
AB
GRAD
CON23

1
00:00:11,770 --> 00:00:09,910
[Music]

2
00:00:14,990 --> 00:00:11,780
hello everyone

3
00:00:16,970 --> 00:00:15,000
my name is jono Abshire I am a second

4
00:00:19,250 --> 00:00:16,980
year PhD student at Portland State

5
00:00:21,650 --> 00:00:19,260
University working in the center for

6
00:00:23,150 --> 00:00:21,660
life in extreme environments more

7
00:00:25,070 --> 00:00:23,160
specifically out of the extreme virus

8
00:00:27,130 --> 00:00:25,080
lab and today I'll be giving you a

9
00:00:29,570 --> 00:00:27,140
little bit of insight into Life In Hell

10
00:00:31,910 --> 00:00:29,580
understanding the role of toxin

11
00:00:33,709 --> 00:00:31,920
antitoxin systems in prokaryotic genomes

12
00:00:37,610 --> 00:00:33,719
and their potential for virus host

13
00:00:39,170 --> 00:00:37,620

co-evolution tldr extreme organisms the

14
00:00:40,549 --> 00:00:39,180
viruses that infect them and their

15
00:00:42,709 --> 00:00:40,559
interactions in these extreme

16
00:00:44,630 --> 00:00:42,719
environments and our journey kind of

17
00:00:46,810 --> 00:00:44,640
begins right here so this is a personal

18
00:00:49,130 --> 00:00:46,820
image of Lassen Volcanic National Park

19
00:00:51,350 --> 00:00:49,140
it is one of the many areas on our

20
00:00:53,750 --> 00:00:51,360
beautiful planet that is home to these

21
00:00:56,330 --> 00:00:53,760
volcanic Hot Springs this is one of the

22
00:00:57,709 --> 00:00:56,340
main sampling sites of our lab and while

23
00:00:59,810 --> 00:00:57,719
most people wouldn't believe that there

24
00:01:02,209 --> 00:00:59,820
are things living in this environment

25
00:01:03,889 --> 00:01:02,219
there certainly are

26
00:01:05,390 --> 00:01:03,899
um specifically these microbes from hell

27
00:01:07,490 --> 00:01:05,400
and I'll get back to these guys in just

28
00:01:09,770 --> 00:01:07,500
a second but a little bit of background

29
00:01:11,690 --> 00:01:09,780
about why we why we study these

30
00:01:13,250 --> 00:01:11,700
particular environments so these

31
00:01:15,170 --> 00:01:13,260
volcanic Hot Springs are often

32
00:01:17,210 --> 00:01:15,180
considered and understood to be

33
00:01:19,210 --> 00:01:17,220
analogues for both for planets both

34
00:01:21,950 --> 00:01:19,220
outside and inside of our solar system

35
00:01:25,010 --> 00:01:21,960
referring back to some of the ancient

36
00:01:26,570 --> 00:01:25,020
Hot Springs found recently on Mars which

37
00:01:29,149 --> 00:01:26,580
may or may not have looked something

38
00:01:31,609 --> 00:01:29,159

like this boiling Mud Pot that we find

39
00:01:32,690 --> 00:01:31,619
in Devil's Kitchen at Lassen Volcanic

40
00:01:34,789 --> 00:01:32,700
National Park

41
00:01:38,810 --> 00:01:34,799
getting back to the microbes one such

42
00:01:41,210 --> 00:01:38,820
microbe is this um micro right here uh

43
00:01:43,069 --> 00:01:41,220
spherical cell known as sacrolobus so

44
00:01:44,870 --> 00:01:43,079
factoricus this is a scanning electron

45
00:01:46,370 --> 00:01:44,880
microscope showing you the topology of

46
00:01:49,670 --> 00:01:46,380
the cells

47
00:01:52,490 --> 00:01:49,680
um coined s441 by our lab really thrives

48
00:01:54,469 --> 00:01:52,500
and uh lives in these hot acidic

49
00:01:58,730 --> 00:01:54,479
conditions with temperatures from around

50
00:02:01,190 --> 00:01:58,740
70 to 75 to 80 degrees C and ph's of

51
00:02:04,310 --> 00:02:01,200
around 3 to as low as one so these

52
00:02:06,109 --> 00:02:04,320
really extreme environments and when we

53
00:02:09,290 --> 00:02:06,119
think about these environments and the

54
00:02:12,530 --> 00:02:09,300
reach ecosystems that uh and habitat

55
00:02:15,650 --> 00:02:12,540
them we can also think about one of the

56
00:02:17,570 --> 00:02:15,660
most abundant molecules on the planet so

57
00:02:19,790 --> 00:02:17,580
that of viruses and yes there are these

58
00:02:22,130 --> 00:02:19,800
extreme viruses infecting these

59
00:02:24,229 --> 00:02:22,140
extremophiles uh the one which I work

60
00:02:26,510 --> 00:02:24,239
with in lab is sopholobus spindle shape

61
00:02:29,809 --> 00:02:26,520
virus one sacrilebus is a natural host

62
00:02:32,089 --> 00:02:29,819
of this particular virus this ssv1 this

63
00:02:34,670 --> 00:02:32,099

is Stanley uses they them pronouns a

64
00:02:36,589 --> 00:02:34,680
really character by his lemon shape so

65
00:02:39,110 --> 00:02:36,599
these shapes are really unique to both

66
00:02:41,570 --> 00:02:39,120
archaeal organisms extremophiles and

67
00:02:43,430 --> 00:02:41,580
some of these extreme viruses

68
00:02:45,110 --> 00:02:43,440
and when we think about looking at these

69
00:02:47,270 --> 00:02:45,120
organisms and the interactions between

70
00:02:49,009 --> 00:02:47,280
them in these extreme environments we

71
00:02:52,070 --> 00:02:49,019
can look at some systems currently

72
00:02:55,550 --> 00:02:52,080
prevalent today in bacterial cells so

73
00:02:58,130 --> 00:02:55,560
these toxin antitoxin systems usually

74
00:03:00,650 --> 00:02:58,140
known as addiction modules found on

75
00:03:05,030 --> 00:03:00,660
plasmids again really prevalent in

76
00:03:07,550 --> 00:03:05,040
bacterial genomes only recently being uh

77
00:03:09,229 --> 00:03:07,560
being discovered to have some viral

78
00:03:12,470 --> 00:03:09,239
encoding

79
00:03:15,410 --> 00:03:12,480
and what this particular system confers

80
00:03:17,330 --> 00:03:15,420
is when you have a plasmid that has the

81
00:03:19,910 --> 00:03:17,340
positive uh or is positive for that

82
00:03:21,830 --> 00:03:19,920
particular addiction module that cell

83
00:03:23,690 --> 00:03:21,840
will needs that plasmid in order to

84
00:03:26,089 --> 00:03:23,700
continue its life in that particular

85
00:03:29,330 --> 00:03:26,099
environment so here we have the presence

86
00:03:31,309 --> 00:03:29,340
of the TA should that cell or progeny

87
00:03:33,110 --> 00:03:31,319
continue with the presence of that

88
00:03:35,210 --> 00:03:33,120

plasmid you would expect normal growth

89
00:03:37,009 --> 00:03:35,220
in the environment whereas if it were to

90
00:03:38,930 --> 00:03:37,019
lose that plasmid it would would have

91
00:03:41,149 --> 00:03:38,940
been addicted to that particular genome

92
00:03:43,070 --> 00:03:41,159
it would die off whereas in a negative

93
00:03:45,410 --> 00:03:43,080
system you would get growth either way

94
00:03:47,330 --> 00:03:45,420
whether or not there's plasmid loss and

95
00:03:49,130 --> 00:03:47,340
we can further visualize this particular

96
00:03:51,949 --> 00:03:49,140
mechanism by looking at what might

97
00:03:53,869 --> 00:03:51,959
happen to some uncolonized cells some

98
00:03:55,789 --> 00:03:53,879
sort of event happens in which the

99
00:03:57,050 --> 00:03:55,799
addiction module is introduced to that

100
00:03:59,030 --> 00:03:57,060
population

101
00:04:01,190 --> 00:03:59,040
and you have your addicted Survivor

102
00:04:02,809 --> 00:04:01,200
going on to make new progeny and then

103
00:04:05,270 --> 00:04:02,819
conferring that group protection and

104
00:04:08,149 --> 00:04:05,280
persistence so these systems are really

105
00:04:11,449 --> 00:04:08,159
understood in bacteria to confer a

106
00:04:14,270 --> 00:04:11,459
microbial persistence phenotype some

107
00:04:17,509 --> 00:04:14,280
have been referred to as fate defense

108
00:04:21,229 --> 00:04:17,519
mechanisms and largely considered uh as

109
00:04:23,330 --> 00:04:21,239
plasmid stabilizers on the plasm

110
00:04:25,010 --> 00:04:23,340
um and we can also uh assume that

111
00:04:26,270 --> 00:04:25,020
another group of uncolonized cells were

112
00:04:28,189 --> 00:04:26,280
to come in here perhaps that group

113
00:04:30,950 --> 00:04:28,199

encounter you would still get that toxic

114
00:04:33,230 --> 00:04:30,960
culling uh from that toxin antitoxin

115
00:04:35,030 --> 00:04:33,240
system uh one important note they are

116
00:04:37,490 --> 00:04:35,040
characterized as two genes that are

117
00:04:39,770 --> 00:04:37,500
typically right next to each other

118
00:04:42,290 --> 00:04:39,780
um the toxin being just Downstream of

119
00:04:44,990 --> 00:04:42,300
the antitoxin uh pretty stable toxin

120
00:04:47,570 --> 00:04:45,000
pretty unstable antitoxin

121
00:04:49,310 --> 00:04:47,580
and looking at this system with ssv1 a

122
00:04:54,469 --> 00:04:49,320
previous student did quite a bit of work

123
00:04:56,510 --> 00:04:54,479
in uh mutagenesis of the ssv1 genome and

124
00:04:59,150 --> 00:04:56,520
we use this at least these mutants to

125
00:05:00,650 --> 00:04:59,160
test whether or not some of these uh

126
00:05:03,170 --> 00:05:00,660
genes or open reading frames are

127
00:05:05,870 --> 00:05:03,180
essential to the virus and two genes in

128
00:05:08,090 --> 00:05:05,880
particular this T3 and TX transcript

129
00:05:11,090 --> 00:05:08,100
these particular two genes we can make

130
00:05:14,090 --> 00:05:11,100
changes to what I think is the antitoxin

131
00:05:15,710 --> 00:05:14,100
and we don't see too much

132
00:05:18,050 --> 00:05:15,720
um difference in terms of viral

133
00:05:20,390 --> 00:05:18,060
infection viral function whereas if we

134
00:05:21,830 --> 00:05:20,400
were to delete this uh or insert a

135
00:05:23,749 --> 00:05:21,840
sequence into this particular open

136
00:05:26,390 --> 00:05:23,759
reading frame what I think is the toxin

137
00:05:28,070 --> 00:05:26,400
we do see differences in infection

138
00:05:32,450 --> 00:05:28,080

mechanisms

139
00:05:34,430 --> 00:05:32,460
these extreme viruses and just virus

140
00:05:36,950 --> 00:05:34,440
reproduction overall viruses can

141
00:05:39,469 --> 00:05:36,960
typically go through two Pathways or a

142
00:05:42,409 --> 00:05:39,479
combination of both so a lyric cycle in

143
00:05:44,090 --> 00:05:42,419
which the viral genome or the viral DNA

144
00:05:46,310 --> 00:05:44,100
will insert itself into the cell

145
00:05:49,010 --> 00:05:46,320
you have some replication going on

146
00:05:51,170 --> 00:05:49,020
eventually assembly of those virions and

147
00:05:53,090 --> 00:05:51,180
the cell will then burst die and those

148
00:05:55,969 --> 00:05:53,100
viruses will go on to infect other cells

149
00:05:58,249 --> 00:05:55,979
whereas in a lysogenic cycle the viral

150
00:06:00,350 --> 00:05:58,259
genome is incorporated into the host

151
00:06:02,629 --> 00:06:00,360
genome and there's usually a latent

152
00:06:05,529 --> 00:06:02,639
phase in which it kind of just stays

153
00:06:09,230 --> 00:06:05,539
there maybe some induction event happens

154
00:06:11,810 --> 00:06:09,240
in ssv's case it actually just buds from

155
00:06:13,550 --> 00:06:11,820
the cell without killing the cell and

156
00:06:16,249 --> 00:06:13,560
one of the one of the two ways that we

157
00:06:18,650 --> 00:06:16,259
use to test for this viral reproduction

158
00:06:20,990 --> 00:06:18,660
is of course PCR so amplifying a

159
00:06:23,590 --> 00:06:21,000
sequence that's specific to viral DNA

160
00:06:27,230 --> 00:06:23,600
looking for its presence in cell-free

161
00:06:29,210 --> 00:06:27,240
supernatants another way is through Halo

162
00:06:30,710 --> 00:06:29,220
assay so very similar to a plaque assay

163
00:06:31,670 --> 00:06:30,720

in which you look where cells are

164
00:06:35,150 --> 00:06:31,680
bursting

165
00:06:37,249 --> 00:06:35,160
we cultivate a lot of cells uninfected

166
00:06:39,950 --> 00:06:37,259
sacraloba cells like you saw in the

167
00:06:41,990 --> 00:06:39,960
slide a while back and then we spot cell

168
00:06:43,490 --> 00:06:42,000
free supernatants which contain these

169
00:06:46,129 --> 00:06:43,500
mutant viruses

170
00:06:48,950 --> 00:06:46,139
onto the plate and look for clearings

171
00:06:51,950 --> 00:06:48,960
and this Halo assay is made possible

172
00:06:55,189 --> 00:06:51,960
because of the fact that ssv1 buds from

173
00:06:57,590 --> 00:06:55,199
its cell without killing the cell

174
00:06:59,689 --> 00:06:57,600
um and the onion the infected cells grow

175
00:07:02,029 --> 00:06:59,699
quite slower so it really converts this

176
00:07:03,950 --> 00:07:02,039
growth stunting phenotype in the

177
00:07:06,469 --> 00:07:03,960
sacrolobus cell

178
00:07:08,150 --> 00:07:06,479
and looking at the toxin protein and

179
00:07:09,590 --> 00:07:08,160
large a large majority of my work has

180
00:07:13,490 --> 00:07:09,600
been looking at mutants that we've made

181
00:07:15,409 --> 00:07:13,500
in this toxin protein and several uh

182
00:07:17,029 --> 00:07:15,419
machine learning softwares have

183
00:07:20,450 --> 00:07:17,039
indicated that there's a quite a high

184
00:07:22,969 --> 00:07:20,460
probability of a cleavage site over here

185
00:07:25,730 --> 00:07:22,979
behind this very hydrophobic

186
00:07:27,589 --> 00:07:25,740
uh Helix you right here and so I sought

187
00:07:30,830 --> 00:07:27,599
to characterize at least this particular

188
00:07:33,050 --> 00:07:30,840

mechanism in ssv1 through using some of

189
00:07:36,650 --> 00:07:33,060
these mutants that we already have

190
00:07:38,330 --> 00:07:36,660
um and while largely these over here are

191
00:07:40,550 --> 00:07:38,340
our wild type so really shouldn't expect

192
00:07:43,430 --> 00:07:40,560
any kind of change in viral function you

193
00:07:46,309 --> 00:07:43,440
can see some really nice Halos and we

194
00:07:48,290 --> 00:07:46,319
can confer that you know the cells are

195
00:07:49,969 --> 00:07:48,300
not dying but they're sick

196
00:07:53,749 --> 00:07:49,979
and in our mutants where we have

197
00:07:55,909 --> 00:07:53,759
insertions in in that specific toxin uh

198
00:07:57,469 --> 00:07:55,919
open reading frame we don't see any Halo

199
00:08:00,589 --> 00:07:57,479
formation

200
00:08:02,930 --> 00:08:00,599
um likewise I sought to substitute those

201
00:08:05,689 --> 00:08:02,940
two uh residues at the cleavage site

202
00:08:08,629 --> 00:08:05,699
since it's largely important for protein

203
00:08:10,490 --> 00:08:08,639
maturation protein function and we still

204
00:08:13,430 --> 00:08:10,500
don't see a Halo just switching those

205
00:08:15,170 --> 00:08:13,440
two residues but the main takeaway from

206
00:08:16,969 --> 00:08:15,180
this is that we still get virus

207
00:08:19,550 --> 00:08:16,979
replication

208
00:08:21,230 --> 00:08:19,560
um we still get quite a bit of at least

209
00:08:23,869 --> 00:08:21,240
high levels of viral replication from

210
00:08:25,610 --> 00:08:23,879
some of these mutants and one of these

211
00:08:28,249 --> 00:08:25,620
mutants particular we didn't see

212
00:08:29,869 --> 00:08:28,259
anything so maybe that one's detrimental

213
00:08:32,630 --> 00:08:29,879

to that particular open reading frame

214
00:08:34,550 --> 00:08:32,640
but we do see that there is virus

215
00:08:38,389 --> 00:08:34,560
replication happening in the cell

216
00:08:40,250 --> 00:08:38,399
supernatant when we screen for DNA

217
00:08:42,829 --> 00:08:40,260
um and it's important to kind of note

218
00:08:44,329 --> 00:08:42,839
that this this protein isn't just unique

219
00:08:46,190 --> 00:08:44,339
to ssv1

220
00:08:48,650 --> 00:08:46,200
um in in looking at these systems in

221
00:08:50,690 --> 00:08:48,660
these extreme organisms uh this one in

222
00:08:53,210 --> 00:08:50,700
particular up here is another SSV so

223
00:08:55,190 --> 00:08:53,220
another spindle shaped virus in which we

224
00:08:58,370 --> 00:08:55,200
see really low sequence similarity

225
00:09:01,490 --> 00:08:58,380
across these particular genes but quite

226
00:09:03,769 --> 00:09:01,500
a hot quite a high bit of um structural

227
00:09:05,410 --> 00:09:03,779
similarity between these genes and a lot

228
00:09:08,210 --> 00:09:05,420
of these are

229
00:09:11,150 --> 00:09:08,220
genomes of extremophiles while some are

230
00:09:13,430 --> 00:09:11,160
virally encoded

231
00:09:15,410 --> 00:09:13,440
and uh one of the main takeaways really

232
00:09:17,210 --> 00:09:15,420
just wrapping uh wrapping it all back

233
00:09:19,070 --> 00:09:17,220
around looking for these particular

234
00:09:20,750 --> 00:09:19,080
mechanisms and how they confer

235
00:09:23,570 --> 00:09:20,760
persistence with both their

236
00:09:26,210 --> 00:09:23,580
extremophilic organism and their viruses

237
00:09:28,970 --> 00:09:26,220
would be a really nice first start in

238
00:09:32,630 --> 00:09:28,980

looking for these biosignatures perhaps

239
00:09:34,790 --> 00:09:32,640
um and ways that we can look into how

240
00:09:36,829 --> 00:09:34,800
the microbes might be interacting

241
00:09:39,050 --> 00:09:36,839
in these particular extreme environments

242
00:09:41,389 --> 00:09:39,060
this is another sampling video

243
00:09:43,910 --> 00:09:41,399
um just of Lassen Volcanic Park pretty

244
00:09:45,290 --> 00:09:43,920
pretty close to where s441 was isolated

245
00:09:47,329 --> 00:09:45,300
from

246
00:09:49,130 --> 00:09:47,339
uh looks pretty similar to maybe

247
00:09:50,870 --> 00:09:49,140
something we'd see on another planet

248
00:09:54,410 --> 00:09:50,880
that we could sample at

249
00:09:56,389 --> 00:09:54,420
and then a Shameless plug but looking

250
00:09:58,009 --> 00:09:56,399
for viruses in space I think is the

251
00:10:00,050 --> 00:09:58,019
obvious next step we know that they're

252
00:10:03,350 --> 00:10:00,060
the most abundant molecule on the planet

253
00:10:04,970 --> 00:10:03,360
and just understanding that these

254
00:10:07,490 --> 00:10:04,980
mechanisms and that these systems are

255
00:10:10,190 --> 00:10:07,500
out there allowing these cells to thrive

256
00:10:13,370 --> 00:10:10,200
in this particular environment would be

257
00:10:16,009 --> 00:10:13,380
a great uh in starter conversation for

258
00:10:17,269 --> 00:10:16,019
looking for these small biomolecules in

259
00:10:19,490 --> 00:10:17,279
space

260
00:10:20,870 --> 00:10:19,500
and with that I just want to thank my

261
00:10:23,449 --> 00:10:20,880
lab

262
00:10:26,570 --> 00:10:23,459
um my group over here at Boiling Springs

263
00:10:31,770 --> 00:10:26,580

Lake when we collected samples and my Pi

264
00:10:31,780 --> 00:10:35,570
[Music]

265
00:10:43,250 --> 00:10:38,210
thank you General we have a time for

266
00:10:46,850 --> 00:10:45,350
hey my name is Pia and I'm really

267
00:10:48,650 --> 00:10:46,860
interested in like Christopher Cross

268
00:10:50,150 --> 00:10:48,660
Community of microbes

269
00:10:52,009 --> 00:10:50,160
um have you looked at all into the

270
00:10:53,210 --> 00:10:52,019
interactions of other phage defense

271
00:10:57,170 --> 00:10:53,220
systems

272
00:10:59,449 --> 00:10:57,180
um yeah so at least in terms of uh this

273
00:11:01,670 --> 00:10:59,459
toxin antitoxin system they're pretty

274
00:11:03,170 --> 00:11:01,680
understood in bacterial cells to like

275
00:11:06,650 --> 00:11:03,180
incorporate themselves into the genomic

276
00:11:09,110 --> 00:11:06,660
crispr cas9 there are some proteins that

277
00:11:10,970 --> 00:11:09,120
um that look pretty similar to this a291

278
00:11:14,990 --> 00:11:10,980
and some of these other virally encoded

279
00:11:18,530 --> 00:11:15,000
genes that do have some kind of crispr

280
00:11:20,449 --> 00:11:18,540
casts editing mechanism so yeah I think

281
00:11:21,829 --> 00:11:20,459
they it might be leaning towards that

282
00:11:24,050 --> 00:11:21,839
way but they're pretty well

283
00:11:26,750 --> 00:11:24,060
characterized in terms of like how they

284
00:11:28,910 --> 00:11:26,760
work with proteins and mRNA so um yeah

285
00:11:30,530 --> 00:11:28,920
not too far there yet but

286
00:11:44,090 --> 00:11:30,540
um definitely definitely somewhere in

287
00:11:49,790 --> 00:11:46,310
uh thank you for the talk um Marshall

288
00:11:51,470 --> 00:11:49,800

Seton JPL and I I was curious so um

289
00:11:53,569 --> 00:11:51,480
you're talking about looking for viruses

290
00:11:55,190 --> 00:11:53,579
and extraterrestrial environments um do

291
00:11:57,230 --> 00:11:55,200
you think there would be or I'm curious

292
00:11:59,990 --> 00:11:57,240
I'm completely ignoring yeah so no no I

293
00:12:02,210 --> 00:12:00,000
dropped out of biotube so for this

294
00:12:04,370 --> 00:12:02,220
um for viruses specifically like it

295
00:12:07,370 --> 00:12:04,380
would small molecule biosignature

296
00:12:09,650 --> 00:12:07,380
classes vary from viruses to like what

297
00:12:12,769 --> 00:12:09,660
you'd be looking for to cells yeah yeah

298
00:12:14,210 --> 00:12:12,779
I I for sure and that kind of brings me

299
00:12:15,769 --> 00:12:14,220
at least back to a point like of looking

300
00:12:18,170 --> 00:12:15,779
for fossils and stuff like that so

301
00:12:20,150 --> 00:12:18,180
viruses and sediment

302
00:12:22,490 --> 00:12:20,160
um and at least our lab there's been

303
00:12:24,470 --> 00:12:22,500
some work in like silica and coding

304
00:12:26,990 --> 00:12:24,480
viruses and how you know the stability

305
00:12:28,910 --> 00:12:27,000
of them so maybe there's a pretty silica

306
00:12:30,710 --> 00:12:28,920
Rich environment in which we might be

307
00:12:32,870 --> 00:12:30,720
able to look for any kind of these

308
00:12:35,509 --> 00:12:32,880
signatures so like proteins

309
00:12:37,190 --> 00:12:35,519
um or or yeah just specific things that

310
00:12:38,870 --> 00:12:37,200
might might have been preserved in those

311
00:12:41,150 --> 00:12:38,880
particular environments

312
00:12:43,790 --> 00:12:41,160
um considering that these viruses live

313
00:12:45,590 --> 00:12:43,800

and thrive in in pretty extremes

314
00:12:47,269 --> 00:12:45,600
um you know they're they're they got

315
00:12:50,210 --> 00:12:47,279
they got to be out there at least in my

316
00:12:52,310 --> 00:12:50,220
mind so you mentioned um looking at like

317
00:12:54,590 --> 00:12:52,320
morphology and fossils and things like

318
00:12:57,350 --> 00:12:54,600
that I know that at least for

319
00:13:00,110 --> 00:12:57,360
um looking at cells and things they've

320
00:13:02,629 --> 00:13:00,120
been shown to to mimic abiotic systems

321
00:13:06,170 --> 00:13:02,639
uh pretty well because humans are very

322
00:13:08,949 --> 00:13:06,180
good pattern recognition and so um has

323
00:13:13,190 --> 00:13:08,959
anything been seen like that for viruses

324
00:13:14,750 --> 00:13:13,200
yeah not the not that I'm familiar with

325
00:13:16,670 --> 00:13:14,760
um I know it's at least a brand new

326
00:13:18,829 --> 00:13:16,680
conversation of starting to look for

327
00:13:21,170 --> 00:13:18,839
like viruses in space Astro virology

328
00:13:23,269 --> 00:13:21,180
things like that so uh yeah we're just

329
00:13:24,590 --> 00:13:23,279
kind of getting up and running oh yeah

330
00:13:26,389 --> 00:13:24,600
yeah no sorry I don't mean to like play

331
00:13:32,590 --> 00:13:26,399
20 Questions oh no I just thought it was

332
00:13:37,610 --> 00:13:35,870
yeah there's a there's a little cure lab

333
00:13:40,009 --> 00:13:37,620
that like goes on right now that I teach

334
00:13:44,030 --> 00:13:40,019
so I'm obviously not there but they're

335
00:13:44,040 --> 00:13:57,520
any other questions