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An Interview with Sandra Faber

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Host: Interviewer

Interviewer: Hello and welcome to Annual Reviews Audio, a podcast from Annual Reviews, where insightful research begins. I'm your host, Interviewer. On each episode of our show, we'll speak with a top scientist in fields ranging from biology to sociology. Today we'll talk with Sandra Faber, coeditor of the *Annual Review of Astronomy and Astrophysics*. She is a Department Chair and Professor of Astronomy and Astrophysics at U.C. Santa Cruz and on staff of the University of California Observatories. She recently won the esteemed Bower Prize for her work on the formation of galaxies and her service to the Astronomy community. Professor Faber, thank you so much for joining us.

Sandra Faber: Well, it's a real pleasure to be here, looking forward to this.

Interviewer: Can you pinpoint a moment in your childhood or early education when you first knew you would spend your life studying the stars?

Sandra Faber: Gosh no. I think that moment didn't come until much later, and there were two reasons for that. First of all, when I was young I was living in a family that was not scientific. There was only one person who had gone to college and I didn't get exposed very much to how people actually did science. So science was kind of a remote thing that was wonderful to study, but other people did it, not me. And also there was the additional problem, of when I was growing up in those years, this was the '50s, there weren't any women scientists and in fact, I had no idea growing up what was in store for me.

I saw that the women around me were housewives and that didn't interest me a whole lot, but I had real—no hope that I'd move on and do anything very different. So it wasn't until much later when I started going to high school and I got a lot of encouragement from my high-school teachers and finally, I went to Swarthmore College and began to rub shoulders with real astronomers. At that point I could see that there was a path. You went to graduate school, you got a PhD, you worked for a university, etc. The whole thing didn't become very real to me until quite late.

Interviewer: And what was it about astronomy in particular, that drew you?

Sandra Faber: Well, I always loved astronomy. As a kid I was a science geek. I studied the weather, I had a microscope, and I looked at bugs from pond water. I studied spiders. I did all of those things, but I was always very drawn to astronomy. I didn't have a telescope, but my dad had a pair of binoculars, and I would go out on a summer night and lie down on the grass and just take my binoculars and my star charts and scan the heavens. And I read books, simple books that people gave me about astronomy. And I thought the questions were very interesting, deep, and important.

Interviewer: Give me an example of one of the questions that really intrigued you.

Sandra Faber: Well, I'll answer that by harkening back to my application to Swarthmore, because this is the time when my scientific curiosity was maturing a bit. So, Swarthmore, you know, they ask you to write essays that somehow reveal something about you and the question was: "What do you think you would do with a Swarthmore education?" And, I answered back that what I was really interested in was the origin and evolution of the universe. But I wasn't sure how you could study that. You could study it maybe, by studying the universe in the large, and I understood that was astronomy. So I said, "Maybe I want to be an astronomer."

But then I had an interesting idea, maybe the way to study the universe was to understand it's laws microscopically, you know, if you could understand how matter behaves, where it came from and all of that then maybe that's the key to understanding how the universe evolves. And I said, "And so maybe I should be a chemist." Because I didn't really understand that what I meant was particle physics. I'd never heard of particle physics. So I came to Swarthmore and I started to take both astronomy and chemistry. I didn't like the chemistry; it was too much like cooking doing these experiments at the lab.

But when I saw the telescope at Swarthmore; they had a small refracting telescope. When I saw that I was just absolutely hooked. It was like, you know, a lamb looking at its mother for the first time. I was imprinted on this gorgeous big machine. And I started to observe with that and I got completely hooked. So I guess— It's hard for me to remember the past, but I remember this essay very clearly and in some sense I anticipated there, I take some credit for this, the entire development for cosmology that ensued during the 1970's up to now because it has been truly, a

marriage of particle physics in the small and astronomy in the large. And this is really how we've come to understand the universe.

Interviewer: In your autobiographical sketch you talk about some lucky breaks you had and other opportunities that you had that aren't really available to students today. You talk about having children in the middle of your first professorship and getting a tenure track position right out of school. What advice do you have for young astronomers getting into the field today?

Sandra Faber: I think getting into the field today is a lot tougher. And I would say it's especially true of women because now there seems to be a tradition after you get your PhD, you circulate through one and maybe two post-doctoral fellowships. And that means that you're pulling up stakes every two, three, four years, moving to an entirely new place, setting up household all over again, and starting a new phase of your research career. So I really— I find it hard to give advice to this generation of young scientists because I think they have it a lot harder than I did.

Interviewer: Can you talk a little bit about the balance that you found between family and work?

Sandra Faber: It's always been very, very important to me to have a balance between family and work. And I actually think that my work has been helped, especially in those early years, by having to tear myself away and do something different for some hours a day. I actually don't have that as much now and I think I'm overall, not as efficient per unit time; I get more done now because I have more hours, but I don't think I'm as efficient as I was back then. So we had a daily routine. I do best when I divide up my attention and spend some hours focusing completely on one thing and then switching attention and doing something different.

So that was my mode then, I would come to work and I would largely forget about my family completely, unless somebody called and said that a child was sick. But then at 5 o'clock, I went to pick up my kids and then I was doing nothing except focusing on them for the next four or five hours until it was bedtime. And that was very refreshing, it was an excellent break. Not to mention weekends when we spent a huge amount of time with our children. I would like to mention here— I owe a huge debt to my spouse, Andy because he was always very willing to fill in, more than fill in, take his share, his half of the share. And he's been, you know, a great dad and we've been a real team in parenting. It hasn't been just me.

Interviewer: In your graduate work were you still one of the only women in your field?

Sandra Faber: When I went to graduate school, it was beginning to change. I had a small graduate class. I went to Harvard. There were only five students. Two of us were female and three were men. So already, you could see the pendulum start to swing. But there was quite a lot of resistance to women out there and in fact, I can tell a story about this woman in graduate school. We became very good friends. And a few years later, we're looking for jobs and she got a post-doctoral fellowship at Caltech and a very famous professor from Caltech was visiting Harvard, knew about her, wanted to meet her, said hello, and immediately launched into the following statement, he said, looking at her pleasantly, "You know, I really have nothing against women in science." And then there was a little pause. "As long as they don't get pregnant."

Interviewer: Wow.

Sandra Faber: Now as it happens, we were both thinking about getting pregnant at that time and she was pregnant.

Interviewer: Wow.

Sandra Faber: And as a measure of how things have changed, she was so intimidated, she didn't speak up and say, "Well, that's completely ridiculous and by the way, let me tell you something about myself." She didn't say that, she meekly kept quiet.

Interviewer: How do you sort of maintain your status in the scientific community in an atmosphere like that?

Sandra Faber: I think I was personally very much helped by having a demeanor that is kind of unisex.

Interviewer: What does that mean?

Sandra Faber: Well, in the sense that— I think that the world at large and scientists in general, are less tolerant of either too meek or too aggressive behavior on the part of women. I think more latitude is tolerated in men's behavior. Women are really expected to be quite businesslike, supportive, not passive, but not aggressive, and if you stray to either side you know, you can get labeled as— well I won't use the words that come immediately to mind. So I was very fortunate in that my own personal style fit these needs perfectly.

Interviewer: And when you did leave to start a family, did—do you feel you had to work harder to come back and sort of regain your position in the community?

Sandra Faber: I never left to have a family. I didn't take any maternity to leave of any significance. I had— This is a measure of how things have changed. There wasn't any such thing as maternity leave in the University of California then. And so, I had my first child nine months after I took my job here and I took two weeks off, and I took another two weeks kind of halftime, and then I was back at work full time. And well, full, in you know, in the sense of 40 hour weeks. Professors when they really work full time are working more like 70 or 80 hours a week and I didn't do that for years, and years, and years. And the routine was pretty much the same with the second child, three and a half years later.

Interviewer: And did that hold you back at all?

Sandra Faber: I felt very much when I was an assistant professor with young children— I envied my male colleagues that they had more time to spend on their career than I did. And I think probably it held me back somewhat, but it also probably made me more ruthless about trying to limit my other involvement; it made me focus.

Interviewer: Let's talk about your work on the Hubble Telescope. You were part of the original Wide Field Camera Instrument Group back in the late '80's and you've recently submitted a new proposal for Hubble. Can you talk about you vision for the telescope and how things will be different this time around?

Sandra Faber: Well Hubble I think has been the most productive telescope in the history of astronomy. And the discoveries that you could just tick off here have just been phenomenal. It's hard to communicate now, the degree of incredible anticipation that astronomers had before the launch of Hubble. It's not as though we underestimated the telescope, far from it. We knew very well, what it was likely to do for us, and so there was an incredible fever of excitement. So when Challenger exploded and delayed the launch of Hubble for over four years that was a very, very painful event. So as you know, the original Hubble had a fatal optical flaw. And when that was fixed and the beautiful pictures began to come in, it really was a whole new universe. But the wonderful thing about Hubble is that it's been remade several times over. It's in low earth orbit, which means that astronauts can go up and fix it, service it, and put in new instrumentation. I was on a committee not too long ago that was arguing for one more servicing mission for Hubble and I set to calculating how many—by what factor Hubble is better now than it was when it was first launched, and I came up with a factor of 60. And that's just because better cameras and better instrumentation have been installed in the meantime. So this last servicing mission is kind of the last in a long series of wonderful successes and for me the most important thing is a new camera that's going to operate at longer wavelengths.

And since the universe is expanding, the light rays of distant galaxies are all shifted to the red. And to follow that out into space and time, you have to have a camera, that images at longer wavelengths of light and that's what this camera is going to do. We've had our first pictures from it now and it is truly phenomenal, wonderfully sensitive, and we're all very, very excited about using it.

Interviewer: And you said that your proposal has a— What was it? A five percent chance of being accepted?

Sandra Faber: Yeah, I think it's just about that. We learned later that 37 proposals in this category were received. And they're probably going to make available maybe two or three, something like that. So assuming that everybody is equally deserving, it's like a five or ten percent chance.

Interviewer: What is it about your proposal that should be accepted?

Sandra Faber: Well, my proposal was in a particular area. And it's an area which Hubble has pursued in the past. Maybe you've heard of something called the Hubble Deep Field? It's an example of an extremely deep exposure, the Ultra Deep Field was taken again later, even deeper. These are very long pictures of certain regions of the sky that penetrate out to very large distances and see galaxies as they were back in time. So my proposal was in the same spirit, but to do this now with this new camera and see even farther to earlier times. So a good idea following in an honorable and very productive tradition. There will be many proposals in this particular area and what made our proposal the best I think, was that we combined various levels of exposure into one proposal. We suspect that our competitors will either focus on very deep exposures in short areas or short exposures over longer areas. We stood back and said, "Hmm, if we were the time assignment committee for Hubble wanting to do the best for this area of science, let's try to make a balanced package that has all the right things in it in one place." And so that's what we tried to do.

Interviewer: Tell me a little bit about the optical design flaw.

Sandra Faber: Well, this is the design— This is the construction flaw actually in Hubble. The design was fine. It was just that they polished the mirror, the main mirror to the wrong curve. And so when the telescope went up and started taking pictures, they didn't look like they were just out of focus, they looked worse than that. Part of the mirror was in focus and part was out of focus. It's an optical aberration called, spherical aberration. And it took some time to discover this because there were a lot of prepicture check outs that had to be executed and they were not working because the optics weren't working and people didn't realize why this was. So—

There were a lot of experts, who were ostensibly in charge of checking out Hubble, but it fell to my camera team and me in particular, and a post-doctoral fellow, to really think about this, and we coaxed project management to take a series of pictures moving the telescope through focus. Moving the secondary mirror in and out. And this series of pictures showed a very distinctive series of patterns. And when we saw that we knew immediately that it was spherical aberration and we looked at, and we even measured how big it was. And so we delivered the message to the project that this was a horrible, horrible flaw and that Hubble would never work in its present state.

Interviewer: What was it like to be a part of that team to realize that something that had, you know, so much time had been put in, time that you spent yourself, and that millions of dollars, to find out that it had this terrible flaw?

Sandra Faber: That's a very interesting question. And I was aware of my feelings at the time because actually, I was completely conflicted. On the one hand, I was very upset that Hubble wasn't right. On the other hand, it's hard for me to convey this here on the phone, but that was probably the most interesting science investigation of my entire career. Because nobody knew why this telescope wasn't working and it was really a very small number of people who— It was a combination of politics and optics, trying to get project management to take the observations that we needed in order to diagnose the problem. This went on for about six weeks. And I was going to project meetings, listening to results, buttonholing people in the hall, trying to convince them to do things my way, bringing home new images, and analyzing them. It was exciting. That's what I'm trying to tell you. We really felt that we were on the trail of something very fundamental. And so it was paradoxical. On the one hand, we solved the scientific problem and we felt a thrill that any scientist would feel. On the other hand, in solving the problem, we showed that Hubble was a disaster. I've never been so conflicted before or since but probably also never as fully as engaged as I was then.

Interviewer: You were recently awarded the Bower Prize, acknowledging three decades of your contributions to the field of astronomy. How does it feel to think back over 30 years of your work and what stands out to you as the most significant accomplishment in that time?

Sandra Faber: Well, it's interesting, I don't really think in the terms of accomplishment. I think more in terms of enjoyment. And overall, what really stands out for me is the fact that by choosing to work on galaxies when I was in graduate school; I chose galaxies because so little was known about them. They seemed like the next big thing, and that was a very acute observation. It's been a very, very productive field of research. So I got in on the ground floor. I rubbed shoulders with some of the very best people and learned from them.

Opportunities came my way one after another and so I just kind of feel as though, yeah, I've been a participant in the movie, but mainly, it's been my privilege to watch this movie unfold and with enough training to really understand it. So my thrill is the fact that, you know, 30, 40 years later I'm going to leave the field with a huge amount of understanding about where my topic, galaxies—where they came from. And it's not that so much that I contributed to that, but that I managed in the process to understand a lot.

Interviewer: Along the same lines, some of the— Many of the theories and technology that you helped develop remain a big part of cosmology today. In a world where things can change so quickly, what does it mean to you to have your work stand up to the test of time?

Sandra Faber: Well, I think that actually makes me feel very good. If I could point to one single achievement, it would be collaborating with two of my colleagues here at Santa Cruz, Primack and Blumenthal. Together we wrote a paper in 1984 that laid out the bare bones of everything we know today about galaxy formation; the gravitational clustering of dark matter, and the later infall of ordinary gas to form stars to make galaxies—the galaxies that we see. So I feel now that, that paper is seminal paper in galaxy formation and I feel really great that I managed to be a coauthor of that paper.

Interviewer: What do you see as the most significant find in astronomy over the past 30 years, either your work or the work of someone else?

Sandra Faber: I would say that there are two significant finds in astronomy. One of them is what really my work has been embedded in and that is the understanding of the general sweep of events from the big bang to where we are now in the Milky Way. That's not just one find. It was a lot of finds, but it's a worldview and you know, it's an intellectual edifice, which I think is really most remarkable, that we can sit here on our little planet and figure out what happened over 14 billion years of time; testimony to human ingenuity.

The other thing that I think that is going to be important and that is the more recent discovery of all of these extrasolar planets. We now know 500 of them and dozens more are being discovered every year. My observatory is actually a leader in this. And again, it's hard to know how this knowledge ultimately will be important for us, but over a million or a billion years or so, I think it's possible that somehow we're going to interact with these planets or maybe their inhabitants in some way or another. So I think that's an interesting possibility.

Interviewer: Finally, what would you like the Annual Reviews audience to know about you or about astronomy in general?

Sandra Faber: Well, I'm a great proponent of astronomical knowledge. And very often people, they ask me, "Why should we be doing astronomy?" And it's not so easy to answer right off the cuff. It's not like chemistry for example, better living through chemistry, or physics, nuclear power—any of those things. But I actually would argue that astronomical knowledge is the most important knowledge we have for the human race. And here's why I think this. I think that it's astronomy that puts us in perspective. It tells us where we come from and cosmically, where we're going. So there are many lessons that you learn from this. First of all, astronomy tells us that we're all stardust. All of the atoms, the heavy elements in our body, were generated in Supernovae. They went out into interstellar space, they agglomerated into the solar system and finally, five billion

years later, they're making you and me. So there's an unbroken chain of cause and effect here. So, if we want to understand our roots it's not just where our ancestors came from on earth; it's really our cosmic roots. We are one with our universe and that has good things and bad things about it. It means that in some sense, we're limited. We're prisoners of the laws of physics.

Astronomy tells us that there really aren't miracles. Maybe there was an original miracle in the big bang, we don't understand that, but after that, one thing follows from another in predictable fashion. And we can use that lesson to think about consequences here and now on earth. So what we're doing today, according to the laws of physics is going to have consequences. And this is all about the environment and global warming. And astronomy again, says, cosmic stage, the nearest help is very far away, don't count on colonizing Mars. I mean, colonizing Mars is a million times harder than colonizing Antarctica. Nobody would even think about doing that.

These notions are totally ridiculous. But at the same time, it holds out hope. It says that the sun and the solar system are going to live another billion or two years. So you know, we have the gift of cosmic time, there's motivation here if you care about the legacy of our species to get through this very difficult time, which is here and now and live sustainably on our planet. If we can make that transition, then wow, there's just no telling what we might be able to achieve and do.

Interviewer: Professor Faber, thank you so much for talking with us.

Sandra Faber: You're very welcome.

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