The best place to do cutting edge science isn't always on Earth...

It's 220 miles in space, onboard the International Space Station.

Welcome to NASA GeneLab.

Life is different up here in microgravity.

Wounds heal slower.

Infections develop faster.

Bones grow thinner.

The building blocks of life, including genetic coding and molecular signaling networks, undergo drastic change.

Understanding the principles that drive those changes is why we are here.

At GeneLab we seek answers to the fundamental questions of life itself.

The data GeneLab collects and generates is meant to be shared with scientists and researchers.
around the world, who will take the data, explore it, analyze it, publish their results, and magnify its impact.

What GeneLab reveals will help us on our journey into deep space, and will improve generations of lives back home on Earth.

This is GeneLab.

Hello, and welcome to today's GeneLab discussion.

I'm Dr. Marshall Porterfield coming from you today here from headquarters in Washington, DC.

And joining me in the studio is Dr. Gioia Massa, one of our lead scientists on a project we call Veggie.

Welcome, Gioia.

Welcome, Gioia.

Thanks, Marshall.
Glad to be here.

Thank you very much for coming, and can you tell us a little bit about Veggie and what the project is about and tell us a little bit about how that helps us on our journey to Mars?

Sure.

So, Veggie is a small, deployable plant growth chamber that we've sent up to the International Space Station, and it has a whole bunch of different roles.

And it's really a platform for doing a wide variety of research.

We can do large plant, you know, crop research in there and actually produce edible plants that the crew can eat.

And so, we were lucky enough to do that this year.

We could also grow smaller plants in petri dishes in Veggie because Veggie has, you know,
a really outstanding lighting system, specifically designed for plants.

So we've been testing a variety of species to be able to grow in Veggie, and our first crop for Veggie was a red Romaine lettuce, which we grew because it--you know, it's an attractive crop.

It has good germination, pretty rapid growth, and it's something that's got high palatability or acceptability.

Most people really, you know, don't hate lettuce, I guess is the best way to put it.

It also has high levels of antioxidants because it's a red Romaine lettuce.

And so, this is actually a good potentially important thing for astronaut health, to have higher antioxidants in the diet.

And it has low natural microbial levels.

So, we were able to grow the first crop, get some samples back, and do analysis on them,
including looking at the food safety and the total micro biome of those plants and looking at, you know, what bacteria might grow on them.

A lot of those bacteria are actually coming from the astronauts, human-associated bacteria. But, we found that the crops were safe, had pretty low levels of bacteria.

And so, we got approval to have the crew grow a second crop and actually eat part of that crop.

So, we're really excited about that, and they seemed to enjoy it.

We've done a lot of other science in Veggie using petri dishes with the model organization Arabidopsis thaliana, and we have a number of other experiments with Arabidopsis and with other model organisms scheduled to grow in Veggie in the future.

We're also looking at growing other types of crops for the astronauts to eat, including small Chinese cabbage and tomatoes.
So, one of the questions I always get when people see Veggie is why are the lights the color they are?

Can you explain that to us?

Right.

Yeah, it's a really attractive kind of pinkish purple light.

We use red and blue LEDs as well as a few green LEDs inside Veggie.

The green LEDs, there aren't very many of them.

But, they're really just to make the plants look more green because people tend to like plants to look green.

But, the red and the blue LEDs are there to really maximize the efficiency of plant growth.

Plants tend to be green because they're reflecting more green light, and they're absorbing more light in the red and the blue areas, especially the molecule chlorophyll, which makes plants
green.

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00:05:19,339 --> 00:05:20,529
It absorbs very strongly in the red and the blue.

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00:05:20,529 --> 00:05:27,289
So, if we use red and blue LEDs, we can get better efficiency for crop production.

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00:05:27,290 --> 00:05:32,360
And it's been really interesting because NASA's done a lot of this research on these LED lights over the years.

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00:05:32,360 --> 00:05:33,509
But, now commercial plant producers are using these types of lights.

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00:05:33,509 --> 00:05:38,639
So, the astronauts grew a crop of lettuce.

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00:05:38,639 --> 00:05:41,180
They consumed it on the last mission.

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00:05:41,180 --> 00:05:43,959
And we--this is something that we're developing because we believe it would be useful on the journey to Mars.

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00:05:43,959 --> 00:05:48,519
And so, how do you see that?

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00:05:48,519 --> 00:05:49,519
What scale do you see plant systems contributing to life support on a mission to Mars?

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00:05:49,519 --> 00:05:51,259
Yeah.
That's exactly why we were doing this because, you know, in the near term on Space Station, the astronauts are really--you know, most of their food is coming from Earth.

It's very easy to supply the crew with food, relatively easy, because they're in a low-Earth orbit.

But, having a supplemental salad crop or diet could be, you know, really nice, so some fresh vegetables for their diet.

And so, that's really what we're trying to do with Veggie, is to start that process.

But, plants, you know, while they're making food are also helping to recycle the atmosphere.

So, you and I and the astronauts breathing out carbon dioxide all of the time, and plants use that carbon dioxide.

And through the process of photosynthesis, they generate oxygen.

So, it's kind of a byproduct of the food that they're making.
We're getting this atmospheric recycling at the same time.

So, for a longer duration scenario where you're going to be gone a long time, it's harder to resupply.

You can use the plants to help clean the atmosphere at the same time as you're growing food.

They're also cleaning water.

You know, through the process of transpiration, they're taking up water from the media and through their roots.

And as they take it up and use it and they transpire it out through their leaves, that water is totally pure.

So, you could recapture that water and use it for drinking water or for other purposes.

So, these are really nice byproducts of growing plants for food.

On Space Station, there's no way to cook your food.
So, you're really just eating fresh salad crops, things that you could pick and eat.

Maybe we could have fruits, small fruits, like strawberry.

Maybe we can have some herbs that you could add to the packaged diet.

But, the longer and farther away we go, maybe we'll take a microwave.

And then we could grow things like potato or sweet potato and cook them.

Maybe if we're firmly established somewhere on Mars for a long time, then we take some other food processing and preparation equipment, and we can grow other types of plants, you know?

So, if we wanted to grow wheat and take a flour mill and a bread machine and a pasta maker, you know, if we have that equipment there, which is heavy and expensive to launch,

but if we're going to be there long enough, then we can start doing more and more of the diet and more and more of the atmosphere using plants.
So, I think there's a lot of opportunity to build on, you know, the small step that we're taking with Veggie in the future.

So, scientists at NASA have already envisioned a scenario similar to The Martian movie that we've just seen?

Yeah.

We actually had researchers working on potatoes for quite a long time, and, you know, I think we have the world record yield for potatoes in a growth chamber at Kennedy Space Center.

You know, they're a very productive crop and very good to support life.

And, you know, eventually we want to learn how to kind of untether ourselves from Earth so that we're not completely reliant on that logistical supply chain of having to take,

you know, and send all of our food.

So, I think the more that we learn about becoming self-sufficient for space, the more that we
can apply that on Earth to become more sustainable in our lifestyle here.

So, as you know, there's a lot of science that needs to be done between now and a real Mars mission.

And it's really important that we're utilizing the International Space Station to the highest level possible.

How do you see Veggie contributing to the GeneLab effort?

So, Veggie is a platform for doing all different kinds of research, mostly plant research.

And I think that the data sets that will become available from the plant research in Veggie when, you know, as part of this GeneLab, will be open to the whole scientific community.

And so, I can see a lot of different data sets coming out of the Veggie platform that could contribute to this.
Like I said, with small plants in petri dishes, we can grow 30 petri dishes in Veggie under pretty uniform lighting and environmental conditions and get a tremendous number of different plant samples.

And whether those are wild type plants or mutant plants with specific pathways that have been altered, that's a huge amount of biology.

So, people have been designing these studies, and in the future, we'll be able to have GeneLab reference missions designed that can use this footprint and this light source of Veggie to grow these types of plants to do data sets [unintelligible] sets.

So, I think from the small plant side of things, there's a lot of potential there, especially because, you know, some of the mutants or others things that people may be interested in would probably grow really well, you know, with the Veggie light system because it is a very good light system for plants.
At the same time, we can do the large plant studies.

So, we can grow, you know, leafy greens.

We can grow dwarf tomatoes.

We can grow moderate-sized plants within Veggie.

And these are, you know, already sequenced genomes, a lot of these crop plants.

So, a lot of the crop plants will have a direct impact.

The knowledge that we gain in Veggie will have a direct impact for how agriculturalists might be interested in understanding the gene expression of those crops on Earth.

And then, the other aspect of the plant micro biome, that plant/human/microbial interaction and getting kind of the whole picture of that, because it's really a closed ecosystem up there, so Veggie gives you the unique capability to do this kind of ecosystem study and figure out, okay, which microorganisms from humans might survive well in plants?
And really untangle that situation and figure out what's going on there.

And I think these data sets then will be available to the broader community, and people will be able to really extract a lot of knowledge from these types of data.

You know, we have the micro biome from the first lettuce crop that is--it's being kind of worked on right now.

And then that will be available to the research community to, you know, figure out what's going on, learn more about these interactions, and kind of start to put those pieces together.

So, the impact of the science that NASA's conducting today is going to be multiplied through GeneLab.

Veggie can play an important role.

But, the scientific community needs to help NASA at the same time.

So, what are the opportunities you think for the broader scientific community?
And how important is the broader scientific community for GeneLab efforts?

Yeah.

I think that's definitely the case.

And so, we have, you know, kind of two scientific communities that we're talking about here.

One are kind of the community of space biology and organismal genomics experts who are going to help design the reference missions that will occur in hardware platforms like Veggie.

And so, these experts will design an experiment that will really a tremendous body of information.

And then, once that information is attained, that will be put into the public database for everybody worldwide to access, you know.

And we'll have graduate students and professors in all different areas being able to kind of interpret and mine that data set.

So, you can kind of think of it as we have a smaller community of experts who are designing
What the puzzle will look like.

And they'll bring these puzzle pieces back to earth.

And then they'll open this giant puzzle box, and the whole world can plant and can figure out how those pieces fit together and find the unique combinations, unique gene expression and transcriptome and all the other -omics that are going on to really figure out what's going on in these systems.

And I think it's really exciting because, you know, the potential is just huge.

But, it's--you know, I think it's just kind of this untapped well that will spring forth and provide a lot of information.

And then other people will, you know, springboard off of that information.

So, yeah, I think it's just going to be tremendous for the scientific community.

As you know, NASA is in the process of planning to issue NASA research announcements against...
the GeneLab data sets.

So, it's fascinating that some of the data that's already been produced by Veggie will be available to the broader research community.

But, hearing you talk about it makes me think about even high school students doing high school science fair projects based on real data from the International Space Station.

That's really exciting.

Why not?

Yeah.

I mean we're already doing some citizen science with middle school and high school students related to Veggie, where they're starting to look at crop selection for this.

And I think it could totally be expanded into the -omics area.

You know, most students in high schools and many students in colleges don't obviously
have the ability to do their own genomics.

But, everybody will have the ability to look at these data and to do their own, you know,

own experiments essentially on the data.

Ask questions, form hypotheses, and then test the data to see whether or not their hypotheses are met.

So, it's a tremendous opportunity for that.

So, you've talked about Veggie.

We've learned about how Veggie contributes to GeneLab.

And we're pursuing the science.

That's very important in terms of a mission to Mars and the translation of science for

the NASA mission.

But, also the research that we're doing benefits life back here on Earth.

So, tell us about Veggie and how it contributes broadly to our society.
So, you know, Veggie is really a plant growth system, an agricultural system in a lot of ways.

And, you know, many decades of research on LED lighting, on watering, on controlled environment crop production went into Veggie.

And the knowledge that we've gained through the experimentation that led to Veggie and through the implementation of Veggie is very translatable urban agriculture and controlled environment agriculture on Earth.

So, greenhouses now, commercial greenhouses around the world are using similar LED lights for supplemental lighting for crops.

And then indoor farms, plant factories, which are basically starting in urban areas all over the world, are using LED lights similar to what we're using in Veggie as sole-source crop lighting.

It's really fascinating.
You can see these kind of layered arrangements with electric lights and very dense rows of plants where they're growing, you know, salad crops and shipping them out every day, 365 days a year to cities and, you know, restaurants and things around the world. So, I think there's a lot of potential for that type of translation. What we're learning from watering, from controlled release fertilizer, all of these things can also translate directly into being more sustainable with our agriculture systems on Earth because we're figuring out, you know, how much water do plants actually need, you know, what minerals will give what types of nutrition in the different crops. And all of that I think is very applicable to agriculture. You know, we're trying to become more sustainable in our farming. And we have to be.
You know, resources are very limited, and we've got more and more people forming all
the time.

And we need to stay nourished and healthy.

So, what we're doing at NASA directly feeds into that information and really contributes.

Thank you, Gioia.

We really are impressed with what's being learned on Station through GeneLab.

To learn more, go to GeneLab.NASA.gov.