Luke Fountain:

Really, at the moment, we are looking at supplementing the astronauts' diet with fresh food. Eventually, we're hoping to replace calories. And as we transition to become more earth-independent, obviously, we want the astronauts to be able to supply, grow more of their own food, so we're less reliant on resupply.

Speaker 2:

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Matthew Underwood:

Welcome to Further Together, the ORAU podcast. My name is Matthew Underwood, and I'm going to be hosting this episode of Further Together. And I'm really excited about today's episode. We are talking to a fellow in the NASA Postdoctoral Program, so we're always excited to have these conversations with the fellows to learn more about their program and what they're doing and the research that they're taking part in. So today, we are welcoming Luke Fountain. Luke, how are you today?

Luke Fountain:

I'm good, thanks. Great to be here.

Matthew Underwood:

Awesome. So Luke, first, just talk about a little bit about who you are and your background and kind of how you got to where you are today.

Luke Fountain:

Yeah, sure. So I am British, in case you can't tell. So I've always been passionate about space exploration, as I'm sure many people in the program are. And I'm actually a biologist by training, molecular biologist. I batted around several different fields before arriving there. So it was always physics first, and then, it's like, "Ah, physics is quite hard. Maybe geology." I was in planetary geology for a while and then, got stuck before going to university there. So I ended up with molecular biology, but really kept with that passion for space exploration, kept up with research that's been going on in the International Space Station, learned about plants actually during my degree, sort of halfway through my degree. And I was like, "Okay, this is kind of cool. Maybe there are some opportunities there." And luckily, I was doing my degree at the University of Sheffield in the UK at the time.

They have a really good plant science facility there, a lot of good research going on there. So kind of approached those folks, and it went from there. So I did a master's degree in plant molecular biology and then, onto a PhD straight afterwards, again, in plant and soil science. So really, by the end of my PhD, I had a much firmer understanding of plant science in general, but what are the important things to consider when you're growing plants in space and all that kind of thing? I should say my PhD wasn't actually focused on space at all. There were no space components. I did have a couple of projects I was running independently, which did help me, ultimately, get onto the NASA Fellowship. But that was all kind of tangential to my main research goals. But I knew that the NASA Postdoctoral Fellowship was really my only route into NASA as a foreign national, as a scientist.

And so, was actively looking for those kinds of opportunities, that was coming towards the end of my PhD. And I had given a lunch and learn seminar actually about some of my master's research a couple of years prior to that. So I knew some of the researchers that were working in the group here at Kennedy Space Center. I reached out to those and said, "Looking for opportunities, is anything going to come up soon? I don't know if you can say anything." And luckily, that following January, an opportunity did come up in the group, so I applied for that. The research, which I'm sure we'll talk about, was actually based on some of the work I did during my PhD. So when I was proposing this work, I already had that kind of background, which is really exciting, because now, I see my fellowship as an extension of my PhD research. So yeah.

Matthew Underwood:

Absolutely. Well, since you brought it up, let's talk a little bit about that research. What kind is your focus within PPM? What are you looking to gain? And what is your research focused on?

Luke Fountain:

So yeah, so as I mentioned, my research is very plant-focused, so I'm in the Space Crop Production Team at Kennedy Space Center in Florida. And really, we're looking to, in general, grow food for the support of future missions in space. So whether that is missions to the moon, deep space missions in microgravity, and then, hopefully, of course, one day, the journey to Mars. So really, at the moment, we are looking at supplementing the astronauts' diet with fresh food. Eventually, we're hoping to replace calories. And as we transition to become more earth-independent, obviously, we want the astronauts to be able to supply, grow more of their own food, so we're less reliant on resupply. But there are also a wealth of psychological benefits for growing plants in space and even atmospheric control. Humans, all animals that respire, have evolved to coexist with plants, plants take in CO₂, they release oxygen that, of course, we, in turn, breathe.

So there is the atmospheric control aspect as well in this concept of biological life support systems, can we use plants to help with our habitation? So of course, those are the central goals, but growing plants in space is not easy, right? Nothing in space is easy. And so, we have a whole bunch of different research gaps and areas that we are trying to tackle, so that we can get to that, to achieve those objectives. So one of those is plant responses to elevated CO₂, elevated carbon dioxide. Of course, that's an issue on earth as well. We have rising CO₂ levels on earth. And currently, I think the CO₂, at the moment, on earth, is around 420 parts per million. And we expect that to be anywhere between 650 and 1100 by the end of the century, depending on estimates and what mitigation strategies we put in place. But just for context, on the International Space Station, on average, the CO₂ is around 3000 parts per million.

So we are way above and beyond even the top level estimates for what CO₂ is going to look like in the future. So the unfortunate situation we have is that we have that 3000 PPM CO₂ now, and until we figure out better ways of reducing that CO₂ level, we're kind of stuck with it. So if we're going to grow plants in a spaceflight environment, the CO₂ is going to be there and we're going to have to understand how plants respond to that environment. So that is, again, kind of the overarching research area. Specifically my research is investigating how plant nitrogen uptake changes in response to this high CO₂. So nitrogen is one of the most crucial nutrients for plant survival. It's often the rate-limited nutrient in the plant system. So plants don't have enough nitrogen, they don't grow very well. But what a lot of people don't realize is that there are different forms of nitrogen that you can give to plants.

So classically, we would just consider nitrogen as one of the nutrients that we give to plants in our fertilizers, our nutrient solutions. But they're actually different forms. So usually, those take the form of either ammonium or nitrate, and they can take up different forms, depending on the environment, depending on what plant species it is, what variety, a whole host of different factors, even the system that you're growing in. If you're growing in soil compared to hydroponics for example, they take up different forms. And one of those environmental conditions that can affect that nitrogen uptake is elevated CO₂. And that was where my PhD work, that's where it came from. So at the time, I was investigating, I'd seen that plants, barley plants, in this case, spring barley is a very important crop in the UK, they tended to prefer ammonium compared to nitrate under hydroponic conditions.

But that was exacerbated, in some cases, by this elevated CO₂. And after digging around the literature and figuring all this stuff out, we've realized that this is because the use of nitrate, not the uptake of nitrate, but the actual conversion of nitrate to a form that is usable by the plant, that process is actually inhibited by CO2. So the more CO2 you have, the less able a plant is to use nitrate as a nitrogen source. So if they have ammonium available, they'll take that up instead, because that's not affected. And so, I was coming at that from a completely different angle at the time. It was nothing to do with space, but it really got me thinking, "What form of nitrogen are we giving to the plants in a spaceflight environment? Have we ever thought about that before?" Because if we're giving all the plants nitrate and they can't use it in this high CO2 environment, we might actually be limiting growth.

And even if we are giving them some nitrogen as ammonium, then perhaps we can adjust the ammonium to nitrate ratio to maximize growth in this environment. So that was really what my proposal was based on. And we're kind of expanding that now into still doing that. So over the last year, so I've just entered the second year of my fellowship now. In the first year, we used some really cool techniques to show that, in fact, this does happen, in lettuce as well, which is a candidate space crop. So I have several lettuce varieties that have been grown in space that I've tested over the past year, and they all show the same response, rather, the plant chooses to take up nitrogen as ammonium in a hydroponic system. But that's exacerbated by this ISS level CO₂, this 3000 PPM CO₂. So now, we're trying to understand what the optimal ammonium to nitrate ratio is.

But we also have a human health perspective here, because nitrate levels are of concern for human health. So they've been listed as potentially carcinogenic and the levels of nitrates in both plants, particularly leafy greens like lettuce, and even processed meats, where it's added as an additive, a preservative, they can become carcinogenic if consumed in large enough quantities. So of course, we're trying to reduce the amount of nitrates that we include in our plants, and one's mitigation strategy for that might be to give the plants more nitrogen as ammonium. So it's kind of a two pronged approach now, the human health and the plant responses to this environment. So yeah. So that's it in a nutshell.

Matthew Underwood:

That's awesome. I love the research. And it's kind of cool to see that progression from year one to year two kind of how it keeps growing and you can bring in different aspects. And I love that you were able to even continue some of your research from your PhD to bring into this program and just have this evolution of research going on. So of course, you mentioned you're from Britain. What was that transformation like to go to Florida and continue research? What was that process like for you?

Luke Fountain:

It was an experience, let's put it that way. Yeah, I've been coming to Florida on vacation my entire life. I've been pretty lucky to be able to do that. And so, Florida is somewhere that I'd always considered I would like to live here, but my argument has always been, "Well, the only thing that will make me move to Florida is if I get a job at NASA," thinking that it was never going to happen. And of course, as fate would have it, it has. I've been incredibly lucky. So there was never that doubt in my mind, I guess, like there might be in some cases. It was never really a factor. I'm still relatively young, so we decided it was the right decision for me and my wife to come over. So the transition is difficult.

Matthew Underwood:

For sure. I bet.

Luke Fountain:

So it is actually surprisingly quite a different culture compared to the UK. There are a lot of things that I miss. Family, of course, cold weather. Florida is very hot.

Matthew Underwood:

I was about to say, you don't get much cold weather in Florida, for sure.

Luke Fountain:

No, no, not at all. So that was kind of a difficult transition. I kind of knew what to expect, because id experienced it before. But I love the hot weather, but it does get monotonous after a while. But I think the most difficult transition, if I'm being honest, was more so the transition from academia to working in a federal agency like NASA. And of course, both have their challenges, but things tend to work pretty slowly here. You have to think about things pretty far in advance. That can be difficult when your research is constantly changing. So it can be kind of difficult to implement some things.

There is the issue of being a foreign national and working for a federal agency. There are certain things that I can't do that citizens can. So that also adds a little bit more of a challenge to myself and the rest of our team. But overall, it's been a really positive experience. It's been everything I hoped it would be, getting the chance to... First of all, being lucky enough to be based at Kennedy Space Center, so we get to watch rocket launches every week. You can never get tired of that.

Matthew Underwood:

Absolutely.

Luke Fountain:

So I can just look out my window and there's a launch pad there. It's insane. But getting to interact on a daily basis with the scientist whose work I've been reading for the last decade almost is incredible. It's a really enriching experience. And the number of opportunities that have been presented to me over the last year, because I am here or because I am now affiliated with NASA, the name does carry weight. It's just such a household name. You say you're from NASA, people want to come and talk to you.

Matthew Underwood:

Absolutely.

Luke Fountain:

And that's great. We're always advocating for talking about our research, talking about the importance of our work. So yeah, it's been no complaints really.

Matthew Underwood:

So you mentioned some of the other scientists that you've read about and you've read their research and now, you're in the same room as them. And how has the mentorship program really helped you, given the chance to be even mentored by some of those other scientists? What has that meant to you?

Luke Fountain:

It means everything. To put it into context, so my first interaction with members of the group, I believe, was maybe six or seven years ago now, right when I started my PhD. And that was because, so during my PhD, I was lucky enough to have a fully funded PhD by the UK government. And as part of that PhD, they want you to do a three month placement, it's called a PIPS placement. So a Professional Internship for PhD Students. And there are no rules really. The only rule is that it cannot be directly related to your research, but you can go anywhere, you can do anything you want for three months, and it is funded. So at the time of applying for my PhD, I'd said, "Can I go to NASA?" And they were like, "Eh, sure, if you can make those connections and you can make it work, then sure."

So I had been reading lots of papers from the plant group, and I came across the name Ray Wheeler on nearly every paper. And everybody in the space plant biology field knows who Ray is. And at the time, I didn't realize, but now, again, being in that community, I sort of realized what a household name he is. And I just sent him an email. I didn't really know what I was going to get back with or I was even going to get a response, because at that time, NASA was this faceless mass that we all know what NASA does, but how do you actually talk to somebody there and interact with such a large agency?

And he replied back to me within, I don't know, a couple of days, which I just thought was amazing. Not only that I'd heard back from him, but that the feedback I got from him, the response I got, was incredibly positive, something to the effect of, "You're a foreign national. It might be challenging, but we'll see what we can do. I'd really like you to be here. Your research sounds interesting," kind of thing. And to go from that, ultimately, it didn't happen during my PhD, mostly because of COVID. We were nearly there with something, but then, COVID hit and it was an absolute, "No, this is not going to happen." And that was really unfortunate. But the projects I got was still space focused, and we built a lot of collaborations out of that. And it all worked out in the end. But really, the point I wanted to make was to go from that to Ray's office being down the hall, he actually just retired this year, which makes me feel even more fortunate that I managed to get here before he retired.

And he was always willing. His door was always open. I could come talk to him about anything. He was instrumental in planning my research that I'm performing now. And even just now, I'm looking at writing another proposal now. And he's still there via email, right? He's still there providing feedback. He doesn't have to, so having that level of mentorship is incredible. And it's the same with Joya and Ellison, my two advisors, they're always there, always there to help. And really, the rest of the team, it's just a really inclusive team and inclusive environment. So I never struggle so much as I might have done in the past. To ask for help, to feel like I can ask for help, but also, to receive the level of help that I do is really incredible.

Matthew Underwood:

That's awesome. Well, I've loved hearing about your research and then, kind of your journey from England to the US and kind of the whole experience of now getting to do your research. So looking from back side of it, what advice would you give to someone who is an up and coming scientist who wants to be in your shoes one day? What would you tell them?

Luke Fountain:

I would tell them, take every opportunity that is presented to you and apply for anything. If there is something you want to do, don't think about how likely it is or how difficult it is. Science is hard. Everything in science is hard. If it was easy, everybody would be doing it. But particularly, when I was applying for my fellowship, it was, "I don't think I'm going to get this, but I have to try," and look where I am now. So I don't think there's really anything special about me, about people that... We're just people. But what does set us apart is that we're always passionate. We're always dedicated to what we're doing. We take every opportunity that's available to us, and we enjoy what we do. That's the most important thing. And that would be the case for doing a degree, doing a PhD, doing research in general. You have to enjoy what you're doing, because it is so difficult, it will be very easy to give up if you don't enjoy it. So I would say, have fun and take every opportunity that's available to you would be my advice.

Matthew Underwood:

So just from an overarching perspective, how would you say that this experience has impacted your career? And where do you want to head next?

Luke Fountain:

Wow, that's a loaded question. So I think this has been the single greatest career move I've ever made. For me personally, it has opened the door to a research area, which otherwise might have been inaccessible to me in my particular situation, not through anybody's fault in particular, other than the fact that most of the research in space crop production, space plant biology, is conducted in the US. So if you're outside the US, unless you can find a way into that US-based research, it's very difficult to enter that field. So the NPP has been my doorway into that field.

So going forward, of course, I want to stay in this field, now I'm here. And I feel like the NPP has really helped me with that. I don't know yet where I see myself after the NPP, whether that is staying here, whether that is moving elsewhere. But I think, for sure, I know that this kind of research area, this space crop production research area, is where I want to stay. So I will be actively looking for opportunities in that area. And I think, really, the connections I've made along the way are going to go a long way to helping with that.

Matthew Underwood:

That's awesome. So final question, what brings you joy?

Luke Fountain:

What brings me joy? Coming to work.

Matthew Underwood:

Other than seeing the rockets every day.

Luke Fountain:

Seeing the rockets, yeah.

Matthew Underwood:

Other than that?

Luke Fountain:

Well, my single greatest passion, other than space and science, is Star Wars.

Matthew Underwood:

Okay.

Luke Fountain:

So you can see I've got a little gonk droid here.

Matthew Underwood:

Yeah, I love it.

Luke Fountain:

Yeah, so I would say anything Star Wars brings me joy, which is a lot of stuff. But yeah, I guess, being in Florida, we go to the theme parks a lot. We have Star Wars Galaxy's Edge nearby, so I make sure I go there every week. And that certainly brings me a lot of joy.

Matthew Underwood:

That's awesome. I love that. That's a unique answer that we don't hear very often. And I love Star Wars too, so I appreciate that.

Luke Fountain:

That's great.

Matthew Underwood:

Well, Luke, thank you so much for joining us today. We really appreciate the time letting us learn a little bit more about your research and yourself and kind of your journey. So we really appreciate your time today.

Luke Fountain:

Yeah, thank you. Thank you for having me.

Matthew Underwood:

Absolutely. Have a good day.

Luke Fountain:

Thanks, you too.

Speaker 2:

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