
AbSciCon
2019

1
00:00:00,790 --> 00:00:07,320
[Music]

2
00:00:12,400 --> 00:00:10,120
[Applause]

3
00:00:13,990 --> 00:00:12,410
hi everybody i'm ben from the university

4
00:00:15,670 --> 00:00:14,000
of southern california at the center for

5
00:00:18,190 --> 00:00:15,680
dark energy buys for your investigations

6
00:00:19,480 --> 00:00:18,200
so i have two pieces of bad news one I

7
00:00:20,980 --> 00:00:19,490
woke up with a really bad head cold

8
00:00:24,099 --> 00:00:20,990
today so I'm being fueled mostly by

9
00:00:26,320 --> 00:00:24,109
dayquil and caffeine and two I don't

10
00:00:27,519 --> 00:00:26,330
have any phase diagrams in my talk I

11
00:00:30,249 --> 00:00:27,529
didn't realize that was a requirement

12
00:00:33,880 --> 00:00:30,259
for apps icon is my first meeting so I I

13
00:00:36,250 --> 00:00:33,890

apologize for that in advance too just

14
00:00:37,480 --> 00:00:36,260
to start I'm gonna make the talk is

15
00:00:39,040 --> 00:00:37,490
mostly gonna be about phage host

16
00:00:40,660 --> 00:00:39,050
dynamics and I'm gonna make some soft

17
00:00:43,420 --> 00:00:40,670
pitches about why evolution is important

18
00:00:45,490 --> 00:00:43,430
for thinking about astrobiology as well

19
00:00:47,410 --> 00:00:45,500
as the system that we're working in as

20
00:00:49,270 --> 00:00:47,420
an analog for majority of ocean world so

21
00:00:51,310 --> 00:00:49,280
even though it's in the title it will be

22
00:00:53,440 --> 00:00:51,320
just a fairly small part of the talk at

23
00:00:54,910 --> 00:00:53,450
the end of the day and we start off by

24
00:00:56,590 --> 00:00:54,920
thanking the people who are part of this

25
00:00:58,270 --> 00:00:56,600
project most of this work is being done

26
00:01:00,340 --> 00:00:58,280
with my graduate student Lena Graham I

27
00:01:01,390 --> 00:01:00,350
have a lot of conversations with Olivia

28
00:01:03,010 --> 00:01:01,400
and I grow about phages

29
00:01:04,660 --> 00:01:03,020
and then there's this big group of

30
00:01:06,700 --> 00:01:04,670
people who have all worked on some

31
00:01:08,080 --> 00:01:06,710
aspect of North Pond at some point the

32
00:01:10,179 --> 00:01:08,090
site that we work at and I like to

33
00:01:12,220 --> 00:01:10,189
really thank Julie Huber who brought me

34
00:01:14,170 --> 00:01:12,230
on on this project a bunch of years ago

35
00:01:16,180 --> 00:01:14,180
now and and has kept me in the

36
00:01:18,730 --> 00:01:16,190
subsurface thinking about these types of

37
00:01:21,460 --> 00:01:18,740
processes even though life moves on and

38
00:01:23,110 --> 00:01:21,470

we go different places so I'm gonna

39
00:01:24,430 --> 00:01:23,120
introduce North Pond which is a site

40
00:01:27,160 --> 00:01:24,440
that's off axis at the mid-atlantic

41
00:01:28,330 --> 00:01:27,170
ridge an 8 million year old crust and

42
00:01:30,340 --> 00:01:28,340
this is we're gonna make my pitch about

43
00:01:32,230 --> 00:01:30,350
it being an analog for a majority of

44
00:01:34,870 --> 00:01:32,240
ocean worlds so the ridge flanks that we

45
00:01:37,090 --> 00:01:34,880
see off axis occupy about 70 percent of

46
00:01:39,850 --> 00:01:37,100
the area of the ocean basins and so

47
00:01:41,830 --> 00:01:39,860
while hydrothermal vents are very fun

48
00:01:43,270 --> 00:01:41,840
and active and have a lot of energy it

49
00:01:44,530 --> 00:01:43,280
means that a lot of the water rock

50
00:01:46,180 --> 00:01:44,540
interactions that we're thinking about

51
00:01:48,219 --> 00:01:46,190
on a global scale are actually happening

52
00:01:51,160 --> 00:01:48,229
in colder waters interacting with rocks

53
00:01:53,230 --> 00:01:51,170
in these Ridge flank areas North might

54
00:01:57,310 --> 00:01:53,240
might be might not be the best example

55
00:01:58,539 --> 00:01:57,320
for in solar system water worlds because

56
00:02:00,070 --> 00:01:58,549
it actually has a quite a bit of oxygen

57
00:02:03,730 --> 00:02:00,080
in it but if we start thinking about

58
00:02:05,260 --> 00:02:03,740
other systems and other solar systems it

59
00:02:08,949 --> 00:02:05,270
might be good to be thinking about these

60
00:02:11,530 --> 00:02:08,959
low energy cool water rock interactions

61
00:02:12,330 --> 00:02:11,540
that might lead to evidence for life

62
00:02:17,280 --> 00:02:12,340
when

63
00:02:20,009 --> 00:02:17,290

there and so we can observe go randomly

64
00:02:22,110 --> 00:02:20,019
we can observe microorganisms in the

65
00:02:23,850 --> 00:02:22,120
crust using these Cork observatories

66
00:02:26,130 --> 00:02:23,860
short for circulation obvi a shin

67
00:02:27,390 --> 00:02:26,140
retrofit kits and so we can hang some

68
00:02:29,400 --> 00:02:27,400
equipment off the bottom with this

69
00:02:31,740 --> 00:02:29,410
platform here and we can measure life

70
00:02:33,600 --> 00:02:31,750
and look for elements that might be

71
00:02:36,780 --> 00:02:33,610
interesting to us as microbiologists in

72
00:02:38,610 --> 00:02:36,790
the subsurface a North Pond we have two

73
00:02:40,440 --> 00:02:38,620
set of corks set up right here I'm only

74
00:02:41,910 --> 00:02:40,450
going to talk about this first one what

75
00:02:43,949 --> 00:02:41,920
we were able to do is we were able to

76
00:02:46,380 --> 00:02:43,959
leave these genome microbes sleds the

77
00:02:50,100 --> 00:02:46,390
top of the well here and sample fluids

78
00:02:51,690 --> 00:02:50,110
over a two-year time course represent

79
00:02:54,150 --> 00:02:51,700
right here where were able to collect

80
00:02:55,890 --> 00:02:54,160
DNA and RNA while we weren't there and

81
00:02:58,380 --> 00:02:55,900
then come back and see what that looked

82
00:03:00,780 --> 00:02:58,390
like and in in the while we weren't

83
00:03:02,819 --> 00:03:00,790
there and so the water comes and flows

84
00:03:04,589 --> 00:03:02,829
this way so we're getting fairly fresh

85
00:03:06,630 --> 00:03:04,599
recharged water so this is looks a lot

86
00:03:09,180 --> 00:03:06,640
like bottom water but not quite and then

87
00:03:12,720 --> 00:03:09,190
we'll travel north and discharge on the

88
00:03:14,400 --> 00:03:12,730

northeast flank here and so in the

89
00:03:16,319 --> 00:03:14,410
bottom water we can expect about 10 to

90
00:03:18,479 --> 00:03:16,329
the fourth cells per meal while in the

91
00:03:20,250 --> 00:03:18,489
subsurface we actually get too much

92
00:03:22,470 --> 00:03:20,260
lower level something about but some

93
00:03:24,390 --> 00:03:22,480
occasionally a mostly ten to the third

94
00:03:26,120 --> 00:03:24,400
cells per mil and this is where I want

95
00:03:27,780 --> 00:03:26,130
to make the pitch for evolution right so

96
00:03:30,030 --> 00:03:27,790
hypothetically we send something

97
00:03:31,530 --> 00:03:30,040
somewhere to an ocean world and maybe we

98
00:03:33,270 --> 00:03:31,540
make a really big mistake and we

99
00:03:35,460 --> 00:03:33,280
contaminate where we get there but it's

100
00:03:38,009 --> 00:03:35,470
low abundance and so we're measuring

101
00:03:39,300 --> 00:03:38,019
some sample and we see numbers go up and

102
00:03:40,860 --> 00:03:39,310
we go ha we got growth it's not

103
00:03:42,809 --> 00:03:40,870
contamination it's something that was

104
00:03:44,430 --> 00:03:42,819
there from the beginning but when you're

105
00:03:46,199 --> 00:03:44,440
talking about 10 to the third cells per

106
00:03:47,309 --> 00:03:46,209
mil what you're talking about is you

107
00:03:49,379 --> 00:03:47,319
know if you're a microbiologist you

108
00:03:51,330 --> 00:03:49,389
think 1% is like okay one percent of

109
00:03:54,569 --> 00:03:51,340
cells that's that's pretty good that's

110
00:03:56,670 --> 00:03:54,579
ten cells so if you go from 1% to 2%

111
00:03:58,770 --> 00:03:56,680
you're going from 10 to 20 cells you're

112
00:04:00,059 --> 00:03:58,780
really not sure if that's growth if

113
00:04:01,379 --> 00:04:00,069

that's something else that's happening

114
00:04:03,690 --> 00:04:01,389
something that you've contaminated with

115
00:04:04,770 --> 00:04:03,700
so if you add evolution into that you'd

116
00:04:06,569 --> 00:04:04,780
actually would be able to say to

117
00:04:07,800 --> 00:04:06,579
checkmarks we have growth we have

118
00:04:10,289 --> 00:04:07,810
evolution this might actually be

119
00:04:11,699 --> 00:04:10,299
something that's a sign of life and and

120
00:04:14,550 --> 00:04:11,709
something that we can confirm more

121
00:04:16,710 --> 00:04:14,560
accurately so we've answered a number of

122
00:04:18,569 --> 00:04:16,720
force first-order questions at North

123
00:04:20,190 --> 00:04:18,579
Pond such as which microorganisms are

124
00:04:21,630 --> 00:04:20,200
there what are they doing and can they

125
00:04:23,800 --> 00:04:21,640
shape the chemistry of the marine

126
00:04:26,170 --> 00:04:23,810
aquifer the answer being there are

127
00:04:27,820 --> 00:04:26,180
some endemic microbes so these are

128
00:04:29,470 --> 00:04:27,830
microbes that phylogenetically look like

129
00:04:31,750 --> 00:04:29,480
they're unique to North Pond

130
00:04:33,970 --> 00:04:31,760
there are also some microbes coming in

131
00:04:35,290 --> 00:04:33,980
from the surface ocean so that would be

132
00:04:36,760 --> 00:04:35,300
interesting that would be allow us to

133
00:04:38,409 --> 00:04:36,770
ground truth some of our evolution

134
00:04:39,640 --> 00:04:38,419
questions do we have microbes that

135
00:04:42,340 --> 00:04:39,650
aren't really designed to be in the

136
00:04:44,200 --> 00:04:42,350
subsurface occurring there what are they

137
00:04:47,170 --> 00:04:44,210
doing we have evidence that's just both

138
00:04:48,760 --> 00:04:47,180

heterotroph II and autotroph II and can

139
00:04:50,980 --> 00:04:48,770
they shape the aquifer the answer is yes

140
00:04:53,500 --> 00:04:50,990
through changes in the nitrogen and

141
00:04:55,300 --> 00:04:53,510
carbon cycle if you're interested in

142
00:04:57,159 --> 00:04:55,310
this work there are two papers here from

143
00:04:59,740 --> 00:04:57,169
Julie's lab that really cover this

144
00:05:01,540 --> 00:04:59,750
pretty well the other thing that's

145
00:05:03,430 --> 00:05:01,550
interesting about all this is that when

146
00:05:05,620 --> 00:05:03,440
these microbes entered the aquifer

147
00:05:06,670 --> 00:05:05,630
normally through this recharge site they

148
00:05:10,030 --> 00:05:06,680
actually are down there for a really

149
00:05:12,190 --> 00:05:10,040
long time and so this work shows that we

150
00:05:14,530 --> 00:05:12,200
can see organic carbon being removed

151
00:05:16,450 --> 00:05:14,540
slowly it the longer it's down there for

152
00:05:18,940 --> 00:05:16,460
but then it's actually also aging so by

153
00:05:21,850 --> 00:05:18,950
the time you reach our second site it's

154
00:05:23,409 --> 00:05:21,860
about 2,000 years of time so less here

155
00:05:26,170 --> 00:05:23,419
so maybe like 200 so we're looking in

156
00:05:27,670 --> 00:05:26,180
our two-year time series about 1% of

157
00:05:29,460 --> 00:05:27,680
maybe what could happen over I love

158
00:05:32,860 --> 00:05:29,470
evolutionary timescale for the

159
00:05:34,150 --> 00:05:32,870
consumption of this organic carbon which

160
00:05:36,190 --> 00:05:34,160
allows us to do something because we

161
00:05:39,370 --> 00:05:36,200
have time to look at evolution and

162
00:05:41,590 --> 00:05:39,380
adaptation and so we do this by sampling

163
00:05:44,980 --> 00:05:41,600

the bulk cutoff here a little bit

164
00:05:47,290 --> 00:05:44,990
sampling the bulk DNA like this we can

165
00:05:48,550 --> 00:05:47,300
use this to then regenerate microbial

166
00:05:50,770 --> 00:05:48,560
genomes which will tell us what they're

167
00:05:53,350 --> 00:05:50,780
doing and how many there are of them and

168
00:05:55,029 --> 00:05:53,360
then sometimes if we're lucky we can

169
00:05:56,980 --> 00:05:55,039
reconstruct phage and firewall genome

170
00:06:00,070 --> 00:05:56,990
viral genomes so phage are specifically

171
00:06:01,450 --> 00:06:00,080
viruses that infect microbes and so one

172
00:06:03,550 --> 00:06:01,460
of the things that happens here is we we

173
00:06:06,040 --> 00:06:03,560
don't know the difference or we can't

174
00:06:07,690 --> 00:06:06,050
tell who these organisms belong to right

175
00:06:09,070 --> 00:06:07,700
so the phage are just entities that we

176
00:06:10,810 --> 00:06:09,080
have the microbes were just energy so we

177
00:06:12,670 --> 00:06:10,820
have we don't actually know how this

178
00:06:14,860 --> 00:06:12,680
interacts because what normally happens

179
00:06:16,659 --> 00:06:14,870
or one of the classical models of

180
00:06:19,060 --> 00:06:16,669
viruses is that they act as predators

181
00:06:22,120 --> 00:06:19,070
and so here you have a microbe and a

182
00:06:24,850 --> 00:06:22,130
phage the phage infects kills the host

183
00:06:26,230 --> 00:06:24,860
and then spreads to other organisms when

184
00:06:27,340 --> 00:06:26,240
we look at population dynamics it looks

185
00:06:30,550 --> 00:06:27,350
something like this where we have the

186
00:06:32,350 --> 00:06:30,560
prey our microbe here being consumed and

187
00:06:34,839 --> 00:06:32,360
then the virus is peaking in abundance

188
00:06:36,639 --> 00:06:34,849

afterwards and then collapsing and this

189
00:06:38,859 --> 00:06:36,649
continues as the prey keeps coming up

190
00:06:41,100 --> 00:06:38,869
the viruses then can eat them down and

191
00:06:43,600 --> 00:06:41,110
then it goes on so on and so forth

192
00:06:46,089 --> 00:06:43,610
but if your virus and your full predator

193
00:06:48,129 --> 00:06:46,099
that's one option for staying alive the

194
00:06:50,169 --> 00:06:48,139
other option is you know I made a DNA

195
00:06:52,269 --> 00:06:50,179
you're made of DNA what if I just hitch

196
00:06:54,969 --> 00:06:52,279
a ride with you and so this in this case

197
00:06:56,439 --> 00:06:54,979
the virus infects the host incorporates

198
00:06:58,629 --> 00:06:56,449
itself into the genome and then spreads

199
00:07:01,749 --> 00:06:58,639
by every time the host divides it

200
00:07:03,100 --> 00:07:01,759
becomes part of the host genome and then

201
00:07:04,449 --> 00:07:03,110
there's a mixture of this called a

202
00:07:06,489 --> 00:07:04,459
chronic infection where you can have an

203
00:07:07,989 --> 00:07:06,499
infected host that's also producing

204
00:07:11,529 --> 00:07:07,999
viruses and also passing it along

205
00:07:12,939 --> 00:07:11,539
through its daughter cells and so I was

206
00:07:15,699 --> 00:07:12,949
saying we don't actually know most of

207
00:07:17,469 --> 00:07:15,709
time how viruses and/or phages and their

208
00:07:18,969 --> 00:07:17,479
hosts are interacting the microbes but

209
00:07:20,320 --> 00:07:18,979
sometimes we get to do that we can't

210
00:07:22,480 --> 00:07:20,330
actually see that using this mechanism

211
00:07:26,199 --> 00:07:22,490
called CRISPR which is actually an

212
00:07:28,269 --> 00:07:26,209
innate way for for the microbes to

213
00:07:30,609 --> 00:07:28,279

prevent infection going forward and the

214
00:07:33,399 --> 00:07:30,619
way this works is when a phage infects a

215
00:07:35,769 --> 00:07:33,409
cell the host will cut it up if it's

216
00:07:37,989 --> 00:07:35,779
lucky and doesn't die and will acquire

217
00:07:39,759 --> 00:07:37,999
what is known as a protostar that

218
00:07:42,279 --> 00:07:39,769
matches the virus exactly and

219
00:07:44,199 --> 00:07:42,289
incorporates it into its DNA and what

220
00:07:45,850 --> 00:07:44,209
happens then is then this spacer is

221
00:07:48,069 --> 00:07:45,860
expressed and any time it sees this

222
00:07:49,569 --> 00:07:48,079
virus again the host it can actually

223
00:07:52,299 --> 00:07:49,579
degrade the DNA before the virus has a

224
00:07:54,730 --> 00:07:52,309
chance to infect it fully so it's a it's

225
00:07:56,679 --> 00:07:54,740
a way of preventing infection going

226
00:07:59,350 --> 00:07:56,689
forward and so once we do this we can

227
00:08:01,749 --> 00:07:59,360
actually say this spacer matches this

228
00:08:04,209 --> 00:08:01,759
virus so this host must be infected by

229
00:08:06,579 --> 00:08:04,219
this virus and so we can do that in

230
00:08:07,839 --> 00:08:06,589
North Pond which is pretty exciting so

231
00:08:10,119 --> 00:08:07,849
we can get examples like this where we

232
00:08:12,459 --> 00:08:10,129
have a CRISPR array or these spacers in

233
00:08:16,089 --> 00:08:12,469
green this one here matches one phage

234
00:08:18,609 --> 00:08:16,099
right here this one has seven spacers

235
00:08:20,889 --> 00:08:18,619
that match one phage and this one is a

236
00:08:23,319 --> 00:08:20,899
fairly small CRISPR that then matches

237
00:08:26,109 --> 00:08:23,329
this phage here and so we know that

238
00:08:27,749 --> 00:08:26,119

CRISPR targets are non-random so this is

239
00:08:31,269 --> 00:08:27,759
a recent paper just came out this year

240
00:08:33,189 --> 00:08:31,279
that shows here in yellow and and some

241
00:08:35,529 --> 00:08:33,199
of the lighter blue colors that the

242
00:08:37,209 --> 00:08:35,539
CRISPR spacers actually target genes in

243
00:08:39,490 --> 00:08:37,219
the virus that potentially have some

244
00:08:39,750 --> 00:08:39,500
essential part of viral replication so

245
00:08:42,719 --> 00:08:39,760
this

246
00:08:44,910 --> 00:08:42,729
new element to understanding CRISPR

247
00:08:45,960 --> 00:08:44,920
phage and microbe dynamics because at

248
00:08:47,520 --> 00:08:45,970
some point we all thought it didn't

249
00:08:48,720 --> 00:08:47,530
matter if you can just degrade a virus

250
00:08:50,580 --> 00:08:48,730
you can just do create a virus why does

251
00:08:51,720 --> 00:08:50,590
it matter what gene you target but it

252
00:08:53,070 --> 00:08:51,730
turns out that some of these genes

253
00:08:54,600 --> 00:08:53,080
actually are more important than others

254
00:08:56,340 --> 00:08:54,610
and there's some type of selection

255
00:08:58,260 --> 00:08:56,350
potentially happening between hosts and

256
00:09:01,800 --> 00:08:58,270
phage which are selecting for spacers at

257
00:09:03,870 --> 00:09:01,810
target certain and proteins so

258
00:09:05,850 --> 00:09:03,880
ultimately can we observe phage

259
00:09:08,610 --> 00:09:05,860
evolution that would eventually lead to

260
00:09:10,980 --> 00:09:08,620
CRISPR avoidance in our data set so this

261
00:09:12,810 --> 00:09:10,990
means if your phage and you're trying to

262
00:09:15,030 --> 00:09:12,820
infect a cell and they have your spacer

263
00:09:17,190 --> 00:09:15,040

you're you're done you're not getting

264
00:09:19,530 --> 00:09:17,200
anywhere evolutionarily but if you have

265
00:09:21,300 --> 00:09:19,540
the ability to change in your space or

266
00:09:23,130 --> 00:09:21,310
if you can change your DNA just one base

267
00:09:25,410 --> 00:09:23,140
pair all of a sudden you now avoid that

268
00:09:27,060 --> 00:09:25,420
CRISPR target and you can go back and be

269
00:09:30,720 --> 00:09:27,070
awesome and infect cells as much as you

270
00:09:32,610 --> 00:09:30,730
want so we can track phage abundance and

271
00:09:35,010 --> 00:09:32,620
correlate it to hosts abundance here so

272
00:09:36,960 --> 00:09:35,020
and I have been blue in both of these we

273
00:09:40,500 --> 00:09:36,970
have the hosts and in orange we have the

274
00:09:42,600 --> 00:09:40,510
phage and this axis we have just

275
00:09:44,790 --> 00:09:42,610
abundance phage and host are on the same

276
00:09:47,040 --> 00:09:44,800
scale here over here phage are much more

277
00:09:48,810 --> 00:09:47,050
abundant relative to the hosts over time

278
00:09:50,220 --> 00:09:48,820
and then the time are 24 months of

279
00:09:51,780 --> 00:09:50,230
sampling that we have so in this

280
00:09:53,580 --> 00:09:51,790
instance a lot of times the phage

281
00:09:55,410 --> 00:09:53,590
correlate exactly directly with the

282
00:09:57,570 --> 00:09:55,420
hosts which is interesting because if

283
00:09:58,920 --> 00:09:57,580
you remember the first abundance graph I

284
00:10:00,780 --> 00:09:58,930
showed you there's might be some

285
00:10:02,370 --> 00:10:00,790
expected to be some offset between where

286
00:10:03,240 --> 00:10:02,380
we see the phage and where we see the

287
00:10:04,650 --> 00:10:03,250
host but that could just be the

288
00:10:06,120 --> 00:10:04,660

resolution that we're sampling at and

289
00:10:08,190 --> 00:10:06,130
then in some instances we actually have

290
00:10:11,790 --> 00:10:08,200
examples where the host is abundant and

291
00:10:13,110 --> 00:10:11,800
we don't see the phage so this is this

292
00:10:14,190 --> 00:10:13,120
is the meat and potatoes of this top

293
00:10:16,170 --> 00:10:14,200
right here and so I'm going to walk

294
00:10:18,210 --> 00:10:16,180
through this pretty slowly and then I'll

295
00:10:20,160 --> 00:10:18,220
show you two more examples of it so here

296
00:10:22,740 --> 00:10:20,170
we have the phage genome all along the

297
00:10:26,340 --> 00:10:22,750
x-axis with the genes that represent the

298
00:10:28,320 --> 00:10:26,350
phage here these light gray lines that

299
00:10:29,940 --> 00:10:28,330
you can see shifting just represent the

300
00:10:31,830 --> 00:10:29,950
coverage how much of the phage that we

301
00:10:34,260 --> 00:10:31,840
can measure in our samples in this case

302
00:10:36,600 --> 00:10:34,270
time points 1 3 & 4 so we're having this

303
00:10:38,520 --> 00:10:36,610
phage appear and then disappear and then

304
00:10:41,720 --> 00:10:38,530
appear and disappear in our samples and

305
00:10:43,920 --> 00:10:41,730
then these large black lines you can see

306
00:10:47,340 --> 00:10:43,930
represent changes in at the DNA level

307
00:10:49,560 --> 00:10:47,350
and so these phage is here and here and

308
00:10:51,630 --> 00:10:49,570
here look different at the pot as you

309
00:10:52,700 --> 00:10:51,640
look at the population in these time

310
00:10:54,980 --> 00:10:52,710
points than they did at the

311
00:10:56,540 --> 00:10:54,990
so if you have this nice little cluster

312
00:10:58,130 --> 00:10:56,550
here or this one right here this one

313
00:11:00,230 --> 00:10:58,140

wasn't present here it's not present

314
00:11:01,970 --> 00:11:00,240
here but it is present there and then I

315
00:11:03,860 --> 00:11:01,980
can overlay where the crisper spacer

316
00:11:06,410 --> 00:11:03,870
matches and look to see if there's a

317
00:11:07,790 --> 00:11:06,420
change in the DNA level of the virus so

318
00:11:09,769 --> 00:11:07,800
in this example there are two CRISPR

319
00:11:12,530 --> 00:11:09,779
spacers that hit one particular gene and

320
00:11:14,510 --> 00:11:12,540
in this case even though we have six

321
00:11:17,449 --> 00:11:14,520
months of data the virus doesn't change

322
00:11:19,400 --> 00:11:17,459
at all it's DNA so the fate of the host

323
00:11:21,199 --> 00:11:19,410
keeps killing the phage and at this

324
00:11:22,639 --> 00:11:21,209
point this phage would not be able to

325
00:11:23,810 --> 00:11:22,649
infect the one host that we're looking

326
00:11:25,250 --> 00:11:23,820
at that we see this match for it might

327
00:11:27,079 --> 00:11:25,260
be able to infect other hosts which

328
00:11:28,639 --> 00:11:27,089
might mean it can still hang around for

329
00:11:32,630 --> 00:11:28,649
a little while but for right now that's

330
00:11:35,720 --> 00:11:32,640
what we show it's the second example we

331
00:11:38,000 --> 00:11:35,730
have the CRISPR here and so we have one

332
00:11:40,100 --> 00:11:38,010
sample where this is probably the origin

333
00:11:42,199 --> 00:11:40,110
of it because there's no evidence of DNA

334
00:11:44,210 --> 00:11:42,209
changes here but we have one example

335
00:11:47,480 --> 00:11:44,220
here where the genus targeting is

336
00:11:50,210 --> 00:11:47,490
essential for viral replication and at

337
00:11:52,940 --> 00:11:50,220
the same time there's lots of changes

338
00:11:55,070 --> 00:11:52,950

happening on that particular gene but

339
00:11:57,440 --> 00:11:55,080
the CRISPR spacer still hits a region

340
00:11:59,000 --> 00:11:57,450
that doesn't change there's an element

341
00:12:01,730 --> 00:11:59,010
of this which I don't have enough data

342
00:12:04,640 --> 00:12:01,740
for that might suggest that the phage is

343
00:12:06,980 --> 00:12:04,650
able to freely allow some mutations to

344
00:12:09,290 --> 00:12:06,990
occur on this part of the gene of its

345
00:12:11,269 --> 00:12:09,300
gene in an attempt of quote-unquote

346
00:12:14,720 --> 00:12:11,279
attempt there's no actual it's just

347
00:12:17,150 --> 00:12:14,730
evolution here's know not directed it

348
00:12:19,550 --> 00:12:17,160
might actually allow the the phage to

349
00:12:21,260 --> 00:12:19,560
try and avoid detectives but it can so

350
00:12:23,329 --> 00:12:21,270
maybe in the same way that we're

351
00:12:25,490 --> 00:12:23,339
selecting certain spacers that hit

352
00:12:26,930 --> 00:12:25,500
certain genes for the viruses the hosts

353
00:12:29,780 --> 00:12:26,940
are also selecting certain regions that

354
00:12:32,420 --> 00:12:29,790
can't change in the virus and the last

355
00:12:34,699 --> 00:12:32,430
one the real big daddy of them all

356
00:12:37,490 --> 00:12:34,709
so we have multiple time points on this

357
00:12:38,690 --> 00:12:37,500
again spacers hitting certain genes

358
00:12:40,069 --> 00:12:38,700
again with annotations that are

359
00:12:42,079 --> 00:12:40,079
important to the virus for replication

360
00:12:44,120 --> 00:12:42,089
you have to think my word on it but for

361
00:12:45,829 --> 00:12:44,130
every one of these pink lines again it

362
00:12:48,560 --> 00:12:45,839
hits a region where there aren't any D

363
00:12:51,199 --> 00:12:48,570

changes in the DNA except for this last

364
00:12:53,750 --> 00:12:51,209
one right here in this last one we

365
00:12:56,630 --> 00:12:53,760
actually see changes so if in this

366
00:12:59,180 --> 00:12:56,640
example this organism only had one

367
00:13:01,250 --> 00:12:59,190
CRISPR spacer and it was only hitting

368
00:13:03,490 --> 00:13:01,260
this one spot after the first time the

369
00:13:04,750 --> 00:13:03,500
phage and host interacted

370
00:13:06,700 --> 00:13:04,760
you would actually have this ability for

371
00:13:08,290 --> 00:13:06,710
the phage to keep infecting the hosts

372
00:13:11,140 --> 00:13:08,300
unfortunately for it that actually

373
00:13:12,940 --> 00:13:11,150
there's six other spacers hitting it so

374
00:13:15,550 --> 00:13:12,950
it's gonna keep getting degraded and and

375
00:13:17,260 --> 00:13:15,560
not be able to infect anymore so with

376
00:13:19,660 --> 00:13:17,270
that I'll wrap up so we're able to

377
00:13:21,730 --> 00:13:19,670
change watch look at the changes at the

378
00:13:24,520 --> 00:13:21,740
phage population at the DNA level over

379
00:13:26,260 --> 00:13:24,530
time that these CRISPR spacers target

380
00:13:28,150 --> 00:13:26,270
regions on the phage that seem to not be

381
00:13:30,190 --> 00:13:28,160
able to undergo change if that's

382
00:13:31,420 --> 00:13:30,200
intentional or not intentional we don't

383
00:13:33,760 --> 00:13:31,430
know yet we don't have enough data and

384
00:13:36,520 --> 00:13:33,770
then except for in all instances except

385
00:13:39,700 --> 00:13:36,530
for one the CRISPR is keep working and

386
00:13:41,050 --> 00:13:39,710
and the phage and the phage dies so the

387
00:13:42,220 --> 00:13:41,060
next step is actually to go back to the

388
00:13:45,280 --> 00:13:42,230

host and just look at the host without

389
00:13:46,870 --> 00:13:45,290
any elements of phage and part of it so

390
00:13:48,460 --> 00:13:46,880
here's an example where we have an

391
00:13:50,850 --> 00:13:48,470
organism that's abundant and then not

392
00:13:53,230 --> 00:13:50,860
abundant over time in the green lines

393
00:13:55,300 --> 00:13:53,240
our reference point actually ends up

394
00:13:57,460 --> 00:13:55,310
being our last time point but as we go

395
00:13:59,740 --> 00:13:57,470
back in time the population of organisms

396
00:14:02,110 --> 00:13:59,750
that make up this or host actually

397
00:14:04,180 --> 00:14:02,120
changes its proteome changes it has

398
00:14:05,890 --> 00:14:04,190
changes at the amino acid level in its

399
00:14:08,700 --> 00:14:05,900
proteins that might suggest that it's

400
00:14:11,410 --> 00:14:08,710
undergoing some type of evolution either

401
00:14:13,540 --> 00:14:11,420
randomly or through some positive

402
00:14:15,130 --> 00:14:13,550
selection on there and if that's the

403
00:14:17,350 --> 00:14:15,140
case that we'd have this change over

404
00:14:18,579 --> 00:14:17,360
time which we could call evolution and

405
00:14:20,950 --> 00:14:18,589
that would give us two check marks in

406
00:14:22,600 --> 00:14:20,960
terms of both growth and evolution in

407
00:14:25,420 --> 00:14:22,610
our samples that were collecting

408
00:14:28,030 --> 00:14:25,430
somewhere else far far from Earth and

409
00:14:30,030 --> 00:14:28,040
that's it I'll take some questions

410
00:14:37,560 --> 00:14:30,040
[Applause]

411
00:14:40,410 --> 00:14:37,570
it's time for one question remember we

412
00:15:04,680 --> 00:14:40,420
come up to the microphone can you or

413
00:15:06,540 --> 00:15:04,690

just yeah sure yeah so the questions

414
00:15:09,270 --> 00:15:06,550
about the methodologies you use to

415
00:15:11,220 --> 00:15:09,280
sterilize a system going out into space

416
00:15:13,200 --> 00:15:11,230
that's a great question and I don't have