows, both of them are Fellows of this Academy.

Susanne von Cae...: 02:22 Yeah. We always had very close connections with our families. My sister, who was the goddaughter of Hanna Neumann, actually, came and went to school here for a year. We've always had that communication. Their children came and lived with us in Germany, and so on.

TJ Higgins: 02:39 So you knew about Australia?

Susanne von Cae...: 02:41 I knew a little bit about Australia, yes.

TJ Higgins: 02:43 You went to a girl's school?

Susanne von Cae...: 02:45 Yes. I went to a girl's school and actually it stopped being a girl's school the year after I had my intake, when the German government decided that all schools should be mixed.

TJ Higgins: 02:56 Yeah.

Susanne von Cae...: 02:57 It was a girl's school and I was lucky that it was a girls school that focused on science.

TJ Higgins: 03:03 Yes. I was quite surprised by that.

Susanne von Cae...: 03:05 Yes. It sort of meant there were girl schools that... Well, there were schools, it was also boy schools that focused more on languages. And there were some that focused more on science and having a school that focused on science was very good.

TJ Higgins: 03:19 Suited you very well?

Susanne von Cae...: 03:20 It suited me very well. I got to go there, because my mother had thought it was really good to go to a mixed school and send my brother to the humanities school, where he had to do Greek and Latin. She realized that was not very... Didn't suit him all that well. Actually, I finished my high school. My abitur in Freiburg and I had the invitation from my aunt and my uncle to come here to Australia. My aunt, unfortunately, had already died the year before.

TJ Higgins: 03:46 Oh, had she.

Susanne von Cae...: 03:47 Yeah. I guess, it was a good opportunity for me to travel and it seemed ideal to get away from home.

TJ Higgins: 03:55 Yes. So, when you arrived in Canberra on your gap year, what did you do in that first year? You did enrol later.

Susanne von Cae...: 04:03 No, I did enrol in that first year. My uncle, being very proactive, had enrolled me. He'd also booked me into Bruce Hall, one of the colleges. I enrolled in pure mathematics and applied mathematics. I was in the Arts Faculty, and I could do two sub-majors. I did one in philosophy and one in botany, which was a lot of fun.

TJ Higgins: 04:24 Which was really ideal for you, considering what you wanted to do in your earlier life. It's very interesting that you got a Bachelor of Arts degree?

Susanne von Cae...: 04:36 Yes. I'm very proud of it. I always thought mathematics was an art.

TJ Higgins: 04:40 Yes. At that time, it was possible for you to get an education that was relatively inexpensive. You didn't end up with a big debt?

Susanne von Cae...: 04:48 No, I didn't. I think the first year I was here, there were still fees, and my uncle very kindly paid them. Some of my aunts very kindly paid my accommodation. I had a family that sort of supported all us cousins in our education.

TJ Higgins: 05:05 Gough Whitlam had a big influence on the cost of university?

Susanne von Cae...: 05:10 Yeah. I could not have stayed if universities had not become free in Australia, because, of course, they were free in Germany.

My parents were perfectly prepared to pay for my living allowance, but I think, university fees would've been too much, and I would've had to go back.

TJ Higgins: 05:27 The politics in Australia, at that time, one could say, contrast a lot with the current situation.

Susanne von Cae...: 05:36 Yes. Yes, and it's very sad.

TJ Higgins: 05:38 Governments, at that time, were more interested in evidence and in science and philosophy than, say modern day politicians. I would say.

Susanne von Cae...: 05:50 Yes, I think so. Yes. I think, yes, it was a very good time to be at university.

TJ Higgins: 05:54 So when you finished your Bachelor of Arts degree, you either had to go back to Germany or you had to do something to get a visa.

Susanne von Cae...: 06:06 Because I was on a typical student visa, which, of course, expired once I had finished my degree. But at the time, the immigration department was in Barton and very relaxed. They made me a cup of tea, sat me down and said, now, these are the things that you..

TJ Higgins: 06:23 Told you what to do?

Susanne von Cae...: 06:23 ..and told me what to do. I looked through the job ads and the technical officer positions, or technical laboratory technicians' positions at the time were permanent.

TJ Higgins: 06:35 Oh, okay.

Susanne von Cae...: 06:36 Yes. They were all permanent, so that suited me very well, and I applied to RSBS Environmental Biology.

TJ Higgins: 06:42 So who were you working for initially?

Susanne von Cae...: 06:45 Initially, I was working for Dave Sheriff, who then later on moved to Darwin, and I just sort of bumbled about a bit. He was very pleased to have someone with some statistical knowledge and so on.

TJ Higgins:	06:57	Yes.
Susanne von Cae...:	06:57	Yeah. So, I did some interesting experiments.
TJ Higgins:	07:00	Graham Farquhar then asked you if you'd like to do a PhD?
Susanne von Cae...:	07:05	Yes. In the department, we had a lot of conversations, always. I think people underestimate how important morning and afternoon teas were. We would sit around and discuss some of the science.
TJ Higgins:	07:17	Absolutely.
Susanne von Cae...:	07:17	Graham said, was I interested. They were just starting on wanting to do a model for C3 photosynthesis, because he and Ian Cowan were working on Stomatal Optimization theories.
TJ Higgins:	07:29	Yes. So, you were a real find for them, because of your mathematical background? I would say.
Susanne von Cae...:	07:37	Yes, I think so. I think what I brought, actually, I mean, pure math isn't really that useful. Quite honestly, but what I brought was a different way of thinking about biology, which I think was useful.
TJ Higgins:	07:50	Oh, absolutely, yes. You benefited a lot, I think, from your interactions with Ian Cowan?
Susanne von Cae...:	07:56	Yes. He was very good. He was a very good mentor and always took the time to explain.
TJ Higgins:	08:00	A classic mentor, I would say.
Susanne von Cae...:	08:02	Yes. He was very good. I learned a lot from him.
TJ Higgins:	08:06	You still have his little book?
Susanne von Cae...:	08:08	Yes, I do. It's handwritten. Because at those times, we didn't have computers and the departmental secretary would not have wanted to type it.
TJ Higgins:	08:19	He also helped you out with physics, I think?

Susanne von Cae...: 08:22 Yes, he did, because I hadn't done it. I mean, we had very good physics at my high school, but I didn't have a lot of the sort of gas law physics that I needed for what I was doing with the models. So that was very helpful to get that really good and very, very rigorous grounding.

Susanne von Cae...: 08:41 When you finish a PhD, you look around for postdoctoral fellowships. And actually, there was no email. So, I had applied for a postdoc with Joe Berry, but I also had applied for several postdoctoral fellowships in Germany. I had applied for one with Professor Heber. I'm not sure whether you know him? But, of course, mail is slow, and the letter of acceptance came after the one from Stanford. So, I took the one from Stanford, but I think it was actually the right choice to stay, not go back to Germany, because being a female scientist in Germany was still very difficult.

Susanne von Cae...: 09:23 I must admit, I've always had excellent support from people like Professor Heber. He has always supported my career all through, but many of them gave me the advice. Don't bother coming back just at the moment, just because it's too difficult. So, I did sort of one and a half years at Stanford, and I was very grateful that. Barry Osmond had a fellowship that I could go to. And I came straight back to Australia.

TJ Higgins: 09:51 So Graham Farquhar and Chin Wong were important colleagues?

Susanne von Cae...: 09:57 Yes. Very important colleagues.

Susanne von Cae...: 09:59 I could always go to Graham, again, with a cigarette in hand and ask some questions if I didn't understand something.

TJ Higgins: 10:07 This was an incredibly important time in photosynthesis. I think that Graham was desperately trying to figure out CO2 diffusion and getting a good model system?

Susanne von Cae...: 10:18 Yes.

TJ Higgins: 10:19 And I think that's where you excelled, made a huge contribution to their work?

Susanne von Cae...: 10:25 I guess, we really worked together. I think Graham and I were very lucky, and we still are, that we can talk with each other

without having to say a lot of words and know exactly what the other one is thinking. We may not agree, but we were a good team.

TJ Higgins: 10:40 Yes. So, you can develop equations yes. Rather than talking and using lots of words.

Susanne von Cae...: 10:44 Yes. That's right.

TJ Higgins: 10:47 You also had international collaborations at that time. I think Joe Berry was probably very important at the Carnegie Institution of Washington and Stanford?

Susanne von Cae...: 10:57 Yes. He was very important. I guess we were very lucky actually, at the time, because we had Barry Osmond as Head of Department of Environmental Biology, part of my PhD. And he always invited everybody to RSBS so there were lots of international visitors to the department.

TJ Higgins: 11:12 Sabbatical visitors.

Susanne von Cae...: 11:13 Yes. A sabbatical visitor.

TJ Higgins: 11:15 Really important.

Susanne von Cae...: 11:16 So our department was always full with people that one could talk to. I realized after I finished my PhD, I think, it was '81. There was a botanical Congress in Sydney.

TJ Higgins: 11:30 Oh, I remember that Congress.

Susanne von Cae...: 11:31 Yeah. I went to that and presented my work and I realized, I already knew everybody who was working in photosynthesis, because Barry had them all in our department.

TJ Higgins: 11:40 All the people who were making big contributions in that area?

Susanne von Cae...: 11:43 Yes. It was a wonderful time to do research in photosynthesis.

TJ Higgins: 11:47 Murray Badger was a colleague of yours around that time, too?

Susanne von Cae...: 11:52 Yes. He was also in the department, and, of course, he was more biochemistry-focused. I really admired his knowledge in f physical chemistry if you sort of know what... Yeah. Yeah. I had

this mathematical model I was trying to do, but, of course, I also wanted to do experiments, and so on. Murray was someone I could always talk to on how to best, perhaps, do the experiments.

TJ Higgins: 12:21 He's a real experimentalist.

Susanne von Cae...: 12:22 Because he's a real experimentalist, but also a real biochemist. Trying to get enzymes out of a leaf is not that easy. You can get a brown soup very quickly.

TJ Higgins: 12:31 Yes. Or a green brown soup anyway, at the best.

Susanne von Cae...: 12:34 Yeah. So, all that knowledge that I needed was really in the department and helped a great deal.

TJ Higgins: 12:40 So one of your many big contributions was the gas exchange equation?

Susanne von Cae...: 12:45 Yes.

TJ Higgins: 12:45 I think that has had a huge long-standing impact.

Susanne von Cae...: 12:48 Yes.

TJ Higgins: 12:49 Still.

Susanne von Cae...: 12:50 Yeah. Graham sort of said, go and do it, and gave me a paper to read. Yes, that has been very influential. It's used in every piece of machine that measures gas exchange. It was a novel way of doing it because it was looking actually at the ternary diffusion rather than just binary diffusion. So, I was taking into account the effect water coming out of the leaf would have on CO2, trying to come in, which had not been considered.

TJ Higgins: 13:18 But later, other contributions that you've made, many contributions, as I've said, was the relationship between rubisco, that the enzyme that fixes CO2 and electron transport and gas exchange. I think you added a quantitative aspect to that?

Susanne von Cae...: 13:34 Yes. I think, everybody knew rubisco, the primary carboxylation, and there's a lot of rubisco protein in the leaf. Gas exchange was only just becoming doable, popular, people had

instruments. There were lots of experiments around where people had measured photosynthesis and then they had extracted something like rubisco and found that both varied together when you grew plants at different light, nutrition, and all that sort of stuff. But no one had actually bothered to put the numbers together.

Susanne von Cae...: 14:04 So there'd be CO2 simulation rates and micromolar per meter squared and then mg protein for rubisco and no one really thought about what the quantitative relationship should be. That's something we sorted out with the model.

TJ Higgins: 14:16 You certainly did, and your mathematical background probably helped you?

Susanne von Cae...: 14:21 Yes. I think it sort of gave me that interest and actually working out, had I got out all the rubisco out of the leaf that I wanted.

TJ Higgins: 14:30 Following on from that, a little later, work that had been done by Murray Badger and John Andrews on using biotechnology to make transgenic plants allowed you to then maybe verify some of those?

Susanne von Cae...: 14:48 Yes. That was a very exciting time, actually. We had this model hypothesis, which was based on rubisco kinetics, that we could say, CO_2 assimilation rates are limited by the amount of rubisco under low CO2 or limited by electron transport capacity. But all through my PhD, I wasn't really able to probe or test that hypothesis, because whenever I tried to grow plants under different growth conditions. For example, I tried elevated CO2, because I argued, Plants would actually need less rubisco under those conditions. But plants didn't seem to know that.

TJ Higgins: 15:21 Or they adapted.

Susanne von Cae...: 15:22 Everything was always correlated, so correlations are really very hard.

Susanne von Cae...: 15:29 So when John Andrews and Murray Badger started doing transgenic plants, that was really a tool for me that was ideal for a mathematician, because with the antisense technology, you could get plants that had a whole range of rubisco activities and you could make wonderful graphs with that.

TJ Higgins:	15:49	Yeah. So that was a great era?
Susanne von Cae...:	15:50	Yes.
TJ Higgins:	15:51	That technology was hugely valuable to you and your colleagues. Later you, I'm not sure exactly of the timing of this, but you were interested in C4 photosynthesis?
Susanne von Cae...:	16:05	Yes.
TJ Higgins:	16:06	And you'd done a lot of work on C3 plant, but you also became very interested in C4?
Susanne von Cae...:	16:12	Yes, of course, that interest was sparked by having Hal Hatch up at CSIRO doing C4 photosynthesis. So, it was a natural progression.
TJ Higgins:	16:21	So it was helpful. Of course, one of Hal's post doctorate students, Bob Furbank was a collaborator that you continue to work with even to today?
Susanne von Cae...:	16:32	Yes. We still work very closely together, and we used to have what we called C4 lunches and Hal Hatch would come and we'd tell him all the new things we thought we'd just done.
TJ Higgins:	16:43	And Hal would be delighted with this.
Susanne von Cae...:	16:45	He would be delighted. Yes. It was always great. So yes, it was actually Joe Berry who had done the very first rudimentary C4 model. It was empirical and the equations were a little bit rough, but he had shown that if you concentrated CO2 in the bundle sheath, you could get the sort of gas exchange phenotype you would expect and I sort of built on that and developed some analytical equations, which were easier to solve.
TJ Higgins:	17:12	So mathematics came back into it, again?
Susanne von Cae...:	17:14	Yes. Mathematics came back into it.
TJ Higgins:	17:15	And equations?
Susanne von Cae...:	17:18	Yes, and I've actually just updated that model last year.

TJ Higgins:	17:20	Have you?
Susanne von Cae...:	17:21	Yes. Because one of the big problems with models is to have good parametrization and for a long time it was sort of higgledy-piggledy of rubisco kinetics for maize. PEP carboxylase kinetics from this plant and it was all a bit of a mix. Now we have the model species *Setaria viridis* that people have embraced.
Susanne von Cae...:	17:43	It's sort of our C4 Arabidopsis and people have actually developed all the kinetic constants for the different enzymes. So, I was able to put together a coherent model parameterized from one species.
TJ Higgins:	17:56	You've been involved in a very big project funded by the Bill and Melinda Gates Foundation with colleagues, originally, I think, at IRRI in the Philippines. But now with colleagues in Oxford, of course. And Bob is still continuing.
Susanne von Cae...:	18:11	Yeah.
TJ Higgins:	18:11	So that's still a big activity for you and probably still a challenge?
Susanne von Cae...:	18:16	Yeah. It's a big challenge. We have another two years of funding and I guess we're hoping we may get some more. It's a very big challenge and it's quite interesting how that project has changed from when we began in 2009, where we did lots of mutagenesis screening at IRRI of EMS sorghum mutants and so on. And all our transgenic plants that we made at the time in rice, was sort of one gene at a time and then crossing it in.
Susanne von Cae...:	18:48	Of course, now, it's developed. We now put five or six genes into a golden gate construct and do it all at once. So, during that long course of research the technology has really developed.
TJ Higgins:	19:04	But also, not just the technology, your knowledge about some of those genes has greatly helped you?
Susanne von Cae...:	19:09	Yes. That's right., When we started, we didn't know all the genes. We'd only just sort of probably almost completed the metabolic list.
Susanne von Cae...:	19:23	Bob Furbank and I have been mainly working on the metabolism of C4 photosynthesis, whereas Jane Langdale's lab in Oxford has been focusing on the sort of leaf development and things like

that. transporters were one of the things that were still missing. We didn't know all of the transporters that were getting metabolites in and out

TJ Higgins: 19:42 Which ones were important.

Susanne von Cae...: 19:43 Yeah. Important for chloroplast.

TJ Higgins: 19:45 And are you getting there?

Susanne von Cae...: 19:46 I think we're getting there. Yeah. We're not 100% sure of all of them, but we're getting there. So that's exciting. We're starting to put our metabolic constructs together with leaf development construct...

TJ Higgins: 20:03 I just wanted to go back to one other area of work that you've been involved in for a long time and that's your collaboration with John Evans? Another Fellow of this Academy. The work that you did on partial pressure of CO2 in the chloroplast versus elsewhere in the cells?

Susanne von Cae...: 20:30 So John, of course, was also doing his PhD with Graham. He was just a year behind me. He did the first experiments together with, I think, it was Joe Berry actually trying to make measurements of carbon isotope discrimination. They wrote a paper, and I very strongly disagreed with what they concluded. I thought it really wasn't right. That sort of started an argument between John and myself, and we decided the...

TJ Higgins: 21:00 A friendly argument.

Susanne von Cae...: 21:01 A friendly argument, scientific argument. Yeah. And we decided that really the best way to resolve it was to do some experiments together, and sort it out. That turned out to be very fruitful.

TJ Higgins: 21:14 Did you correct John and Joe's paper?

Susanne von Cae...: 21:17 Yes. I think I did, but it actually turned out that both of us weren't completely right. As often it happens, and we came up with slightly newer ideas. In the initial model of C3 photosynthesis, Graham, and I had thought that the drop in CO2 partial pressure from the intercellular air space to the chloroplast, wasn't very large, and that we could actually ignore

it. But later on, it did turn out that it would perhaps be important, because, of course, that drop changes with flux and so on. It affects the carbon isotope discrimination, which is why we can make measurements of it. But that, of course, also affects atmospheric carbon isotope composition. So, getting it right is actually quite important.

TJ Higgins: 22:06 Being quantitative, again?

Susanne von Cae...: 22:08 Yeah. Helps.

Susanne von Cae...: 22:09 I guess, sometimes I'm a bit surprised. All my research is actually focused on the leaf. I've hardly ever done research on the whole plant and all these sorts of things. I guess it's the interplay between leaf structure and the biochemistry that are really important to understand. Going back to mesofphyllconductance, which is sort of what seems like such a trivial thing, but at the moment, all the terrestrial photosynthesis models are still parameterized without it.

TJ Higgins: 22:39 Are they?

Susanne von Cae...: 22:41 Yes, and it's really sort of the next step. They have to incorporate it. Some of the things that we're currently learning is that the temperature dependence of that conductance is actually quite diverse with different species. We just published a paper on it in 2015. So, there's quite a lot to put in to improve the global models, really.

Susanne von Cae...: 23:01 Well, impact of improving the global models, we'll be able to give better predictions of what the global CO2 uptake is, which of course, in climate change is very important. Only talking about the terrestrial biosphere, not the oceans, which are equally important. I guess what's thrilled me most is that all these leaf-level processes, which seem very obscure and a little bit... Why would you want to know the difference in CO2 partial pressure between inside the leaf and the chloroplast. They do actually have an impact, that you can study leaf-level processes that impact on the global scale.

TJ Higgins: 23:38 What role did Margaret Barbour have in this? Have I misinterpreted her role? I know that you did some work with her.

Susanne von Cae...: 23:47 Yeah. We've done work with her, also, in mesophyll conductance. I guess she was also a student of Graham's, later on. Her research focused more on water relations and O18 discrimination, but she then also became interested in mesophyll conductance. Perhaps a little bit after John and I did but as often happens with research around the world other labs were also suddenly getting interested in mesophyll conductance and CO2 partial pressures inside the leaf. So, we were not the only one.

TJ Higgins: 24:20 Yeah. So, she made a contribution, as well?

Susanne von Cae...: 24:23 So she made a contribution as well, and she was always very proactive in getting in new instrumentations up and so on. So, I took advantage of that and visited her.

TJ Higgins: 24:31 Just speaking of international collaborations, of which you have many. You have also worked with Steven Long and Christine Raines for many years in the UK and more recently in the US?

Susanne von Cae...: 24:48 Yes. So, Christine, struck up the collaboration with me and she came actually to RSBS, because she wanted to learn gas exchange in those techniques. Then very kindly, she got me a Leverhulme Visiting Professorship to come and visit her at Essex. That sort of started our collaboration, and it's actually where I learned most of my molecular biology. Having come from pure mathematics I really had very little knowledge. So very slowly step-by-step I managed to accumulate some knowledge

TJ Higgins: 25:19 Re-educate yourself?

Susanne von Cae...: 25:19 Yeah. Re-educate myself.

TJ Higgins: 25:21 Yeah. Which you have done really in a most exemplary fashion, I would say.

Susanne von Cae...: 25:26 That sort of has continued as an ongoing collaboration. We're doing some very exciting research together at the moment as part of RIPE [Realizing Increased Photosynthetic Efficiency for Sustainable Increased in Crop Yield].

TJ Higgins: 25:34 Yes. Well, that's another big collaboration that you've got funded by the Bill and Melinda Gates Foundation and really

some important advances have been made there, as well. Not just in C4, but in C3 plants.

Susanne von Cae...: 25:50 Yeah. In C3 plants. So RIPE has focused more on C3 plants, and I have worked mainly on mesophyll conductance together with Steve Long. We have a joint little group, which is really exciting. We have our monthly meetings.

TJ Higgins: 26:03 He has also focused quite a bit on modelling and sort of mathematical approaches, which probably appeals to you a little bit?

Susanne von Cae...: 26:11 A little bit, but the thing about mathematicians is that they only like their own models. It's a terrible thing to say.

TJ Higgins: 26:24 I think Steve likes your model.

Susanne von Cae...: 26:26 Yeah. He likes my model. Yeah. We like each other's models and it's good to talk to some other models, but Steve has very much tried to make more complete models, put every enzyme step in which is, of course, something you can only do if you have a lot of computing power.

TJ Higgins: 26:41 Which has changed, of course, with time.

Susanne von Cae...: 26:42 Which of course has changed and of course, you can do. The other thing, of course, you need is the ability to parameterize. All those functions. So, I guess the model that Graham and I did was very much streamlined. We wanted as few equations as possible.

TJ Higgins: 26:59 I know you got rid of a lot of things just to make the equations work.

Susanne von Cae...: 27:00 Yeah. Just so you could actually do it by hand, you don't need a computer.

TJ Higgins: 27:04 Did not need an international-

Susanne von Cae...: 27:05 But the models inter-mesh and yeah. Steve Long had a PhD student, Xinguang Zhu. He's now in Shanghai and we are very close friends, we always discuss the various model outputs.

TJ Higgins: 27:21 Yes, you have a huge number of international collaborators.

TJ Higgins:	27:21	One of the things that I think you say you struggled with is the role of chloroplast and stomatal function. I think you feel that perhaps you haven't sorted that out yet?
Susanne von Cae...:	27:33	No. I probably won't have time to sort it out. As I was sort of struggling, you think, what will I write my next grant on? And C4 photosynthesis having the model, it seemed very easy for me to get funding and progress with it. That was sort of... and again, in collaboration with Bob, we made the transgenics in Flaveria. In stomatal function, I had some really interesting results that no one liked. I got booed down at a stomatal meeting in Snowbird from the physiologists and one of the molecular biologists said, oh, you did wake up the people, didn't you.
Susanne von Cae...:	28:16	It was actually, Chin Wong's thesis with Graham had pointed out, that there is a really close correlation between photosynthetic capacity and stomatal capacity. They always go hand-in-hand, so the ratio of intercellular to ambience CO2, is almost conserved. So, when we then had the transgenic plants and we reduced the amount of photosynthesis by reducing the amount of rubisco, we realized that we could completely break that link, so it really was just a correlation. I guess that question is still open, how these two processes are coordinated.
TJ Higgins:	28:54	So that's a big challenge for future?
Susanne von Cae...:	28:57	I think it's a challenge for future generations. And it's also quite interesting. I don't think chloroplasts in guard cells - I think they've just been some recent papers - do the same thing as chloroplasts in mesophyll cells.
TJ Higgins:	29:09	I wanted to turn to something else, now, and that is your career as a woman in science during an interesting period of time. I think you did very well.
Susanne von Cae...:	29:21	It was very interesting. The one thing that I didn't write in my notes, but I was very careful of at the time. When I wrote my first papers, I noticed that in Plant Physiology, the American Society Journal, that the men, their names were listed with just the initial for the first name. But for women, the whole first name was spelled out. And so, I was very careful to only ever use an initial for my first name, because I didn't want it to be known that I wasn't a man, because I think my work would've not been regarded in the same way at the time.

TJ Higgins:	29:54	It's very interesting and very sad.
Susanne von Cae...:	29:56	Yeah. I mean, it has passed now, but...
TJ Higgins:	29:58	It is passed now, but it must have been extremely difficult at the time.
Susanne von Cae...:	30:03	Yeah. It was difficult.
TJ Higgins:	30:05	But you were lucky as well. I think you had your colleagues, like Graham and Barry, particularly, were probably supportive?
Susanne von Cae...:	30:11	They were both very, very supportive. I could see just how supportive they were because there were other postdocs within the Research School of Biological Sciences that didn't get the same support once they had children. -
TJ Higgins:	30:23	Plenty of women didn't get that support.
Susanne von Cae...:	30:25	No. So, I really got it.
TJ Higgins:	30:28	Well, you earned it as well.
Susanne von Cae...:	30:30	I think I was a bit bossy too, which is a terrible thing to say.
TJ Higgins:	30:36	I can't believe this, Susanne.
Susanne von Cae...:	30:37	I made them change all the seminar times, because we used to have seminars from four to five, in the afternoon. But if you came late to pick up your child from creche, you got slugged something like $10 for every five minutes. So, I couldn't afford to be late.
TJ Higgins:	30:53	So there was a good reason to change things around and you got them to agree, and that would've been difficult at the time. Much easier now, of course.
Susanne von Cae...:	31:01	It's much easier now, but Graham and Barry, of course, were always supportive, and yeah, we did it. Yeah.
TJ Higgins:	31:06	Yeah. So, I'm glad to be able to count some men as doing the right thing.
Susanne von Cae...:	31:09	Yes.

TJ Higgins:	31:10	At the time. This is, 40 years ago. Really.
Susanne von Cae...:	31:13	Yes. It's a long time ago.
TJ Higgins:	31:14	It's a long time ago, and you did really well to manage that. I think.
Susanne von Cae...:	31:19	Yeah. I think it was more the perception in the general science community or wider one. That once you had children, you were no longer fully committed to doing science. It was sort of a subconscious bias, that's what was the case. So, it was hard to counter that.
TJ Higgins:	31:38	Yes. Very hard, but you did.
Susanne von Cae...:	31:40	Yeah, but I did it. I was going to go and work three quarter time or part-time and Graham just said, don't bother, just work full-time. You'll do enough work, even if you're not there all the time.
TJ Higgins:	31:53	Oh, I see. In terms of pay, he was talking about?
Susanne von Cae...:	31:55	Yes. Yeah. Just yeah.
TJ Higgins:	31:57	But you did take some leave without pay?
Susanne von Cae...:	31:58	I did. Well, I had to, I mean, when you have a baby, you have to look after it.
TJ Higgins:	32:03	Yes. You do have to. There are some responsibilities there, and I think you had a supportive husband, as well?
Susanne von Cae...:	32:08	I did. Yes. He was very good.
TJ Higgins:	32:09	Jim, was it?
Susanne von Cae...:	32:10	Yeah. And because he was a teacher, later in life, when the kids were older, it was also easier to manage the family that way. But he's very supportive. I was very lucky. At the time when we worked with all the antisense plants, we were a group doing it together. We were all young and we had young children at home. And I don't know if you have young children, you know that they're always sick, and plants grow. And tobacco plants,

they will be a seedling one week, and then next week, they will be almost too big to do experiments on.

Susanne von Cae...: 32:39 So, we had to really coordinate ourselves. When children got sick, we sort of had these complicated timetables of trying to cover off on the experiments that needed doing and still get the work done and still be home and look after the kids. So, one paper in particular, it hit us all very hard. All the kids had middle ear infections and creche just wouldn't take them. We had to sort of have a schedule of you come for two hours, then I hand over to you and then you go.... but we got it done.

TJ Higgins: 33:11 Susanne, I know you won't want to talk about this, but you have had many awards. You've been a distinguished Professor at ANU. You've been the deputy leader of the ARC Center of Excellence. You've been elected to the Leopoldina. You've been elected to the Australian Academy of Science, equivalent to the Leopoldina, which is in Germany. You've been elected to the Royal Society, a major, major, major honour. There aren't too many Australian scientists or German scientists who are Fellows of the Royal Society. More recently, you've received the Suzanne Cory Medal for biological research. How important do you think some of these recognitions have been?

Susanne von Cae...: 33:58 I've always been delighted, if I got one of these recognitions, because I think it sort of emphasized that the research we were doing here in Australia actually had international impact. That I think was really gratifying to know, because you get these awards if you have international supporters that write you kind references and so on.

TJ Higgins: 34:21 But they write you kind references, because of the work that you have done. They're not doing it without backing

Susanne von Cae...: 34:28 No, but you know what I mean.

Susanne von Cae...: 34:32 So photosynthesis was actually a big research area, as you know, in the 1980s, and so on.

TJ Higgins: 34:39 In Australia. Yes?

Susanne von Cae...: 34:40 In Australia.

Susanne von Cae...:	34:40	So that opened up the possibility to get these awards. There will be other research areas on root microbiome or other areas. Where there's not the density of people researching it, and it would be much harder.
TJ Higgins:	34:56	Yes, Australia was doing fantastic research in photosynthesis for many, many years. Not just at the universities and several universities were very important in this, but also even at CSIRO where it was quite difficult to do such research with some of the leaders, who were then at CSIRO. But it was still hugely influential.
Susanne von Cae...:	35:21	I think I've been incredibly fortunate to have been born into that environment as I was doing my PhD, which I think really set me up for succeeding.
TJ Higgins:	35:30	So you have developed scientific friendships internationally as a result of all of this as well? So, your life has been, I think, enriched by these friendships.
Susanne von Cae...:	35:45	Yes.
TJ Higgins:	35:45	As well as scientific collaboration, it goes beyond the scientific collaborations to friendships as well?
Susanne von Cae...:	35:52	It does. Yes. I think that's one of the fantastic things about doing science, that you really get to know so many people and become close friends with them.
TJ Higgins:	36:00	Yes. You've done a lot of teaching as well, even though you were in the Institute of Advanced Science. Which I think, you regard it as being very helpful to your career?
Susanne von Cae...:	36:10	Yes.
TJ Higgins:	36:11	Being able to devote so much of your time to research only, but then you did do a lot of teaching later?
Susanne von Cae...:	36:19	I guess, I did a little bit of teaching, and I did actually enjoy it. It was always quite interesting. I would ram the equations down their throat. I just felt the students just had to cop it. There were always two halves to the class. Some that really liked it, for them, it made everything clear.

Susanne von Cae...:	36:40	Then the other part of the students just groaned.
TJ Higgins:	36:43	She's got the equations up there again!
Susanne von Cae...:	36:45	Yeah. She's got the equations up there again. Teaching, of course, is very, very instructive in clarifying thoughts. Isn't it?
TJ Higgins:	36:54	Yes. As well.
TJ Higgins:	36:57	I remember walking past a lecture theatre, where you were lecturing. And I was just coming from a lecture that I had given in a different course, but I just stood out there at the door without you knowing that I was there. I found it absolutely fascinating to hear you teaching.
Susanne von Cae...:	37:15	Okay.
TJ Higgins:	37:16	At the time you were talking about C4 photosynthesis in that particular lecture and talking about some of the people that we've talked about earlier, Hal Hatch being one of them. It was very instructive. I enjoyed it, even though I was auditing the lecture, illegally, probably.
TJ Higgins:	37:34	You've had a lot of PhD students, nearly 20 of them, 18, I think. 20 postdocs. You've done a lot of other teaching, not just to undergraduates, but teaching to graduate students and to postdocs.
Susanne von Cae...:	37:50	Yes. Yes. I guess that's sort of a general collaboration, isn't it, with other scientists, which is always really, really rewarding, especially with PhD students [who are] starting to develop their own thoughts and their own interests and being able to help them.
TJ Higgins:	38:08	Yes. Well, you mentioned mentoring earlier when we were talking about Ian Cowan, for instance. The mentoring that you did was probably equally important.
Susanne von Cae...:	38:19	I think taking time with students and perhaps filling in the little gaps I have and helping them along. It's very gratifying.
TJ Higgins:	38:28	Very, yes. I mentioned that you were elected to the Australian Academy of Science a couple of decades ago really. You've had other roles in the Academy? How important was your election

to the Academy of Science as well as the other things that you have done [there]?

Susanne von Cae...: 38:46 I guess, when I first got elected to the Academy, Well, I knew a little bit about it but no really close contact. What delighted me most was suddenly being immersed into a group of scientists from all different disciplines.

TJ Higgins: 39:03 Yes.

Susanne von Cae...: 39:03 I really enjoyed that greatly. John Passioura persuaded me to participate in running dinners for ACT scientists, which were always accompanied by a scientific talk. It gave me immense opportunity to talk to lots of different scientists and learn new things, which I really liked.

TJ Higgins: 39:26 Physics or astronomy?

Susanne von Cae...: 39:29 Yeah. Physics and astronomy and all sorts of things.

TJ Higgins: 39:30 All kinds of things. That's one of the great things about being a Fellow of the Academy.

Susanne von Cae...: 39:36 Yes. I think so, it really is, because it comes with lots of different points of views.

TJ Higgins: 39:39 And you were on committees at the Academy?

Susanne von Cae...: 39:43 Yes, I did. I guess we all do the Sectional Committees. Electing new Fellows, which is actually really difficult. Isn't it?

TJ Higgins: 39:50 It's very difficult

Susanne von Cae...: 39:51 Because you have a long list of excellent scientists.

TJ Higgins: 39:55 Or candidates.

Susanne von Cae...: 39:55 Or candidates, having to make decisions. Yeah.

TJ Higgins: 39:59 You were also on Council?

Susanne von Cae...: 40:00 Yes. I really enjoyed that, actually. It was Andrew Holmes, who was the President at the time. I thought he was an excellent President.

TJ Higgins:	40:10	Yes. Wonderful.
Susanne von Cae...:	40:11	He was absolutely wonderful. I learned a lot from Council, on how to conduct meetings. What to do? How to behave? And all these things that you don't get at the lab bench so easily.
TJ Higgins:	40:26	You've played an important role there as well for science in Australia, by being on those Academy committees. Not to be underestimated, the importance of those contributions. I want to turn now to something that's a bit more politically difficult perhaps, and that is the future of science in Australia. What do you think of science now in Australia compared to what it was like, say back in 1980?
Susanne von Cae...:	40:56	Well, I guess in 1980, we were so very, very fortunate at ANU to have the Institute of Advanced Science.
Susanne von Cae...:	41:04	Which was really an institution for research only. It was in physics and chemistry and biology and medicine and so on. That's, of course, now gone at ANU, but I actually think it's not completely gone within Australia. I think other universities have seen the benefit of having research only little hubs and have set them up at their own universities.
TJ Higgins:	41:27	Yes.
Susanne von Cae...:	41:30	Certainly ARC [Australian Research Council] Centres of Excellence are good opportunities to focus on research. So, I think, there is still a good density of opportunity for doing research-intensive work. I guess when I was doing research, I could think about how CO2 diffuses from the intercellular airspace to the chloroplast. I think it'd be much more difficult to make that palatable now, the very basic research. I think it is much harder to fund, because from the government's attitude that it has to have application.
TJ Higgins:	42:10	Yes. Immediately.
Susanne von Cae...:	42:10	Immediately. At the University I've been on promotions, committees, and lots of different committees. What I realized was, that actually is quite easy in engineering and some of the other disciplines, but, of course, not necessarily quite as easy in the biological sciences. That perhaps the government is not really nuanced enough to see those distinctions.

TJ Higgins:	42:36	Yes. That's a very kind way of putting it. I would say. We need more nuance in the government and investment in science.
Susanne von Cae...:	42:45	Investment in basic science, really.
Susanne von Cae...:	42:47	Yeah. I mean, we would not have Wi-Fi, would we? If we didn't have basic science.
TJ Higgins:	42:52	No. Do you have any advice for PhD students and postdocs?
Susanne von Cae...:	43:02	When you come out of undergraduate and you have finished your honours, you sort of have to make a decision of what you want to do. I think the most important thing about doing a PhD is that you actually want to do some research or it's something you can see yourself doing for three years and enjoying.
Susanne von Cae...:	43:24	I think that's probably the best criteria for the decision: should I do a PhD or not?
TJ Higgins:	43:30	Yes.
Susanne von Cae...:	43:32	If you think you're going to be doing something that you love. Doing a PhD, just for the sake of getting a PhD is probably difficult.
TJ Higgins:	43:42	Not the right...
Susanne von Cae...:	43:42	Not the right way to go.
Susanne von Cae...:	43:43	I would not recommend that.
TJ Higgins:	43:44	I would agree with that 100%. That you have to be absolutely committed to it and not worry about the fact that you may not have a high paying job at the end.
Susanne von Cae...:	43:55	Yes. You probably won't have a high paying job, but you will have learned a lot.
TJ Higgins:	43:59	You'll have a very satisfying job, probably.
Susanne von Cae...:	44:01	Yes, that's right. I guess the fantastic thing about my career is that I've always enjoyed the work I do.

TJ Higgins: 44:10 Just going back to the very beginning, when you first left Germany and arrived in Australia on a gap year. I'm focusing a bit on this, because gap years, I think, are important times for people to think about what it is they want to do. Whether they want to go on to university or want to do something else.

Susanne von Cae...: 44:32 Yes, yes.

TJ Higgins: 44:33 For you. This was relatively easy, I think?

Susanne von Cae...: 44:39 Not really, I wanted to become a violin builder, but my mother really didn't think that was good.

TJ Higgins: 44:46 At wood work?

Susanne von Cae...: 44:48 Yeah. I played the violin, and I was friends was the one violin builder we had in Freiburg and I used to often go to his workshop. I thought, oh, that's something I should try. But my parents were very adamant that I had to go to university.

TJ Higgins: 45:03 Yeah. And do something more academic.

Susanne von Cae...: 45:06 Do something a little bit more academic. Yes.

TJ Higgins: 45:07 Yeah. So, when you came here, having access to the Neumann's?

Susanne von Cae...: 45:14 Yeah. So, it was nice. I mean, I was lucky that my uncle paid for me to stay at the college.

Susanne von Cae...: 45:20 Bruce Hall at the time was very vibrant. There was a lot of international students there and I think a lot of students still had Commonwealth scholarships so they could afford to stay there. So, it was a really lovely community. The nice thing about staying at a college was that, again, I met with lots of people from different disciplines, not just what I was studying myself. I think a lot of students now miss out on that, because they live at home with their parents, because they can't afford to live away from home or at colleges. The nice thing about studying pure mathematics is that there were very few people that actually wanted to study it.

TJ Higgins: 45:57 So you had small classes?

Susanne von Cae...: 45:59 We had very small classes. At the time, it was still terms. We started up in the first year and for the first term, everybody was given a basic course. Then you did a test, and then you were divided into a pass or an honours stream. So pure mathematics had honours right from first year.

TJ Higgins: 46:16 The start of first year.

Susanne von Cae...: 46:18 From the start of first year, because they taught a different type of mathematics, than what they taught in the pass classes, which was more aimed at either physics students, and chemistry students, and so on. I got into the honours stream. Then I think in second year we had 10 students and then went down to six and the last year it was four.

TJ Higgins: 46:38 Had a lot of attention?

Susanne von Cae...: 46:39 We got a lot of attention, and I was the only woman in the class. So, of course. Yeah.

TJ Higgins: 46:45 But that was not a disadvantage?

Susanne von Cae...: 46:47 That was not a disadvantage. I think the pure maths department, I guess it had been led by...my aunt [Hanna Neumann] had set it up. So, no, it wasn't a disadvantage.

TJ Higgins: 46:57 People were ready for it.

Susanne von Cae...: 46:59 Yeah. People were ready for it.

TJ Higgins: 47:00 Yeah. Outside of science, I know that you have been involved in singing, amongst other things. Clearly, you mentioned the violin, which I wasn't aware of. I know that you took part in operas and that you sang in Canberra?

Susanne von Cae...: 47:15 Yeah. Yeah. My husband, Jim, got me into that. He was a keen singer and he said, why don't you come along? So, we joined the Canberra opera chorus, and it was great fun. To go to the country towns and perform operas, just singing in the chorus, which is not a difficult thing to do.

TJ Higgins: 47:32 Yeah. You also did some singing in Stanford, as well. I think.

Susanne von Cae...:	47:37	Yeah. Well Jim, because he couldn't work joined the Middleton or something opera company, which was just between Stanford and San Francisco. So, it was sort of a local opera, which was sort of a steppingstone for people wanting to go to San Francisco. It was great. I mean, I didn't think that. Jim really entertained himself while with doing that. It was good because it got us into a different group of people.
TJ Higgins:	48:03	Yes, absolutely. So important.
Susanne von Cae...:	48:05	Yeah. That's right.
TJ Higgins:	48:06	To have that something else outside of science, as well.
Susanne von Cae...:	48:08	Yeah. That's right. So, it was nice to have the contrast and we enjoyed our time at Stanford.
TJ Higgins:	48:14	I think I'd like to call the interview to an end and thank you, Susanne, for your very open and interesting answers that you've given. It's been just beautiful.
Susanne von Cae...:	48:24	Yeah. Thank you.