DISCOVERY AND NEW FRONTIERS ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

KEVIN RIGHTER
INTERVIEWED BY SANDRA JOHNSON
ROCHESTER, NEW YORK – AUGUST 15, 2024

JOHNSON: Today is August 15th, 2024. This interview with Kevin Righter is being conducted for the Discovery and New Frontiers Oral History Project. The interviewer is Sandra Johnson and Dr. Righter is in Rochester, New York, and talking to me today over Microsoft Teams. I appreciate you joining me today and agreeing to talk to us for the project.

I wanted to start by asking you to briefly describe your education and background and how that prepared you for your work with NASA's Astromaterials Research and Exploration Science Division at JSC.

RIGHTER: Okay. My educational background is in geology. In college I majored in geology. I attended Haverford College [Pennsylvania]. Haverford didn't have a geology department, but Bryn Mawr College did, Bryn Mawr is a women's college that's about a mile up the road from Haverford, and they had cross-registrations. I took all my geology classes at Bryn Mawr College, which was great. They have a nice geology department there. Really longstanding historically. It dates back into the 1800s teaching geology.

But from Bryn Mawr and Haverford I went on to get graduate degrees, master's at [University of] Michigan [Ann Arbor], and a PhD at the University of California in Berkeley. Both in geological sciences.

In between there, between bachelor's and graduate school, I had a summer internship in Houston [Texas] at the Lunar and Planetary Institute [LPI]. They have a summer intern program.

It was the summer of 1987. I was an intern at LPI and I worked with Gordon [A.] McKay at the Johnson Space Center in his experimental lab for that 10-week period. I already had an interest in planetary science and extraterrestrial materials; astromaterials we call them today. Anyway that was a great summer. I learned a lot, met a bunch of people who had like interests, and got to see what research is like. I was at NASA for a couple months. That was really exciting.

That was an experience. I mention that because I returned after a couple of educational experiences and my research at those graduate institutions. I was in Earth science. When I got my doctorate degree, I had a chance to return and do planetary science at the University of Arizona [Tucson], which is what I ended up doing.

I went to Arizona; I ended up being there eight years as a postdoc or a research scientist and doing planetary geochemistry with Mike [Michael J.] Drake and his group. That's a longish story, but those are all the kinds of influences I had that ultimately led to my opportunity to work at Johnson Space Center, which came after Arizona. That was in 2002; they were hiring an antarctic meteorite curator in Houston and it turned out that my background was suited for that. In addition, the research division there was interested in my high pressure research as well. There were curation and research divisions, and both were supportive of my coming to join the group at JSC [Johnson Space Center Houston, Texas].

It was a little funny because my time as a summer intern years before that turned out to be key, because I had known a lot of people at JSC already. They had sort of followed my research and we had stayed in contact. I think when I applied for the curator position, the research people also noticed and thought maybe it would be nice to have Kevin's research expertise as well. That's how I started there at JSC.

JOHNSON: That's interesting because you were working with Michael Drake and his group and then not long after you left, they decided to try with OSIRIS [Origins, Spectral Interpretation, Resource Identification, and Security] and answer that 2004 AO [announcement of opportunity] for Discovery. Were you aware that that was something that was in the works or something that they were thinking of doing at that point?

RIGHTER: Yes. When I started at JSC, because I was with the curation group, there were a number of missions being proposed by various members of the community. Some of them were lunar sample return missions. There were a few competing. In fact one of them was led by Mike [Michael B.] Duke who I mentioned earlier whose oral history I had read from the NASA oral history group. Then in addition to the lunar sample return proposals there were asteroid sample return proposals. I was asked by my boss, the Astromaterials Curator Carlton Allen at the time to join the mission called Hera which was led by Derek Sears. I hadn't thought of Hera for a while. That was a while ago. But Hera was a direct competitor with OSIRIS and both proposing to visit asteroids and bring samples back. Neither one were selected initially.

The person who was representing curation for OSIRIS was Mike [Michael E.] Zolensky. In that timeframe, 2004, 2005, Mike was also involved with the Stardust Discovery mission and he was the curator for Stardust collection[1]. That mission was ramping up for the sample return. Carl asked me if I could switch over from Hera to work with the OSIRIS because Mike Zolensky had to depart to be available for Stardust. Carl knew that Mike Drake and I had a close relationship

[1] Stardust was the first spacecraft to bring samples from a comet to Earth, flying within 155 miles of comet P/Wild 2 and collecting samples of dust and volatiles from the comet's coma. It also collected samples of interstellar dust and flew by asteroid 5535 Annefrank. The sample reentry capsule separated from Stardust and landed in the Utah desert in January 2006.

from my previous position, so I knew Mike and we were still collaborating on research topics. He thought that maybe it would be good for me to assume the role of curation lead for OSIRIS for the recompete. So I did, and Carl took my role on Hera before the proposals were due.

That was exciting, but it was a little awkward too because I had been part of one and then shifted over to the other. I think some of the Hera team were initially surprised by that, and they were worried that I was taking secrets from their mission over to OSIRIS. It's a serious—I shouldn't laugh. But I'm laughing because we talked and I reassured everyone and we talked through everything and I said, "My role is a curation lead for the mission. I'm focused on ultimately curating whatever samples come back to our collections and dedicated to preserving the materials."

But from then on, I was associated with OSIRIS and OSIRIS-REx [Origins, Spectral Interpretation, Resource Identification, and Security – Regolith Explorer] and we started progressing[2]. We were selected to compete for the next round which was three different groups competing. Then we were finally selected in 2011. That was a long period from say about 2006 or '07 until 2011 when we were finally selected.

Even then 2011 until now is 13 years. It's a very long mission. That was part of the challenge I think of OSIRIS-REx, was the length of the mission and how that affects planning and resources. But I'm getting ahead of things here maybe.

JOHNSON: That's okay. It's interesting that the curation part of it and you as lead for that was brought in at the beginning when they were doing the proposal. Talk about that team and how you

[2] OSIRIS was first competed under the Discovery Program, was picked as a finalist, but did not win that competition. OSIRIS-REx was then competed and selected under the New Frontiers Program.

worked with them and how you proposed for that curation. How did you know how you were going to be handling these samples 13, 14 years later? Because they were just deciding on the spacecraft at that point and how they were going to get those samples. Walk through that process early on and that proposal process and your part in that.

RIGHTER: The New Frontiers and I think the Discovery Program as well, had learned from past missions some important lessons. I think one of them was that the funding for curation was not as robust as it could have been for missions like Stardust. Especially Stardust. I think Genesis was slightly different because they had to build the class 10 clean room for Genesis before launch because they used it to assemble the components of the spacecraft that were then transported from JSC to Kennedy [Space Center, Florida], or maybe they were first transported to Denver, [Colorado], I'm not sure. But the initial assembly was in JSC's clean room. Curation was on their radar early for Genesis.[3]

For Stardust it wasn't necessarily. There were curators engaged early on but they didn't have much of a resource profile with the mission. The reason I'm saying all this is because for OSIRIS-REx and those announcements of opportunity in that timeframe for both New Frontiers and Discovery they had a requirement that any proposal had to include funding for curation that extended two years after the samples came to Earth.

This was a requirement for the mission, and I think it really paid off. I'm not sure how much you've heard about this by interviewing others from the mission. Because it goes back a

[3] The Genesis spacecraft spent more than two years collecting samples of the solar wind. The spacecraft then brought the sample canister back to Earth where it parachuted to the ground. Despite a hard landing in the Utah desert, the Genesis samples were recovered.

ways. It goes back 20 years. The management at the Science Mission Directorate or their equivalent at the time decided that they needed to do this. I think it's really good for funding of curation.

I think what had happened is the earlier missions, they brought material back and there wasn't necessarily funding for a clean room or for all the personnel to assume the duties of curating this new collection, and so it was a little bit of a shock, it was a fiscal shock. They wanted to avoid that again. I think if you take that perspective for OSIRIS-REx it worked really well. We had a large staff that was well rehearsed and trained and ready. Fully integrated with the mission. I might be a little biased but I think it worked really well. Funding for two years of curation staffing and support after sample return was missing in earlier missions. That's really good.

But in the early days during the proposal stage, which was getting back to your question, I think it was really important to have curation personnel engaged with the mission early on. I think just in general that's a good idea, but in particular for OSIRIS-REx the science goals related to characterizing organic compounds on this carbonaceous asteroid. Organic compounds are everywhere on Earth in different kinds. They can be biogenic or biology-derived, originated, they can be artificial compounds, or I should say artificially made compounds that end up being a contaminant for something that's occurring naturally in an asteroid or a rock.

Having curation expertise on the team early on was able to bring that issue up where it needed to be raised. We could bring it up and let the other team members, whether they're engineers or other scientists or mission managers, know about these issues early rather than doing a lot of backpedaling and be reactionary later in the mission when somebody realized it might be a problem. That was really good too I think to be ready like that.

All of the reviews that we went through, whether they were competitive reviews before selection or afterwards when the mission was being reviewed by various elements, whether they're standing boards or [NASA] Headquarters review panels, the curation team was always integrated into those reviews and we got good feedback and suggestions from the panelists.

However, I should also say that those reviews were oftentimes really focused on engineering capabilities. The early parts of the mission. Could the team actually do this? Could they achieve this? The emphasis was really on the early part and the launch and the operational parts of the mission. There was less intense focus on curation-related issues. Which I think is natural because you can't have one without the other. You can't have curation without everything else happening successfully. But the review process, it was nice to be involved, but oftentimes a lot of the detailed questioning and stressful parts were on the engineers and the engineering teams rather than the curation team. I hope that gets to some of your questions about the proposal or the early stages.

JOHNSON: I think it's interesting because like you said the emphasis was on building the spacecraft, the engineers and the scientists, what they were planning. But at the same time, what you were doing was going to be handling these samples. How much interaction did you have with the spacecraft, and especially the TAGSAM [Touch-and-Go Sample Acquisition Mechanism], once that was being built, as far as contamination control? You mentioned they had the clean room here at JSC for Genesis, when they put that together. For OSIRIS-REx how did that contamination control work on that?

RIGHTER: We were involved I guess you'd say. There was a Contamination Knowledge and Contamination Control Working Group that was part of the mission. That was a pretty large group made up of engineers and scientists.

The mission contamination control officer was at Goddard [Space Flight Center, Greenbelt, Maryland], Chris [Charles C.] Lorentson, and mission contamination knowledge was overseen by Dr. Jason Dworkin also at Goddard. Lockheed Martin had a number of engineers and scientists as well that were supporting the contamination control. The curation group I think was involved marginally just to observe that. We weren't part of the contamination control operational, watching from the sidelines and actively encouraged to be part of it, to be engaged, which is good. But a lot of that work was done by Lockheed and Goddard. Lockheed had certain requirements that they had to demonstrate, and so that was all managed and overseen by the group at Goddard – Lorentson and D mission contamination knowledge who worked together very well and for the duration of the mission.

Like you said, the curation group didn't have a clean room at that point. We were planning a clean room and were trying to get all the lessons learned from previous experiences wrapped into that. But that was all, even back then in 2010, that was still something five or six years in the future. That was always the tough part of the mission and how long it was. For so many years the activity for curation was way off in the future. So many of the mission elements peaked either with launch or with sample return or leading up to sample return. That's just when we were ramping up. All our operations were midramp at sample return.

Then we peaked, or I guess you'd say we're peaking now. We've got the curation team that's still active in this last what they call Phase F of the mission. Most of the other mission elements have either ceased or are ramping down or scaled back significantly. This was going to

happen. We knew that most of the large components to the mission would be tailing off at the end when we're ramping. That's something that I think is important to understand for future missions as well. Ours was just so long that that made it more important. For a mission that might be three or four years long everyone's excited for that whole time. But to be excited for over a 15-year period is more difficult.

JOHNSON: Hard to keep that excitement.

RIGHTER: Yes. Then with ours too, with the timing of our mission and planning for curation, we had the whole pandemic and the COVID [SARS-CoV-2 virus] restrictions that came into play. Again I might be getting ahead of things but that really was a significant factor in everything that happened.

JOHNSON: I was going to ask you about that too. But just for a few minutes let's talk about planning that clean room, Building 31. Once you were planning for that clean room and those early on plans, how much did they change once building had actually started? Talk about some of the issues they had to overcome once that building started and how that process went.

RIGHTER: That was a long process. We had some precedents with the Genesis and Stardust clean rooms that were built most recently. Then there were a few experiences as well or one I guess at that point with the Hayabusa, curating 10 percent of the Hayabusa1 collected material that was

provided by JAXA [Japan Aerospace Exploration Agency][4]. That was a relatively new clean room as well.

At the early part of the mission we were planning similar kinds of clean rooms. Maybe slightly cleaner. Slightly different rating or higher cleanliness level. More like Stardust in that it's a class 100 clean room. We had some good experience to build on.

The spaces that were available in Building 31 were limited. We had some space identified that the management had been reserving or having available for sample return missions. We looked at those spaces—this would have been the 2006, '07 timeframe—figured out how to fit a clean room into these spaces that could house the gloveboxes and the storage cabinets that the mission would need. We had this simple plan for many years. From probably 2006 until 2014 or so, that eight-year period, the plan was pretty similar. We were talking about a single room with a changing or anteroom and could fit easily into the space we had available.

In 2014 there was a memorandum of understanding signed between NASA and JAXA involving the Hayabusa2 mission and the sample exchange between OSIRIS-REx and JAXA and Hayabusa2 and NASA.[5]

The curation group realized that they would need a second clean room or an additional clean room for the Ryugu sample. It would be unacceptable to curate these two kinds of samples in the same space because there's too much potential for cross contamination. At that point then we had a new challenge, which was where to put this second clean room. Similar cleanliness level, and maybe similarly sized, although not quite as much space needed as OSIRIS-REx.

[4] Japan's Hayabusa was the first spacecraft to take samples from an asteroid and the first mission to successfully land and take off from an asteroid. It brought samples from asteroid 25143 Itokawa to Earth on June 13, 2010.
[5] Hayabusa2 studied the asteroid Ryugu, collected samples, and brought them to Earth. The spacecraft is now on an extended mission to the asteroid 1998KY26.

At that point the curation group decided to get a company involved with designs to look at the existing space in the building and look at our requirements. At that point the company came back. They had done clean rooms all over the country and had some really specific recommendations for the space. Their recommendations involved renovating more space than we had in the previous plans. Those labs would need a bigger footprint.

The plan from that point forward was to take over half of the second floor of Building 31, which was a larger scale than had been imagined. That changed a lot. This was the part that goes along with the length of the mission. If the mission is that long and you're waiting for samples to come back, and the basic requirements are changing slowly over time, then the plan has to change, and it did. It morphed into this larger project, and then the attitude at NASA Headquarters changed a bit too. They started realizing hey, this is a big deal. We've got samples coming back from an asteroid. It's a lot of material. It could be Apollo-like levels of interest scientifically, both in the United States and internationally. They thought we should not be constrained to the modest budget that was part of the mission profile, and maybe we should think about a more robust longer-term facility with more permanence and maybe a longer lifetime.

One of the lessons from Apollo is that 50 years later the samples are still providing new constraints on scientific theories for the origin of the Moon, origin of the Earth and Moon, for planetary science in general. Basic things like where does the water come from in the inner solar system. Apollo samples have been really part of that bigger picture science. They started thinking about that for OSIRIS-REx. In 50 years what do we want the facility to look like? The sort of facility we had planned was based on earlier clean rooms and we had a couple of decades of experience for those under our wing already and realized that a lot of those facilities needed to be either revamped or some investment into the basic infrastructure was needed to keep them going.

In short Headquarters decided that really, we should invest more in the long-term viability of these clean rooms so that we don't have to refurbish them after a decade or two and think about the longer-term preservation of the samples. That change in attitude led to an additional aspect of the clean room project that expanded to the first floor and included some other supporting curation facilities that would help, not only our mission and Hayabusa2, but also looking ahead into the future for future sample return missions as well.

The project then to build the clean room got wrapped up in this larger-scale project. It was good because the construction would start sooner. I think that's good because a lot of times constructions projects start on time but then they get delayed and then the delays end up potentially hurting the mission in the end. In this case, the construction started earlier than we had originally planned, and that ended up being good because there were delays, there were some delays. Then we had the pandemic as well, which was a big factor in some of the delay.

But in the end the clean room was completed and ready well before the samples came back in September, and that's exactly what we wanted. That was part of our plan, to have the clean room ready for outfitting, ready for testing and monitoring, so we understand that environment before the samples come in. That was a long-winded answer but it unfolded. The requirements changed slowly between 2014 and 2020, that six-year period or so, the requirements changed a bit and the design changed as well. But part of your question was what changes were made during the building of the clean room.

There really weren't. There were some minor things, but once the design is fixed and the construction starts, you have to wait until the end to see what needs to be adjusted or fixed. There were a couple minor things that needed to be addressed before samples came back, but I was expecting some minor things. I think it's true of any construction project. There are always a

couple of little things that need to be fixed or tweaked to get exactly what you need. That was certainly true with our clean room project. But all doable within the timeframe we had.

JOHNSON: Luckily it started a little early because they did find things in the building itself that had to be fixed before they could go ahead with the clean room build. You mentioned it a couple times, so let's go ahead and talk about COVID and when that happened. At that time the clean room was being built. I know things were being designed and built like gloveboxes. In March of 2020 everybody had to go home. Talk about how that affected what you were doing and what you were trying to do with your team to get things moving forward for the curation.

RIGHTER: Thinking back to that time period. On our list of plans one of the things we had was to get engineering design units of the TAGSAM head that we could use with our staff to practice disassembly and understand the geometry of the TAGSAM head, where sample is likely to be, how easy it would be to access that and remove, how easy it would be to remove some of the hardware pieces.

The way we had set up the transfer of responsibility is that because the spacecraft and the SRC were built by Lockheed, SRC is the sample return capsule, and then within the SRC is the canister. The canister is what was shipped to JSC, and the canister design is such that we decided that the handoff point where Lockheed would hand off responsibility from them to curation would be when the canister lid was opened revealing the sample inside. They would need to do that. There are certain disassembly steps that made sense for their technicians to take care of. Once that was done then the JSC group, the curation group, would take over and start slowly disassembling more of the hardware pieces associated with the samples.

We were ready. We were all ready for those rehearsal steps. We had a plastic model that we were using in early rehearsal activities, and that was nice because you could just put it out on a table and start taking it apart. Everyone was getting familiar with that and excited about that. That's about when COVID started.

We were just getting our feet wet and starting to get excited about all this and then all of a sudden, we couldn't meet as a group for example. We didn't have spaces where we could go. Even if we could meet it could just be one or two people that go and coordinate. I even forget what the restrictions were at that point. I think that maybe one or two people could be working over the period of a day but you couldn't have a big group of people. But that's when we needed it most. We really needed to have people together learning together how to disassemble, what it would take, because it's not a one-person operation. It's definitely a team effort. Two people working in a glovebox trying to disassemble these pieces.

The next steps for us were to be practicing this in a mock glovebox or cabinet. All of a sudden it was not clear how we were going to do that. We had a few team members at that point who were savvy enough and had enough self-motivation and flexibility in their schedule or in their time to make some gloveboxes, prototypes, out of foamcore and acrylic and so forth. They were able to make these cabinets in their garage or people were working from home. Slowly as the restrictions lifted, we were able to move this operation that may have occurred in somebody's garage to slowly move it to space at JSC. Meanwhile time was compressed. We were also supposed to have received these real, more real, engineering design units like a spare unit. Lockheed though was holding on to those because—one thing that I hadn't mentioned yet was the original sampling timeframe was supposed to be July. They were talking about sampling on Bennu I think even on July 4th. It would be a spectacular U.S. birthday celebration, sampling an asteroid.

That was delayed until October. For us that was a big deal. It doesn't sound like much. That's maybe three and a half months. But for us that was a lifetime because time was ticking, and we needed all the practice we could get. Because of the delay in sampling, Lockheed was hesitant to part with their design unit hardware because they still needed it to troubleshoot or think about the sampling geometry and sampling issues. Our hardware was delayed getting to Houston, and that was a little stressful too. All these scheduling issues were bad enough with COVID delaying us and impairing our abilities, but then we had the delayed hardware as well.

At some point we had access to the mock gloveboxes where two or three or four of us could meet in a common space at JSC. Again the other challenge we had was the construction. The construction had displaced enough people and moved resources around that there were very limited spaces where we could meet to do this kind of activity. We were meeting in buildings we weren't familiar with. They were open space. We were able to get enough space to do what we needed to do, but sometimes we were worried that we would have nowhere to rehearse some of this stuff. Building 37 was having roof leaks and some of our rehearsal space was right underneath the roof leak.

JOHNSON: Of course.

RIGHTER: We couldn't move into 31 because the construction wasn't quite done and the rooms weren't ready to be occupied because they hadn't been officially turned over to JSC. They were still in this gray zone. Hadn't been signed off by the construction team, the construction manager. We couldn't really use them. Then even if we could use them, there weren't official lab rules or

lab operating procedures in place yet either. We were sort of between a rock and a hard place but looking for ways to gain the experience.

Slowly we did. Over that period the team grew as well and was able to hire a lot of new sample processing people, which was great. They're coming on board in this atmosphere. It was all new for all of us. I think the team really jelled naturally because of that. We all felt like we were learning together, figuring out how to do this on almost every front. Maybe in that sense the challenge of COVID had a good influence on the team. It was an unusual challenge and everyone rose to the occasion.

JOHNSON: The feeling of working in the trenches together.

RIGHTER: Yes. What's our challenge going to be today? Or this week. I remember we had a rehearsal. It was the first time the mission had met, large elements of the mission had met, since the pandemic restrictions had been lifted. We had mission management. We had people from Lockheed. We had science team members. We had our curation team. All meeting in Building 31 to rehearse.

The building was still, parts of it were still under construction, still roped off. All the spaces were new. We were inviting everyone to join us at this rehearsal. It's just asking for trouble, right? It all went fine. There were a couple little hiccups but that was exciting too because finally we had the team all back together. I think that was November of '21 timeframe if I recall. That was an exciting time. Just having the team finally back together and starting to sharpen up the focus of what needed to be done and completed in time.

JOHNSON: You were talking about hiring new people and the team was growing during that time. But talk about that team and the type of people that were coming on that team. You had the curation people, scientists, people with your kind of background. But there were also people that were working with you that were helping to create some of that specialized equipment that you needed, engineering people. Also you had photographers that were going to be involved at some point. That had to be practiced and trained too. Sometimes when you think of curation you just think of people doing what you did, that one thing. But I know there was so much more involved in getting that room set up and getting things ready for those samples.

RIGHTER: Yes. There were a lot of challenges for sure and differences between the Bennu collection and some of the others. One thing that I mentioned earlier, I was the NASA Antarctic meteorite curator. The Antarctic meteorite collection, it's a large collection. It's like 23,000 plus meteorites. Some of them are quite large. They're large. Some of them have to be cut with a saw to subdivide them. Some are multiple pounds. They're big samples. We usually didn't have an issue with material supply to fill requests.

But one issue that we identified, and we tried to get the OSIRIS-REx team thinking about this as well, is how difficult they are to image or photograph, because they're dark. Especially the carbonaceous material. It's very dark. It's difficult to photograph in a clean room setting. They're difficult to photograph at all really. When you see pictures of meteorites that are maybe optimized. You might see these. If you go to a museum, a meteorite on display, there's usually very specific lighting. Different colors that are in the background. There's a lot of flexibility that you don't have in a clean room. In the clean room you need to have stainless steel, Teflon, and aluminum. These are all not the greatest materials for optimizing photographs. That's just the material around

them. Then the lighting itself is another. Lighting, you can't have a lot of handheld lights or lights that you can move around because usually that comes with other materials that are part of that lighting system that we can't allow in a clean room.

What it means is even Antarctic meteorites the photography was a challenge, but they're larger. They're larger samples, so we can get away with some simple approaches. When we started working with the Bennu size material I think the team realized. So we made some activities for the OSIRIS-REx team to come back in the meteorite lab and get a sense of what it's like visually. What's this carbonaceous material like to look at, to image, to handle? How friable is it? How difficult is it to pick pieces up and move them around? I think that was helpful to them.

But the imaging in particular, I think they realized how challenging it is. Everyone realized this was going to be a challenge. The science team had an imaging system that they were working on and the curation team had slightly different requirements and needs. They worked on their imaging system. Nobody really knew I think in advance which one was going to work well, because there's still this element of unknown. What is this sample that we're bringing back? What is it actually going to be? We have a little bit of information from the spacecraft and the imaging but in the end, we really didn't know until we had it in the lab and start looking at it.

The imaging that the curation group had developed became the baseline imagery that people started using for the selection of material and just characterizing, knowing what's there. Then the resolution of the imaging was really outstanding as well. But very difficult. They're dark rocks. The shiniest features are these little flecks of sulfide that you can see throughout the sample and they are really almost the only thing. There's some other white phases that you can see as well on some pieces. But those two are really the only features that you can see in the

images that would allow you to make an inference about the sample. Otherwise it's just all dark material. It's hard to see features.

The imaging was a real challenge. I think giving the imaging team a little bit of time to work on defining the best approach for imaging was important. That's tough too at a time when everyone's really excited about having the sample in the lab. The last thing you want to do is wait. Everyone wants to get their hands on the sample. But it was important to work out the best imaging approach so that everyone felt more confident about what was being selected and what was being allocated for study. The imaging was a real challenge.

The other area that you mentioned was engineering. This was something that became a real—the challenge was exacerbated by COVID for sure because we really needed to have that knowledge that we gain from allowing people to interact with the hardware during the rehearsals to test different tools, different environments, and scenarios. All that ended up being delayed by COVID and it made the pace of engineering development and innovations that they came up with, it made that pace really compressed. A lot higher pace than we had wanted or planned. The engineering team, they were part of all of our rehearsals looking at the steps that needed to be accomplished and the constraints that the sample processors had in the glovebox. How much lateral freedom they had to move their arms around in the gloveports and how far they had to reach into the cabinet, what angles and how much torque they had to apply to loosen fasteners, etc. All of this went into their designs for some of the specialized tools that were developed.

Then the other thing was containers. Let's say you remove a piece of hardware. You have to have a container ready to put it in. Containers need to be simple. They need to have, again, all the same contamination-free materials or minimal contamination that are part of their design and makeup. They have to be something that the processors can handle and close easily wearing

gloves. A lot of that development happened in a short period of time and the curation engineers that were part of the team were critical. Any success that the team had in getting samples out, distributed, and characterized is, a great part of it, because of the engineering team that was integrated with the sample processors. I think that was pretty unique. We didn't have that capability in other missions.

JOHNSON: I was going to ask you how that worked or if that was a normal practice. Also the communication between people. Because scientists have their language, engineers have their language, artistic or photography people have their language. Everyone has their own way of communicating with people that are doing the same thing. But then you have to cross-communicate. How did you help facilitate that? How do you feel that that worked within that team?

RIGHTER: Again everything was compressed but we had a very rapid-paced series of rehearsals planned. I think a lot of that was due to Nicole [G. Lunning]. She put together a very dense but realistic schedule to rehearse the various steps. She kept that pace going in the fall and the spring before sample return. Those rehearsals included, they were usually daily, we reserved a whole day for that activity.

We would get the sample processors and the engineers in the same room looking over each other's shoulders doing the kinds of work that needed to be done. There was a lot of exchange of ideas. The engineers were really good at observing and then giving feedback like, "Hey, I see what you need to accomplish there and I think that there's an easier way to do that than that particular tool that you're using, so let me." They would sketch out what they thought would work

and show it to everyone and people would have an opportunity to give some feedback. Then ultimately, they would make a protolith tool that we could test. That was really the general approach that was taken for a while. We'd highlight what steps needed to be refined and then just work on it together. Then when the prototype tool was ready, we'd reconvene, run through the process again.

Something that we haven't mentioned is the documentation. There were procedure documents that we put together. They all had to be updated every time there was a new step or a change to a step. That was a task as well with a team that big and with the number of steps there were just disassembling the TAGSAM head, which alone took a few weeks to do. To get everything correct we had to start integrating the simple disassembly steps with the imaging steps. What do you want to image? How long do we want to pause at this step for imaging? What kinds of images do we want? We had to go through that. Reiterate those as well. Sometimes we'd get feedback from within our group. That took a while. Then we would land at a spot where everyone was happy. Then we would send it over for the science team to look at and then there would be a whole other round of iterations. For a while there it was probably a year or so, probably more than a year. Maybe two years. Just a never-ending process of iteration, reiteration, integrating change, and updating, and then having different feedback loops at different levels. It was pretty amazing to be part of all that.

JOHNSON: Documentation. That's interesting. Was that anyone specific in the team that was handling that documentation? Or was everyone just adding and writing? I know you had to have it step-by-step as you're saying, everything had to be documented, what you were going to do. It

kept changing as things would change. But did you have a group of people that was doing the documentation on the team or were you all doing that?

RIGHTER: There were two kinds. It was mostly Nicole and myself doing the documentation as far as the procedures go. We had a number of plans that we were working on. We had help with different procedures depending on the nature of the procedure. Jeff [Jeffrey N.] Grossman at NASA Headquarters was the Headquarters rep for the mission for a while, and he was very interested in the nomenclature for samples. He was helping us with the nomenclature plan.

Christopher Snead, who ultimately became a deputy curator as well to help out with the mission. He's the Hayabusa2 curator as well, but he dedicated a significant amount of his time to OSIRIS-REx. In particular he was our resident expert on the contact pads and imaging as well. He contributed a lot to both of those plans and just in general to the disassembly.

But most of the actual writing and the text, I think Nicole and I handled most of that just for simplicity maybe. Just so we could bounce things back and forth from her to me or me to her. That worked okay. We got a lot of feedback. There were a lot of reviews internally within ARES [Astromaterials Research and Exploration Science] or within the curation group. But mostly it was us.

There were really two kinds of documentation. There were mission documents, and so the curation plan for example was the largest document probably that we had to work on. That was a mission document. We had a lot of eyes on that document in the end. Mission management, contamination control working groups, science team, the New Frontiers program office. A lot of different kinds of people reviewed that document. Again through any feedback we got, Nicole or I would make the changes and fix the documentation.

That was one kind of documentation we had. The other kind was in-house curation procedures. For a lot of those, now that's where the curation staff was involved. They wrote a lot of those procedures too because a lot of the procedures were similar to what was used in other labs. It was more familiar maybe to our in-house staff to write procedures that were specific to the clean room or to some of the other aspects. We did have a lot of help from our curation staff on the more localized procedures. I'm not sure who had more documentation. Could have been the curation group had more documents in the end than the mission. But the mission documents just seemed to go on forever and constantly being edited and updated and reviewed. Just when we thought we had all the signatures, somebody would come and say, "Oh, wait a minute. Section eight, we need something here. I'm not going to sign this until you fix this and this." Then we would go, "Oh no. Another. We just want to be done with this document."

JOHNSON: Seems like it would be a full-time job just doing the documentation on top of everything else. That's incredible.

RIGHTER: Yes, a lot of it. There was quite a bit, but by the time of 2023 we were doing nothing but responding to reviews and revising documentation. Getting through all that was a big relief finally. Recovery, we were not in charge of recovery. We had a more supporting role out there in Utah [Test and Training Range, UTTR], which was nice because we didn't have to worry about maybe documentation as much as Lockheed did. But once we got to that stage, I think everyone was so excited, it was finally close enough we could all focus on that instead of focusing on documents.

JOHNSON: I bet. That would get old really quickly I can imagine. The glovebox design was completely new. I talked to Nicole and she was talking about it. In my head I was thinking the old Apollo gloveboxes. I didn't realize that new ones had to be designed for the OSIRIS-REx samples. Talk about that for a minute, getting those gloveboxes designed and ready to go for the samples.

RIGHTER: Yes. It's a big deal and it's a pretty subtle point but it's one that's central to our operations and success. I think that a few people in our group had some experience with gloveboxes and they were worried about this. They knew about the issues.

Some of the issues were that—well, mainly how long does it take. With a few of the collections, for example Hayabusa2, they had ordered a glovebox from a company and it took so much longer. The agreed upon date was so long. But then it took so much longer than that actually.

There aren't many companies that make gloveboxes, so the choices were limited. I think there were similar experiences with other companies, and a few people were very worried about this, thinking about our timeframe and how far in advance we would need to have the glovebox ready and in place. That was one aspect. That was always hanging there in the forefront.

The other thing was really just being able to decide on a final design for the glovebox. Again we were under time pressure just because of COVID. It took us a while to get where we were using these mock-up gloveboxes to get feedback and get the design down. We ended up lengthening the design of the TAGSAM glovebox. Because of the rehearsals we realized hey, there's just simply not enough space in here to accomplish everything that we need to accomplish. We've got to make this longer.

We had to revise all the drawings, add a couple of gloveports on each side. But in the end, we got the design finalized and then Jacobs had been working with a company in Italy to do the work, to do the glovebox for us, or gloveboxes. That was the other thing. It was not just one glovebox, it was two, and they're sizable.

Going back a little bit, so in the early stages of mission planning we had thought that we could use or retrofit Apollo era cabinets. As we started getting details about the hardware and disassembly steps, we realized that it would probably be possibly even more expensive to retrofit these old cabinets than it would be to just start from scratch and design new ones. Those kinds of ideas were abandoned at some point, retrofitting.

I think we still retrofit a couple of smaller cabinets but the main cabinets we realized okay, we need to start from scratch. That was a big deal. The gloveboxes were completed I think in January and were delivered in February. Maybe late February early March. That gave us about six months to understand how they work, get them integrated into the clean room. Maybe rehearse a little bit with them, get the staff familiar with how they work. Defining the differences between them and our standard kind of gloveboxes.

Yes, that was quite an experience. Again in the end it came out very successfully. I'm sure there are lessons learned, looking ahead, because there are more sample return missions on the horizon. But yes, that was something that I think it dawned on everyone we've been relying on these in-house cabinets and gloveboxes for so long but it's not going to be true for OSIRIS-REx. We really need to have new ones. That sunk in and people really hunkered down and went the distance to get it done.

JOHNSON: I know Nicole took over as the lead curator in 2023. I guess it was towards the end. She was also the lead out in Utah for the recovery part, the curation part of that. But I was wondering, did you retire during that time period or were you involved in those rehearsals out in Utah or getting everything set up to go out there and do that curation out in Utah?

RIGHTER: I was involved. Not as much as the other team members, but I was involved and I was part of the recovery effort. I was on what they called the [SRC Breach team]. But essentially my role was to be out in a vehicle at the edge of the range when the capsule returned. Deployed and ready to travel. There were three vehicles that were ready to deploy and travel to the capsule location in case of an off-nominal landing, like if the parachute didn't deploy or if it landed and then was dragged across the floor of the desert. Anything like that that was a little strange. We had a team ready to go out and meet or address any capsule issues.

They wanted a curation representative to be part of that team, so that that person could radio back or communicate back what curation resources would be needed to move on from that point. I was out there. There were a bunch of activities that I had to be part of rehearsals to be ready for that role.

Thank goodness we didn't need that capability on the day of recovery. I was up early like everyone, maybe earlier. Early, drove out to the edge of the stage there at the edge of the landing ellipse and then waited. We did drive within, I don't know, maybe a half a kilometer or something of the recovery, and then when we realized everything was fine then we returned, drove back to the high-bay and the clean room there that we had established.

When I started at JSC in 2002 the curation team was a lot more lean in terms of people. It was a smaller operation, limited resources. Basically all the curators helped out with the Genesis

sample recovery efforts. Most of them. Not everyone, but most of them were out there. Myself included. I was there for the Genesis return. That was really interesting. That's a whole other topic.

JOHNSON: Yes. That is interesting. I didn't realize that you were one of the ones that was out there. A completely different experience.

RIGHTER: Yes. I think because of that they wanted me to be engaged with the recovery efforts, because I had been out there. I think with Stardust for example everything went so smoothly, it was over quickly. They went out, they did their rehearsal, and then they had recovery. The recovery team was only out there for, I don't know, a day and a half or something like that. The curation group was out there for a few weeks getting everything ready. But everything was over quickly compared to Genesis where there was a curation presence out there for a couple months into November, I think. From September through November. It was a longer effort.

The JSC staff got to know the UTTR staff pretty well. That made a big impression on me. You realize how important it is for those teams to have a good relationship. Going back there almost 20 years later was a very strange feeling. But everyone remembered Genesis and Stardust. Everyone who was part of that or worked there at the time remembered.

That was nice. But my role was a little bit focused just on the SRC Breach team. That's the name of the team I was part of. We don't want an SRC breach. But that was part of the recovery plan. That was my role. That allowed other people to take on leadership roles, like Nicole being the recovery lead I think was great. She did a great job with that. I think she was really excited to be in that role. Gave her experience as a young curator that might translate over

directly to the next sample return activity that we do which is likely to be out there. I think it's really great that somebody in her position is likely to be around and share her direct experience with a new team in the future, whereas like me, I'm gone already. They're not going to get my direct experience easily. If they want to invite me out to talk about stuff that's possible, I guess. I think you see my point. It's really nice to be able to have a highly trained generation pass on information and experience to the next. I think that'll be really easy to do with the experience that she had.

Also the curation recovery team was largely—there were a lot of civil servants out there—largely a Jacobs contractor operation staffingwise. People were out there with really specific and highly rehearsed and trained roles. The team just did a great job. Everything went so smoothly. There was no team drama. It was all really positive team spirit all the way through. We're so fortunate and lucky and so happy that that's the way it was.

JOHNSON: Definitely. Did you get to come back on the plane with the samples back to Houston?

RIGHTER: No, I didn't. Melissa Rodriguez and I, we stayed back, we stayed till the day after. That was actually a really big aspect of the planning. We had the huge team out there but we had the sample being transported back to Houston, and a lot of the people that were in Utah needed to be back in Houston for various steps. We had a team of people in Houston who weren't at recovery who were ready to receive and help with that. But none of those people were trained to do anything in the clean room. We needed all the clean room folks to come back. I didn't have any roles in the clean room for that first week or first couple days. Neither did Melissa. We were pretty clear candidates to stay back and have a delayed return, so we got back the next day.

But we were teasing everyone on the plane. Everyone assembled that morning and they were lining up to get on the plane and one of our colleagues acknowledged us and said, "Hey, good luck to you guys. Wish you'd be coming with us," and waved goodbye. But nobody else did. It's not a big deal but Melissa and I, we were talking about it later and we were saying, "Okay, we've got to remind everyone that Aaron [B. Regberg] was the only one who waved goodbye to us."

JOHNSON: Everybody's so focused on getting on that plane.

RIGHTER: Yes. For a while there Melissa and I, we were just playing that up and being dramatic about it. Having fun with that. But everyone realized that we were just joking around. The other issue was we had rental vehicles to return. We had a team of I don't know, maybe 12, 15 sharing two vans. We had to return those, but we couldn't return them till everyone was on the plane and on their way. Melissa and I did that and we cleaned up any loose ends in the clean room. Think we brought some witness plates back that were deployed in the clean room. Some little things like that. Then we joined everyone the next day in Houston.

JOHNSON: I imagine everybody was excited and ready to get those things open once they got back and see how successful it was. I know there was some worries because of the way it was collected. Some of the sample of course was lost before they realized what was going on, and then they got the head stored in time. I know you saw the same photographs that were sent back showing what it looked like. Everybody was estimating that amount. When it was opened were there any surprises other than yes, there was enough there, there was plenty of sample?

RIGHTER: Yes, I think when it was first opened it was still difficult to tell how much was in there. I think really what was attracting everyone was how fresh and sparkly the sample was. Meteoritic material, which is similar in a lot of ways to the asteroid material, meteoritic material though becomes weathered quickly at the surface of Earth, and then it always develops this thin melted skin, the fusion crust, on the exterior from atmospheric heating. Between the weathering and the fusion crust and any even minimal oxidation in the Earth's atmosphere dulls the look of a meteorite like a carbonaceous meteorite like this.

When you open it up in that clean room and see you don't have the weathering, you don't have the alterations, it's just beautiful fresh bright sparkly sample. I think everyone's jaw dropped at that. Because it's just such a beautiful sample. But we're all sample geeks. Beautiful to us is very narrow. I'm sure to a lot of the public it looks like a dark rock, and that's totally fine too. But we get excited about these things. That's what we wanted. You got to get the fresh pristine material. From that we're going to learn the most about Bennu.

JOHNSON: How long did you stay at JSC after the return?

RIGHTER: Let's see. The return was in September and I retired officially on June 15th.

JOHNSON: Oh, of '24?

RIGHTER: Of '24, yes.

JOHNSON: You were there when they were starting to get things opened up. Talk about that. They couldn't get too far into it before they found a problem with some of the latches or the fasteners. Talk about that for a minute and how again that engineering group had to help figure out a way of getting that open.

RIGHTER: Yes. That was a difficult time of course because we had the science team who was raring to go. They wanted to get material. But I think in the end they all understood that getting that material needed to be done without compromising the sample with any potential contaminant. Some of the options that were on the table were more risky, like using a tool that would probably work and get the latch loosened, but there was a significant risk of material being galled or abraded and contaminating the loose material that was in the TAGSAM head. That might be one. There might be other scenarios that involved reaching in and loosening other fasteners or like a secondary route into the head. But those, the risk was not only contaminating the sample, but maybe physically affecting the sample like breaking or compromising dust and so forth that was on the surfaces.

I think with all of that as a backdrop they developed an approach that would take a little time to fruition. But in the end, it caused the least effect on the sample, least risk, and allowed them to get those fasteners off. I forget how long. Maybe it was about a three-week or a month, something like that, delay.

JOHNSON: I think it was in January, they finally got it open.

RIGHTER: Yes. It took them a while to get to that point. Yes. Might have been a two-month delay. Something like that. But right before that they had scooped out enough material for the science team to start their studies. I think that was great. All things considered and under the circumstances and hindsight looking back I think those were all great. That was a great decision pathway that allowed people to accomplish some of the science. Whereas at the same time the sample was protected from potential contamination or just from being compromised in some way. Could be compromised physically instead of chemically for example.

JOHNSON: OSIRIS-REx was pretty high-profile for NASA. It got more attention than some NASA missions get. Talk about that for a minute. As lead curator, and then I know Nicole took that position over, but during that time period, what are the pressures even building up to the sample return? What are some of the pressures as lead curator or in that position that you felt or that you had to deal with as far as media interest and those kinds of things? Did you have to deal with the media?

RIGHTER: There are a couple of aspects to your question. There was a lot of media interest for sure, and a lot of that, I think our team in general, the science team, some of the science team members were really excited about the media interest. With all the technical gadgetry that's available these days, people were imagining live streaming from the lab and doing things like this kind of real-time broadcasting. We had some discussions about all of this that were difficult because I think the PI of the mission in particular, he really wanted to have the live streaming and have live activities from the lab, and we were hesitant to do that.

Our position as curators, a lot of our staff is used to working in a clean room with a few people. There's not pressure of somebody watching. Even some of our clean rooms have windows, like they've got a window in and you can see people working. Many of the clean rooms don't. I know from my years working in the group there a lot of the people working on sample, they say things like, "Oh, I'm so glad there are no windows, because I'm not sure how well I would do this work if I knew somebody was watching. I think I would make mistakes." It's more of the human element.

We had to be really cognizant of that. Our approach was we didn't want anyone who was working on sample to feel like they were uncomfortable to the point that the sample would be jeopardized if something happened like a tool dropped or somebody was nervous. That's hard to rehearse for, and it's hard to know exactly how it's going to go until it actually happens.

We had this kind of trade-off, this kind of back-and-forth, about how much would be open and how much would not. But really in the end we did compromise there. We had some element of live action that was portrayed by the mission. Handling the sample and opening the TAGSAM. That was all very carefully planned. The discussions were extensive about that. How to do it, who should be involved, what parts, what steps make most sense. But the thing I need to say is what really ruled all of this was the clean room environment.

Everyone was imagining that the clean room would be this environment where you could communicate easily out. You have somebody in there talking and could be relaying information. But the clean room was very loud. It's a loud environment. With the fans blowing in there it was not easy. It was hard enough for the team to communicate with each other because the gloveboxes are high. They're high enough that most of our staff couldn't even stand on their tippy-toes and talk over the cabinets or the gloveboxes. You had to go around, talk in person, make a plan, and

then go back to your side of the cabinet, so you're on opposite sides. That's just one example. Talking to your colleague that you're working with. That was not easy because it's loud enough in there. Then you're wearing the headgear and the fans are going. Communicating in the clean room was not easy.

Then doing things like filming or having a camera in there wasn't easy to do either without that person being in the way or maybe having the equipment in the way of some of the operations. In other words it was difficult to do logistically, to have an open environment like that, for a lot of reasons. Sound, visually, and then just having the sample handling team feel relaxed and doing their best work. All of those things I think fed into the final plan that we had for the opening and for what was broadcast out of the clean room. I think in the end it was actually a lot more than I thought we would agree on, because for a while we were really concerned about any kind of live aspect because it would just jeopardize the operations so much.

JOHNSON: I know there was a lot of interest to have that thing open and to do the live look, NASA is opening it up.

RIGHTER: Yes. Again I think the element of the uncertainty and what the nature of the sample was even right up until we opened it there were just so many questions. I think people were hesitant to do too much planning or to make too many decisions in advance until they see what the sample was actually like. That was hanging over us all the way through all the planning. The curation plan had all these different scenarios. If the sample is this then we'll do this. If the sample is like this then we'll do a different plan. That was just riddled throughout all of our documentation because of that basic question.

JOHNSON: We've been going a couple hours. Do you have a few more minutes? I just have a couple more questions if we can just talk about that.

RIGHTER: I'm fine if you are, yes.

JOHNSON: The sample catalog was also something that was required that it would come out within a certain period of time. Did you have anything to do with getting that? The sample catalog of course is to make the samples available so researchers can look through it and see pictures and decide what they wanted. Talk about that for a minute.

RIGHTER: Yes. The catalog. For all of our collections at JSC there we have a catalog. In the Apollo days they were printed catalogs. They were multiple volumes for example for each Apollo mission. You had to leaf through. You'd leaf through the catalog and try to figure out what to look at or try to figure out what to request.

But at some point, maybe 15 years ago or so our catalogs all started going digital. The Antarctic meteorite collection for example, we don't even do a pdf, we just have a web page that announces samples and sample availability and we provide photographs of the sample in the field, photograph in the lab, and then a few photographs of the samples at the microscopic scale.

That's the approach that we took for OSIRIS-REx. I'm trying to think when that planning started. Probably a couple years in advance or three years in advance of the sample return. What we should include in the catalog for each sample, what kind of information, what would be available.

The idea of the catalog is you don't want to provide more science than is actually needed. There's a fine line between reporting basic characterization information that the community needs to be able to put in a sample request. You don't want to go too far and determine some properties or measurements that somebody in the community might want to make for their own science, addressing their own science problem or research that they're working on. We have to be careful there, just provide a minimum.

We had planned on doing that for the mission, so just having photographs, a few pieces of information maybe that were available for some samples like density and lithologic types or rock types. We had just a couple of categories like that that would allow scientists to put in requests for material. Because we had the delay in opening up the TAGSAM head, those sorts of activities were also delayed. The catalog in the end had slightly less information in it than we had all imagined because we had plans to be characterizing a subset of the total sample by that February timeframe and that all got delayed. But still with enough time left to put a catalog together, that was a workable and useful catalog for the community.

I think there was discussion about whether we should delay the catalog release, but that had just had such a long far-ranging impact on other deadlines. I think everyone decided no, we don't want to do that, let's just release the catalog.

The catalog is also sort of a living document. It can be updated at any point when we learn something new about a sample, get new documentation or information, we can add it to the web page. From that perspective I think the impact of the delay was lessened compared to maybe like 30 years ago if there was a delay, then they probably wouldn't want to print. They'd want to wait and print the full catalog because it couldn't be updated easily with a second printing. I think the flexibility of the digital age helped us a little bit there.

JOHNSON: Yes. I can imagine making changes to those printed catalogs would have been a real pain.

RIGHTER: Yes.

JOHNSON: Looking at OSIRIS-REx and your experience with this mission, what would you say were some of the most important lessons learned for curation from this mission?

RIGHTER: I think one big one is—and I've alluded to this a little bit already—just being flexible. Having flexibility. I think again maybe that is the first one I mention probably because the duration of our mission was so long. Near the end of the mission I was thinking that our planning and our budgets were so vulnerable to changes. You don't want that to be a bad thing. You want to be able to make change.

But I think that because we're curation and we're at the very end of the mission, people were hesitant to give us the attention and resources we needed at the time, eight years out. They've got all these other issues they're working. Things that might be related to the launch or things that might be related to the spacecraft functioning. You can't argue with that. You can't say, "Hey, forget them, you need to put some effort into curation." It's not going to happen. But we probably need to be thinking about that in future missions. The management teams need to be willing to make change or accommodate change to our plans.

I got the feeling a lot of times that they would consult our plan and if we wanted to change something they would say, "Oh, well, this doesn't seem any different than it was eight years ago,

why are you changing it now?" Then we'd have to explain the whole thing. That was the toughest part, just having to be open for change over that timeframe. We had some basic requirements that changed. Again in the end I think everything worked out fine and we had more resources allocated to our needs by the end of the mission than we had initially planned. But that was a tough one, I think.

Another thing I should say, which was a challenge sometimes, was the reverse of all that. The mission goes through different phases. Phase A is more preliminary, Phase B is definition, Phase C/D is design and development, and then there's the build and then each of them has a fixed duration and a review cycle that's part of the process.

Our mission was managed by Goddard and for each phase I think we had a new mission manager. We got to meet a lot of people that way. The management teams changed with each of the phases. The early phases we had people on the first two or three years who then rotated off and they started working some other mission. It was really cool actually to see them either at launch or later at sample return. They would come back and we had a chance to reflect on those early years.

To me that's really cool. It's fun to meet these people with all different experiences. A lot of the mission managers had never been involved with a sample return mission that had curation. A lot of times they weren't even sure what curation was at first. That was fun talking to people about that too. A lot of times we had discussions about topics that all of us at curation took for granted.

For example we have dedicated clean rooms for all the collections because we don't want to have cross contamination or even a scare or risk of cross contamination. I remember one of the first meetings we had with a new management team from Goddard they were all excited and they

were saying, "Hey, we want to talk to your curators because we think we have a basic question for you that might be a game changer." The question was, "Why do we need a new clean room? You have a lot of clean rooms at JSC. Why can't we just reuse and refurbish one of your existing clean rooms, wouldn't that save a lot of money?" We got that question and it's one of those questions like you put your head in your hand and say, "Okay, where do I even start with this question?" But that's us because that's what we do. It's so obvious to us but it's not obvious to everyone. That was an interesting example.

We had a discussion and I think at the end they realized, "Well, that makes a lot of sense, I realize now that we can't just revamp a clean room, so I'm glad we had this discussion." That gave them a greater appreciation for curation, I think.

But that's sort of a common theme with sample return missions. NASA missions have this very rigid structure. The main life cycle Phases are A through E usually. There's usually not a substantial Phase F (closeout) but we had sample return and analysis in Phase F. All the phases, there are the review cycles that are part of those phases. It's a lingo that all the mission managers are familiar with. They reel off these acronyms. They're shaking their heads oh yes, yes, we got to do that before FOR [flight operations review]. We got MOR [mission operations review] coming up but you can't do that. You got to have a subsystem EPR [engineering peer review]. All this kind of lingo. The curators were lost at first really. What does all this mean?

But the mission management really has an extensive experience with missions that are not sample return, and so making that connection is important from both sides. The curators need to be immersed in that and educated in the mission life cycle structure and how they fit into that. Then I think the mission managers need to be more tuned into what sample return really means. What does it require? What are the differences from their normal missions?

I felt really good in general with interactions with our mission management team about sample curation. But it was pretty clear. Some of the managers were more willing to talk about things and learn than others. Or at least that's the sense I got from a very superficial sense, maybe it's not entirely true. There was a range of responses to curation that we got. I think it's an important variable in the whole big picture. If you have a mission management that's not too tuned in to curation, but you're a sample return mission, that would be kind of sad. That did not happen with OSIRIS-REx. But I could see it happening easily in some other mission because there was not really any pressure from anyone to make sure that happens. I think we had a good rotation or clip of management coming in in the different phases with good backgrounds and receptive personalities to taking curation under their wing and working them in to the fold.

JOHNSON: I can see where that communication across all the different groups or specialties would definitely be important especially in a mission like this that covers so many things. Engineering and the spacecraft first of all. Just going to this asteroid was such a task. Then building the equipment that would be able to do the sample. Then bringing that sample back and getting it on the ground safely. There's so many facets to this. Then the curation on top of that. Communication would definitely be important I think during that kind of mission.

Looking at this mission and your part in it as the curation lead and doing this for a good many years, what would you say you're most proud of on this mission in this work?

RIGHTER: Oh boy. I've had the sensation a couple times over the years working at NASA where sometimes I feel like I get into a grind, or get into a routine, and it becomes repetitive. I start thinking I'm just not enjoying this as much as I used to, or this is getting, not boring, but just

predictable. Sometimes I have an opportunity to either talk with family or go somewhere and I've talked to people and they say, "So what do you do?" We start talking about work, and it's then that I realize what a weird job this is. It's a very niche job and unique and exciting. We work on materials that are just so fascinating and rare. Sometimes it takes interaction with people who are outside of your field or the public or whatever. You have to explain what you do. Then the response is usually, "Oh my gosh, you do that, that's cool."

I've had that sensation both about curation and research at times. People just get so excited. Wow, I can't believe. That is such a cool job. Then I start thinking okay, maybe I'm immersed too deep in this. It is a cool job. I should appreciate this more. Don't get so bored with some of the day-to-day stuff or the predictability.

I feel that way a little bit about OSIRIS-REx. I was with it for so long and we had so many reviews and so many meetings. Monthly meetings, annual meetings. Different kinds of reviews. It gets very tedious. Some of that gets very tedious.

When you finally accomplish something and then you get to a major milestone and it gives you an opportunity like wow, we just accomplished this. The thing maybe that I'm most proud of is looking back on it all. The end result. All the years of hard work. All the dedication to some particular aspect like getting the clean room done. Getting the clean room done the way we want it to be. Completing a collection. We had this large contamination knowledge collection that we put together in support of the mission as well. It's been really useful. Just getting that done and cataloged. That's a good feeling.

All these little elements. Then when you finally get finished, you get to this point, and you can look back at all of this, all these things are linked together to create the big picture. It's just very gratifying. Definitely something to be proud of.

But really though it's hard to accomplish any of that without a huge team. You get a question like this. It's really impossible to imagine any of it without a big team, a team that's working well together. I think the easy response to your question is look what we were able to accomplish, it's an amazing accomplishment really to bring material back from an asteroid. Think of all the technical details that had to fall into place to get that. We've talked about a lot of them the last couple of hours. That's amazing. That's really certainly something to be proud of. But also, I'm proud of being associated with a team that can make it happen.

We're lucky. I think I've said something like this in the past hour or so, that it would be very easy to have a team that didn't have these qualities and that ability to accomplish was not fully realized. Having the team work so well together, having very diverse skills and input into satisfying the big picture. That's a big deal. So I think there are two parts to the answer, the accomplishments and then recognizing the team.

JOHNSON: When we ask that question, people usually do bring that up. You can't accomplish what you accomplish without the people you work with. Is there anything we haven't talked about that you wanted to mention?

RIGHTER: One thing that I really like that I've enjoyed is the international aspect of the mission. I'm not sure. There aren't many sample return missions to compare. Maybe it's unfair to try to compare because of that. But the OSIRIS-REx mission had some collaborations with Canada and with Japan. I worked with the Canadian [Space Agency, CSA] team early on. The Canadian team produced the [OSIRIS-REx] laser altimeter, OLA. We worked with them on contamination

knowledge collection. I think they sent, I don't know, 20 or 30 different items to put into our collection that were related to the OLA instrument.

I had a good time working with them and felt really fortunate to meet them at launch after all the work we put together, putting that collection together before, and then at launch just getting to meet them and talk with them about the mission was really satisfying. I really liked the fact that NASA was working with other countries in that capacity.

That's also true with JAXA and working with Japan. We had the same kind of—but more so—interaction with Japan. We traded ideas and thoughts on clean room design and on contamination knowledge collection ideas and on basic sample characterization with them and their team. We had multiple visits of the JAXA team to JSC where they looked over some of our plans. It was after the Ryugu [asteroid] sample had come back. They had a year or so of experience under their belt and they were looking at our operations and that was really valuable for us to hear their firsthand observations and experiences. They got a lot out of their visits as well I think looking at our different clean room suites.

They're a lot younger or newer at this than we are with the Hayabusa collection being the first in 2010 timeframe. They benefited from our interaction as much as we did. That was really satisfying. I think those two groups have really meshed well and that'll continue for a long time, the interaction between JAXA and NASA.

I can't help but think also that the Canadian Space Agency and NASA will have a close connection here too because now they'll have their first space collection there at the CSA. It'll be just very exciting for them to start building on that. That NASA has a role in both of those planning and initial activities is something really satisfying as well.

JOHNSON: I imagine so. It sounds like you got to see a lot of people at launch that maybe you didn't get a chance to meet before. Or you had communicated with but hadn't seen before. That must have been an experience going out there.

RIGHTER: That was fun. Yes. There was a big launch party down there at one point that was a good opportunity to wander around and meet people. But I had the—I think it was pretty random—the opportunity to sit with the Canadian group and enjoy the banquet with them. Totally unplanned but it was a nice way to do it in the end.

JOHNSON: Some of the perks of getting to work on these projects is getting to meet those people from all over. It really is.

RIGHTER: Yes.

JOHNSON: I appreciate you talking to me today. If there's anything else you want to add at any point just let me know. Or anything that we haven't covered that you think is important that we cover. We can get together again and do that. Or we can do it through your transcript. Either way. But I do appreciate you talking to me today.

RIGHTER: Okay.

[End of interview]