1
00:00:05,130 --> 00:00:09,580
The best place to do cutting edge science
isn't always on Earth...

2
00:00:09,580 --> 00:00:16,920
It’s 220 miles in space, onboard the International
Space Station.

3
00:00:16,920 --> 00:00:21,280
Welcome to NASA GeneLab.

4
00:00:21,280 --> 00:00:24,830
Life is different up here in microgravity.

5
00:00:24,830 --> 00:00:26,900
Wounds heal slower.

6
00:00:26,900 --> 00:00:29,720
Infections develop faster.

7
00:00:29,720 --> 00:00:34,660
Bones grow thinner.

8
00:00:34,660 --> 00:00:40,520
The building blocks of life, including genetic
coding and molecular signaling networks, undergo

9
00:00:40,520 --> 00:00:42,220
drastic change.

10
00:00:42,220 --> 00:00:52,920
Understanding the principles that drive those
changes is why we are here.

11
00:00:52,920 --> 00:00:57,440
At GeneLab we seek answers to the fundamental
questions of life itself.

12

00:00:57,440 --> 00:01:05,110
The data GeneLab collects and generates is
meant to be shared with scientists and researchers

13
00:01:05,110 --> 00:01:08,869
around the world, who will take the data,
explore it, analyze it, publish their results,

14
00:01:08,869 --> 00:01:12,119
and magnify its impact.

15
00:01:12,119 --> 00:01:16,469
This is science amplified.

16
00:01:16,469 --> 00:01:47,350
What GeneLab reveals will help us on our journey
into deep space, and will improve generations

17
00:01:47,350 --> 00:01:49,810
of lives back home on Earth.

18
00:01:49,810 --> 00:01:51,040
This is GeneLab.

19
00:01:51,040 --> 00:01:52,040
[Music]

20
00:01:52,040 --> 00:01:53,499
Hello, and welcome to today's GeneLab discussion.

21
00:01:53,499 --> 00:01:57,979
I'm Dr. Marshall Porterfield coming from you
today here from headquarters in Washington,

22
00:01:57,979 --> 00:01:58,979
DC.

23
00:01:58,979 --> 00:02:02,649
And joining me in the studio is Dr. Gioia

Massa, one of our lead scientists on a project

24
00:02:02,649 --> 00:02:03,659
we call Veggie.

25
00:02:03,659 --> 00:02:04,659
Welcome, Gioia.

26
00:02:04,659 --> 00:02:05,659
Thanks, Marshall.

27
00:02:05,659 --> 00:02:06,659
Glad to be here.

28
00:02:06,659 --> 00:02:10,890
Thank you very much for coming, and can you
tell us a little bit about Veggie and what

29
00:02:10,890 --> 00:02:14,680
the project is about and tell us a little
bit about how that helps us on our journey

30
00:02:14,680 --> 00:02:15,680
to Mars?

31
00:02:15,680 --> 00:02:16,680
Sure.

32
00:02:16,680 --> 00:02:21,240
So, Veggie is a small, deployable plant growth
chamber that we've sent up to the International

33
00:02:21,240 --> 00:02:25,480
Space Station, and it has a whole bunch of
different roles.

34
00:02:25,480 --> 00:02:30,070
And it's really a platform for doing a wide
variety of research.

35
00:02:30,070 --> 00:02:35,710
We can do large plant, you know, crop research
in there and actually produce edible plants

36
00:02:35,710 --> 00:02:36,710
that the crew can eat.

37
00:02:36,710 --> 00:02:40,080
And so, we were lucky enough to do that this
year.

38
00:02:40,080 --> 00:02:44,470
We could also grow smaller plants in petri
dishes in Veggie because Veggie has, you know,

39
00:02:44,470 --> 00:02:49,570
a really outstanding lighting system, specifically
designed for plants.

40
00:02:49,570 --> 00:02:57,000
So we've been testing a variety of species
to be able to grow in Veggie, and our first

41
00:02:57,000 --> 00:03:02,620
crop for Veggie was a red Romaine lettuce,
which we grew because it--you know, it's an

42
00:03:02,620 --> 00:03:03,840
attractive crop.

43
00:03:03,840 --> 00:03:09,330
It has good germination, pretty rapid growth,
and it's something that's got high palatability

44
00:03:09,330 --> 00:03:10,510
or acceptability.

45
00:03:10,510 --> 00:03:15,230

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

46
00:03:15,230 --> 00:03:20,120
It also has high levels of antioxidants because it's a red Romaine lettuce.

47
00:03:20,120 --> 00:03:25,621
And so, this is actually a good potentially important thing for astronaut health, to have

48
00:03:25,621 --> 00:03:27,990
higher antioxidants in the diet.

49
00:03:27,990 --> 00:03:30,930
And it has low natural microbial levels.

50
00:03:30,930 --> 00:03:36,570
So, we were able to grow the first crop, get some samples back, and do analysis on them,

51
00:03:36,570 --> 00:03:42,840
including looking at the food safety and the total micro biome of those plants and looking

52
00:03:42,840 --> 00:03:45,770
at, you know, what bacteria might grow on them.

53
00:03:45,770 --> 00:03:51,400
A lot of those bacteria are actually coming from the astronauts, human-associated bacteria.

54
00:03:51,400 --> 00:03:57,569
But, we found that the crops were safe, had pretty low levels of bacteria.

55
00:03:57,569 --> 00:04:03,510
And so, we got approval to have the crew grow a second crop and actually eat part of that

56
00:04:03,510 --> 00:04:04,510
crop.

57
00:04:04,510 --> 00:04:08,510
So, we're really excited about that, and they seemed to enjoy it.

58
00:04:08,510 --> 00:04:13,800
We've done a lot of other science in Veggie using petri dishes with the model organization

59
00:04:13,800 --> 00:04:19,239
Arabidopsis thaliana, and we have a number of other experiments with Arabidopsis and

60
00:04:19,239 --> 00:04:23,210
with other model organisms scheduled to grow in Veggie in the future.

61
00:04:23,210 --> 00:04:29,430
We're also looking at growing other types of crops for the astronauts to eat, including

62
00:04:29,430 --> 00:04:31,570
small Chinese cabbage and tomatoes.

63
00:04:31,570 --> 00:04:38,450
So, one of the questions I always get when people see Veggie is why are the lights the

64
00:04:38,450 --> 00:04:39,450
color they are?

65
00:04:39,450 --> 00:04:40,580
Can you explain that to us?

66
00:04:40,580 --> 00:04:41,580
Right.

67
00:04:41,580 --> 00:04:45,770
Yeah, it's a really attractive kind of pinkish purple light.

68
00:04:45,770 --> 00:04:51,500
We use red and blue LEDs as well as a few green LEDs inside Veggie.

69
00:04:51,500 --> 00:04:54,400
The green LEDs, there aren't very many of them.

70
00:04:54,400 --> 00:04:59,850
But, they're really just to make the plants look more green because people tend to like

71
00:04:59,850 --> 00:05:01,400
plants to look green.

72
00:05:01,400 --> 00:05:08,380
But, the red and the blue LEDs are there to really maximize the efficiency of plant growth.

73
00:05:08,380 --> 00:05:13,090
Plants tend to be green because they're reflecting more green light, and they're absorbing more

74
00:05:13,090 --> 00:05:18,340
light in the red and the blue areas, especially the molecule chlorophyll, which makes plants

75
00:05:18,340 --> 00:05:19,340
green.

76
00:05:19,340 --> 00:05:20,530
It absorbs very strongly in the red and the blue.

77

00:05:20,530 --> 00:05:27,290
So, if we use red and blue LEDs, we can get
better efficiency for crop production.

78
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

79
00:05:32,360 --> 00:05:33,510
over the years.

80
00:05:33,510 --> 00:05:38,639
But, now commercial plant producers are using
these types of lights.

81
00:05:38,639 --> 00:05:41,180
So, the astronauts grew a crop of lettuce.

82
00:05:41,180 --> 00:05:43,960
They consumed it on the last mission.

83
00:05:43,960 --> 00:05:48,520
And we--this is something that we're developing
because we believe it would be useful on the

84
00:05:48,520 --> 00:05:49,520
journey to Mars.

85
00:05:49,520 --> 00:05:51,260
So, how do you see that?

86
00:05:51,260 --> 00:05:57,210
What scale do you see plant systems contributing
to life support on a mission to Mars?

87
00:05:57,210 --> 00:05:58,230
Yeah.

88
00:05:58,230 --> 00:06:03,480

That's exactly why we were doing this because,
you know, in the near term on Space Station,

89
00:06:03,480 --> 00:06:07,680
the astronauts are really--you know, most
of their food is coming from Earth.

90
00:06:07,680 --> 00:06:13,980
It's very easy to supply the crew with food,
relatively easy, because they're in a low-Earth

91
00:06:13,980 --> 00:06:14,980
orbit.

92
00:06:14,980 --> 00:06:21,090
But, having a supplemental salad crop or diet
could be, you know, really nice, so some fresh

93
00:06:21,090 --> 00:06:22,520
vegetables for their diet.

94
00:06:22,520 --> 00:06:27,820
And so, that's really what we're trying to
do with Veggie, is to start that process.

95
00:06:27,820 --> 00:06:35,780
But, plants, you know, while they're making
food are also helping to recycle the atmosphere.

96
00:06:35,780 --> 00:06:41,460
So, you and I and the astronauts breathing
out carbon dioxide all of the time, and plants

97
00:06:41,460 --> 00:06:43,820
use that carbon dioxide.

98
00:06:43,820 --> 00:06:46,740
And through the process of photosynthesis,
they generate oxygen.

99
00:06:46,740 --> 00:06:50,389
So, it's kind of a byproduct of the food that
they're making.

100
00:06:50,389 --> 00:06:53,800
We're getting this atmospheric recycling at
the same time.

101
00:06:53,800 --> 00:06:59,389
So, for a longer duration scenario where you're
going to be gone a long time, it's harder

102
00:06:59,389 --> 00:07:00,860
to resupply.

103
00:07:00,860 --> 00:07:07,229
You can use the plants to help clean the atmosphere
at the same time as you're growing food.

104
00:07:07,229 --> 00:07:08,840
They're also cleaning water.

105
00:07:08,840 --> 00:07:13,540
You know, through the process of transpiration,
they're taking up water from the media and

106
00:07:13,540 --> 00:07:14,980
through their roots.

107
00:07:14,980 --> 00:07:19,370
And as they take it up and use it and they
transpire it out through their leaves, that

108
00:07:19,370 --> 00:07:20,930
water is totally pure.

109
00:07:20,930 --> 00:07:26,229
So, you could recapture that water and use
it for drinking water or for other purposes.

110
00:07:26,229 --> 00:07:30,850
So, these are really nice byproducts of growing plants for food.

111
00:07:30,850 --> 00:07:33,020
On Space Station, there's no way to cook your food.

112
00:07:33,020 --> 00:07:37,510
So, you're really just eating fresh salad crops, things that you could pick and eat.

113
00:07:37,510 --> 00:07:41,010
Maybe we could have fruits, small fruits, like strawberry.

114
00:07:41,010 --> 00:07:44,200
Maybe we can have some herbs that you could add to the packaged diet.

115
00:07:44,200 --> 00:07:49,660
But, the longer and farther away we go, maybe we'll take a microwave.

116
00:07:49,660 --> 00:07:53,500
And then we could grow things like potato or sweet potato and cook them.

117
00:07:53,500 --> 00:07:58,419
Maybe if we're firmly established somewhere on Mars for a long time, then we take some

118
00:07:58,419 --> 00:08:03,520
other food processing and preparation equipment, and we can grow other types of plants, you

119
00:08:03,520 --> 00:08:04,520
know?

120
00:08:04,520 --> 00:08:09,440
So, if we wanted to grow wheat and take a
flour mill and a bread machine and a pasta

121
00:08:09,440 --> 00:08:13,759
maker, you know, if we have that equipment
there, which is heavy and expensive to launch,

122
00:08:13,759 --> 00:08:17,560
but if we're going to be there long enough,
then we can start doing more and more of the

123
00:08:17,560 --> 00:08:20,919
diet and more and more of the atmosphere using
plants.

124
00:08:20,919 --> 00:08:25,800
So, I think there's a lot of opportunity to
build on, you know, the small step that we're

125
00:08:25,800 --> 00:08:28,210
taking with Veggie in the future.

126
00:08:28,210 --> 00:08:33,180
So, scientists at NASA have already envisioned
a scenario similar to The Martian movie that

127
00:08:33,180 --> 00:08:34,180
we've just seen?

128
00:08:34,180 --> 00:08:35,180
Yeah.

129
00:08:35,180 --> 00:08:40,670
We actually had researchers working on potatoes
for quite a long time, and, you know, I think

130
00:08:40,670 --> 00:08:46,310
we have the world record yield for potatoes

in a growth chamber at Kennedy Space Center.

131
00:08:46,310 --> 00:08:51,250
You know, they're a very productive crop and
very good to support life.

132
00:08:51,250 --> 00:08:56,390
And, you know, eventually we want to learn
how to kind of untether ourselves from Earth

133
00:08:56,390 --> 00:09:02,710
so that we're not completely reliant on that
logistical supply chain of having to take,

134
00:09:02,710 --> 00:09:05,280
you know, and send all of our food.

135
00:09:05,280 --> 00:09:10,960
So, I think the more that we learn about becoming
self-sufficient for space, the more that we

136
00:09:10,960 --> 00:09:15,540
can apply that on Earth to become more sustainable
in our lifestyle here.

137
00:09:15,540 --> 00:09:20,730
So, as you know, there's a lot of science
that needs to be done between now and a real

138
00:09:20,730 --> 00:09:21,730
Mars mission.

139
00:09:21,730 --> 00:09:25,560
And it's really important that we're utilizing
the International Space Station to the highest

140
00:09:25,560 --> 00:09:26,990
level possible.

141

00:09:26,990 --> 00:09:33,310
And that's why NASA's embarked on developing
a new platform called GeneLab.

142
00:09:33,310 --> 00:09:36,980
How do you see Veggie contributing to the
GeneLab effort?

143
00:09:36,980 --> 00:09:44,710
So, Veggie is a platform for doing all different
kinds of research, mostly plant research.

144
00:09:44,710 --> 00:09:49,890
And I think that the data sets that will become
available from the plant research in Veggie

145
00:09:49,890 --> 00:09:56,670
when, you know, as part of this GeneLab, will
be open to the whole scientific community.

146
00:09:56,670 --> 00:10:01,710
And so, I can see a lot of different data
sets coming out of the Veggie platform that

147
00:10:01,710 --> 00:10:03,690
could contribute to this.

148
00:10:03,690 --> 00:10:10,270
Like I said, with small plants in petri dishes,
we can grow 30 petri dishes in Veggie under

149
00:10:10,270 --> 00:10:16,250
pretty uniform lighting and environmental
conditions and get a tremendous number of

150
00:10:16,250 --> 00:10:17,520
different plant samples.

151
00:10:17,520 --> 00:10:21,920
And whether those are wild type plants or

mutant plants with specific pathways that

152
00:10:21,920 --> 00:10:25,390
have been altered, that's a huge amount of biology.

153
00:10:25,390 --> 00:10:32,040
So, people have been designing these studies, and in the future, we'll be able to have GeneLab

154
00:10:32,040 --> 00:10:37,750
reference missions designed that can use this footprint and this light source of Veggie

155
00:10:37,750 --> 00:10:43,589
to grow these types of plants to do data sets [unintelligible] sets.

156
00:10:43,589 --> 00:10:48,910
So, I think from the small plant side of things, there's a lot of potential there, especially

157
00:10:48,910 --> 00:10:54,440
because, you know, some of the mutants or others things that people may be interested

158
00:10:54,440 --> 00:10:58,400
in would probably grow really well, you know, with the Veggie light system because it is

159
00:10:58,400 --> 00:11:00,800
a very good light system for plants.

160
00:11:00,800 --> 00:11:04,110
At the same time, we can do the large plant studies.

161
00:11:04,110 --> 00:11:07,190
So, we can grow, you know, leafy greens.

162
00:11:07,190 --> 00:11:08,450
We can grow dwarf tomatoes.

163
00:11:08,450 --> 00:11:12,180
We can grow moderate-sized plants within Veggie.

164
00:11:12,180 --> 00:11:18,680
And these are, you know, already sequenced genomes, a lot of these crop plants.

165
00:11:18,680 --> 00:11:21,980
So, a lot of the crop plants will have a direct impact.

166
00:11:21,980 --> 00:11:28,770
The knowledge that we gain in Veggie will have a direct impact for how agriculturalists

167
00:11:28,770 --> 00:11:33,970
might be interested in understanding the gene expression of those crops on Earth.

168
00:11:33,970 --> 00:11:42,270
And then, the other aspect of the plant micro biome, that plant/human/microbial interaction

169
00:11:42,270 --> 00:11:47,870
and getting kind of the whole picture of that, because it's really a closed ecosystem up

170
00:11:47,870 --> 00:11:54,770
there, so Veggie gives you the unique capability to do this kind of ecosystem study and figure

171
00:11:54,770 --> 00:12:00,360
out, okay, which microorganisms from humans might survive well in plants?

172
00:12:00,360 --> 00:12:05,560

And really untangle that situation and figure out what's going on there.

173
00:12:05,560 --> 00:12:12,680
And I think these data sets then will be available to the broader community, and people will

174
00:12:12,680 --> 00:12:16,720
be able to really extract a lot of knowledge from these types of data.

175
00:12:16,720 --> 00:12:23,120
You know, we have the micro biome from the first lettuce crop that is--it's being kind

176
00:12:23,120 --> 00:12:24,120
of worked on right now.

177
00:12:24,120 --> 00:12:29,790
And then that will be available to the research community to, you know, figure out what's

178
00:12:29,790 --> 00:12:36,130
going on, learn more about these interactions, and kind of start to put those pieces together.

179
00:12:36,130 --> 00:12:41,640
So, the impact of the science that NASA's conducting today is going to be multiplied

180
00:12:41,640 --> 00:12:43,550
through GeneLab.

181
00:12:43,550 --> 00:12:45,100
Veggie can play an important role.

182
00:12:45,100 --> 00:12:50,700
But, the scientific community needs to help NASA at the same time.

183
00:12:50,700 --> 00:12:53,860
So, what are the opportunities you think for
the broader scientific community?

184
00:12:53,860 --> 00:12:58,480
And how important is the broader scientific
community for GeneLab efforts?

185
00:12:58,480 --> 00:12:59,480
Yeah.

186
00:12:59,480 --> 00:13:01,940
I think that's definitely the case.

187
00:13:01,940 --> 00:13:07,580
And so, we have, you know, kind of two scientific
communities that we're talking about here.

188
00:13:07,580 --> 00:13:15,500
One are kind of the community of space biology
and organismal genomics experts who are going

189
00:13:15,500 --> 00:13:22,290
to help design the reference missions that
will occur in hardware platforms like Veggie.

190
00:13:22,290 --> 00:13:31,620
And so, these experts will design an experiment
that will really a tremendous body of information.

191
00:13:31,620 --> 00:13:39,950
And then, once that information is attained,
that will be put into the public database

192
00:13:39,950 --> 00:13:44,640
for everybody worldwide to access, you know.

193
00:13:44,640 --> 00:13:50,740
And we'll have graduate students and professors

in all different areas being able to kind

194
00:13:50,740 --> 00:13:54,730
of interpret and mine that data set.

195
00:13:54,730 --> 00:14:00,370
So, you can kind of think of it as we have
a smaller community of experts who are designing

196
00:14:00,370 --> 00:14:02,190
what the puzzle will look like.

197
00:14:02,190 --> 00:14:05,440
And they'll bring these puzzle pieces back
to earth.

198
00:14:05,440 --> 00:14:09,860
And then they'll open this giant puzzle box,
and the whole world can plant and can figure

199
00:14:09,860 --> 00:14:16,240
out how those pieces fit together and find
the unique combinations, unique gene expression

200
00:14:16,240 --> 00:14:23,330
and transcriptome and all the other -omics
that are going on to really figure out what's

201
00:14:23,330 --> 00:14:25,400
going on in these systems.

202
00:14:25,400 --> 00:14:29,910
And I think it's really exciting because,
you know, the potential is just huge.

203
00:14:29,910 --> 00:14:35,490
But, it's--you know, I think it's just kind
of this untapped well that will spring forth

204

00:14:35,490 --> 00:14:37,459
and provide a lot of information.

205
00:14:37,459 --> 00:14:41,650
And then other people will, you know, springboard
off of that information.

206
00:14:41,650 --> 00:14:45,990
So, yeah, I think it's just going to be tremendous
for the scientific community.

207
00:14:45,990 --> 00:14:53,070
As you know, NASA is in the process of planning
to issue NASA research announcements against

208
00:14:53,070 --> 00:14:54,170
the GeneLab data sets.

209
00:14:54,170 --> 00:14:58,580
So, it's fascinating that some of the data
that's already been produced by Veggie will

210
00:14:58,580 --> 00:15:00,850
be available to the broader research community.

211
00:15:00,850 --> 00:15:05,370
But, hearing you talk about it makes me think
about even high school students doing high

212
00:15:05,370 --> 00:15:09,910
school science fair projects based on real
data from the International Space Station.

213
00:15:09,910 --> 00:15:10,910
That's really exciting.

214
00:15:10,910 --> 00:15:11,910
Why not?

215

00:15:11,910 --> 00:15:12,910
Yeah.

216
00:15:12,910 --> 00:15:17,029
I mean we're already doing some citizen science
with middle school and high school students

217
00:15:17,029 --> 00:15:21,720
related to Veggie, where they're starting
to look at crop selection for this.

218
00:15:21,720 --> 00:15:25,480
And I think it could totally be expanded into
the -omics area.

219
00:15:25,480 --> 00:15:30,190
You know, most students in high schools and
many students in colleges don't obviously

220
00:15:30,190 --> 00:15:33,840
have the ability to do their own genomics.

221
00:15:33,840 --> 00:15:41,340
But, everybody will have the ability to look
at these data and to do their own, you know,

222
00:15:41,340 --> 00:15:43,779
own experiments essentially on the data.

223
00:15:43,779 --> 00:15:49,450
Ask questions, form hypotheses, and then test
the data to see whether or not their hypotheses

224
00:15:49,450 --> 00:15:50,450
are met.

225
00:15:50,450 --> 00:15:53,139
So, it's a tremendous opportunity for that.

226

00:15:53,139 --> 00:15:55,270
So, you've talked about Veggie.

227
00:15:55,270 --> 00:15:58,370
We've learned about how Veggie contributes
to GeneLab.

228
00:15:58,370 --> 00:16:00,830
And we're pursuing the science.

229
00:16:00,830 --> 00:16:05,990
That's very important in terms of a mission
to Mars and the translation of science for

230
00:16:05,990 --> 00:16:07,220
the NASA mission.

231
00:16:07,220 --> 00:16:11,490
But, also the research that we're doing benefits
life back here on Earth.

232
00:16:11,490 --> 00:16:16,670
So, tell us about Veggie and how it contributes
broadly to our society.

233
00:16:16,670 --> 00:16:23,350
So, you know, Veggie is really a plant growth
system, an agricultural system in a lot of

234
00:16:23,350 --> 00:16:24,350
ways.

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00:16:24,350 --> 00:16:30,820
And, you know, many decades of research on
LED lighting, on watering, on controlled environment

236
00:16:30,820 --> 00:16:34,550
crop production went into Veggie.

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00:16:34,550 --> 00:16:38,990
And the knowledge that we've gained through
the experimentation that led to Veggie and

238
00:16:38,990 --> 00:16:46,550
through the implementation of Veggie is very
translatable urban agriculture and controlled

239
00:16:46,550 --> 00:16:48,950
environment agriculture on Earth.

240
00:16:48,950 --> 00:16:55,010
So, greenhouses now, commercial greenhouses
around the world are using similar LED lights

241
00:16:55,010 --> 00:16:58,010
for supplemental lighting for crops.

242
00:16:58,010 --> 00:17:04,100
And then indoor farms, plant factories, which
are basically starting in urban areas all

243
00:17:04,100 --> 00:17:09,429
over the world, are using LED lights similar
to what we're using in Veggie as sole-source

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00:17:09,429 --> 00:17:11,230
crop lighting.

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00:17:11,230 --> 00:17:12,280
It's really fascinating.

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00:17:12,280 --> 00:17:19,579
You can see these kind of layered arrangements
with electric lights and very dense rows of

247
00:17:19,579 --> 00:17:27,179
plants where they're growing, you know, salad
crops and shipping them out every day, 365

248
00:17:27,179 --> 00:17:31,340
days a year to cities and, you know, restaurants
and things around the world.

249
00:17:31,340 --> 00:17:36,450
So, I think there's a lot of potential for
that type of translation.

250
00:17:36,450 --> 00:17:43,420
What we're learning from watering, from controlled
release fertilizer, all of these things can

251
00:17:43,420 --> 00:17:50,380
also translate directly into being more sustainable
with our agriculture systems on Earth because

252
00:17:50,380 --> 00:17:55,660
we're figuring out, you know, how much water
do plants actually need, you know, what minerals

253
00:17:55,660 --> 00:17:58,980
will give what types of nutrition in the different
crops.

254
00:17:58,980 --> 00:18:02,650
And all of that I think is very applicable
to agriculture.

255
00:18:02,650 --> 00:18:06,890
You know, we're trying to become more sustainable
in our farming.

256
00:18:06,890 --> 00:18:07,890
And we have to be.

257
00:18:07,890 --> 00:18:12,500
You know, resources are very limited, and
we've got more and more people forming all

258

00:18:12,500 --> 00:18:13,500
the time.

259
00:18:13,500 --> 00:18:15,630
And we need to stay nourished and healthy.

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00:18:15,630 --> 00:18:23,680
So, what we're doing at NASA directly feeds
into that information and really contributes.

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00:18:23,680 --> 00:18:25,930
Thank you, Gioia.

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00:18:25,930 --> 00:18:29,570
We really are impressed with what's being
learned on Station through GeneLab.