
ASK AN
ASTROBIOLOGIST
EPISODE 57: APRIL 26, 2023
DR. GARY TRUBL
#AskAstrobio
NASA

1
00:00:01,830 --> 00:00:00,470
[Music]

2
00:00:22,730 --> 00:00:01,840
foreign

3
00:00:23,970 --> 00:00:22,740
[Music]

4
00:00:40,810 --> 00:00:23,980
[Applause]

5
00:00:43,850 --> 00:00:40,820
[Music]

6
00:00:46,610 --> 00:00:43,860
greetings friends fellow earthlings and

7
00:00:48,709 --> 00:00:46,620
relatively large living things welcome

8
00:00:50,990 --> 00:00:48,719
to ask an astrobiologist the show that

9
00:00:53,090 --> 00:00:51,000
celebrates the science and celebrates

10
00:00:55,549 --> 00:00:53,100
the scientists involved in our quest to

11
00:00:58,490 --> 00:00:55,559
understand the nature of life I'm your

12
00:01:00,470 --> 00:00:58,500
host Dr Graham the cosmo biologist Lao

13
00:01:04,070 --> 00:01:00,480

and we're brought to you by the NASA

14
00:01:05,570 --> 00:01:04,080
astrobiology program and Sega net.org as

15
00:01:08,210 --> 00:01:05,580
always we want to thank all of you out

16
00:01:10,070 --> 00:01:08,220
there in the interwebs who share about

17
00:01:11,870 --> 00:01:10,080
our show who interact with our guests

18
00:01:13,250 --> 00:01:11,880
during the live stream we love

19
00:01:14,390 --> 00:01:13,260
highlighting the things that you do and

20
00:01:16,609 --> 00:01:14,400
the ways that you get involved in

21
00:01:18,649 --> 00:01:16,619
Sharing in this journey of astrobiology

22
00:01:21,230 --> 00:01:18,659
with all of us this month we want to

23
00:01:23,990 --> 00:01:21,240
highlight Conor J Ballard who is a PhD

24
00:01:26,630 --> 00:01:24,000
student in astrobiology and geology at

25
00:01:28,609 --> 00:01:26,640
University College of London for giving

26
00:01:31,490 --> 00:01:28,619
us a shout out on Twitter recently about

27
00:01:33,170 --> 00:01:31,500
our last month's episode it's always fun

28
00:01:35,210 --> 00:01:33,180
to have all of you engage in any ways

29
00:01:36,950 --> 00:01:35,220
you can I love engaging with you on any

30
00:01:38,569 --> 00:01:36,960
place in the social media realm out

31
00:01:40,130 --> 00:01:38,579
there and there are certainly a lot of

32
00:01:42,649 --> 00:01:40,140
social media places out there to engage

33
00:01:44,390 --> 00:01:42,659
with today's episode is going to be

34
00:01:47,390 --> 00:01:44,400
pretty exciting we're going down to the

35
00:01:50,149 --> 00:01:47,400
world of the small today the very small

36
00:01:52,429 --> 00:01:50,159
Our Guest for this episode is Dr Gary

37
00:01:53,810 --> 00:01:52,439
troubal and I'm so excited to finally

38
00:01:55,609 --> 00:01:53,820

have him on the show I've been thinking

39
00:01:57,410 --> 00:01:55,619
about having him here for a while but he

40
00:01:59,090 --> 00:01:57,420
just recently had a new paper published

41
00:02:01,249 --> 00:01:59,100
and that made me think well it's time we

42
00:02:03,410 --> 00:02:01,259
have to have him on the show uh Dr

43
00:02:04,730 --> 00:02:03,420
Trubel earned his bachelor's degree at

44
00:02:07,010 --> 00:02:04,740
the University of Arizona in

45
00:02:08,389 --> 00:02:07,020
environmental sciences and then earned a

46
00:02:09,830 --> 00:02:08,399
master's degree in environmental science

47
00:02:12,410 --> 00:02:09,840
and health at the University of Nevada

48
00:02:14,270 --> 00:02:12,420
in Reno while also working at the desert

49
00:02:15,650 --> 00:02:14,280
Research Institute where he was doing

50
00:02:18,710 --> 00:02:15,660
some research into determining the

51
00:02:21,410 --> 00:02:18,720
origin of n2o in Lake Vita Brian's in

52
00:02:23,570 --> 00:02:21,420
Antarctica uh Dr trubo then went on to

53
00:02:25,610 --> 00:02:23,580
his PhD in microbiology at the Ohio

54
00:02:27,589 --> 00:02:25,620
State University where he worked on

55
00:02:30,110 --> 00:02:27,599
characterizing viruses and Arctic

56
00:02:31,910 --> 00:02:30,120
peatlands along a permafrost thaw

57
00:02:34,550 --> 00:02:31,920
gradient to understand their roles in

58
00:02:37,369 --> 00:02:34,560
permafrost thaw and ecosystem carbon

59
00:02:39,350 --> 00:02:37,379
processing all very cool research of

60
00:02:41,270 --> 00:02:39,360
course Dr trible then went on to do his

61
00:02:43,490 --> 00:02:41,280
postdoc in his now a research staff

62
00:02:46,550 --> 00:02:43,500
scientist at the Lawrence Livermore

63
00:02:49,610 --> 00:02:46,560

National Laboratory his ongoing research

64
00:02:51,530 --> 00:02:49,620
here Gary's using multiple meta-omic

65
00:02:53,990 --> 00:02:51,540
approaches like metagenomics and meta

66
00:02:55,850 --> 00:02:54,000
transcriptomics and viromics in

67
00:02:57,710 --> 00:02:55,860
combination with stable isotopes and

68
00:03:00,110 --> 00:02:57,720
radioisotope probing to better

69
00:03:02,869 --> 00:03:00,120
understand the mechanisms that viruses

70
00:03:05,210 --> 00:03:02,879
use to control microbial physiology and

71
00:03:07,729 --> 00:03:05,220
to quantify nutrient exchanges in soils

72
00:03:09,770 --> 00:03:07,739
so I'm so excited to have him join us

73
00:03:11,630 --> 00:03:09,780
Gary thanks so much for joining us here

74
00:03:13,910 --> 00:03:11,640
and ask an astrobiologist

75
00:03:15,470 --> 00:03:13,920
hi thanks for having me on

76
00:03:16,550 --> 00:03:15,480
uh like I said I've been you know kind

77
00:03:17,869 --> 00:03:16,560
of wanting you on the show for a while

78
00:03:20,750 --> 00:03:17,879
I've been super excited about the work

79
00:03:22,610 --> 00:03:20,760
you've done uh you hosted a NASA

80
00:03:25,250 --> 00:03:22,620
astrobiology Institute Workshop some

81
00:03:27,410 --> 00:03:25,260
years back on this realm of Astro

82
00:03:29,509 --> 00:03:27,420
virology and so today we're going to

83
00:03:31,910 --> 00:03:29,519
talk a lot about viruses what they are

84
00:03:34,610 --> 00:03:31,920
your research and viruses and

85
00:03:37,190 --> 00:03:34,620
astrovirology but before we get there I

86
00:03:38,869 --> 00:03:37,200
always love for our guests to share kind

87
00:03:40,490 --> 00:03:38,879
of their their pathway their their

88
00:03:42,410 --> 00:03:40,500

science origin story that has brought

89
00:03:44,089 --> 00:03:42,420
them to where they are uh would you mind

90
00:03:45,410 --> 00:03:44,099
laying out for us what the moment was

91
00:03:47,570 --> 00:03:45,420
for you where you realized this was

92
00:03:50,030 --> 00:03:47,580
going to be your career

93
00:03:52,729 --> 00:03:50,040
yeah that's tricky I don't know if there

94
00:03:54,589 --> 00:03:52,739
was just a single moment or accumulation

95
00:03:57,350 --> 00:03:54,599
of many moments you know when I went in

96
00:03:59,990 --> 00:03:57,360
to do my undergrad I had no idea what I

97
00:04:03,050 --> 00:04:00,000
wanted to do I tried veterinary science

98
00:04:04,610 --> 00:04:03,060
I tried political science I helped

99
00:04:06,350 --> 00:04:04,620
around environmental science kind of

100
00:04:08,509 --> 00:04:06,360
spanned everything and you could focus

101
00:04:10,789 --> 00:04:08,519
in different areas so I kind of went

102
00:04:13,429 --> 00:04:10,799
with that and that was enjoyable

103
00:04:14,929 --> 00:04:13,439
I got involved in undergrad research lab

104
00:04:16,969 --> 00:04:14,939
which really helped me go to graduate

105
00:04:18,650 --> 00:04:16,979
school during my grad school I started

106
00:04:20,930 --> 00:04:18,660
tinking around I realized I like cold

107
00:04:22,909 --> 00:04:20,940
environments I like extreme stuff like

108
00:04:25,010 --> 00:04:22,919
what are the limits of life

109
00:04:27,469 --> 00:04:25,020
so I started working in Antarctic

110
00:04:28,730 --> 00:04:27,479
research and I enjoyed that but then I

111
00:04:30,950 --> 00:04:28,740
really wanted to know what's all this

112
00:04:32,570 --> 00:04:30,960
new meta-omics of this out there there

113
00:04:34,969 --> 00:04:32,580

was barely any courses when I was an

114
00:04:38,510 --> 00:04:34,979
undergrad so then I moved on to do a PhD

115
00:04:40,430 --> 00:04:38,520
using those tools during my PhD

116
00:04:41,629 --> 00:04:40,440
I was working on a permafrostolic

117
00:04:43,790 --> 00:04:41,639
gradient I was originally going to look

118
00:04:46,850 --> 00:04:43,800
at the bacteria in archaea but then I

119
00:04:49,790 --> 00:04:46,860
came across Maya bright Parts 2012 paper

120
00:04:52,070 --> 00:04:49,800
Marine viruses truth or dare

121
00:04:53,749 --> 00:04:52,080
and that that maybe if you're going to

122
00:04:56,930 --> 00:04:53,759
talk about one moment that was the paper

123
00:04:59,450 --> 00:04:56,940
that just changed my life forever it is

124
00:05:01,490 --> 00:04:59,460
captivating it's engaging it's well

125
00:05:03,469 --> 00:05:01,500
written and it's even got these great

126
00:05:06,230 --> 00:05:03,479
cartoons that really show you why

127
00:05:08,450 --> 00:05:06,240
viruses are important and before that I

128
00:05:10,969 --> 00:05:08,460
had not taken a virology course but I

129
00:05:13,670 --> 00:05:10,979
took a microbiology course and you know

130
00:05:16,370 --> 00:05:13,680
you learn about human viruses HIV herpes

131
00:05:18,110 --> 00:05:16,380
kind of boring I I didn't really find

132
00:05:20,330 --> 00:05:18,120
them too exciting right I wanted to know

133
00:05:22,249 --> 00:05:20,340
about ecology how they interact with

134
00:05:24,050 --> 00:05:22,259
everything around them and I didn't

135
00:05:26,689 --> 00:05:24,060
really know this was possible but then

136
00:05:29,029 --> 00:05:26,699
after reading Maya's paper I was hooked

137
00:05:31,010 --> 00:05:29,039
oh very cool and I feel like you know

138
00:05:32,749 --> 00:05:31,020

our understanding of the biological

139
00:05:35,090 --> 00:05:32,759
realm around us of course it's evolved

140
00:05:37,010 --> 00:05:35,100
over time but understanding viruses in

141
00:05:38,870 --> 00:05:37,020
their roles feels like a fairly new

142
00:05:41,390 --> 00:05:38,880
thing uh compared to you know

143
00:05:43,909 --> 00:05:41,400
understanding microorganisms um you know

144
00:05:45,770 --> 00:05:43,919
other things like bacteria and archaea

145
00:05:47,930 --> 00:05:45,780
or understanding larger creatures like

146
00:05:49,850 --> 00:05:47,940
plants animals and fungi you know it's

147
00:05:51,230 --> 00:05:49,860
viruses are so small it seems like it's

148
00:05:53,629 --> 00:05:51,240
just taken us a long time to really

149
00:05:56,330 --> 00:05:53,639
engage with our understanding of them

150
00:05:59,990 --> 00:05:56,340
yeah I think that's exactly right I mean

151
00:06:01,550 --> 00:06:00,000
if we go back 30 40 years ago what we're

152
00:06:04,070 --> 00:06:01,560
talking about for viruses was the same

153
00:06:05,689 --> 00:06:04,080
for microbes right we were just figuring

154
00:06:08,270 --> 00:06:05,699
out oh archaea is a thing that's

155
00:06:11,090 --> 00:06:08,280
Eubacteria what's going on with that and

156
00:06:12,469 --> 00:06:11,100
I think in 20 30 years from now it's

157
00:06:14,689 --> 00:06:12,479
going to be the next smallest thing

158
00:06:16,730 --> 00:06:14,699
right so it's it's great how our tools

159
00:06:19,310 --> 00:06:16,740
are progressing and allowing us to see

160
00:06:21,290 --> 00:06:19,320
even smaller things each year

161
00:06:23,930 --> 00:06:21,300
absolutely and it's you know science has

162
00:06:25,969 --> 00:06:23,940
unlocked scales of time and space for us

163
00:06:28,129 --> 00:06:25,979

that we did not evolve to think about uh

164
00:06:29,689 --> 00:06:28,139
quite honestly uh and then our knowledge

165
00:06:32,090 --> 00:06:29,699
you know an astrobiology our knowledge

166
00:06:34,730 --> 00:06:32,100
is evolving of what life even really is

167
00:06:36,950 --> 00:06:34,740
or how to characterize life uh I did put

168
00:06:39,110 --> 00:06:36,960
up a poll on my own Twitter account last

169
00:06:41,510 --> 00:06:39,120
night just asking the question that I'm

170
00:06:44,390 --> 00:06:41,520
sure you get all the time our virus is

171
00:06:47,029 --> 00:06:44,400
alive and of the answers of you know yes

172
00:06:49,490 --> 00:06:47,039
no maybe or what's a virus

173
00:06:51,770 --> 00:06:49,500
um about 60 almost 60 percent of the

174
00:06:54,590 --> 00:06:51,780
respondents said maybe a little bit of

175
00:06:56,090 --> 00:06:54,600
both maybe alive and not alive

176
00:06:58,909 --> 00:06:56,100
um I wonder if you can give us a little

177
00:07:01,070 --> 00:06:58,919
virology 101 of what our current

178
00:07:03,770 --> 00:07:01,080
knowledges of viruses and how they they

179
00:07:06,830 --> 00:07:03,780
interact with the environment of course

180
00:07:08,090 --> 00:07:06,840
so I want I appreciate you putting that

181
00:07:10,909 --> 00:07:08,100
out there and I appreciate you even

182
00:07:12,830 --> 00:07:10,919
giving the option of more than a yes or

183
00:07:15,050 --> 00:07:12,840
no because as we're seeing with life

184
00:07:16,969 --> 00:07:15,060
everything's a spectrum there's no block

185
00:07:18,710 --> 00:07:16,979
there's no white it's all the Spectrum

186
00:07:20,089 --> 00:07:18,720
for everything that comes to do with

187
00:07:24,290 --> 00:07:20,099
Biology

188
00:07:26,390 --> 00:07:24,300

so I do get that question a lot and it's

189
00:07:28,670 --> 00:07:26,400
somewhat frustrating and the reason why

190
00:07:31,370 --> 00:07:28,680
it's frustrating is we still don't have

191
00:07:33,950 --> 00:07:31,380
a definition of what life is we have

192
00:07:36,710 --> 00:07:33,960
working definition for something we may

193
00:07:38,990 --> 00:07:36,720
see but if you actually look at the

194
00:07:41,870 --> 00:07:39,000
support for it it continuously changes

195
00:07:43,490 --> 00:07:41,880
if you think about all right what are

196
00:07:45,890 --> 00:07:43,500
the characteristics of life well they

197
00:07:48,650 --> 00:07:45,900
have to grow crystals grow

198
00:07:51,770 --> 00:07:48,660
they're not life right so what exactly

199
00:07:54,589 --> 00:07:51,780
is needed and currently we have the tree

200
00:07:57,230 --> 00:07:54,599
of life which is based on you know a set

201
00:07:59,749 --> 00:07:57,240
of marker genes and currently viruses

202
00:08:01,370 --> 00:07:59,759
don't have or we haven't found a virus I

203
00:08:02,990 --> 00:08:01,380
wouldn't say they do though

204
00:08:05,570 --> 00:08:03,000
um to have this marker Gene so they're

205
00:08:07,249 --> 00:08:05,580
not included in the in the tree of life

206
00:08:10,249 --> 00:08:07,259
but

207
00:08:12,050 --> 00:08:10,259
to say viruses are alive or not is it's

208
00:08:13,850 --> 00:08:12,060
just it's interesting because if we went

209
00:08:15,830 --> 00:08:13,860
to another planet and we found a virus

210
00:08:18,110 --> 00:08:15,840
would we really argue that there's not

211
00:08:20,150 --> 00:08:18,120
life there so if we talk about the

212
00:08:22,249 --> 00:08:20,160
things we know about viruses they need a

213
00:08:24,830 --> 00:08:22,259

host so if we found a virus we know

214
00:08:27,290 --> 00:08:24,840
there has to be a host nearby viruses

215
00:08:30,230 --> 00:08:27,300
themselves don't have metabolism so

216
00:08:32,029 --> 00:08:30,240
maybe if we look at the virus particle

217
00:08:33,469 --> 00:08:32,039
itself so we call it a virium it's when

218
00:08:36,469 --> 00:08:33,479
you hear the virus shape and then you

219
00:08:38,750 --> 00:08:36,479
also have nucleic acid which can be DNA

220
00:08:41,089 --> 00:08:38,760
or RNA

221
00:08:44,449 --> 00:08:41,099
maybe it's not active in that state

222
00:08:46,550 --> 00:08:44,459
right there's not generation of ATP but

223
00:08:48,110 --> 00:08:46,560
sure enough when it infects a host

224
00:08:49,910 --> 00:08:48,120
it takes advantage of those it

225
00:08:52,550 --> 00:08:49,920
reprograms host it uses the host

226
00:08:54,769 --> 00:08:52,560
metabolic machinery

227
00:08:56,930 --> 00:08:54,779
and it does what the virus wants so at

228
00:08:59,509 --> 00:08:56,940
that point it must be the virus right

229
00:09:01,009 --> 00:08:59,519
the virus is now alive so I would

230
00:09:04,009 --> 00:09:01,019
definitely argue a little bit of both

231
00:09:06,829 --> 00:09:04,019
and just to say a hard no or hard yes is

232
00:09:08,750 --> 00:09:06,839
is hard to say

233
00:09:11,030 --> 00:09:08,760
that's awesome yeah and I will say some

234
00:09:12,230 --> 00:09:11,040
of the commenters on that post they

235
00:09:13,490 --> 00:09:12,240
brought up exactly things like that we

236
00:09:15,470 --> 00:09:13,500
had a conversation about information

237
00:09:17,090 --> 00:09:15,480
Theory and whether we should be

238
00:09:18,650 --> 00:09:17,100

characterizing life by how it how it

239
00:09:21,170 --> 00:09:18,660
stores and transfers information which

240
00:09:22,910 --> 00:09:21,180
viruses most certainly do and then one

241
00:09:24,889 --> 00:09:22,920
person even mentioned you know like that

242
00:09:26,449 --> 00:09:24,899
would you know the viruses might not be

243
00:09:28,610 --> 00:09:26,459
alive and I I did pose that question

244
00:09:30,170 --> 00:09:28,620
what happens if we find a viral particle

245
00:09:31,730 --> 00:09:30,180
on Mars

246
00:09:33,110 --> 00:09:31,740
um even though it doesn't no it doesn't

247
00:09:35,090 --> 00:09:33,120
show us the cell that it could be

248
00:09:37,970 --> 00:09:35,100
infecting I think a lot of us would

249
00:09:39,530 --> 00:09:37,980
argue that counts as a life detection

250
00:09:41,389 --> 00:09:39,540
um and so yeah there's a lot for us to

251
00:09:42,949 --> 00:09:41,399
explore there and to learn about viruses

252
00:09:44,329 --> 00:09:42,959
now I think you know you mentioned

253
00:09:45,769 --> 00:09:44,339
earlier kind of how a lot of our

254
00:09:47,210 --> 00:09:45,779
thinking about viruses especially you

255
00:09:48,949 --> 00:09:47,220
know with the recent coronavirus

256
00:09:50,210 --> 00:09:48,959
pandemic that we've all suffered through

257
00:09:51,350 --> 00:09:50,220
together

258
00:09:53,090 --> 00:09:51,360
um we all know about things like you

259
00:09:55,190 --> 00:09:53,100
know HIV and some of these other viruses

260
00:09:57,230 --> 00:09:55,200
that infect humans and cause you know

261
00:09:58,970 --> 00:09:57,240
everything colds all kinds of stuff but

262
00:10:01,009 --> 00:09:58,980
you know we don't think as often about

263
00:10:02,509 --> 00:10:01,019

the other kinds of viruses that are out

264
00:10:03,769 --> 00:10:02,519
there and how they are involved in the

265
00:10:05,810 --> 00:10:03,779
environment that's been more of your

266
00:10:08,030 --> 00:10:05,820
research I wonder if you can give us

267
00:10:10,250 --> 00:10:08,040
kind of your vision of of viruses as

268
00:10:12,590 --> 00:10:10,260
they are involved in in the environment

269
00:10:13,670 --> 00:10:12,600
in an ecological kind of sense here on

270
00:10:16,190 --> 00:10:13,680
Earth

271
00:10:18,230 --> 00:10:16,200
yeah and that's exactly what got me

272
00:10:20,210 --> 00:10:18,240
excited about viruses it's not that I

273
00:10:22,370 --> 00:10:20,220
don't care about humans it's just that

274
00:10:24,110 --> 00:10:22,380
we're looking at the minority of ours is

275
00:10:25,430 --> 00:10:24,120
because we're human-centric right we

276
00:10:28,370 --> 00:10:25,440
care about things that are relevant to

277
00:10:30,949 --> 00:10:28,380
us and that makes sense but if we look

278
00:10:34,490 --> 00:10:30,959
at what the majority of viruses are out

279
00:10:36,590 --> 00:10:34,500
there it's such a diverse term and and

280
00:10:38,750 --> 00:10:36,600
what I've spent most of my time studying

281
00:10:41,329 --> 00:10:38,760
are actually bacteriophage which are

282
00:10:43,070 --> 00:10:41,339
viruses that kill bacteria and there's

283
00:10:45,110 --> 00:10:43,080
more bacteriophage than there are of any

284
00:10:46,910 --> 00:10:45,120
other type of virus out there right you

285
00:10:50,030 --> 00:10:46,920
have bacteriophage you have viruses all

286
00:10:51,829 --> 00:10:50,040
over you and I like to say viruses as a

287
00:10:53,810 --> 00:10:51,839
loose term because there's so many other

288
00:10:56,990 --> 00:10:53,820

viruses there's microviruses which are

289
00:10:59,930 --> 00:10:57,000
viruses infect fungi are teal viruses

290
00:11:02,870 --> 00:10:59,940
anything out there gets infected by a

291
00:11:05,569 --> 00:11:02,880
virus including viruses themselves

292
00:11:08,389 --> 00:11:05,579
so when we're thinking about you know oh

293
00:11:10,009 --> 00:11:08,399
viruses bad viruses is good that's not

294
00:11:11,569 --> 00:11:10,019
how it is we have to think about the

295
00:11:13,009 --> 00:11:11,579
ecology everything about the ecosystem

296
00:11:14,930 --> 00:11:13,019
what are they all doing They're all

297
00:11:17,389 --> 00:11:14,940
playing a component in the ecosystem

298
00:11:19,790 --> 00:11:17,399
right and so I like to think of things

299
00:11:21,949 --> 00:11:19,800
at a systems level and I started going

300
00:11:24,710 --> 00:11:21,959
with soils because soils are arguably

301
00:11:27,290 --> 00:11:24,720
the most diverse system out there and

302
00:11:29,030 --> 00:11:27,300
they are really tough to sort to study

303
00:11:30,410 --> 00:11:29,040
and I love it though because we can

304
00:11:32,449 --> 00:11:30,420
interact with soil we grow up with soil

305
00:11:34,550 --> 00:11:32,459
it's all around us there's so many

306
00:11:37,250 --> 00:11:34,560
ecosystem processes that soils gives us

307
00:11:39,350 --> 00:11:37,260
and in soils it's not just one thing is

308
00:11:40,910 --> 00:11:39,360
doing this it's this affecting this

309
00:11:43,310 --> 00:11:40,920
affecting this there's a Cascade of

310
00:11:45,829 --> 00:11:43,320
effects and we need to know how they all

311
00:11:48,050 --> 00:11:45,839
interact as an ecosystem as a whole and

312
00:11:50,210 --> 00:11:48,060
this is part of the reason why I use the

313
00:11:52,550 --> 00:11:50,220

metagenomics The Meta transcriptomics

314
00:11:54,050 --> 00:11:52,560
and to give everyone a background this

315
00:11:56,030 --> 00:11:54,060
is where instead of looking at an

316
00:11:58,550 --> 00:11:56,040
ecosystem we're not pulling out one bug

317
00:12:00,889 --> 00:11:58,560
and saying hey what are you doing we are

318
00:12:03,470 --> 00:12:00,899
extracting nucleic acid so DNA from

319
00:12:05,810 --> 00:12:03,480
metagenome or RNA for metatrine crypto

320
00:12:07,970 --> 00:12:05,820
of the environment so we take one sample

321
00:12:10,970 --> 00:12:07,980
we have some soil here we extract all of

322
00:12:12,530 --> 00:12:10,980
the DNA out when we extract that DNA we

323
00:12:14,329 --> 00:12:12,540
sequence it so we can put on the

324
00:12:15,829 --> 00:12:14,339
computer and see what each individual

325
00:12:17,990 --> 00:12:15,839
does and we have to bring them back and

326
00:12:20,509 --> 00:12:18,000
reconstruct their genomes and then we

327
00:12:22,130 --> 00:12:20,519
figure out how they're interacting and

328
00:12:24,949 --> 00:12:22,140
we can't just look at DNA alone because

329
00:12:26,690 --> 00:12:24,959
DNA tells us what is the Baseline what's

330
00:12:28,970 --> 00:12:26,700
the potential what do they encode what

331
00:12:31,130 --> 00:12:28,980
can they possibly do not that they do it

332
00:12:33,110 --> 00:12:31,140
though The Meta transcriptomes is when

333
00:12:37,190 --> 00:12:33,120
we start looking at RNA so we have to go

334
00:12:39,949 --> 00:12:37,200
from DNA to RNA so RNA shows hey this is

335
00:12:43,490 --> 00:12:39,959
metabolism that's happening right but we

336
00:12:45,290 --> 00:12:43,500
also kind of pre to pre uh preempt

337
00:12:47,930 --> 00:12:45,300
things right so a great example would be

338
00:12:49,730 --> 00:12:47,940

in soils when it's going to rain right

339
00:12:51,170 --> 00:12:49,740
when the rain is about to happen you

340
00:12:53,629 --> 00:12:51,180
smell that especially if you're in a

341
00:12:55,850 --> 00:12:53,639
desert environment a group in Arizona I

342
00:12:58,129 --> 00:12:55,860
love the smell of the desert before

343
00:13:01,670 --> 00:12:58,139
during and after a rain that that

344
00:13:02,269 --> 00:13:01,680
Jasmine smells so good that dirt smell

345
00:13:04,670 --> 00:13:02,279
um

346
00:13:06,889 --> 00:13:04,680
so the microbes get ready right they

347
00:13:08,269 --> 00:13:06,899
start chugging out aren't mRNA which is

348
00:13:09,829 --> 00:13:08,279
the messenger RNA they're getting ready

349
00:13:11,090 --> 00:13:09,839
if it's going to rain sometimes it

350
00:13:13,430 --> 00:13:11,100
doesn't rain or it's not going to rain

351
00:13:15,110 --> 00:13:13,440
where they are so then we look at meta

352
00:13:16,490 --> 00:13:15,120
proteomics these are all the proteins to

353
00:13:18,290 --> 00:13:16,500
show okay something that actually

354
00:13:20,930 --> 00:13:18,300
happened right we had a protein that was

355
00:13:22,850 --> 00:13:20,940
produced now we can arguably say that it

356
00:13:24,829 --> 00:13:22,860
had to happen because if a cell is

357
00:13:26,810 --> 00:13:24,839
making a protein and it doesn't use it

358
00:13:29,090 --> 00:13:26,820
that's exhausting that's a lot of energy

359
00:13:31,490 --> 00:13:29,100
where mrnas like chunk change so we can

360
00:13:33,170 --> 00:13:31,500
make mRNA but then to make proteins you

361
00:13:35,329 --> 00:13:33,180
really need to hope it happens

362
00:13:37,610 --> 00:13:35,339
but if you want to be sure then we can

363
00:13:38,990 --> 00:13:37,620

go into meta metabolismics which is

364
00:13:41,870 --> 00:13:39,000
where we're looking at the metabolites

365
00:13:43,730 --> 00:13:41,880
the interactions with these proteins

366
00:13:45,410 --> 00:13:43,740
and so cool and like you know the

367
00:13:47,449 --> 00:13:45,420
knowledge that we have to even do this

368
00:13:49,550 --> 00:13:47,459
is evolving rapidly right now I remember

369
00:13:52,370 --> 00:13:49,560
when I was earning my my bachelor's

370
00:13:54,410 --> 00:13:52,380
degree in biology we were at the place

371
00:13:55,790 --> 00:13:54,420
of doing meta transcriptomics or meta

372
00:13:57,769 --> 00:13:55,800
metabolomics at that point those things

373
00:13:59,449 --> 00:13:57,779
have really been evolving over the last

374
00:14:00,889 --> 00:13:59,459
20 some years

375
00:14:02,210 --> 00:14:00,899
um to allow us to do this now and to

376
00:14:04,190 --> 00:14:02,220
look into the environment and see these

377
00:14:05,810 --> 00:14:04,200
things I will mention another poll that

378
00:14:08,210 --> 00:14:05,820
we did through the NASA astrobiology

379
00:14:09,769 --> 00:14:08,220
YouTube channel just yesterday

380
00:14:12,350 --> 00:14:09,779
um asking people about the scale of

381
00:14:14,569 --> 00:14:12,360
viruses in the environment uh there are

382
00:14:17,150 --> 00:14:14,579
more viruses than stars in our known

383
00:14:19,190 --> 00:14:17,160
universe uh an estimated 10 nonillion

384
00:14:20,389 --> 00:14:19,200
viruses here on Earth

385
00:14:23,150 --> 00:14:20,399
um but they only make up a very small

386
00:14:24,889 --> 00:14:23,160
percentage of the total biomass uh so we

387
00:14:26,810 --> 00:14:24,899
gave the audience some some options for

388
00:14:29,269 --> 00:14:26,820

possible biomass fourteen percent four

389
00:14:31,610 --> 00:14:29,279
percent zero point four percent or point

390
00:14:33,530 --> 00:14:31,620
zero four percent uh the correct answer

391
00:14:35,030 --> 00:14:33,540
was point four percent

392
00:14:37,850 --> 00:14:35,040
um so they are a very small amount of

393
00:14:39,470 --> 00:14:37,860
the biomass even though there is so many

394
00:14:41,269 --> 00:14:39,480
of them and thanks to things like the

395
00:14:43,129 --> 00:14:41,279
work you're doing with you know not just

396
00:14:45,290 --> 00:14:43,139
the metagenomics but also

397
00:14:47,329 --> 00:14:45,300
transcriptomics and metabolomics kind of

398
00:14:49,310 --> 00:14:47,339
understanding uh what they're producing

399
00:14:50,930 --> 00:14:49,320
in the environment around them

400
00:14:52,730 --> 00:14:50,940
um well what the bacteria are producing

401
00:14:54,889 --> 00:14:52,740
in the environment around them and how

402
00:14:56,569 --> 00:14:54,899
the viruses are involved in that

403
00:14:59,150 --> 00:14:56,579
um from all of this what do you think is

404
00:15:01,610 --> 00:14:59,160
the most misunderstood thing about

405
00:15:03,850 --> 00:15:01,620
viruses and their behavior maybe

406
00:15:06,530 --> 00:15:03,860
especially in the environment

407
00:15:08,030 --> 00:15:06,540
yeah it's hard to pin it down to one

408
00:15:09,290 --> 00:15:08,040
thing

409
00:15:12,050 --> 00:15:09,300
um so if we talk about the general

410
00:15:13,550 --> 00:15:12,060
public I think most people think that

411
00:15:15,470 --> 00:15:13,560
viruses

412
00:15:18,290 --> 00:15:15,480
aren't really interacting with the

413
00:15:19,790 --> 00:15:18,300

environment that they are moving to the

414
00:15:21,170 --> 00:15:19,800
environment this environments just the

415
00:15:22,550 --> 00:15:21,180
medium there's no interactions and

416
00:15:24,110 --> 00:15:22,560
they're making their way to a human to

417
00:15:26,389 --> 00:15:24,120
hurt a human

418
00:15:27,470 --> 00:15:26,399
um and then if we think about scientist

419
00:15:30,650 --> 00:15:27,480
level

420
00:15:33,110 --> 00:15:30,660
it's more of ah viruses are really hard

421
00:15:35,329 --> 00:15:33,120
right we're talking about photograms of

422
00:15:38,150 --> 00:15:35,339
DNA we're talking about particles that

423
00:15:40,370 --> 00:15:38,160
on a nanometer scale right so really

424
00:15:43,490 --> 00:15:40,380
hard to get at and science is already

425
00:15:45,410 --> 00:15:43,500
hard and we critique ourselves so hard I

426
00:15:48,650 --> 00:15:45,420
mean the peer review process is strong

427
00:15:50,269 --> 00:15:48,660
and that's exactly what we want so we

428
00:15:51,769 --> 00:15:50,279
tend not to go for the hardest thing

429
00:15:56,449 --> 00:15:51,779
possible even though that's kind of what

430
00:15:57,949 --> 00:15:56,459
I did uh so I think there's there's a a

431
00:16:00,590 --> 00:15:57,959
misunderstanding is that if we can just

432
00:16:02,930 --> 00:16:00,600
ignore the viruses and we can describe

433
00:16:04,370 --> 00:16:02,940
our system and that's fine that it's

434
00:16:07,069 --> 00:16:04,380
it's can be described without the

435
00:16:09,889 --> 00:16:07,079
viruses and that's just not true

436
00:16:11,269 --> 00:16:09,899
hmm interesting yeah I feel like you

437
00:16:13,009 --> 00:16:11,279
know from my own understanding I really

438
00:16:14,509 --> 00:16:13,019

haven't thought that much about viruses

439
00:16:15,650 --> 00:16:14,519
in the environment

440
00:16:18,710 --> 00:16:15,660
um especially things you mentioned like

441
00:16:20,329 --> 00:16:18,720
bacteriophages are the most abundant of

442
00:16:22,310 --> 00:16:20,339
the viruses out there

443
00:16:23,990 --> 00:16:22,320
um I had another poll I asked people in

444
00:16:26,090 --> 00:16:24,000
my Twitter account

445
00:16:28,069 --> 00:16:26,100
um what were the most abundant viruses

446
00:16:29,210 --> 00:16:28,079
and luckily most of the respondents 75

447
00:16:30,949 --> 00:16:29,220
percent got it right and said

448
00:16:32,629 --> 00:16:30,959
bacteriophages

449
00:16:34,730 --> 00:16:32,639
um I want to present kind of a Sci-Fi

450
00:16:36,829 --> 00:16:34,740
idea to you and tell me if it's just

451
00:16:38,449 --> 00:16:36,839
bogus and silly or not

452
00:16:41,110 --> 00:16:38,459
um because you've done work in studying

453
00:16:43,850 --> 00:16:41,120
viruses and permafrost and polar regions

454
00:16:46,249 --> 00:16:43,860
there was a science fiction horror film

455
00:16:48,650 --> 00:16:46,259
some years back called the thaw that

456
00:16:50,569 --> 00:16:48,660
presented this idea that maybe during

457
00:16:52,550 --> 00:16:50,579
you know current issues with global

458
00:16:54,350 --> 00:16:52,560
climate change and global warming with

459
00:16:56,810 --> 00:16:54,360
the glaciers receding and permafrost

460
00:16:59,030 --> 00:16:56,820
thawing there could be organisms that

461
00:17:00,710 --> 00:16:59,040
you know have been isolated for

462
00:17:03,290 --> 00:17:00,720
thousands of years that could harm

463
00:17:05,150 --> 00:17:03,300

humans or other creatures is it possible

464
00:17:06,710 --> 00:17:05,160
for there to be like old viruses that

465
00:17:09,350 --> 00:17:06,720
infected humans long ago that could be

466
00:17:10,689 --> 00:17:09,360
buried permafrost and could still infect

467
00:17:13,370 --> 00:17:10,699
us in the future

468
00:17:15,289 --> 00:17:13,380
yeah that that's actually a question I

469
00:17:17,630 --> 00:17:15,299
get a lot especially with the with the

470
00:17:20,689 --> 00:17:17,640
recent pandemic um

471
00:17:23,530 --> 00:17:20,699
so this is tricky right we only know

472
00:17:26,030 --> 00:17:23,540
what we know but what I will say is

473
00:17:29,150 --> 00:17:26,040
viruses tend to be where the host is

474
00:17:31,130 --> 00:17:29,160
right so when humans are sick

475
00:17:32,510 --> 00:17:31,140
viruses around humans right that that's

476
00:17:34,010 --> 00:17:32,520
what we look for so if we want to look

477
00:17:35,810 --> 00:17:34,020
for a human if you want to look for a

478
00:17:37,730 --> 00:17:35,820
human virus you go to a human that's

479
00:17:40,970 --> 00:17:37,740
sick you'll find that virus

480
00:17:43,070 --> 00:17:40,980
so with permafrost so just to give some

481
00:17:44,750 --> 00:17:43,080
context on permafrost I appreciate you

482
00:17:46,850 --> 00:17:44,760
using the word thought and not the word

483
00:17:48,590 --> 00:17:46,860
melt because it's like a chicken when

484
00:17:50,990 --> 00:17:48,600
you pull out of the freezer the chicken

485
00:17:53,450 --> 00:17:51,000
doesn't melt it doesn't change right the

486
00:17:55,549 --> 00:17:53,460
ice within it melts right but the

487
00:17:56,990 --> 00:17:55,559
chicken itself is Thigh so we have the

488
00:17:59,390 --> 00:17:57,000

chicken there so permafrost is like that

489
00:18:01,250 --> 00:17:59,400
we'll look at it as frozen ground and it

490
00:18:04,070 --> 00:18:01,260
can have ice within it

491
00:18:05,690 --> 00:18:04,080
for a virus to be there for a human that

492
00:18:06,710 --> 00:18:05,700
means humans would have to be there as

493
00:18:08,810 --> 00:18:06,720
well

494
00:18:12,130 --> 00:18:08,820
so if there were humans that were sick

495
00:18:14,990 --> 00:18:12,140
with viruses long ago and they got

496
00:18:17,390 --> 00:18:15,000
entrapped in the permafrost then there

497
00:18:20,090 --> 00:18:17,400
could be human viruses the problem is

498
00:18:22,430 --> 00:18:20,100
the viruses need to replicate and each

499
00:18:24,350 --> 00:18:22,440
virus itself is it's different how

500
00:18:26,270 --> 00:18:24,360
persistent it can be how long it could

501
00:18:28,789 --> 00:18:26,280
start how long before the capsule gets

502
00:18:30,350 --> 00:18:28,799
degraded right so within a human that

503
00:18:31,970 --> 00:18:30,360
could probably last a bit longer than

504
00:18:34,430 --> 00:18:31,980
the environment if we think about

505
00:18:36,230 --> 00:18:34,440
putting a human virus in the environment

506
00:18:37,850 --> 00:18:36,240
that's when it gets tricky then you're

507
00:18:40,970 --> 00:18:37,860
in an unknown habitat this is like us on

508
00:18:43,789 --> 00:18:40,980
the moon right so it's going to be it's

509
00:18:46,190 --> 00:18:43,799
going to change what I would say is that

510
00:18:47,930 --> 00:18:46,200
we for sure will find bacteriophage

511
00:18:50,990 --> 00:18:47,940
because there's bacteria and permafrost

512
00:18:52,549 --> 00:18:51,000
we find giant viruses that infect amoeba

513
00:18:53,570 --> 00:18:52,559

and permafrost because the amoeba used

514
00:18:56,450 --> 00:18:53,580
to be there

515
00:18:58,490 --> 00:18:56,460
thousands of years ago we actually wrote

516
00:18:59,990 --> 00:18:58,500
a review about this that came out last

517
00:19:02,210 --> 00:19:00,000
year talking about the potential for

518
00:19:03,350 --> 00:19:02,220
permafrost to be a reservoir for

519
00:19:05,210 --> 00:19:03,360
pathogens

520
00:19:07,669 --> 00:19:05,220
and you know that's a great question

521
00:19:10,669 --> 00:19:07,679
because for other pathogens it can be so

522
00:19:13,909 --> 00:19:10,679
we think of bacteria like anthrax

523
00:19:16,070 --> 00:19:13,919
itself it's a normal soil bacterium when

524
00:19:18,710 --> 00:19:16,080
it becomes a problem is if it's like an

525
00:19:20,570 --> 00:19:18,720
animal carcass that gets entrapped in

526
00:19:22,010 --> 00:19:20,580
the permafrost right and when that

527
00:19:24,049 --> 00:19:22,020
thoughts that's something that we have

528
00:19:30,230 --> 00:19:24,059
to worry about

529
00:19:31,970 --> 00:19:30,240
maybe people who were infected with a

530
00:19:33,650 --> 00:19:31,980
virus if they were buried and their body

531
00:19:36,110 --> 00:19:33,660
was preserved and you came around the

532
00:19:37,850 --> 00:19:36,120
body so just to protect yourself if

533
00:19:39,590 --> 00:19:37,860
you're ever in an icy area and you come

534
00:19:40,850 --> 00:19:39,600
across the body don't touch it Don't Go

535
00:19:43,490 --> 00:19:40,860
Near it

536
00:19:45,650 --> 00:19:43,500
um but I'm not aware of a case where

537
00:19:47,630 --> 00:19:45,660
somebody's got sick from a virus from

538
00:19:49,970 --> 00:19:47,640

permafrost

539
00:19:53,270 --> 00:19:49,980
that's good to know so maybe I shouldn't

540
00:19:54,830 --> 00:19:53,280
lose sleep over it just yet

541
00:19:55,850 --> 00:19:54,840
um so you know all of this is fantastic

542
00:19:57,350 --> 00:19:55,860
and you mentioned you know like could

543
00:19:59,029 --> 00:19:57,360
viruses infect us on the moon you know

544
00:20:00,830 --> 00:19:59,039
and we talked earlier about whether or

545
00:20:03,590 --> 00:20:00,840
not we find a virus on Mars is that a

546
00:20:06,110 --> 00:20:03,600
sign of Life uh you just LED this paper

547
00:20:07,430 --> 00:20:06,120
called astrovirology how viruses enhance

548
00:20:09,350 --> 00:20:07,440
our understanding of life in the

549
00:20:10,730 --> 00:20:09,360
universe it was published in the

550
00:20:12,770 --> 00:20:10,740
international Journal of astrobiology

551
00:20:14,810 --> 00:20:12,780
for those who want to read more about

552
00:20:16,909 --> 00:20:14,820
viruses and this realm this new realm of

553
00:20:18,110 --> 00:20:16,919
astrovirology I highly recommend that

554
00:20:19,490 --> 00:20:18,120
paper

555
00:20:21,650 --> 00:20:19,500
um it feels like a really great way to

556
00:20:24,169 --> 00:20:21,660
kind of introduce viruses as being

557
00:20:25,970 --> 00:20:24,179
important to astrobiology and our our

558
00:20:28,250 --> 00:20:25,980
sheer understanding of what life is and

559
00:20:29,510 --> 00:20:28,260
how life might function uh can you kind

560
00:20:31,070 --> 00:20:29,520
of give our audience basically an

561
00:20:32,830 --> 00:20:31,080
overview of what you mean when you say

562
00:20:35,289 --> 00:20:32,840
astrovirology

563
00:20:37,909 --> 00:20:35,299

yeah so first I might give some context

564
00:20:40,130 --> 00:20:37,919
if you want to access that paper go

565
00:20:41,810 --> 00:20:40,140
ahead I always try to publish an Open

566
00:20:43,730 --> 00:20:41,820
Access which means that you don't have

567
00:20:45,169 --> 00:20:43,740
to pay for right we do this work for

568
00:20:46,490 --> 00:20:45,179
government tax dollars we want to make

569
00:20:48,110 --> 00:20:46,500
sure you can be able to read it so we

570
00:20:49,250 --> 00:20:48,120
can disseminate the science throughout

571
00:20:51,110 --> 00:20:49,260
the public

572
00:20:54,890 --> 00:20:51,120
now when it comes to astrobiology it's

573
00:20:56,930 --> 00:20:54,900
kind of a catchy term really you know

574
00:20:59,510 --> 00:20:56,940
understanding astrobiology is a study of

575
00:21:01,430 --> 00:20:59,520
life in the universe and Earth is part

576
00:21:03,049 --> 00:21:01,440
of life in the universe so everyone who

577
00:21:04,610 --> 00:21:03,059
studies life on Earth is an

578
00:21:06,890 --> 00:21:04,620
astrobiologist we're asking the same

579
00:21:09,049 --> 00:21:06,900
questions right whether you're focused

580
00:21:10,850 --> 00:21:09,059
just on Earth the potential for going

581
00:21:13,490 --> 00:21:10,860
into space in the space environment

582
00:21:15,529 --> 00:21:13,500
whether it's on another Celestial body

583
00:21:17,870 --> 00:21:15,539
those are you're asking similar

584
00:21:20,029 --> 00:21:17,880
questions persistence interactions

585
00:21:21,650 --> 00:21:20,039
survivability

586
00:21:23,870 --> 00:21:21,660
um adaptation right these are all things

587
00:21:26,390 --> 00:21:23,880
we're thinking about so when I say Astro

588
00:21:29,570 --> 00:21:26,400

Violet virology it's really to put the

589
00:21:33,049 --> 00:21:29,580
emphasis on viruses because they've been

590
00:21:34,430 --> 00:21:33,059
largely unexplored especially in our

591
00:21:36,770 --> 00:21:34,440
understanding of wanting to go into

592
00:21:39,110 --> 00:21:36,780
space but they're critical so in the

593
00:21:42,950 --> 00:21:39,120
paper and and this was a symphony paper

594
00:21:44,450 --> 00:21:42,960
right I was the the conductor and we had

595
00:21:47,090 --> 00:21:44,460
so many scientists that helped out

596
00:21:49,250 --> 00:21:47,100
different experts in different areas so

597
00:21:51,169 --> 00:21:49,260
I am by all means not an expert and

598
00:21:53,149 --> 00:21:51,179
every individual area so I'll answer the

599
00:21:55,370 --> 00:21:53,159
questions the best that I can but we

600
00:21:57,590 --> 00:21:55,380
really thought about okay well how do

601
00:21:59,330 --> 00:21:57,600
viruses change life on Earth and how do

602
00:22:01,370 --> 00:21:59,340
they interact with life on Earth

603
00:22:02,570 --> 00:22:01,380
what about for people going this space

604
00:22:03,830 --> 00:22:02,580
because now we're just gonna we're

605
00:22:05,390 --> 00:22:03,840
getting to the point where anyone can go

606
00:22:07,909 --> 00:22:05,400
into space so what's happening there

607
00:22:09,770 --> 00:22:07,919
then if we think about long-term space

608
00:22:12,409 --> 00:22:09,780
travel how do we make sure we have

609
00:22:15,110 --> 00:22:12,419
recycling food our waste our water

610
00:22:17,090 --> 00:22:15,120
viruses infect everything so we need to

611
00:22:19,490 --> 00:22:17,100
think about them and I just want to

612
00:22:20,690 --> 00:22:19,500
highlight this uh to give everyone a

613
00:22:22,909 --> 00:22:20,700

better understanding of viruses because

614
00:22:25,070 --> 00:22:22,919
I'm saying viruses you probably are

615
00:22:26,870 --> 00:22:25,080
thinking of a cold you had once or if

616
00:22:28,789 --> 00:22:26,880
you had covet or or something else and

617
00:22:30,770 --> 00:22:28,799
how virus can be so different does one

618
00:22:33,169 --> 00:22:30,780
you can get sick with and be sick for

619
00:22:34,909 --> 00:22:33,179
the rest of your life or it re-emerge

620
00:22:37,310 --> 00:22:34,919
later like with shingles and chickenpox

621
00:22:38,930 --> 00:22:37,320
and then there's other viruses we just

622
00:22:41,510 --> 00:22:38,940
have a cold and you're fine

623
00:22:44,029 --> 00:22:41,520
so viruses even though they're small

624
00:22:47,090 --> 00:22:44,039
they're Mighty and complex and we think

625
00:22:49,610 --> 00:22:47,100
of three iconic ways in which they can

626
00:22:51,710 --> 00:22:49,620
really make an impact and this is all

627
00:22:54,649 --> 00:22:51,720
stuff I'm still in from my parts paper

628
00:22:56,870 --> 00:22:54,659
uh I love it she knows this I've told

629
00:22:58,850 --> 00:22:56,880
her and I'll just keep sharing it uh so

630
00:23:01,010 --> 00:22:58,860
in the first form right we have viruses

631
00:23:02,930 --> 00:23:01,020
it's this Grim Reaper this is because

632
00:23:04,490 --> 00:23:02,940
they're lysine their host whether you're

633
00:23:05,930 --> 00:23:04,500
multicellular and they're killing cells

634
00:23:08,149 --> 00:23:05,940
or you're single cellular like a

635
00:23:09,710 --> 00:23:08,159
bacterium and archaea they're slicing

636
00:23:11,390 --> 00:23:09,720
you they're killing you right and this

637
00:23:13,070 --> 00:23:11,400
is releasing your nutrients into the

638
00:23:14,690 --> 00:23:13,080

environment so they're stopping your

639
00:23:16,909 --> 00:23:14,700
metabolism that's impacting the

640
00:23:18,890 --> 00:23:16,919
environment they're releasing your juicy

641
00:23:21,049 --> 00:23:18,900
innards into environment feeding other

642
00:23:23,029 --> 00:23:21,059
organisms right and that's impacting the

643
00:23:25,549 --> 00:23:23,039
environment as well when they do this

644
00:23:28,130 --> 00:23:25,559
they promote diversity because they like

645
00:23:30,350 --> 00:23:28,140
to attack the one that's winning the

646
00:23:31,610 --> 00:23:30,360
most abundant organism so by doing that

647
00:23:32,690 --> 00:23:31,620
they're sharing the wealth they're kind

648
00:23:34,850 --> 00:23:32,700
of the Robin Hood they're sharing the

649
00:23:36,350 --> 00:23:34,860
wealth with everybody else keeping this

650
00:23:37,549 --> 00:23:36,360
diversity so viruses are great for

651
00:23:41,149 --> 00:23:37,559
diversity

652
00:23:43,850 --> 00:23:41,159
their second is as a drug dealer where

653
00:23:45,950 --> 00:23:43,860
when they infect hosts they share genes

654
00:23:48,950 --> 00:23:45,960
right so transduction is the mode in

655
00:23:50,870 --> 00:23:48,960
which viruses infecticell takes some DNA

656
00:23:52,430 --> 00:23:50,880
in fact a new cell give some DNA so

657
00:23:54,230 --> 00:23:52,440
they're moving genes around they're

658
00:23:55,730 --> 00:23:54,240
giving genetic novelty out there and

659
00:23:57,830 --> 00:23:55,740
they're spreading the wealth

660
00:24:00,289 --> 00:23:57,840
and the final form is kind of as a

661
00:24:01,669 --> 00:24:00,299
wizard so when a virus infects an

662
00:24:03,770 --> 00:24:01,679
organism and this is when we get into

663
00:24:05,750 --> 00:24:03,780

saying if our virus is alive or not

664
00:24:07,850 --> 00:24:05,760
right so virus cell is this concept

665
00:24:10,490 --> 00:24:07,860
where when the virus infects the host

666
00:24:12,770 --> 00:24:10,500
the virus is it is the one taking over

667
00:24:15,110 --> 00:24:12,780
is the host now right so if we talk

668
00:24:16,490 --> 00:24:15,120
about that biomass question it becomes a

669
00:24:18,950 --> 00:24:16,500
little controversial we start counting

670
00:24:21,169 --> 00:24:18,960
that as viral viral Maps but uh we won't

671
00:24:22,610 --> 00:24:21,179
have to get into that but as the wizard

672
00:24:25,010 --> 00:24:22,620
right when the virus is infecting the

673
00:24:27,169 --> 00:24:25,020
hose it's wanting the host to do its

674
00:24:28,850 --> 00:24:27,179
bidding so the host is no longer putting

675
00:24:30,770 --> 00:24:28,860
out this metabolic outputs is no longer

676
00:24:33,049 --> 00:24:30,780
producing it's no longer aspiring

677
00:24:34,909 --> 00:24:33,059
releasing CO2 or photosynthesizing

678
00:24:37,789 --> 00:24:34,919
releasing oxygen unless the virus wants

679
00:24:39,830 --> 00:24:37,799
it to some viruses just say hey make my

680
00:24:42,289 --> 00:24:39,840
progeny viruses and then you'll explode

681
00:24:44,149 --> 00:24:42,299
and die other viruses continue to

682
00:24:45,649 --> 00:24:44,159
control the metabolism they can make it

683
00:24:47,210 --> 00:24:45,659
more efficient make them more fit

684
00:24:48,890 --> 00:24:47,220
there's so many different things that

685
00:24:51,529 --> 00:24:48,900
viruses can do so they have a large

686
00:24:53,390 --> 00:24:51,539
impact on our Earth and on the evolution

687
00:24:54,830 --> 00:24:53,400
of life

688
00:24:56,330 --> 00:24:54,840

um it's really cool to think of them in

689
00:24:58,549 --> 00:24:56,340
these different ways as well I wonder

690
00:25:00,409 --> 00:24:58,559
from my own edification to my knowledge

691
00:25:02,870 --> 00:25:00,419
we don't really know when viruses

692
00:25:05,270 --> 00:25:02,880
started were they here with life since

693
00:25:06,890 --> 00:25:05,280
the beginning or did they evolve two

694
00:25:08,810 --> 00:25:06,900
billion years ago or 500 million years

695
00:25:11,810 --> 00:25:08,820
ago do we have any way of knowing yet

696
00:25:14,029 --> 00:25:11,820
when viruses joined the living processes

697
00:25:16,370 --> 00:25:14,039
of life like here on Earth

698
00:25:17,690 --> 00:25:16,380
that's extremely hard so thanks thanks

699
00:25:20,750 --> 00:25:17,700
for throwing the hardest question out

700
00:25:23,690 --> 00:25:20,760
there we have evidence that viruses are

701
00:25:25,850 --> 00:25:23,700
still emerging now right so

702
00:25:29,450 --> 00:25:25,860
if we think of the earth geologic time

703
00:25:33,289 --> 00:25:29,460
so 4.5 to 4.6 billion years ago and we

704
00:25:35,630 --> 00:25:33,299
think life arose around 3.8 billion

705
00:25:37,430 --> 00:25:35,640
years ago give or take with our our

706
00:25:39,169 --> 00:25:37,440
knowledge

707
00:25:40,430 --> 00:25:39,179
um there's many different High policies

708
00:25:43,430 --> 00:25:40,440
out there if you think of the one that's

709
00:25:47,289 --> 00:25:43,440
the virus first hypothesis uh this is

710
00:25:50,090 --> 00:25:47,299
kind of from simple to

711
00:25:52,669 --> 00:25:50,100
extravagant kind of hypothesis where at

712
00:25:55,070 --> 00:25:52,679
first we have oh maybe it's some RNA and

713
00:25:57,049 --> 00:25:55,080

then we have some DNA and then we have

714
00:25:59,090 --> 00:25:57,059
some amino acids that form around that

715
00:26:02,269 --> 00:25:59,100
well that's technically a virus right

716
00:26:03,769 --> 00:26:02,279
there and then if you go up and evolve

717
00:26:05,330 --> 00:26:03,779
from that right so there's one

718
00:26:07,850 --> 00:26:05,340
hypothesis there

719
00:26:09,830 --> 00:26:07,860
there's other ones that make it hard to

720
00:26:12,230 --> 00:26:09,840
identify whether viruses were there or

721
00:26:14,570 --> 00:26:12,240
not and I think the reason is we don't

722
00:26:17,690 --> 00:26:14,580
have like this this Luca this last

723
00:26:19,430 --> 00:26:17,700
common ancestor for viruses and because

724
00:26:21,529 --> 00:26:19,440
viruses are in different groups we have

725
00:26:25,430 --> 00:26:21,539
our RNA viruses which a lot of them

726
00:26:27,529 --> 00:26:25,440
share a specific Gene some don't our DNA

727
00:26:29,570 --> 00:26:27,539
viruses you can have this group that

728
00:26:31,010 --> 00:26:29,580
shares a gene because it's if you think

729
00:26:33,289 --> 00:26:31,020
about their shape they're like oh this

730
00:26:35,210 --> 00:26:33,299
part of my my head my cap said we share

731
00:26:37,610 --> 00:26:35,220
this Gene we're clustered together but

732
00:26:39,289 --> 00:26:37,620
we don't have a universal marker Gene so

733
00:26:41,630 --> 00:26:39,299
it's really hard to go back in time with

734
00:26:43,850 --> 00:26:41,640
our molecular clock and really see when

735
00:26:46,190 --> 00:26:43,860
viruses emerge we have evidence of

736
00:26:48,409 --> 00:26:46,200
ancient viruses there's work especially

737
00:26:50,390 --> 00:26:48,419
in the oceans showing that maybe there

738
00:26:52,070 --> 00:26:50,400

was that Missing Link from the RNA to

739
00:26:54,289 --> 00:26:52,080
DNA world

740
00:26:57,590 --> 00:26:54,299
but then there's evidence showing with

741
00:27:00,590 --> 00:26:57,600
eukaryotes we have viruses emerging and

742
00:27:04,190 --> 00:27:00,600
coming from eukaryotes so it's a tricky

743
00:27:07,130 --> 00:27:04,200
question and to answer we really need to

744
00:27:09,409 --> 00:27:07,140
look more we need to look further I like

745
00:27:11,630 --> 00:27:09,419
for me I would love to sample the Deep

746
00:27:13,430 --> 00:27:11,640
oceans and the Deep sediments and in the

747
00:27:16,010 --> 00:27:13,440
deep Earth to really see if we can have

748
00:27:17,930 --> 00:27:16,020
these ancient preserved viruses to try

749
00:27:20,149 --> 00:27:17,940
to get at that last Universal common

750
00:27:21,769 --> 00:27:20,159
ancestor for viruses

751
00:27:23,510 --> 00:27:21,779
all right that's such a cool answer and

752
00:27:25,010 --> 00:27:23,520
I can say we have some questions coming

753
00:27:27,049 --> 00:27:25,020
in from our audience already on YouTube

754
00:27:28,490 --> 00:27:27,059
uh thanks to those who are asking I

755
00:27:30,590 --> 00:27:28,500
promise I'll get to your questions very

756
00:27:32,390 --> 00:27:30,600
soon uh I know that we have one kind of

757
00:27:34,130 --> 00:27:32,400
similar to that already

758
00:27:35,330 --> 00:27:34,140
um before we get there I do love just

759
00:27:37,310 --> 00:27:35,340
sharing a little bit of what makes us

760
00:27:39,409 --> 00:27:37,320
all human as scientists and engineers

761
00:27:41,029 --> 00:27:39,419
and researchers as well you mentioned to

762
00:27:42,769 --> 00:27:41,039
us that that trail running is one thing

763
00:27:44,690 --> 00:27:42,779

that you're really into I'm wondering

764
00:27:46,010 --> 00:27:44,700
you know so so why trail riding what

765
00:27:48,230 --> 00:27:46,020
does that do for you to help you kind of

766
00:27:50,870 --> 00:27:48,240
get yourself into a better place

767
00:27:53,630 --> 00:27:50,880
um how is that kind of part of your life

768
00:27:55,909 --> 00:27:53,640
yeah so I am somebody that wears my

769
00:27:58,549 --> 00:27:55,919
emotions on my sleeve right I really

770
00:28:00,409 --> 00:27:58,559
care what other people think and it's

771
00:28:02,870 --> 00:28:00,419
because we're humans right I value other

772
00:28:05,570 --> 00:28:02,880
people and I want them to Value me so

773
00:28:08,330 --> 00:28:05,580
running is just a great way for me to

774
00:28:10,789 --> 00:28:08,340
get out it's my time I'm forced to just

775
00:28:12,529 --> 00:28:10,799
focus on me and sometimes it's boring

776
00:28:14,630 --> 00:28:12,539
right sometimes if I'm having a rough

777
00:28:17,090 --> 00:28:14,640
day I am bored and it's not going to be

778
00:28:19,370 --> 00:28:17,100
that long of a run but it helps me focus

779
00:28:21,710 --> 00:28:19,380
on me it helps me get this energy out

780
00:28:24,169 --> 00:28:21,720
and I love exploring and seeing new

781
00:28:25,490 --> 00:28:24,179
things right when you are in a treadmill

782
00:28:26,870 --> 00:28:25,500
you're stuck in one place but when you

783
00:28:29,450 --> 00:28:26,880
go out there could be something

784
00:28:31,549 --> 00:28:29,460
different you could run into a snake uh

785
00:28:33,470 --> 00:28:31,559
you could run into a super bloom right

786
00:28:35,029 --> 00:28:33,480
there you never know what you're going

787
00:28:36,049 --> 00:28:35,039
to see when you get out there and that's

788
00:28:38,029 --> 00:28:36,059

exciting

789
00:28:39,350 --> 00:28:38,039
I love that yeah and I have to say like

790
00:28:40,970 --> 00:28:39,360
for me like I love if you're trying for

791
00:28:43,010 --> 00:28:40,980
a walk and just like speaking to myself

792
00:28:44,930 --> 00:28:43,020
and telling myself the things I want to

793
00:28:46,610 --> 00:28:44,940
think about I even use like otter AI to

794
00:28:47,269 --> 00:28:46,620
like download it and transcribe it for

795
00:28:48,529 --> 00:28:47,279
me

796
00:28:50,990 --> 00:28:48,539
um it's a great way to get exercise and

797
00:28:52,370 --> 00:28:51,000
do some science at the same time okay we

798
00:28:54,409 --> 00:28:52,380
are going to do just really quick our

799
00:28:57,230 --> 00:28:54,419
faster than light segment this is where

800
00:28:59,090 --> 00:28:57,240
I I ask some very simple questions for

801
00:29:00,590 --> 00:28:59,100
short answers from you

802
00:29:02,690 --> 00:29:00,600
um our audience loves to hear it I love

803
00:29:05,930 --> 00:29:02,700
to hear it so let's get going with those

804
00:29:09,830 --> 00:29:05,940
what is your favorite answer to fermi's

805
00:29:14,269 --> 00:29:11,930
I would say

806
00:29:17,029 --> 00:29:14,279
we don't know we don't know we haven't

807
00:29:20,750 --> 00:29:17,039
explored enough and we

808
00:29:22,850 --> 00:29:20,760
are looking based on what we know and

809
00:29:25,970 --> 00:29:22,860
not what we don't know so we have no

810
00:29:28,850 --> 00:29:25,980
idea what we're necessarily looking for

811
00:29:30,350 --> 00:29:28,860
oh I like that and so I mean I'm a huge

812
00:29:32,450 --> 00:29:30,360
science fiction nerd you know I brought

813
00:29:33,710 --> 00:29:32,460

the fall earlier even you speaking about

814
00:29:35,450 --> 00:29:33,720
you know some of these things viruses do

815
00:29:36,769 --> 00:29:35,460
made me think of the thing

816
00:29:39,590 --> 00:29:36,779
um and some of these other stories I

817
00:29:40,970 --> 00:29:39,600
love what stories have inspired you to

818
00:29:43,310 --> 00:29:40,980
want to know more about life in the

819
00:29:50,269 --> 00:29:46,450
yeah uh so biology

820
00:29:52,610 --> 00:29:50,279
is hard and just exciting it's not like

821
00:29:55,190 --> 00:29:52,620
other Sciences where you see something

822
00:29:57,830 --> 00:29:55,200
you'll see it we take technical

823
00:29:59,990 --> 00:29:57,840
biological replicates we still get some

824
00:30:01,970 --> 00:30:00,000
different answers we have to do so many

825
00:30:04,789 --> 00:30:01,980
studies and in this case I'll do this in

826
00:30:07,010 --> 00:30:04,799
this case it's just that so I think

827
00:30:09,169 --> 00:30:07,020
the stories that excite me is when

828
00:30:11,450 --> 00:30:09,179
there's brand new research that comes

829
00:30:13,070 --> 00:30:11,460
out that just makes everyone go gasp oh

830
00:30:15,769 --> 00:30:13,080
and then you can literally find out five

831
00:30:18,830 --> 00:30:15,779
minutes later just kidding that was not

832
00:30:22,070 --> 00:30:18,840
a thing or I was an nf2 or we found it

833
00:30:23,750 --> 00:30:22,080
it doesn't always happen right so that's

834
00:30:26,269 --> 00:30:23,760
that's kind of exciting

835
00:30:28,549 --> 00:30:26,279
um I also get really excited when people

836
00:30:31,310 --> 00:30:28,559
are First Learning and you see that

837
00:30:32,930 --> 00:30:31,320
spark where something excites them and

838
00:30:34,430 --> 00:30:32,940

in their head for at least five months

839
00:30:35,930 --> 00:30:34,440
that's what they're doing that's what

840
00:30:38,330 --> 00:30:35,940
they're going to be doing they're sure

841
00:30:40,310 --> 00:30:38,340
of it right so that I feed off that

842
00:30:42,649 --> 00:30:40,320
that's exciting to to see and to see

843
00:30:44,870 --> 00:30:42,659
people passionate about stuff

844
00:30:47,269 --> 00:30:44,880
um for science in general though I

845
00:30:49,850 --> 00:30:47,279
wasn't a kid who grew up thinking oh I

846
00:30:51,649 --> 00:30:49,860
love science science is amazing

847
00:30:53,330 --> 00:30:51,659
um science was a course that I just kind

848
00:30:54,230 --> 00:30:53,340
of got through

849
00:30:56,470 --> 00:30:54,240
um

850
00:30:59,750 --> 00:30:56,480
it was really in college

851
00:31:01,549 --> 00:30:59,760
uh I had this strong passion for for

852
00:31:02,930 --> 00:31:01,559
climate change right so I kind of

853
00:31:05,149 --> 00:31:02,940
thought about it from the political side

854
00:31:07,010 --> 00:31:05,159
but then I didn't want to just be a

855
00:31:08,330 --> 00:31:07,020
politician talking about science that I

856
00:31:09,590 --> 00:31:08,340
don't know or arguing against sign

857
00:31:13,010 --> 00:31:09,600
someone else so then I took some science

858
00:31:14,690 --> 00:31:13,020
courses and it's really

859
00:31:16,370 --> 00:31:14,700
looking back in time and seeing these

860
00:31:18,049 --> 00:31:16,380
things people discovered that a lot of

861
00:31:19,730 --> 00:31:18,059
times by accident or it's a lot of hard

862
00:31:21,830 --> 00:31:19,740
work we give credit to a single person

863
00:31:24,470 --> 00:31:21,840

but there's been so much research

864
00:31:26,870 --> 00:31:24,480
leading up to that so in in my lifetime

865
00:31:28,490 --> 00:31:26,880
even if I don't want a Nobel Prize the

866
00:31:31,130 --> 00:31:28,500
research I've done other people are

867
00:31:33,409 --> 00:31:31,140
building off it we're a community so I

868
00:31:36,529 --> 00:31:33,419
know I'm helping in some way

869
00:31:37,909 --> 00:31:36,539
I love that yeah no worries

870
00:31:39,049 --> 00:31:37,919
um I agree with that spark that you see

871
00:31:40,549 --> 00:31:39,059
in people's eyes when they learn

872
00:31:42,529 --> 00:31:40,559
something new and it's it's this fun

873
00:31:43,610 --> 00:31:42,539
discussion this conversation that we

874
00:31:46,010 --> 00:31:43,620
have where we learn something together

875
00:31:47,690 --> 00:31:46,020
and that's part of the human endeavor of

876
00:31:49,909 --> 00:31:47,700
Science and learning

877
00:31:51,710 --> 00:31:49,919
if you could go back to the beginning of

878
00:31:56,090 --> 00:31:51,720
your career and and give yourself some

879
00:32:03,190 --> 00:31:59,149
um encase yourself in a suit of armor uh

880
00:32:05,690 --> 00:32:03,200
life is hard and going through college

881
00:32:07,430 --> 00:32:05,700
so when I say college this can be

882
00:32:08,810 --> 00:32:07,440
anything trade schools included a

883
00:32:10,430 --> 00:32:08,820
university is just a collection of

884
00:32:13,430 --> 00:32:10,440
colleges

885
00:32:14,990 --> 00:32:13,440
um you learn things right and people

886
00:32:16,490 --> 00:32:15,000
offer their opinions for you to learn

887
00:32:18,769 --> 00:32:16,500
and then you have to learn what you're

888
00:32:20,690 --> 00:32:18,779

told to learn and it may be a little bit

889
00:32:22,789 --> 00:32:20,700
different depending on where you are but

890
00:32:24,289 --> 00:32:22,799
then you go into grad school and it gets

891
00:32:26,029 --> 00:32:24,299
even harder because you're not only

892
00:32:28,130 --> 00:32:26,039
supposed to learn but then you're

893
00:32:30,529 --> 00:32:28,140
supposed to add now you have to

894
00:32:33,409 --> 00:32:30,539
contribute to science and to make

895
00:32:35,210 --> 00:32:33,419
science valid fair and Equitable we have

896
00:32:36,889 --> 00:32:35,220
to make sure that we're arguing with

897
00:32:38,870 --> 00:32:36,899
each other there's a peer review process

898
00:32:41,870 --> 00:32:38,880
that science needs to go through so we

899
00:32:44,930 --> 00:32:41,880
get attacked all the time and it kind of

900
00:32:46,970 --> 00:32:44,940
makes us hard and really getting back in

901
00:32:48,950 --> 00:32:46,980
tune finding ourselves making sure we

902
00:32:52,730 --> 00:32:48,960
have hobbies making sure we can relate

903
00:32:54,350 --> 00:32:52,740
to people still and not become hard

904
00:32:56,450 --> 00:32:54,360
um I would say for a lot of people

905
00:32:59,510 --> 00:32:56,460
graduate school as a really hard time

906
00:33:01,370 --> 00:32:59,520
myself included so I would if I could

907
00:33:02,930 --> 00:33:01,380
just go back I know I'd trust myself and

908
00:33:05,169 --> 00:33:02,940
say hey you're going to get through this

909
00:33:07,669 --> 00:33:05,179
you can do it's all about perseverance

910
00:33:09,889 --> 00:33:07,679
persistence right you don't have to be

911
00:33:11,330 --> 00:33:09,899
the best person out there you just keep

912
00:33:14,570 --> 00:33:11,340
trying

913
00:33:16,610 --> 00:33:14,580

it's fantastic you know I myself I think

914
00:33:18,230 --> 00:33:16,620
a lot right now where AI is at right now

915
00:33:21,049 --> 00:33:18,240
with all this generative AI going on

916
00:33:22,970 --> 00:33:21,059
like Chachi PT and Bard you know and we

917
00:33:25,190 --> 00:33:22,980
just had this recent test of Starship

918
00:33:26,810 --> 00:33:25,200
from SpaceX there's so much going on

919
00:33:29,090 --> 00:33:26,820
right now in our world with science and

920
00:33:30,769 --> 00:33:29,100
technology things are progressing very

921
00:33:33,049 --> 00:33:30,779
quickly and I'd say right now if you go

922
00:33:34,909 --> 00:33:33,059
through any social media site there's

923
00:33:37,070 --> 00:33:34,919
you know kind of some pessimism right

924
00:33:39,409 --> 00:33:37,080
now about what the future might hold for

925
00:33:40,970 --> 00:33:39,419
our species but it also feels like there

926
00:33:44,330 --> 00:33:40,980
should be a lot for us to be excited

927
00:33:45,529 --> 00:33:44,340
about so I wonder from you

928
00:33:47,870 --> 00:33:45,539
um what's something that excites you

929
00:33:49,909 --> 00:33:47,880
about the future

930
00:33:51,350 --> 00:33:49,919
yeah this is hard as you get older when

931
00:33:53,450 --> 00:33:51,360
you're a kid everything excites you

932
00:33:57,289 --> 00:33:53,460
right we have our creativity our

933
00:33:59,750 --> 00:33:57,299
imagination is huge uh I think talking

934
00:34:01,610 --> 00:33:59,760
with older Generations can be helpful

935
00:34:03,950 --> 00:34:01,620
like a lot of times we'll brush things

936
00:34:05,570 --> 00:34:03,960
off but if you really listen You'll see

937
00:34:07,190 --> 00:34:05,580
the problems we have now are problems

938
00:34:08,450 --> 00:34:07,200

we've always had has always been the

939
00:34:10,369 --> 00:34:08,460
pessimism there's always been the

940
00:34:12,169 --> 00:34:10,379
excitement and you realize always just

941
00:34:14,570 --> 00:34:12,179
something new

942
00:34:17,149 --> 00:34:14,580
um so what excites me is that for

943
00:34:19,430 --> 00:34:17,159
science in general we're moving to a lot

944
00:34:21,770 --> 00:34:19,440
of inner to dinner interdisciplinary

945
00:34:23,930 --> 00:34:21,780
science we're working together I no

946
00:34:25,730 --> 00:34:23,940
longer have to be an expert on this one

947
00:34:27,649 --> 00:34:25,740
gene that does this this person no

948
00:34:29,089 --> 00:34:27,659
longer has to do that right we can start

949
00:34:30,710 --> 00:34:29,099
to understand these fields and come

950
00:34:32,690 --> 00:34:30,720
together just like the paper we

951
00:34:35,690 --> 00:34:32,700
published where we're all experts in

952
00:34:38,450 --> 00:34:35,700
different areas we were able to unite on

953
00:34:40,190 --> 00:34:38,460
a topic that we agree on we could argue

954
00:34:42,169 --> 00:34:40,200
we could debate and we have something to

955
00:34:44,270 --> 00:34:42,179
show of our works of working together

956
00:34:46,190 --> 00:34:44,280
and I think that's something we need to

957
00:34:47,869 --> 00:34:46,200
really think about and excites me for

958
00:34:50,329 --> 00:34:47,879
future this idea that science has been

959
00:34:52,490 --> 00:34:50,339
in a way where we're United against the

960
00:34:54,349 --> 00:34:52,500
science we're seeing more and more

961
00:34:56,149 --> 00:34:54,359
proposals some calls for us coming

962
00:34:57,950 --> 00:34:56,159
together not just

963
00:34:59,990 --> 00:34:57,960

this person can do this but really

964
00:35:02,030 --> 00:35:00,000
looking at a system right and that's

965
00:35:03,290 --> 00:35:02,040
been that's been the Crux of my research

966
00:35:05,450 --> 00:35:03,300
since the beginning I've always wanted

967
00:35:08,089 --> 00:35:05,460
to look at the system so the merging

968
00:35:08,990 --> 00:35:08,099
idea of system science is good science I

969
00:35:10,730 --> 00:35:09,000
guess

970
00:35:12,410 --> 00:35:10,740
very cool

971
00:35:14,630 --> 00:35:12,420
um now you work now at the Lawrence

972
00:35:15,770 --> 00:35:14,640
Livermore National Laboratory

973
00:35:16,790 --> 00:35:15,780
um you know I think some people aren't

974
00:35:18,349 --> 00:35:16,800
aware that there's like these different

975
00:35:20,150 --> 00:35:18,359
things you can do throughout science you

976
00:35:21,170 --> 00:35:20,160
don't have to just just to become a

977
00:35:22,910 --> 00:35:21,180
professor and work at a university

978
00:35:24,530 --> 00:35:22,920
there's there's also research

979
00:35:26,990 --> 00:35:24,540
institutions there's various ways to

980
00:35:28,430 --> 00:35:27,000
work throughout various industries that

981
00:35:31,069 --> 00:35:28,440
are related to science and engineering

982
00:35:32,569 --> 00:35:31,079
as well as National Laboratories

983
00:35:34,970 --> 00:35:32,579
um so what would you say is the best

984
00:35:36,710 --> 00:35:34,980
part of your job

985
00:35:39,109 --> 00:35:36,720
okay so we're never going to just say it

986
00:35:41,810 --> 00:35:39,119
with one thing right uh what I love

987
00:35:43,370 --> 00:35:41,820
about a national lab and they're kind of

988
00:35:45,410 --> 00:35:43,380

this black box that doesn't get

989
00:35:47,510 --> 00:35:45,420
advertised that well

990
00:35:49,550 --> 00:35:47,520
um you grew up going through Academia

991
00:35:51,530 --> 00:35:49,560
thinking oh you need to become this

992
00:35:53,510 --> 00:35:51,540
professor or if you go in Industry

993
00:35:56,690 --> 00:35:53,520
that's where the big bucks are I would

994
00:36:00,770 --> 00:35:56,700
say the National Labs are a great medium

995
00:36:02,150 --> 00:36:00,780
in between where we publish you can

996
00:36:03,530 --> 00:36:02,160
publish as much as you want you don't

997
00:36:05,510 --> 00:36:03,540
need to publish if you don't want to

998
00:36:06,530 --> 00:36:05,520
it's really what kind of science you

999
00:36:08,390 --> 00:36:06,540
want to do

1000
00:36:11,329 --> 00:36:08,400
uh what I do like about the National

1001
00:36:13,069 --> 00:36:11,339
Labs is that our government Congress

1002
00:36:15,349 --> 00:36:13,079
sets aside money to make sure that we're

1003
00:36:18,170 --> 00:36:15,359
on the Forefront of science right so

1004
00:36:20,270 --> 00:36:18,180
we're really always pushing the envelope

1005
00:36:22,190 --> 00:36:20,280
um and then we we want to work with

1006
00:36:24,109 --> 00:36:22,200
other people right we have so many calls

1007
00:36:26,870 --> 00:36:24,119
if you go through Doe's website to

1008
00:36:27,950 --> 00:36:26,880
really get people universities come and

1009
00:36:30,109 --> 00:36:27,960
work with us whether you're Community

1010
00:36:33,470 --> 00:36:30,119
College undergrad High School really

1011
00:36:35,150 --> 00:36:33,480
working with the National Labs

1012
00:36:36,230 --> 00:36:35,160
you know I was worried when I was going

1013
00:36:37,609 --> 00:36:36,240

to come to the National Lab I'm like oh

1014
00:36:38,690 --> 00:36:37,619
I'm never going to be able to teach I'm

1015
00:36:41,150 --> 00:36:38,700
never going to be able to connect with

1016
00:36:43,550 --> 00:36:41,160
students but that's not true we have so

1017
00:36:45,410 --> 00:36:43,560
many universities nearby and even in

1018
00:36:48,170 --> 00:36:45,420
other states I connect with Georgetown

1019
00:36:50,270 --> 00:36:48,180
quite often where I can mentor students

1020
00:36:52,310 --> 00:36:50,280
and have no issues with that

1021
00:36:55,010 --> 00:36:52,320
and if I have to say my favorite thing

1022
00:36:57,349 --> 00:36:55,020
working at the lab is the freedom I have

1023
00:37:00,410 --> 00:36:57,359
to be the scientist I want to be

1024
00:37:02,569 --> 00:37:00,420
so I'm not going to speak for a

1025
00:37:05,030 --> 00:37:02,579
professor at a university but you know

1026
00:37:06,589 --> 00:37:05,040
you generate this lab you're expected to

1027
00:37:08,210 --> 00:37:06,599
do a certain thing that's a sign to kind

1028
00:37:10,190 --> 00:37:08,220
of go down you can kind of shift here

1029
00:37:11,690 --> 00:37:10,200
and there but I don't know if you have

1030
00:37:14,510 --> 00:37:11,700
as much Freedom as you do at a National

1031
00:37:16,430 --> 00:37:14,520
Lab I came in I was a virus guy I'm

1032
00:37:18,530 --> 00:37:16,440
working with another group as a virus

1033
00:37:20,450 --> 00:37:18,540
guy I love it but there's other projects

1034
00:37:22,069 --> 00:37:20,460
I can work on that may not even involve

1035
00:37:24,470 --> 00:37:22,079
viruses or I can actually introduce

1036
00:37:26,690 --> 00:37:24,480
viruses too and it's a system maybe I've

1037
00:37:28,550 --> 00:37:26,700
never worked with and I absolutely love

1038
00:37:29,930 --> 00:37:28,560

that it's just so open and welcoming

1039
00:37:31,730 --> 00:37:29,940
that I can just work with other people

1040
00:37:33,950 --> 00:37:31,740
here at the lab

1041
00:37:35,210 --> 00:37:33,960
and that's excellent yeah it's I think

1042
00:37:37,430 --> 00:37:35,220
it's one pathway people don't think

1043
00:37:39,349 --> 00:37:37,440
about that much we will answer it up

1044
00:37:40,670 --> 00:37:39,359
here as soon as we can to the audience

1045
00:37:42,290 --> 00:37:40,680
questions I promise for those asking

1046
00:37:45,349 --> 00:37:42,300
questions right now in the chat I will

1047
00:37:48,290 --> 00:37:45,359
get to them but first my favorite of all

1048
00:37:49,430 --> 00:37:48,300
of our faster than light segment uh is

1049
00:37:51,530 --> 00:37:49,440
this question

1050
00:37:53,870 --> 00:37:51,540
what is an unbelievable science fact

1051
00:37:58,609 --> 00:37:53,880
that still blows your mind

1052
00:38:02,089 --> 00:38:00,530
that's really hard

1053
00:38:04,370 --> 00:38:02,099
yep

1054
00:38:06,290 --> 00:38:04,380
I would just

1055
00:38:07,849 --> 00:38:06,300
I mean really

1056
00:38:09,770 --> 00:38:07,859
maybe it's a cultivation in fact it's

1057
00:38:11,930 --> 00:38:09,780
the idea that there's

1058
00:38:13,670 --> 00:38:11,940
things all around us that can affect us

1059
00:38:16,910 --> 00:38:13,680
that we can't see

1060
00:38:18,770 --> 00:38:16,920
right we think that we see something and

1061
00:38:22,130 --> 00:38:18,780
that's that but our vision is actually

1062
00:38:23,690 --> 00:38:22,140
pretty bad compared to animals out there

1063
00:38:25,370 --> 00:38:23,700

um

1064
00:38:27,290 --> 00:38:25,380
so I guess

1065
00:38:29,390 --> 00:38:27,300
um

1066
00:38:31,310 --> 00:38:29,400
okay let's think about this I think a

1067
00:38:33,589 --> 00:38:31,320
fact that I really like is growing up

1068
00:38:34,730 --> 00:38:33,599
you think of humans rule the world it's

1069
00:38:37,430 --> 00:38:34,740
about humans you're not thinking about

1070
00:38:39,650 --> 00:38:37,440
animals and everything else but we have

1071
00:38:43,250 --> 00:38:39,660
literally been on the planet

1072
00:38:46,790 --> 00:38:43,260
for seconds and minutes right geologic

1073
00:38:49,849 --> 00:38:46,800
history is billions of years and we're

1074
00:38:52,069 --> 00:38:49,859
just this little blip that's on here so

1075
00:38:53,990 --> 00:38:52,079
the Earth had been around before us the

1076
00:38:57,410 --> 00:38:54,000
Earth will continue to be around without

1077
00:39:00,109 --> 00:38:57,420
us so we are just renting this hotel

1078
00:39:02,390 --> 00:39:00,119
we're renting our time here and so it's

1079
00:39:06,230 --> 00:39:02,400
just crazy that there was just this

1080
00:39:10,790 --> 00:39:08,690
I like that yeah there is so much time

1081
00:39:12,109 --> 00:39:10,800
that we weren't here we are just the

1082
00:39:13,609 --> 00:39:12,119
blink of an eye and who knows what the

1083
00:39:15,290 --> 00:39:13,619
future holds as well

1084
00:39:17,510 --> 00:39:15,300
um I will open it to our audience q a

1085
00:39:20,810 --> 00:39:17,520
now we'll start off with a question from

1086
00:39:22,550 --> 00:39:20,820
Twitter from Dr Jim pass Jim asks what

1087
00:39:24,170 --> 00:39:22,560
risks may occur to humans settling on

1088
00:39:26,210 --> 00:39:24,180

Mars over time

1089
00:39:28,069 --> 00:39:26,220
um assuming that viruses uh or living

1090
00:39:29,510 --> 00:39:28,079
extremophile bacteria exist there

1091
00:39:31,370 --> 00:39:29,520
especially especially for

1092
00:39:33,410 --> 00:39:31,380
astrobiologists and I think I'll add to

1093
00:39:35,630 --> 00:39:33,420
that do we have any knowledge of how

1094
00:39:37,250 --> 00:39:35,640
viruses change in the space environment

1095
00:39:40,250 --> 00:39:37,260
yet

1096
00:39:41,690 --> 00:39:40,260
yeah okay so I'm not a human virologist

1097
00:39:45,230 --> 00:39:41,700
right

1098
00:39:48,109 --> 00:39:45,240
um but I do feel I can answer this we

1099
00:39:51,410 --> 00:39:48,119
when we send people into space your

1100
00:39:53,450 --> 00:39:51,420
microbiome does change and we think it's

1101
00:39:55,609 --> 00:39:53,460
largely due to stress it's similar to

1102
00:39:57,770 --> 00:39:55,619
the stress we see here on Earth right we

1103
00:39:59,870 --> 00:39:57,780
have microgravity

1104
00:40:02,390 --> 00:39:59,880
um just a whole slew of things going on

1105
00:40:03,829 --> 00:40:02,400
and if we're going to be on Mars it's

1106
00:40:06,170 --> 00:40:03,839
going to be an environment difference in

1107
00:40:09,050 --> 00:40:06,180
Earth so we're taking Earth organisms

1108
00:40:11,390 --> 00:40:09,060
like our bacteria our Kiara fungi and

1109
00:40:13,790 --> 00:40:11,400
biological entities like our viruses

1110
00:40:15,109 --> 00:40:13,800
to a habitat that they're not used to

1111
00:40:17,990 --> 00:40:15,119
being so even though they're within us

1112
00:40:19,670 --> 00:40:18,000
we are keeping homeostasis to our

1113
00:40:20,810 --> 00:40:19,680

environment and they have to adjust to

1114
00:40:22,970 --> 00:40:20,820
that as well

1115
00:40:23,750 --> 00:40:22,980
so there are risks we have to think

1116
00:40:25,849 --> 00:40:23,760
about

1117
00:40:27,170 --> 00:40:25,859
they're going to act different and if

1118
00:40:29,210 --> 00:40:27,180
they act differently is that going to

1119
00:40:31,190 --> 00:40:29,220
throw our system out of whack we need to

1120
00:40:34,370 --> 00:40:31,200
think about our youth our sorry our

1121
00:40:36,050 --> 00:40:34,380
health we also need to think about if

1122
00:40:37,910 --> 00:40:36,060
it's going to change our mental state

1123
00:40:40,490 --> 00:40:37,920
right our gut microbiome including

1124
00:40:42,710 --> 00:40:40,500
viruses really affects our Mental Health

1125
00:40:45,050 --> 00:40:42,720
so there's there's a lot of testing that

1126
00:40:46,130 --> 00:40:45,060
we have to do and we are doing this now

1127
00:40:48,470 --> 00:40:46,140
there's people on the International

1128
00:40:50,510 --> 00:40:48,480
Space Station we see that when we send

1129
00:40:52,790 --> 00:40:50,520
people to space and they come back their

1130
00:40:55,609 --> 00:40:52,800
house does change if you have something

1131
00:40:58,069 --> 00:40:55,619
like herpes or Chicken Box these are

1132
00:41:00,109 --> 00:40:58,079
latent viruses you they come back they

1133
00:41:02,210 --> 00:41:00,119
reactivate these people are not happy

1134
00:41:03,290 --> 00:41:02,220
you you're you can get shingles

1135
00:41:04,190 --> 00:41:03,300
um and this is something we have to

1136
00:41:06,710 --> 00:41:04,200
think about when we're sending people

1137
00:41:07,790 --> 00:41:06,720
into space now it doesn't always happen

1138
00:41:10,310 --> 00:41:07,800

um but there's definitely research we

1139
00:41:14,390 --> 00:41:10,320
need to do more there so I I would be

1140
00:41:16,190 --> 00:41:14,400
worried not of a crazy Martian virus

1141
00:41:17,630 --> 00:41:16,200
hurting us right we're going to be

1142
00:41:19,670 --> 00:41:17,640
foreign why would they want to infect us

1143
00:41:21,710 --> 00:41:19,680
viruses are usually host specific so

1144
00:41:22,970 --> 00:41:21,720
they're not going to care about us but

1145
00:41:24,829 --> 00:41:22,980
we need to think about our health and

1146
00:41:27,349 --> 00:41:24,839
how our health is going to change

1147
00:41:29,270 --> 00:41:27,359
I think we have this idea that oh as

1148
00:41:30,829 --> 00:41:29,280
long as we have oxygen we'll be good no

1149
00:41:32,210 --> 00:41:30,839
no we have a whole system that we need

1150
00:41:34,510 --> 00:41:32,220
to think about and we really need to ask

1151
00:41:37,010 --> 00:41:34,520
them what they want

1152
00:41:39,530 --> 00:41:37,020
indeed we have a question from Kelly

1153
00:41:42,050 --> 00:41:39,540
yoak on YouTube uh the question says

1154
00:41:43,670 --> 00:41:42,060
does a virus attack fat or protein I'm

1155
00:41:46,069 --> 00:41:43,680
thinking what their question is is how

1156
00:41:47,630 --> 00:41:46,079
does a virus get into a cell

1157
00:41:50,630 --> 00:41:47,640
um you know what is the pathway for to

1158
00:41:53,569 --> 00:41:50,640
actually approach and attack the cell

1159
00:41:57,290 --> 00:41:53,579
yeah uh I like your interpretation of

1160
00:41:59,450 --> 00:41:57,300
I'm not sure I know how to answer that

1161
00:42:00,530 --> 00:41:59,460
um so you can have viruses that can have

1162
00:42:02,750 --> 00:42:00,540
tails

1163
00:42:05,390 --> 00:42:02,760

um like a common bacterophage will have

1164
00:42:08,510 --> 00:42:05,400
a tail it attaches to the host there's

1165
00:42:10,790 --> 00:42:08,520
receptors that bind it opens up injects

1166
00:42:13,849 --> 00:42:10,800
nucleic acid in or you can have

1167
00:42:16,730 --> 00:42:13,859
enveloped viruses where they have their

1168
00:42:19,190 --> 00:42:16,740
fat around them they attach the host

1169
00:42:21,530 --> 00:42:19,200
cell membrane they fuse with it and the

1170
00:42:23,750 --> 00:42:21,540
whole capsid comes in so is that what

1171
00:42:26,230 --> 00:42:23,760
you're asking I guess I I think that's

1172
00:42:28,370 --> 00:42:26,240
what Kelly was going for

1173
00:42:30,170 --> 00:42:28,380
yeah I think so

1174
00:42:31,430 --> 00:42:30,180
um here's a question um I'm not sure how

1175
00:42:33,349 --> 00:42:31,440
you feel about this one uh this is from

1176
00:42:34,730 --> 00:42:33,359
rendering reality 3D animations on

1177
00:42:36,170 --> 00:42:34,740
YouTube

1178
00:42:38,450 --> 00:42:36,180
um can we discuss the similarities with

1179
00:42:40,250 --> 00:42:38,460
cryo pegs and Ice brine channels as

1180
00:42:42,410 --> 00:42:40,260
having possible root connections to the

1181
00:42:44,630 --> 00:42:42,420
origins of life for example for the

1182
00:42:45,770 --> 00:42:44,640
formation of the first capsid

1183
00:42:47,810 --> 00:42:45,780
um I'm guessing that they're you know

1184
00:42:49,790 --> 00:42:47,820
given your your knowledge of Arctic and

1185
00:42:52,069 --> 00:42:49,800
polar regions they're curious of your

1186
00:42:54,050 --> 00:42:52,079
take on things like cryo pegs ice lenses

1187
00:42:56,390 --> 00:42:54,060
and Ice brine channels for being

1188
00:42:57,470 --> 00:42:56,400

potentially important for the origins of

1189
00:43:00,710 --> 00:42:57,480
life

1190
00:43:03,349 --> 00:43:00,720
okay so caveat here I've studied

1191
00:43:04,970 --> 00:43:03,359
permafrost specifically the active layer

1192
00:43:06,349 --> 00:43:04,980
above the permafrost that's seasonally

1193
00:43:08,150 --> 00:43:06,359
thaws

1194
00:43:10,309 --> 00:43:08,160
um some colleagues I worked with like Dr

1195
00:43:13,069 --> 00:43:10,319
Pacifica Summers has done some cryopake

1196
00:43:15,170 --> 00:43:13,079
work they would be more astute to be

1197
00:43:15,770 --> 00:43:15,180
able to answer these kind of questions

1198
00:43:18,530 --> 00:43:15,780
um

1199
00:43:20,990 --> 00:43:18,540
but what I will say is if you're looking

1200
00:43:22,370 --> 00:43:21,000
for early life like what I was talking

1201
00:43:24,530 --> 00:43:22,380
about earlier going to the bottom of the

1202
00:43:27,349 --> 00:43:24,540
deep ocean below the sediment or deep

1203
00:43:29,990 --> 00:43:27,359
Earth we need to get to an area where

1204
00:43:33,410 --> 00:43:30,000
life can be preserved and not affected

1205
00:43:34,790 --> 00:43:33,420
and the problem is you know we have with

1206
00:43:37,130 --> 00:43:34,800
plates at times we have the Earth is

1207
00:43:40,250 --> 00:43:37,140
moving the Earth is constantly changing

1208
00:43:41,990 --> 00:43:40,260
things are being destroyed being made so

1209
00:43:44,030 --> 00:43:42,000
we need to make sure it's somehow

1210
00:43:46,069 --> 00:43:44,040
preserved in a way where it's not going

1211
00:43:48,890 --> 00:43:46,079
to get in a subduction zone or be lost

1212
00:43:50,150 --> 00:43:48,900
or it's not going to just be okay so let

1213
00:43:52,790 --> 00:43:50,160

me step back for a second if we think

1214
00:43:54,890 --> 00:43:52,800
about fossils most fossils are found in

1215
00:43:56,990 --> 00:43:54,900
the ocean right they can settle they can

1216
00:43:58,970 --> 00:43:57,000
get preserved it's less likely to get

1217
00:44:00,770 --> 00:43:58,980
Disturbed or on land if something

1218
00:44:02,510 --> 00:44:00,780
settles it's going to be kicked around

1219
00:44:05,510 --> 00:44:02,520
there's gonna be climate weather

1220
00:44:08,870 --> 00:44:05,520
affecting it right so I think the idea

1221
00:44:11,150 --> 00:44:08,880
of a cryopag is that it's this preserved

1222
00:44:12,770 --> 00:44:11,160
sub ecosystem

1223
00:44:14,930 --> 00:44:12,780
and that's definitely some something

1224
00:44:17,809 --> 00:44:14,940
that we should be exploring more I would

1225
00:44:20,150 --> 00:44:17,819
also argue that we should explore our

1226
00:44:22,250 --> 00:44:20,160
ice cores from our glaciers and not just

1227
00:44:25,190 --> 00:44:22,260
the glacier and the Arctic or in the

1228
00:44:27,050 --> 00:44:25,200
Antarctic but a high altitude

1229
00:44:28,910 --> 00:44:27,060
um ice chorus that we have and really

1230
00:44:31,970 --> 00:44:28,920
start looking for viruses in there to

1231
00:44:33,290 --> 00:44:31,980
look at past viruses and I think a

1232
00:44:34,790 --> 00:44:33,300
common issue we're going to have and

1233
00:44:37,370 --> 00:44:34,800
this is where we really need to push the

1234
00:44:40,609 --> 00:44:37,380
envelope here is how do we work with low

1235
00:44:43,069 --> 00:44:40,619
biomass right viruses there's not that

1236
00:44:46,309 --> 00:44:43,079
much there I'm commonly from soils

1237
00:44:48,829 --> 00:44:46,319
having to pull nanograms to picograms of

1238
00:44:51,410 --> 00:44:48,839

nucleic acid to look at them so we need

1239
00:44:55,309 --> 00:44:51,420
to become more sophisticated

1240
00:44:57,950 --> 00:44:55,319
and very cool I agree entirely user AC

1241
00:44:59,990 --> 00:44:57,960
on YouTube asks us a question about

1242
00:45:02,390 --> 00:45:00,000
whether or not a chemoautotrophic

1243
00:45:04,010 --> 00:45:02,400
organism could evolve in Rocky

1244
00:45:05,750 --> 00:45:04,020
exoplanets out there much like they have

1245
00:45:07,190 --> 00:45:05,760
on Earth and having anaerobic

1246
00:45:09,349 --> 00:45:07,200
metabolisms that aren't dependent on

1247
00:45:10,250 --> 00:45:09,359
photosynthesis but only on minerals for

1248
00:45:12,410 --> 00:45:10,260
energy

1249
00:45:14,150 --> 00:45:12,420
um so first off AC that's exactly what

1250
00:45:15,470 --> 00:45:14,160
we know of for life here on Earth and so

1251
00:45:17,750 --> 00:45:15,480
it makes entire sense that it could

1252
00:45:19,970 --> 00:45:17,760
happen elsewhere uh and so I think for

1253
00:45:21,230 --> 00:45:19,980
Dr tribal let's explore this a little

1254
00:45:23,390 --> 00:45:21,240
bit more though

1255
00:45:25,630 --> 00:45:23,400
um what do we expect for possible viral

1256
00:45:28,010 --> 00:45:25,640
populations out there in the universe

1257
00:45:30,290 --> 00:45:28,020
for instance if we find a world where

1258
00:45:31,910 --> 00:45:30,300
photosynthesis never evolved do you

1259
00:45:33,829 --> 00:45:31,920
think that would change the kinds of

1260
00:45:35,470 --> 00:45:33,839
viral populations we might see that are

1261
00:45:39,530 --> 00:45:35,480
out there

1262
00:45:41,630 --> 00:45:39,540
uh yes and no I mean there's many verses

1263
00:45:43,849 --> 00:45:41,640

that don't infect photosynthetic

1264
00:45:45,829 --> 00:45:43,859
organisms right so they would be

1265
00:45:47,690 --> 00:45:45,839
arguably the same I mean I think life's

1266
00:45:49,670 --> 00:45:47,700
gonna be way different elsewhere we find

1267
00:45:52,370 --> 00:45:49,680
it right but we don't have something to

1268
00:45:54,109 --> 00:45:52,380
compare to so we don't know but there's

1269
00:45:55,970 --> 00:45:54,119
viruses that in fact organisms that

1270
00:45:58,609 --> 00:45:55,980
don't photos synthesize it's not like

1271
00:46:00,410 --> 00:45:58,619
it's required for a virus

1272
00:46:01,790 --> 00:46:00,420
a virus just needs something that's

1273
00:46:04,130 --> 00:46:01,800
gonna have metabolism it's gonna

1274
00:46:06,349 --> 00:46:04,140
generate ATP to take advantage of that's

1275
00:46:08,329 --> 00:46:06,359
all it needs so whatever weird biology

1276
00:46:11,210 --> 00:46:08,339
is out there the virus is going to fit

1277
00:46:13,550 --> 00:46:11,220
to it no problem I think the question we

1278
00:46:16,250 --> 00:46:13,560
should be asking is when we're looking

1279
00:46:19,069 --> 00:46:16,260
for Life detection we need to think

1280
00:46:22,130 --> 00:46:19,079
about the virus influence right so for

1281
00:46:24,349 --> 00:46:22,140
biosignatures aviron itself is a

1282
00:46:27,530 --> 00:46:24,359
biosignature if we're thinking about

1283
00:46:29,210 --> 00:46:27,540
places where we can't Land Rovers and

1284
00:46:30,470 --> 00:46:29,220
we're just wanting to sample atmosphere

1285
00:46:33,530 --> 00:46:30,480
or maybe

1286
00:46:35,390 --> 00:46:33,540
um measure from a distance we need to

1287
00:46:37,130 --> 00:46:35,400
think about how viruses are influencing

1288
00:46:39,349 --> 00:46:37,140

that signal right so we're thinking

1289
00:46:42,530 --> 00:46:39,359
about stable isotopes and gas products

1290
00:46:45,069 --> 00:46:42,540
for CO2 the fractionation of when it's

1291
00:46:47,390 --> 00:46:45,079
made if a virus is infecting the host

1292
00:46:48,710 --> 00:46:47,400
it's using the genes differently it's

1293
00:46:50,630 --> 00:46:48,720
pushing this Machinery so the

1294
00:46:52,550 --> 00:46:50,640
fractionations can be different so that

1295
00:46:53,750 --> 00:46:52,560
I stop a signature of the gas is going

1296
00:46:56,690 --> 00:46:53,760
to be different

1297
00:46:58,370 --> 00:46:56,700
so just to give a background it when

1298
00:46:59,750 --> 00:46:58,380
we're looking at I guess like a methane

1299
00:47:02,750 --> 00:46:59,760
like methane

1300
00:47:04,790 --> 00:47:02,760
um we look at the fractionation to

1301
00:47:07,010 --> 00:47:04,800
really say a did it come from Life did

1302
00:47:09,170 --> 00:47:07,020
it not come from life we can even get

1303
00:47:10,970 --> 00:47:09,180
down to what exact metabolism did it so

1304
00:47:13,849 --> 00:47:10,980
from methanogenesis it can be

1305
00:47:15,829 --> 00:47:13,859
hydrogenotrophic or acetoplastic

1306
00:47:17,809 --> 00:47:15,839
um you can have if I'm going to say this

1307
00:47:19,069 --> 00:47:17,819
right hygienotrophic is negative 80 per

1308
00:47:21,650 --> 00:47:19,079
male just to throw random numbers

1309
00:47:22,970 --> 00:47:21,660
acetoclastics around negative 60 and

1310
00:47:25,910 --> 00:47:22,980
then you can have variation right so

1311
00:47:27,890 --> 00:47:25,920
life there's always variation what

1312
00:47:30,710 --> 00:47:27,900
variation is caused by the virus what if

1313
00:47:33,410 --> 00:47:30,720

it makes something look more abiotic

1314
00:47:35,990 --> 00:47:33,420
because it's just pushing the genes

1315
00:47:39,470 --> 00:47:36,000
and really this fractionation comes from

1316
00:47:42,589 --> 00:47:39,480
as life when we use things we want to

1317
00:47:44,870 --> 00:47:42,599
use the lighter isotope version sorry if

1318
00:47:47,089 --> 00:47:44,880
I'm getting into signs here

1319
00:47:48,829 --> 00:47:47,099
um and when the virus takes over the

1320
00:47:50,630 --> 00:47:48,839
virus can just

1321
00:47:51,890 --> 00:47:50,640
put put the pedal to the metal right

1322
00:47:53,870 --> 00:47:51,900
it's like let's go let's go let's go

1323
00:47:56,630 --> 00:47:53,880
let's get this done right so there that

1324
00:47:58,130 --> 00:47:56,640
selection is not going to be is this not

1325
00:47:59,569 --> 00:47:58,140
going to be happening as much right and

1326
00:48:01,130 --> 00:47:59,579
so this is a lot of this is more

1327
00:48:03,950 --> 00:48:01,140
research needs to be done right so I'm

1328
00:48:06,050 --> 00:48:03,960
maybe speaking too much on this but when

1329
00:48:08,089 --> 00:48:06,060
we're looking at life elsewhere when you

1330
00:48:09,950 --> 00:48:08,099
think about what are viruses doing and

1331
00:48:11,690 --> 00:48:09,960
we need to be thinking about an earth to

1332
00:48:13,430 --> 00:48:11,700
better equip ourselves for looking for

1333
00:48:14,990 --> 00:48:13,440
life elsewhere

1334
00:48:16,130 --> 00:48:15,000
um I like that a lot and for our

1335
00:48:18,050 --> 00:48:16,140
audience who may don't quite understand

1336
00:48:19,970 --> 00:48:18,060
this idea of fractionation of stable

1337
00:48:21,349 --> 00:48:19,980
isotopes it is worth looking into there

1338
00:48:22,250 --> 00:48:21,359

are some really great explainers out

1339
00:48:23,809 --> 00:48:22,260
there

1340
00:48:26,510 --> 00:48:23,819
um what Dr Trudeau is saying basically

1341
00:48:28,730 --> 00:48:26,520
when it comes to life and enzymes that

1342
00:48:31,430 --> 00:48:28,740
life uses to to have metabolism and do

1343
00:48:33,589 --> 00:48:31,440
things uh life tends to prefer using the

1344
00:48:35,390 --> 00:48:33,599
lighter isotope over the heavy there are

1345
00:48:38,510 --> 00:48:35,400
some very good chemical reasons for that

1346
00:48:40,010 --> 00:48:38,520
and so we see a fractionation or a

1347
00:48:42,410 --> 00:48:40,020
change in the Isotopes that are

1348
00:48:44,809 --> 00:48:42,420
available being produced by life versus

1349
00:48:46,250 --> 00:48:44,819
non-life processes

1350
00:48:49,190 --> 00:48:46,260
um and so that is very intriguing for us

1351
00:48:50,390 --> 00:48:49,200
now I will say our next question

1352
00:48:53,150 --> 00:48:50,400
um maybe someone just could use some

1353
00:48:55,730 --> 00:48:53,160
help in the lab it sounds like so Dan in

1354
00:48:58,809 --> 00:48:55,740
the cave has asked they've just started

1355
00:49:01,309 --> 00:48:58,819
their PHD at the uh OU in the UK

1356
00:49:03,589 --> 00:49:01,319
investigating microbial communities in

1357
00:49:05,450 --> 00:49:03,599
the Botswana salt pans as an analog for

1358
00:49:07,550 --> 00:49:05,460
Mars and they want to know if you have

1359
00:49:10,210 --> 00:49:07,560
any tips for how to separate viral DNA

1360
00:49:13,970 --> 00:49:10,220
from their soil core samples

1361
00:49:15,349 --> 00:49:13,980
super cool that so that's always great

1362
00:49:18,950 --> 00:49:15,359
especially when you're getting to do

1363
00:49:21,650 --> 00:49:18,960

research when something is Sexy Cool It

1364
00:49:23,270 --> 00:49:21,660
kind of it makes you it makes it easier

1365
00:49:25,010 --> 00:49:23,280
to talk about and as science says

1366
00:49:26,690 --> 00:49:25,020
sometimes it's hard right like if I have

1367
00:49:28,790 --> 00:49:26,700
to talk about something in poo you're

1368
00:49:30,050 --> 00:49:28,800
like well this is poo or if I have to

1369
00:49:31,790 --> 00:49:30,060
talk about this and it's not that

1370
00:49:35,210 --> 00:49:31,800
exciting so having something like that

1371
00:49:37,970 --> 00:49:35,220
that's great that's always enjoyable

1372
00:49:40,190 --> 00:49:37,980
um yeah so I can help you more if you

1373
00:49:42,349 --> 00:49:40,200
want to email me we can chat about it

1374
00:49:44,630 --> 00:49:42,359
but what's really hard is you need to be

1375
00:49:46,250 --> 00:49:44,640
thinking about what is binding to the

1376
00:49:49,309 --> 00:49:46,260
virus and is it causing the virus to

1377
00:49:52,370 --> 00:49:49,319
precipitate out or is it causing uh is

1378
00:49:54,710 --> 00:49:52,380
it protecting the virus so we you have

1379
00:49:56,510 --> 00:49:54,720
to be able to tailor your methods to

1380
00:49:58,069 --> 00:49:56,520
your ecosystem right so you have to

1381
00:50:00,050 --> 00:49:58,079
think about the virus interacting with

1382
00:50:01,670 --> 00:50:00,060
what's going on with around them to

1383
00:50:04,069 --> 00:50:01,680
really be able to resuspend and pull the

1384
00:50:05,990 --> 00:50:04,079
viruses out this is a major challenge we

1385
00:50:08,329 --> 00:50:06,000
had in soils especially the peatland

1386
00:50:11,030 --> 00:50:08,339
soils that I worked in because there's a

1387
00:50:13,670 --> 00:50:11,040
lot of Organics so in especially in

1388
00:50:15,589 --> 00:50:13,680

Northern latitudes you'll have plant

1389
00:50:18,050 --> 00:50:15,599
biomass that just accumulates on the

1390
00:50:19,910 --> 00:50:18,060
surface and it's slowly degraded so it's

1391
00:50:22,370 --> 00:50:19,920
very fluffy you kind of walk across it

1392
00:50:25,010 --> 00:50:22,380
like a Tempur-Pedic mattress it's really

1393
00:50:27,470 --> 00:50:25,020
nice it's bouncy uh it was it was cool

1394
00:50:30,170 --> 00:50:27,480
to observe right

1395
00:50:31,849 --> 00:50:30,180
um You can also have certain plants uh

1396
00:50:34,309 --> 00:50:31,859
like muscles like sphagnant Monsters

1397
00:50:36,410 --> 00:50:34,319
like bogs that are in blog sorry that

1398
00:50:38,030 --> 00:50:36,420
producer in assets that inhibit growth

1399
00:50:38,990 --> 00:50:38,040
right so you have a lot of plant biomass

1400
00:50:42,770 --> 00:50:39,000
going on

1401
00:50:45,710 --> 00:50:42,780
now the trick was to get the virions of

1402
00:50:49,190 --> 00:50:45,720
virus particles off the soil particles

1403
00:50:50,870 --> 00:50:49,200
and this plant biomass and make it pure

1404
00:50:52,970 --> 00:50:50,880
to be able to resuspend that and that's

1405
00:50:54,890 --> 00:50:52,980
difficult so we'd do a lot of testing in

1406
00:50:56,990 --> 00:50:54,900
different buffers we do a lot of

1407
00:50:58,910 --> 00:50:57,000
physical desorption methods to get those

1408
00:51:01,069 --> 00:50:58,920
urines off

1409
00:51:03,410 --> 00:51:01,079
um another thing that's helpful is by

1410
00:51:05,270 --> 00:51:03,420
doing size filtration so viruses are

1411
00:51:07,130 --> 00:51:05,280
really small and this again you're going

1412
00:51:08,990 --> 00:51:07,140
to be pushing out most viruses you think

1413
00:51:11,210 --> 00:51:09,000

about what viruses you're critically

1414
00:51:13,250 --> 00:51:11,220
looking at so if it's double-stranded

1415
00:51:15,290 --> 00:51:13,260
DNA bacteriophage

1416
00:51:18,290 --> 00:51:15,300
you can run them through a size

1417
00:51:20,750 --> 00:51:18,300
filtration like 0.22 micron filter and

1418
00:51:22,730 --> 00:51:20,760
really isolate your virus

1419
00:51:24,109 --> 00:51:22,740
um so I I don't want to go too much more

1420
00:51:25,849 --> 00:51:24,119
into it I'd love to be able to have a

1421
00:51:28,490 --> 00:51:25,859
conversation so please just email me I'm

1422
00:51:30,589 --> 00:51:28,500
happy to talk with you awesome uh yeah

1423
00:51:32,470 --> 00:51:30,599
and you know for anyone starting a PhD

1424
00:51:34,549 --> 00:51:32,480
programmer or any realm of research

1425
00:51:36,049 --> 00:51:34,559
always reach out to the people who've

1426
00:51:38,210 --> 00:51:36,059
done the work already and can help you

1427
00:51:40,910 --> 00:51:38,220
in the laboratory there's no reason to

1428
00:51:42,349 --> 00:51:40,920
build new methods or or bang your head

1429
00:51:44,089 --> 00:51:42,359
against the wall I learned that the hard

1430
00:51:46,069 --> 00:51:44,099
way myself as a graduate student when I

1431
00:51:47,450 --> 00:51:46,079
I spend way too much time often in the

1432
00:51:49,069 --> 00:51:47,460
lab trying to figure out how to do

1433
00:51:50,630 --> 00:51:49,079
something when all I really had to do

1434
00:51:52,730 --> 00:51:50,640
was ask somebody else who'd done it

1435
00:51:54,410 --> 00:51:52,740
already it would have saved me a lot of

1436
00:51:55,430 --> 00:51:54,420
time so yes so definitely please reach

1437
00:51:58,430 --> 00:51:55,440
out to The Experts when you have

1438
00:51:59,630 --> 00:51:58,440

questions on how to do your research uh

1439
00:52:02,750 --> 00:51:59,640
our next question I think I'll take

1440
00:52:04,150 --> 00:52:02,760
myself Marvel sushante on YouTube has

1441
00:52:06,470 --> 00:52:04,160
asked if we could explain how

1442
00:52:08,030 --> 00:52:06,480
coxolithophores are important to

1443
00:52:09,410 --> 00:52:08,040
astrobiology

1444
00:52:12,170 --> 00:52:09,420
um so for maybe our viewers not not

1445
00:52:14,329 --> 00:52:12,180
really aware a coxolithophor is a marine

1446
00:52:16,370 --> 00:52:14,339
phytoplankton uh they're a very

1447
00:52:18,410 --> 00:52:16,380
prevalent calcifying organism on this

1448
00:52:19,670 --> 00:52:18,420
planet that means they take calcium and

1449
00:52:22,190 --> 00:52:19,680
the carbon dioxide that turns into

1450
00:52:23,870 --> 00:52:22,200
bicarbonate out of the ocean and make

1451
00:52:25,309 --> 00:52:23,880
calcium carbonate

1452
00:52:27,470 --> 00:52:25,319
um they were they've been involved in

1453
00:52:29,210 --> 00:52:27,480
forming Rock layers of calcium carbonate

1454
00:52:32,089 --> 00:52:29,220
when you think of the White Cliffs of

1455
00:52:34,430 --> 00:52:32,099
Dover uh in the UK those those Cliffs of

1456
00:52:36,430 --> 00:52:34,440
Dover are chalk that are formed from the

1457
00:52:39,710 --> 00:52:36,440
bodies of organisms that have calcified

1458
00:52:41,510 --> 00:52:39,720
in the ocean from long ago and so it's

1459
00:52:43,130 --> 00:52:41,520
important for us in astrobiology if

1460
00:52:45,890 --> 00:52:43,140
we're trying to understand the nature of

1461
00:52:47,930 --> 00:52:45,900
life how did life originate here or did

1462
00:52:49,309 --> 00:52:47,940
it originate elsewhere and come here how

1463
00:52:51,770 --> 00:52:49,319

did it evolve and change with our

1464
00:52:53,930 --> 00:52:51,780
biosphere and our world over time and

1465
00:52:56,930 --> 00:52:53,940
how can we find it out there and so

1466
00:52:58,130 --> 00:52:56,940
understanding how organisms uh calcify

1467
00:53:00,710 --> 00:52:58,140
in the environment how they create

1468
00:53:02,150 --> 00:53:00,720
mineral structures in the environment is

1469
00:53:04,190 --> 00:53:02,160
important for understanding what life

1470
00:53:06,410 --> 00:53:04,200
does and for what we could look like

1471
00:53:08,809 --> 00:53:06,420
look for out there maybe there have been

1472
00:53:11,150 --> 00:53:08,819
calcifying organisms on Mars in the past

1473
00:53:12,530 --> 00:53:11,160
or ancient Venus long ago

1474
00:53:15,650 --> 00:53:12,540
um would any of those signs be left for

1475
00:53:17,930 --> 00:53:15,660
us to find now we truly don't know yet

1476
00:53:20,690 --> 00:53:17,940
um our next question comes to us uh

1477
00:53:24,890 --> 00:53:20,700
Aruna Devi has asked can we find viral

1478
00:53:30,589 --> 00:53:27,770
yeah that that's again hard

1479
00:53:31,970 --> 00:53:30,599
um so you know when we're looking for

1480
00:53:33,650 --> 00:53:31,980
these fossils and we're looking for

1481
00:53:35,809 --> 00:53:33,660
ancient preserve life right we're

1482
00:53:38,030 --> 00:53:35,819
looking at stromatolites and we have

1483
00:53:39,290 --> 00:53:38,040
great evidence of stromatolites all over

1484
00:53:41,809 --> 00:53:39,300
the world

1485
00:53:44,930 --> 00:53:41,819
um I was fortunate enough to do the

1486
00:53:46,430 --> 00:53:44,940
Agron geobiology course in 2014 and got

1487
00:53:48,829 --> 00:53:46,440
to go and actually sample some

1488
00:53:50,630 --> 00:53:48,839

stromatolites myself uh that was

1489
00:53:52,849 --> 00:53:50,640
invaluable that those are great

1490
00:53:55,670 --> 00:53:52,859
experiences so

1491
00:53:57,710 --> 00:53:55,680
you know when we're looking for loss for

1492
00:54:00,049 --> 00:53:57,720
these fossilized organisms or for

1493
00:54:03,170 --> 00:54:00,059
biological entities what's really hard

1494
00:54:06,470 --> 00:54:03,180
is Discerning between is it abiotic or

1495
00:54:09,950 --> 00:54:06,480
is it biotic right and that's tricky we

1496
00:54:11,150 --> 00:54:09,960
can't just extract nucleic acid out

1497
00:54:14,809 --> 00:54:11,160
um

1498
00:54:16,730 --> 00:54:14,819
so we possibly could find a virus it

1499
00:54:18,770 --> 00:54:16,740
would have to it'd have to be an iconic

1500
00:54:20,390 --> 00:54:18,780
shape like a bacteriophage and there

1501
00:54:23,210 --> 00:54:20,400
would have to be great evidence to show

1502
00:54:25,069 --> 00:54:23,220
there was no abiotic process that could

1503
00:54:27,589 --> 00:54:25,079
help form that

1504
00:54:29,809 --> 00:54:27,599
um I don't doubt that it's out there but

1505
00:54:32,089 --> 00:54:29,819
I think it's it's easier to find with

1506
00:54:34,370 --> 00:54:32,099
the larger organisms just because of

1507
00:54:35,990 --> 00:54:34,380
where our resolution is with our current

1508
00:54:38,630 --> 00:54:36,000
technology

1509
00:54:40,609 --> 00:54:38,640
not to say it's not possible

1510
00:54:42,770 --> 00:54:40,619
well let's talk about what's possible

1511
00:54:45,170 --> 00:54:42,780
for just a moment then uh this next

1512
00:54:46,670 --> 00:54:45,180
question I really appreciate from J.A

1513
00:54:48,230 --> 00:54:46,680

Holt on YouTube

1514
00:54:50,030 --> 00:54:48,240
um to what extent are we sure that life

1515
00:54:51,770 --> 00:54:50,040
originated on Earth

1516
00:54:53,510 --> 00:54:51,780
um we aren't

1517
00:54:56,150 --> 00:54:53,520
um my life itself have been brought here

1518
00:54:58,130 --> 00:54:56,160
now Jay says From Another Universe um

1519
00:54:59,390 --> 00:54:58,140
and then the question goes the viruses

1520
00:55:01,309 --> 00:54:59,400
um now we wouldn't say Another Universe

1521
00:55:03,890 --> 00:55:01,319
Jay um we don't have any knowledge of

1522
00:55:05,870 --> 00:55:03,900
Another Universe uh the very idea of a

1523
00:55:08,690 --> 00:55:05,880
Multiverse is really rooted in some

1524
00:55:10,609 --> 00:55:08,700
mathematics and and some speculation but

1525
00:55:12,829 --> 00:55:10,619
we have no evidence that multiverses

1526
00:55:14,270 --> 00:55:12,839
exist yet uh let alone that life could

1527
00:55:16,730 --> 00:55:14,280
be brought here from that that far away

1528
00:55:20,030 --> 00:55:16,740
wherever that is but there is this this

1529
00:55:21,890 --> 00:55:20,040
idea called panspermia that life can be

1530
00:55:24,470 --> 00:55:21,900
moved from one world to another and that

1531
00:55:26,210 --> 00:55:24,480
maybe we are martians or maybe we're

1532
00:55:29,030 --> 00:55:26,220
venusians maybe life started on another

1533
00:55:31,130 --> 00:55:29,040
world and then came here uh and so I

1534
00:55:33,410 --> 00:55:31,140
think Dr tribal for you as well we can

1535
00:55:34,910 --> 00:55:33,420
have some fun and speculate here uh

1536
00:55:36,530 --> 00:55:34,920
could viruses have come from another

1537
00:55:37,609 --> 00:55:36,540
world and then been brought here what do

1538
00:55:40,790 --> 00:55:37,619

you think

1539
00:55:42,170 --> 00:55:40,800
absolutely I mean that's viruses role in

1540
00:55:43,910 --> 00:55:42,180
life they don't have flagella they're

1541
00:55:46,130 --> 00:55:43,920
not moving around like that they're

1542
00:55:47,870 --> 00:55:46,140
hitchhikers they like to get in their

1543
00:55:49,910 --> 00:55:47,880
house move on over to a different host

1544
00:55:51,650 --> 00:55:49,920
sometimes they survive outside the house

1545
00:55:53,870 --> 00:55:51,660
sometimes they go in the house so I

1546
00:55:55,730 --> 00:55:53,880
think they're adapted to survive so

1547
00:55:58,250 --> 00:55:55,740
possible yeah

1548
00:55:59,990 --> 00:55:58,260
love it um so we have another question

1549
00:56:01,130 --> 00:56:00,000
that I also really appreciate I'm glad

1550
00:56:03,170 --> 00:56:01,140
our audience is like thinking

1551
00:56:05,990 --> 00:56:03,180
speculatively here about what's possible

1552
00:56:08,150 --> 00:56:06,000
with viruses and life uh so AC has

1553
00:56:10,970 --> 00:56:08,160
another question they've asked uh what

1554
00:56:13,549 --> 00:56:10,980
makes any of us think that viruses could

1555
00:56:15,829 --> 00:56:13,559
be found uh in other exoplanetary

1556
00:56:18,109 --> 00:56:15,839
ecosystems and not just be a fluke of

1557
00:56:20,150 --> 00:56:18,119
terrestrial Evolution

1558
00:56:21,829 --> 00:56:20,160
um and that's a good question uh do we

1559
00:56:24,170 --> 00:56:21,839
have any reason to assume that viruses

1560
00:56:25,730 --> 00:56:24,180
will exist in other worlds

1561
00:56:27,349 --> 00:56:25,740
I mean we could say the same thing about

1562
00:56:28,130 --> 00:56:27,359
any life

1563
00:56:31,490 --> 00:56:28,140

um

1564
00:56:33,410 --> 00:56:31,500
so if we think with of Life starting off

1565
00:56:35,450 --> 00:56:33,420
as viruses if we're looking for life

1566
00:56:37,370 --> 00:56:35,460
elsewhere then there would be a good

1567
00:56:40,309 --> 00:56:37,380
chance that something of a virus would

1568
00:56:42,470 --> 00:56:40,319
be there I think there is actually a

1569
00:56:44,270 --> 00:56:42,480
better chance of a virus being found

1570
00:56:46,250 --> 00:56:44,280
than some of the other things that we

1571
00:56:47,870 --> 00:56:46,260
are possibly looking for and the reason

1572
00:56:50,630 --> 00:56:47,880
is is because all the different things

1573
00:56:52,010 --> 00:56:50,640
viruses can do right they move things

1574
00:56:54,770 --> 00:56:52,020
around right there are these mobile

1575
00:56:56,210 --> 00:56:54,780
genetic elements and they're critical to

1576
00:56:58,370 --> 00:56:56,220
life so if we're going to find life

1577
00:57:01,970 --> 00:56:58,380
elsewhere we're undoubtedly going to

1578
00:57:04,790 --> 00:57:01,980
find viruses or a virus-like entity

1579
00:57:07,190 --> 00:57:04,800
and very cool all right so I think we

1580
00:57:09,530 --> 00:57:07,200
have time for one more question uh so

1581
00:57:10,849 --> 00:57:09,540
user Florian borius on YouTube has been

1582
00:57:13,309 --> 00:57:10,859
asking

1583
00:57:15,589 --> 00:57:13,319
um about how viruses might be able to

1584
00:57:17,890 --> 00:57:15,599
have more resistance

1585
00:57:20,450 --> 00:57:17,900
um to the space environment to other

1586
00:57:22,010 --> 00:57:20,460
environments out there how they could uh

1587
00:57:25,309 --> 00:57:22,020
survive and develop resistance to

1588
00:57:26,750 --> 00:57:25,319

extreme environments in the cosmos

1589
00:57:28,010 --> 00:57:26,760
um and you know I think you know we kind

1590
00:57:29,390 --> 00:57:28,020
of have to think about what viruses are

1591
00:57:32,030 --> 00:57:29,400
they themselves are not the ones that

1592
00:57:33,290 --> 00:57:32,040
are producing necessarily the resistance

1593
00:57:35,150 --> 00:57:33,300
um you know that they're they're taking

1594
00:57:36,950 --> 00:57:35,160
over these populations of other cells of

1595
00:57:38,150 --> 00:57:36,960
other beings that have developed

1596
00:57:40,069 --> 00:57:38,160
resistance

1597
00:57:42,230 --> 00:57:40,079
um so I think maybe a more enjoyable

1598
00:57:44,930 --> 00:57:42,240
question for us to finish off here Dr

1599
00:57:47,290 --> 00:57:44,940
Trubel would be um what is our knowledge

1600
00:57:50,390 --> 00:57:47,300
right now of how viruses impact

1601
00:57:52,670 --> 00:57:50,400
extremophilic organisms and and do they

1602
00:57:54,470 --> 00:57:52,680
have any kind of role to play in the

1603
00:57:56,630 --> 00:57:54,480
diversification of life to fill these

1604
00:57:58,730 --> 00:57:56,640
more extreme environments

1605
00:58:00,069 --> 00:57:58,740
yeah absolutely

1606
00:58:02,329 --> 00:58:00,079
um

1607
00:58:04,309 --> 00:58:02,339
man there's so many there's a lot of

1608
00:58:05,930 --> 00:58:04,319
good research out there for anyone who

1609
00:58:07,730 --> 00:58:05,940
is thinking about viruses especially in

1610
00:58:10,910 --> 00:58:07,740
extreme environments

1611
00:58:13,849 --> 00:58:10,920
I would tell you to look up Dr Kenneth

1612
00:58:14,770 --> 00:58:13,859
Stedman uh professor at Portland State

1613
00:58:17,510 --> 00:58:14,780

University

1614
00:58:19,309 --> 00:58:17,520
he was a person that I really reached

1615
00:58:22,790 --> 00:58:19,319
out to he's been a great mentor to

1616
00:58:25,190 --> 00:58:22,800
really understand how viruses are really

1617
00:58:28,010 --> 00:58:25,200
involved in astrobiology and extreme

1618
00:58:31,609 --> 00:58:28,020
environments he has a slew of great

1619
00:58:34,010 --> 00:58:31,619
papers so you know viruses

1620
00:58:36,230 --> 00:58:34,020
it's what we say is an extreme

1621
00:58:38,030 --> 00:58:36,240
environment it depends on the host right

1622
00:58:40,549 --> 00:58:38,040
if a host is living there is it really

1623
00:58:42,109 --> 00:58:40,559
extreme that may be where they Thrive it

1624
00:58:44,150 --> 00:58:42,119
may be if you put them in something we

1625
00:58:45,530 --> 00:58:44,160
find as a good environment that they

1626
00:58:48,230 --> 00:58:45,540
actually get out competed they're not

1627
00:58:50,870 --> 00:58:48,240
happy so when we say soil is Harsh I say

1628
00:58:52,609 --> 00:58:50,880
not I think it's harsh to us right so I

1629
00:58:55,190 --> 00:58:52,619
will say extreme to us but not

1630
00:58:57,770 --> 00:58:55,200
necessarily to that organism

1631
00:58:59,690 --> 00:58:57,780
um we know that viruses will take genes

1632
00:59:01,250 --> 00:58:59,700
from their house we're still trying to

1633
00:59:03,470 --> 00:59:01,260
figure out exactly how everything

1634
00:59:04,910 --> 00:59:03,480
happens and why it happens but they can

1635
00:59:07,549 --> 00:59:04,920
have these genes that we'll call

1636
00:59:09,530 --> 00:59:07,559
auxiliary metabolic genes

1637
00:59:11,990 --> 00:59:09,540
um and sometimes when they infected a

1638
00:59:15,710 --> 00:59:12,000

new host uh you know another family

1639
00:59:17,569 --> 00:59:15,720
member within the host they can take

1640
00:59:20,270 --> 00:59:17,579
over the host and cause the host's

1641
00:59:22,609 --> 00:59:20,280
genome or metabolism to express that

1642
00:59:24,549 --> 00:59:22,619
Gene and make the host more fit so

1643
00:59:27,470 --> 00:59:24,559
viruses can definitely help hosts

1644
00:59:30,770 --> 00:59:27,480
survive and not only survive but maybe

1645
00:59:32,589 --> 00:59:30,780
become more fit and out compete others

1646
00:59:34,730 --> 00:59:32,599
in the environment

1647
00:59:37,069 --> 00:59:34,740
very cool great way to finish off our

1648
00:59:41,329 --> 00:59:37,079
episode uh Dr Trudeau thank you so much

1649
00:59:44,270 --> 00:59:42,890
um so if our audience did want to learn

1650
00:59:45,349 --> 00:59:44,280
more about your research or your work

1651
00:59:46,930 --> 00:59:45,359
what's the best way for them to reach

1652
00:59:49,849 --> 00:59:46,940
out and find you

1653
00:59:52,490 --> 00:59:49,859
so I really like Twitter because it's

1654
00:59:54,470 --> 00:59:52,500
very informal I've just messaged other

1655
00:59:56,990 --> 00:59:54,480
scientists and they get back to me and

1656
00:59:58,430 --> 00:59:57,000
so I've Loved I come across not calling

1657
01:00:00,170 --> 00:59:58,440
it Twitter but science sort of

1658
01:00:02,210 --> 01:00:00,180
specifically all the other shenanigans

1659
01:00:04,309 --> 01:00:02,220
that go on not really something I'm

1660
01:00:05,930 --> 01:00:04,319
concerned with but just as the community

1661
01:00:09,230 --> 01:00:05,940
of scientists it's a great way to reach

1662
01:00:10,430 --> 01:00:09,240
out you can also feel free to email me

1663
01:00:11,809 --> 01:00:10,440

um

1664
01:00:14,089 --> 01:00:11,819
yeah I

1665
01:00:15,589 --> 01:00:14,099
any any way that you think you can

1666
01:00:18,530 --> 01:00:15,599
normally email someone I'm happy I'll

1667
01:00:20,210 --> 01:00:18,540
check my emails uh if you I think what's

1668
01:00:21,589 --> 01:00:20,220
hard is sometimes people message me just

1669
01:00:23,270 --> 01:00:21,599
on LinkedIn or something I don't always

1670
01:00:24,950 --> 01:00:23,280
check everything I probably check

1671
01:00:26,930 --> 01:00:24,960
Twitter the most

1672
01:00:28,250 --> 01:00:26,940
um but a good old email I check emails

1673
01:00:29,870 --> 01:00:28,260
every day so let's just go with email

1674
01:00:31,789 --> 01:00:29,880
works best

1675
01:00:33,470 --> 01:00:31,799
love it all right Gary thank you so much

1676
01:00:35,089 --> 01:00:33,480
for joining us it's been a great time

1677
01:00:37,309 --> 01:00:35,099
having on the show to talk a little bit

1678
01:00:39,490 --> 01:00:37,319
about astrovirology there's still so

1679
01:00:42,349 --> 01:00:39,500
much more for us to explore and to learn

1680
01:00:43,670 --> 01:00:42,359
for our audience who are tuning in if

1681
01:00:45,589 --> 01:00:43,680
you want to follow along with more going

1682
01:00:48,230 --> 01:00:45,599
on for ask an astrobiologist of course

1683
01:00:50,690 --> 01:00:48,240
we have the hashtag on Twitter hashtag

1684
01:00:51,770 --> 01:00:50,700
ask astrobio you can also sign up for

1685
01:00:54,470 --> 01:00:51,780
the mailing list for the NASA

1686
01:00:56,390 --> 01:00:54,480
astrobiology program you can learn more

1687
01:00:58,670 --> 01:00:56,400
about current events New Opportunities

1688
01:01:00,650 --> 01:00:58,680

and things that are going on across the

1689
01:01:03,470 --> 01:01:00,660
realm of the NASA astrobiology program

1690
01:01:05,569 --> 01:01:03,480
and so to all of you for tuning in thank

1691
01:01:09,289 --> 01:01:05,579
you so much for joining us and as always

1692
01:01:11,890 --> 01:01:09,299
until next time stay curious

1693
01:01:26,200 --> 01:01:11,900
foreign

1694
01:01:27,510 --> 01:01:26,210
[Music]

1695
01:01:35,930 --> 01:01:27,520
[Applause]

1696
01:01:38,360 --> 01:01:35,940
[Music]