
AB
GRAD
CON23

1
00:00:04,230 --> 00:00:13,330
[Music]

2
00:00:19,609 --> 00:00:16,550
and without further Ado I want to

3
00:00:22,970 --> 00:00:19,619
introduce tonight's keynote speaker Dr

4
00:00:24,650 --> 00:00:22,980
Karen G Lloyd who is a subsurface

5
00:00:25,730 --> 00:00:24,660
microbiologist at the University of

6
00:00:29,630 --> 00:00:25,740
Tennessee

7
00:00:31,370 --> 00:00:29,640
although in 2024 she will be the the

8
00:00:33,470 --> 00:00:31,380
Wrigley professor of Earth Sciences at

9
00:00:36,350 --> 00:00:33,480
the University of Southern California

10
00:00:39,830 --> 00:00:36,360
Dr Lloyd discovers new types of life in

11
00:00:42,889 --> 00:00:39,840
Arctic permafrost volcanic volcanic hot

12
00:00:45,610 --> 00:00:42,899
spring systems and deep sea environments

13
00:00:48,069 --> 00:00:45,620

she combines geochemistry with

14
00:00:51,110 --> 00:00:48,079
metabolomics meta transcriptomics

15
00:00:52,970 --> 00:00:51,120
metagenomics and other environmental

16
00:00:55,790 --> 00:00:52,980
measurements to infer what life is like

17
00:01:03,430 --> 00:00:55,800
in natural complex systems let's welcome

18
00:01:09,410 --> 00:01:07,130
thanks thanks for having me y'all and I

19
00:01:12,289 --> 00:01:09,420
went to AB gradcon here

20
00:01:15,170 --> 00:01:12,299
um would that have been like 2005 I

21
00:01:16,370 --> 00:01:15,180
think it's a as a attendee so it's kind

22
00:01:17,690 --> 00:01:16,380
of nice to be back

23
00:01:19,850 --> 00:01:17,700
um speaking

24
00:01:22,609 --> 00:01:19,860
um so I'm going to talk about

25
00:01:24,410 --> 00:01:22,619
um life inside Earth's crust but one of

26
00:01:26,330 --> 00:01:24,420
the reasons why we study life in Earth's

27
00:01:27,649 --> 00:01:26,340
crust is that we obviously the reason

28
00:01:30,770 --> 00:01:27,659
we're all here is that we want to find

29
00:01:32,390 --> 00:01:30,780
life outside of earth that is something

30
00:01:33,469 --> 00:01:32,400
that it's really kind of nice to give a

31
00:01:36,469 --> 00:01:33,479
talk here because I don't have to

32
00:01:40,069 --> 00:01:36,479
justify that like we all agree

33
00:01:42,530 --> 00:01:40,079
that is a thing worth doing so

34
00:01:44,210 --> 00:01:42,540
um when I think where is likes of where

35
00:01:45,469 --> 00:01:44,220
okay yeah these are some good places

36
00:01:47,090 --> 00:01:45,479
right like I've named some nice

37
00:01:49,609 --> 00:01:47,100
planetary bodies that seem like a place

38
00:01:51,550 --> 00:01:49,619

you can find some stuff but where in

39
00:01:54,109 --> 00:01:51,560
them do we expect to find some stuff

40
00:01:55,850 --> 00:01:54,119
well the place we know the most about on

41
00:01:57,289 --> 00:01:55,860
these planetary bodies is the surface

42
00:01:59,149 --> 00:01:57,299
and

43
00:02:01,429 --> 00:01:59,159
I'm not saying there's not life there

44
00:02:03,350 --> 00:02:01,439
definitely not I mean that would be

45
00:02:05,209 --> 00:02:03,360
ridiculous but there's not like the

46
00:02:07,429 --> 00:02:05,219
Amazon rainforest sitting up there we

47
00:02:09,889 --> 00:02:07,439
would have seen it if it was up there

48
00:02:10,969 --> 00:02:09,899
um so it doesn't seem to be like teeming

49
00:02:13,369 --> 00:02:10,979
on the surface

50
00:02:15,530 --> 00:02:13,379
but the subsurface if you think about

51
00:02:18,110 --> 00:02:15,540
the subsurfaces of all of these places

52
00:02:20,570 --> 00:02:18,120
it's a pretty Clement place to be

53
00:02:22,550 --> 00:02:20,580
there's often liquid water at least in

54
00:02:24,170 --> 00:02:22,560
the case of Europa and Enceladus there's

55
00:02:25,970 --> 00:02:24,180
whole oceans worth of water so that's

56
00:02:27,350 --> 00:02:25,980
cool that's a major thing ticked off our

57
00:02:29,690 --> 00:02:27,360
list

58
00:02:31,610 --> 00:02:29,700
protection from UV damage there's tons

59
00:02:33,229 --> 00:02:31,620
of stuff to build cells with it's kind

60
00:02:35,869 --> 00:02:33,239
of a nice place to be

61
00:02:37,850 --> 00:02:35,879
um and the evidence for this is that I

62
00:02:39,229 --> 00:02:37,860
don't know if you keep up with methane

63
00:02:40,670 --> 00:02:39,239

on Mars but this has been something

64
00:02:42,290 --> 00:02:40,680
that's been kind of controversial over

65
00:02:45,350 --> 00:02:42,300
the years and now is no longer

66
00:02:47,030 --> 00:02:45,360
controversial it is definitely there we

67
00:02:48,830 --> 00:02:47,040
have methane in the Martian atmosphere

68
00:02:50,630 --> 00:02:48,840
and the thing that I love the most about

69
00:02:52,970 --> 00:02:50,640
this methane is that it's not always

70
00:02:54,430 --> 00:02:52,980
there we get whiffs of it and so this

71
00:02:58,130 --> 00:02:54,440
this is something that seems very

72
00:03:00,170 --> 00:02:58,140
lifelike to me if you know Titan Titan

73
00:03:02,390 --> 00:03:00,180
is so full of methane you're like is

74
00:03:03,949 --> 00:03:02,400
that really biological but for for Mars

75
00:03:06,610 --> 00:03:03,959
it seems kind of biological so I wonder

76
00:03:09,110 --> 00:03:06,620
if right now there's a subsurface life

77
00:03:11,750 --> 00:03:09,120
ecosystem happening on Mars right now it

78
00:03:15,170 --> 00:03:11,760
could be and Europa Europa is really

79
00:03:16,850 --> 00:03:15,180
easy right like this is this lovely

80
00:03:18,949 --> 00:03:16,860
artist rendering if I had the artists

81
00:03:20,330 --> 00:03:18,959
that NASA does I would get so much

82
00:03:22,610 --> 00:03:20,340
funding

83
00:03:24,589 --> 00:03:22,620
um but they've got this ice cap and then

84
00:03:26,509 --> 00:03:24,599
these occasional Jets Enceladus

85
00:03:29,449 --> 00:03:26,519
definitely has jets and absolutely for

86
00:03:32,210 --> 00:03:29,459
100 sure there's a giant ocean of liquid

87
00:03:35,630 --> 00:03:32,220
probably saline water on Europa which is

88
00:03:37,729 --> 00:03:35,640

just very intriguing okay so a high

89
00:03:39,770 --> 00:03:37,739
probability shot for astrobiology is to

90
00:03:41,809 --> 00:03:39,780
look for life in the subsurface of

91
00:03:44,630 --> 00:03:41,819
planetary bodies so

92
00:03:47,390 --> 00:03:44,640
we've got this planet to look for so can

93
00:03:49,490 --> 00:03:47,400
we use Earth life the life we find here

94
00:03:50,930 --> 00:03:49,500
is a guide for what might be there on

95
00:03:52,850 --> 00:03:50,940
the subsurface of these other planetary

96
00:03:55,430 --> 00:03:52,860
bodies and I don't know if you guys ever

97
00:03:57,830 --> 00:03:55,440
do this view of Earth do you ever try to

98
00:04:01,309 --> 00:03:57,840
get the to get the land out you know

99
00:04:03,470 --> 00:04:01,319
it's like Hawaii and New Zealand you

100
00:04:05,630 --> 00:04:03,480
know California is fighting them to to

101
00:04:07,309 --> 00:04:05,640
gain place but I love looking at Earth

102
00:04:09,289 --> 00:04:07,319
like this because it really reminds you

103
00:04:11,390 --> 00:04:09,299
that we are an ocean planet we know that

104
00:04:13,850 --> 00:04:11,400
but you can you can look at it from the

105
00:04:15,770 --> 00:04:13,860
back side and some of my colleagues have

106
00:04:17,330 --> 00:04:15,780
added up the total number of microbial

107
00:04:19,129 --> 00:04:17,340
cells that are living underneath the

108
00:04:20,930 --> 00:04:19,139
ocean in the subsurface in the Marine

109
00:04:23,570 --> 00:04:20,940
sediments and it's literally

110
00:04:25,790 --> 00:04:23,580
astronomical it's 10 to the 29

111
00:04:27,409 --> 00:04:25,800
which is a third of the microbes on the

112
00:04:29,450 --> 00:04:27,419
planet are buried in the subsurface

113
00:04:31,730 --> 00:04:29,460

underneath our oceans

114
00:04:33,530 --> 00:04:31,740
which is ten thousand times more than

115
00:04:35,390 --> 00:04:33,540
the number of stars in the universe

116
00:04:37,730 --> 00:04:35,400
um although that number has a big error

117
00:04:40,070 --> 00:04:37,740
bar on it too

118
00:04:42,350 --> 00:04:40,080
um so actually most of the life on Earth

119
00:04:45,650 --> 00:04:42,360
is actually Insider so we are a

120
00:04:47,689 --> 00:04:45,660
subsurface Planet too and if you look at

121
00:04:49,249 --> 00:04:47,699
the terrestrial environment this has

122
00:04:50,930 --> 00:04:49,259
pretty much the same amount of microbes

123
00:04:52,610 --> 00:04:50,940
in it so it's not just the oceans this

124
00:04:54,730 --> 00:04:52,620
stuff is kind of everywhere

125
00:04:57,550 --> 00:04:54,740
um okay so but if you think about

126
00:05:00,469 --> 00:04:57,560
microbes and life inside Earth's crust

127
00:05:01,850 --> 00:05:00,479
our dominant signal is things like the

128
00:05:03,350 --> 00:05:01,860
Amazon rainforest I mean there's no

129
00:05:05,689 --> 00:05:03,360
question that this planet has tons of

130
00:05:06,830 --> 00:05:05,699
surface life so you have to ask the

131
00:05:09,770 --> 00:05:06,840
question

132
00:05:11,150 --> 00:05:09,780
is it real you know like what are all

133
00:05:13,310 --> 00:05:11,160
those little creepy crawlies are they

134
00:05:14,930 --> 00:05:13,320
meant to be there or are they just like

135
00:05:17,270 --> 00:05:14,940
the leftovers

136
00:05:20,030 --> 00:05:17,280
um you know it can be dangerous to

137
00:05:21,770 --> 00:05:20,040
assume that an organism is optimized to

138
00:05:24,170 --> 00:05:21,780

live just where you found it

139
00:05:26,749 --> 00:05:24,180
um I have this really self-deprecating

140
00:05:30,050 --> 00:05:26,759
anecdote hopefully

141
00:05:32,749 --> 00:05:30,060
um you guys will get so I I did a um the

142
00:05:34,430 --> 00:05:32,759
geobiology the agaron geobiology summer

143
00:05:37,070 --> 00:05:34,440
course which is now at Penn State do you

144
00:05:38,090 --> 00:05:37,080
guys know about this it's fantastic you

145
00:05:40,310 --> 00:05:38,100
should look into it if you don't know

146
00:05:41,510 --> 00:05:40,320
about it it's a um I think it's six week

147
00:05:43,490 --> 00:05:41,520
summer course and this year it's going

148
00:05:46,430 --> 00:05:43,500
to be in Italy is anybody going

149
00:05:47,749 --> 00:05:46,440
no okay it's gonna be great Jen mcelady

150
00:05:49,310 --> 00:05:47,759
is running it it's Penn State's first

151
00:05:50,629 --> 00:05:49,320
year so maybe it's a rocky first year go

152
00:05:52,310 --> 00:05:50,639
next year

153
00:05:53,810 --> 00:05:52,320
um

154
00:05:55,129 --> 00:05:53,820
I did that in the second year that it

155
00:05:57,710 --> 00:05:55,139
was ever around and we went to

156
00:05:59,689 --> 00:05:57,720
Yellowstone for our field trip and I was

157
00:06:01,550 --> 00:05:59,699
just like so full of wonder and like my

158
00:06:03,110 --> 00:06:01,560
eyes were saucers and I was taking in

159
00:06:05,090 --> 00:06:03,120
everything that I could and I was

160
00:06:08,150 --> 00:06:05,100
watching in this hot spring I was

161
00:06:10,070 --> 00:06:08,160
watching a spider in a hot spring and I

162
00:06:12,650 --> 00:06:10,080
was like oh my God this place is Magic

163
00:06:14,150 --> 00:06:12,660

even the spiders are adapted to high

164
00:06:16,909 --> 00:06:14,160
temperature and I was just watching this

165
00:06:19,430 --> 00:06:16,919
spider just like you know cool just like

166
00:06:20,990 --> 00:06:19,440
chilling in this hot spring just

167
00:06:22,909 --> 00:06:21,000
thinking oh my God I need to work on

168
00:06:23,770 --> 00:06:22,919
arachnids like I gotta switch my whole

169
00:06:26,150 --> 00:06:23,780
thing

170
00:06:29,809 --> 00:06:26,160
and do you know where this story's going

171
00:06:31,309 --> 00:06:29,819
right it died I wanted to think that it

172
00:06:34,129 --> 00:06:31,319
just like curled up and then I was like

173
00:06:36,650 --> 00:06:34,139
oh my God Karen you're such an idiot you

174
00:06:38,210 --> 00:06:36,660
know that that we have to be conscious

175
00:06:40,070 --> 00:06:38,220
of that like are we just looking at

176
00:06:42,050 --> 00:06:40,080
something that's kind of not really

177
00:06:43,610 --> 00:06:42,060
supposed to be there well I I would like

178
00:06:45,890 --> 00:06:43,620
to convince you in this talk that that

179
00:06:48,050 --> 00:06:45,900
is not true for the subsurface it's got

180
00:06:49,670 --> 00:06:48,060
a lot more going for it than a spider in

181
00:06:52,129 --> 00:06:49,680
a hot spring

182
00:06:53,990 --> 00:06:52,139
um so here's my my list of evidence that

183
00:06:56,450 --> 00:06:54,000
the Deep biosphere on Earth is real

184
00:06:58,430 --> 00:06:56,460
alive and not just leftovers from the

185
00:07:00,590 --> 00:06:58,440
subs are from the surface

186
00:07:02,870 --> 00:07:00,600
first of all there's a lot of energy

187
00:07:04,550 --> 00:07:02,880
sources in the subsurface it's not just

188
00:07:08,510 --> 00:07:04,560

like Marine sediments that are sort of

189
00:07:10,730 --> 00:07:08,520
piling up so um I see this figure a lot

190
00:07:12,710 --> 00:07:10,740
um but it's nice because it encapsulates

191
00:07:15,770 --> 00:07:12,720
a lot of different environments so we've

192
00:07:17,629 --> 00:07:15,780
got polar regions underneath glaciers we

193
00:07:19,610 --> 00:07:17,639
have deep anoxic brines we have

194
00:07:21,890 --> 00:07:19,620
hydrothermal vents we of course have

195
00:07:24,050 --> 00:07:21,900
Marine sediments which cover so much of

196
00:07:26,350 --> 00:07:24,060
the planet we have subduction zones we

197
00:07:29,270 --> 00:07:26,360
have serpentinizing environments we have

198
00:07:32,990 --> 00:07:29,280
volcanic adjacent areas and then we have

199
00:07:34,670 --> 00:07:33,000
human made areas as well for for

200
00:07:38,170 --> 00:07:34,680
human-made environments but all of these

201
00:07:40,370 --> 00:07:38,180
things are are places where you can find

202
00:07:42,170 --> 00:07:40,380
nutrients to drive a subsurface

203
00:07:43,730 --> 00:07:42,180
biosphere so that's that's one thing

204
00:07:46,249 --> 00:07:43,740
it's got going for it

205
00:07:48,110 --> 00:07:46,259
the other thing is that when we look at

206
00:07:49,550 --> 00:07:48,120
what's down there we actually see

207
00:07:52,010 --> 00:07:49,560
evidence that these things are breathing

208
00:07:54,529 --> 00:07:52,020
that they're alive because we can see

209
00:07:56,510 --> 00:07:54,539
the chemical signature that they leave

210
00:07:58,309 --> 00:07:56,520
um and if you are a marine sediment

211
00:08:00,409 --> 00:07:58,319
person like I am you live and breathe

212
00:08:03,170 --> 00:08:00,419
these kind of diagrams but if you're not

213
00:08:05,570 --> 00:08:03,180

if you look at small what is it faint

214
00:08:07,490 --> 00:08:05,580
things next to bright things

215
00:08:09,050 --> 00:08:07,500
atmosphere then maybe you're not used to

216
00:08:12,409 --> 00:08:09,060
looking at stuff like this but this is

217
00:08:14,270 --> 00:08:12,419
this is my life um this is up here

218
00:08:15,650 --> 00:08:14,280
that's the ocean up there this is the

219
00:08:17,450 --> 00:08:15,660
surface of the mud and we're just like

220
00:08:19,129 --> 00:08:17,460
looking down into the muck and look at

221
00:08:21,710 --> 00:08:19,139
the depth scale on this this is meters

222
00:08:24,170 --> 00:08:21,720
this is like drilling a football field

223
00:08:25,550 --> 00:08:24,180
worth down so this is a massive drilling

224
00:08:27,290 --> 00:08:25,560
operation

225
00:08:29,150 --> 00:08:27,300
um and then if you measure you section

226
00:08:30,890 --> 00:08:29,160
this thing into sections and you measure

227
00:08:33,649 --> 00:08:30,900
the concentrations of in this case

228
00:08:34,969 --> 00:08:33,659
sulfate as you go down and then methane

229
00:08:37,130 --> 00:08:34,979
as well

230
00:08:39,050 --> 00:08:37,140
the fact that this is curved like this

231
00:08:41,389 --> 00:08:39,060
and we can measure the sedimentation

232
00:08:42,889 --> 00:08:41,399
rate we can use those two factors and

233
00:08:44,449 --> 00:08:42,899
then just what we know about diffusion

234
00:08:46,610 --> 00:08:44,459
and compaction and basic things like

235
00:08:48,170 --> 00:08:46,620
that to calculate the rate at which

236
00:08:49,910 --> 00:08:48,180
these organisms are breathing the

237
00:08:51,889 --> 00:08:49,920
sulfate and the fact that it's shaped

238
00:08:53,449 --> 00:08:51,899

that it's got this concave shape means

239
00:08:55,310 --> 00:08:53,459
that somebody was breathing it you can't

240
00:08:57,050 --> 00:08:55,320
really get that shape unless you have

241
00:08:59,930 --> 00:08:57,060
upward infection of sulfate-free fluids

242
00:09:01,970 --> 00:08:59,940
which we don't have in this situation so

243
00:09:05,150 --> 00:09:01,980
um this is evidence that these things

244
00:09:07,970 --> 00:09:05,160
are breathing and they're alive

245
00:09:09,949 --> 00:09:07,980
um and it's not like the stuff we find

246
00:09:11,210 --> 00:09:09,959
down there is just surface stuff that's

247
00:09:13,730 --> 00:09:11,220
hanging on

248
00:09:15,769 --> 00:09:13,740
um it's its own thing so if you do this

249
00:09:17,210 --> 00:09:15,779
is a easiest way to show this is one of

250
00:09:20,030 --> 00:09:17,220
my colleagues papers

251
00:09:22,090 --> 00:09:20,040
um this is a non-met non-multi what's

252
00:09:24,769 --> 00:09:22,100
nmds what does that stand for

253
00:09:26,030 --> 00:09:24,779
non-multi-dimensional scaling parametric

254
00:09:30,769 --> 00:09:26,040
test

255
00:09:32,210 --> 00:09:30,779
um this is a uh axis-less axes but all

256
00:09:34,130 --> 00:09:32,220
you have to know to understand these

257
00:09:35,750 --> 00:09:34,140
data are the dots that are close

258
00:09:37,190 --> 00:09:35,760
together have more similar microbial

259
00:09:38,930 --> 00:09:37,200
communities and dots that are farther

260
00:09:41,750 --> 00:09:38,940
apart have more different microbial

261
00:09:43,430 --> 00:09:41,760
communities so all the seawater grouped

262
00:09:45,710 --> 00:09:43,440
together and all the Marine sediment

263
00:09:47,570 --> 00:09:45,720

group together and anybody who works in

264
00:09:49,910 --> 00:09:47,580
seawater and sediment just knows this

265
00:09:51,410 --> 00:09:49,920
intuitively we have almost no overlap in

266
00:09:54,769 --> 00:09:51,420
the types of microbes we find in these

267
00:09:56,810 --> 00:09:54,779
places so it's its own thing and then

268
00:09:59,150 --> 00:09:56,820
the last thing is much harder to show

269
00:10:01,790 --> 00:09:59,160
and I've spent a lot of my career and my

270
00:10:03,410 --> 00:10:01,800
students in my lab have worked on this

271
00:10:05,449 --> 00:10:03,420
um how do you show they're actually

272
00:10:07,310 --> 00:10:05,459
adapted to live in this place that's

273
00:10:08,509 --> 00:10:07,320
that's been a little more I'll spend a

274
00:10:10,970 --> 00:10:08,519
little bit more time talking about this

275
00:10:13,130 --> 00:10:10,980
because it's a bit more nuanced

276
00:10:15,350 --> 00:10:13,140
um but I'll first not go into the whole

277
00:10:17,389 --> 00:10:15,360
story but just talk about one of my

278
00:10:19,910 --> 00:10:17,399
graduate students Jordan bird took

279
00:10:21,769 --> 00:10:19,920
samples from an iotp expedition on the

280
00:10:23,090 --> 00:10:21,779
great shipment Nisha not the geordie's

281
00:10:25,190 --> 00:10:23,100
resolution

282
00:10:27,410 --> 00:10:25,200
um which which the Baltic Sea

283
00:10:30,110 --> 00:10:27,420
and drilled hundreds of meters into the

284
00:10:32,750 --> 00:10:30,120
Baltic Sea and he combined meta

285
00:10:35,210 --> 00:10:32,760
transcriptomes metabolomes if you don't

286
00:10:37,550 --> 00:10:35,220
work with those things we basically if

287
00:10:40,190 --> 00:10:37,560
you think about like a cell as a bag of

288
00:10:41,990 --> 00:10:40,200

biomolecules like DNA RNA proteins

289
00:10:43,490 --> 00:10:42,000
lipids and all that kind of stuff and

290
00:10:46,069 --> 00:10:43,500
then all the chemicals that get pushed

291
00:10:48,050 --> 00:10:46,079
Along by those processes if you take a

292
00:10:49,910 --> 00:10:48,060
natural sample and you pull all those

293
00:10:52,550 --> 00:10:49,920
chemicals out and then just say well

294
00:10:54,530 --> 00:10:52,560
what was there then you can kind of bat

295
00:10:56,870 --> 00:10:54,540
calculate what that cell was doing you

296
00:10:58,190 --> 00:10:56,880
can reconstruct how these organisms were

297
00:11:00,610 --> 00:10:58,200
actually functioning and that's the kind

298
00:11:04,430 --> 00:11:00,620
of stuff we do and so from that

299
00:11:06,230 --> 00:11:04,440
we found that it looks like they do have

300
00:11:08,509 --> 00:11:06,240
some adaptations to being there so we

301
00:11:10,970 --> 00:11:08,519
can see some actual chemical evidence

302
00:11:12,470 --> 00:11:10,980
not just in genes so remember this is

303
00:11:14,449 --> 00:11:12,480
why I'm sort of harping on this is that

304
00:11:16,370 --> 00:11:14,459
you can predict a lot of things from

305
00:11:19,370 --> 00:11:16,380
genes but we saw actual evidence that

306
00:11:22,310 --> 00:11:19,380
these functions were happening we saw a

307
00:11:25,009 --> 00:11:22,320
DNA repair that consumes NAD which is a

308
00:11:26,750 --> 00:11:25,019
cofactor that gets redox cycled in a

309
00:11:29,150 --> 00:11:26,760
cell but in this case is using for

310
00:11:30,889 --> 00:11:29,160
beginning use for DNA repair

311
00:11:32,329 --> 00:11:30,899
we found an accumulation of osmo

312
00:11:34,970 --> 00:11:32,339
protectant so this is not a particularly

313
00:11:37,190 --> 00:11:34,980

saline place we kind of think that

314
00:11:40,190 --> 00:11:37,200
collecting things like triolose inside

315
00:11:41,750 --> 00:11:40,200
cells is a lot about shutting down and

316
00:11:43,430 --> 00:11:41,760
slowing down the cells like pickling

317
00:11:46,490 --> 00:11:43,440
themselves

318
00:11:48,889 --> 00:11:46,500
and we were able to find we discovered

319
00:11:51,170 --> 00:11:48,899
ecology which maybe doesn't sound like

320
00:11:52,670 --> 00:11:51,180
such an exciting thing to find but when

321
00:11:54,769 --> 00:11:52,680
you're dealing with an ecosystem that

322
00:11:56,810 --> 00:11:54,779
might kind of be dead finding ecological

323
00:11:58,730 --> 00:11:56,820
niches is a great little indicator that

324
00:12:02,630 --> 00:11:58,740
they're actually alive so we found that

325
00:12:04,310 --> 00:12:02,640
microbe a eats food a and micro b eats

326
00:12:06,889 --> 00:12:04,320
food B and we've showed that with

327
00:12:08,930 --> 00:12:06,899
functional assays which still blows my

328
00:12:11,210 --> 00:12:08,940
mind that that actually worked so this

329
00:12:13,370 --> 00:12:11,220
may be something that they do to not

330
00:12:15,470 --> 00:12:13,380
fight because basically when you don't

331
00:12:17,569 --> 00:12:15,480
have a lot of resources and nobody gets

332
00:12:19,790 --> 00:12:17,579
to come in and nobody gets to leave if

333
00:12:22,190 --> 00:12:19,800
you compete then it's mutually assured

334
00:12:24,290 --> 00:12:22,200
destruction if you kill that cell it's

335
00:12:26,509 --> 00:12:24,300
never getting another one

336
00:12:28,930 --> 00:12:26,519
um and then we found this one group if

337
00:12:31,370 --> 00:12:28,940
you are a microbiologist this might

338
00:12:32,990 --> 00:12:31,380

make sense to you the atro bacteria

339
00:12:34,190 --> 00:12:33,000
which is a deeply branching uncultured

340
00:12:36,110 --> 00:12:34,200
clade

341
00:12:37,370 --> 00:12:36,120
we think it eats this thing called Alan

342
00:12:39,410 --> 00:12:37,380
toen which is a nitrogen-rich

343
00:12:41,569 --> 00:12:39,420
degradation product and we think it's

344
00:12:44,329 --> 00:12:41,579
maybe a keystone of that Community

345
00:12:46,550 --> 00:12:44,339
because it looks like of all the

346
00:12:47,750 --> 00:12:46,560
transcripts so again those are the MRNA

347
00:12:50,090 --> 00:12:47,760
that are going to turn into proteins

348
00:12:52,910 --> 00:12:50,100
that were the most highly transcribed in

349
00:12:56,030 --> 00:12:52,920
this whole 8 000 year old sediment like

350
00:12:57,470 --> 00:12:56,040
50 meters down into the sea floor the

351
00:12:59,810 --> 00:12:57,480
second most the number one most

352
00:13:01,430 --> 00:12:59,820
transcribed Gene which if you've worked

353
00:13:02,449 --> 00:13:01,440
with transcriptomes you could probably

354
00:13:04,090 --> 00:13:02,459
guess what the number one was

355
00:13:05,870 --> 00:13:04,100
transcribed Gene was

356
00:13:10,610 --> 00:13:05,880
hypothetical

357
00:13:12,170 --> 00:13:10,620
things are like the most important genes

358
00:13:14,509 --> 00:13:12,180
in the whole ecosystem and we have no

359
00:13:17,210 --> 00:13:14,519
clue what they are so the second thing

360
00:13:19,430 --> 00:13:17,220
that was most transcribed was actually a

361
00:13:20,810 --> 00:13:19,440
sharing Gene so this is a starving

362
00:13:23,090 --> 00:13:20,820
environment where they don't have much

363
00:13:24,889 --> 00:13:23,100

to eat and the second most highly

364
00:13:28,009 --> 00:13:24,899
transcribed Gene was actually a

365
00:13:29,750 --> 00:13:28,019
transporter that's used in centrifies to

366
00:13:31,430 --> 00:13:29,760
share your food with others which is

367
00:13:33,050 --> 00:13:31,440
very touching

368
00:13:35,690 --> 00:13:33,060
um but it but it also

369
00:13:37,730 --> 00:13:35,700
um you know basically feeds into one of

370
00:13:41,030 --> 00:13:37,740
my sort of ongoing theories that these

371
00:13:42,470 --> 00:13:41,040
extreme apocalyptic ecosystems are not

372
00:13:44,090 --> 00:13:42,480
dog eat dog at all because it doesn't

373
00:13:46,670 --> 00:13:44,100
make sense to compete when things are so

374
00:13:49,129 --> 00:13:46,680
limited um they actually cooperate I

375
00:13:51,050 --> 00:13:49,139
think quite a bit

376
00:13:51,650 --> 00:13:51,060
um this is another

377
00:13:53,569 --> 00:13:51,660
um

378
00:13:55,250 --> 00:13:53,579
little piece of evidence that we have

379
00:13:57,290 --> 00:13:55,260
some adaptation to this environment is

380
00:13:59,569 --> 00:13:57,300
work that came from one of my another

381
00:14:01,550 --> 00:13:59,579
one of my PhD students Katie Sipes who

382
00:14:03,769 --> 00:14:01,560
is so absolutely addicted to going to

383
00:14:05,389 --> 00:14:03,779
the Arctic after going she can't stay

384
00:14:06,710 --> 00:14:05,399
out of it it's so funny she keeps

385
00:14:07,930 --> 00:14:06,720
finding more projects and I'm like Katie

386
00:14:11,690 --> 00:14:07,940
where are you and she's like Greenland

387
00:14:13,850 --> 00:14:11,700
so what she found in Siberia this is

388
00:14:15,650 --> 00:14:13,860

this beautiful Kalama River this is some

389
00:14:17,569 --> 00:14:15,660
of the oldest permafrost on Earth so

390
00:14:20,389 --> 00:14:17,579
this has been continuously Frozen for a

391
00:14:22,550 --> 00:14:20,399
million years which is crazy

392
00:14:24,470 --> 00:14:22,560
um she found this group which I was

393
00:14:27,430 --> 00:14:24,480
telling some folks at dinner about this

394
00:14:29,930 --> 00:14:27,440
thermal profundalis group is

395
00:14:31,569 --> 00:14:29,940
only ever found in Marine environments

396
00:14:35,150 --> 00:14:31,579
and she found it in this freshwater

397
00:14:37,009 --> 00:14:35,160
place and a lot of these um clades that

398
00:14:39,350 --> 00:14:37,019
she found in this deep weird old

399
00:14:40,790 --> 00:14:39,360
permafrost are very similar to what we

400
00:14:42,350 --> 00:14:40,800
find in these other subsurface

401
00:14:44,990 --> 00:14:42,360
environments so it really seems like

402
00:14:47,090 --> 00:14:45,000
there's something going on and the last

403
00:14:48,350 --> 00:14:47,100
sort of adaptational story I'll tell is

404
00:14:50,090 --> 00:14:48,360
from another one of my former students

405
00:14:52,250 --> 00:14:50,100
Joy Bongiorno

406
00:14:54,230 --> 00:14:52,260
who looked at these transcriptional

407
00:14:56,389 --> 00:14:54,240
differences she has this amazing data

408
00:14:58,670 --> 00:14:56,399
set which actually we're still analyzing

409
00:15:00,530 --> 00:14:58,680
um but depth is here this is now

410
00:15:02,689 --> 00:15:00,540
centimeters so this is like over that

411
00:15:04,490 --> 00:15:02,699
much space it's not super deep

412
00:15:05,990 --> 00:15:04,500
um but what she looked at was the total

413
00:15:08,870 --> 00:15:06,000

amount of transcription of each of these

414
00:15:10,250 --> 00:15:08,880
genes as as you go with depth and this

415
00:15:12,170 --> 00:15:10,260
is the amount of transcription on the

416
00:15:14,990 --> 00:15:12,180
y-axis and you can see it's in log here

417
00:15:17,509 --> 00:15:15,000
so this is quite a huge increase so she

418
00:15:19,610 --> 00:15:17,519
found this very big ramping up of this

419
00:15:21,590 --> 00:15:19,620
transcription of this one gene which

420
00:15:24,110 --> 00:15:21,600
ended up just being a gene to basically

421
00:15:27,050 --> 00:15:24,120
turn it into a Spore it was like a sort

422
00:15:29,449 --> 00:15:27,060
of like a strange type of sporulation so

423
00:15:30,769 --> 00:15:29,459
we think that these things

424
00:15:32,710 --> 00:15:30,779
um we think that there are adaptations

425
00:15:37,069 --> 00:15:32,720
to being in the subsurface you know

426
00:15:40,069 --> 00:15:37,079
sporulating or repairing basically

427
00:15:42,530 --> 00:15:40,079
the we're not done I can't say that

428
00:15:44,509 --> 00:15:42,540
definitively but all of my research sort

429
00:15:46,490 --> 00:15:44,519
of points at the fact that these things

430
00:15:49,069 --> 00:15:46,500
are actually adapted to be where they

431
00:15:52,250 --> 00:15:49,079
are so

432
00:15:54,350 --> 00:15:52,260
now maybe I've convinced you that Earth

433
00:15:56,090 --> 00:15:54,360
does have a Vibrance and varied

434
00:15:57,710 --> 00:15:56,100
subsurface biosphere that's supposed to

435
00:15:59,449 --> 00:15:57,720
be there it's not just waiting to get to

436
00:16:01,910 --> 00:15:59,459
the surface again it's it means to be

437
00:16:03,470 --> 00:16:01,920
there so what can how can we use this

438
00:16:04,790 --> 00:16:03,480

how can we use this to look for life on

439
00:16:07,670 --> 00:16:04,800
Europa

440
00:16:11,150 --> 00:16:07,680
um so I think of the subsurface as being

441
00:16:13,970 --> 00:16:11,160
divided up into two main categories one

442
00:16:15,769 --> 00:16:13,980
is subsurface life that gets its

443
00:16:17,569 --> 00:16:15,779
chemicals from inside Earth so it's

444
00:16:19,670 --> 00:16:17,579
basically got its own lunch with it and

445
00:16:22,009 --> 00:16:19,680
it's you know making its own

446
00:16:24,530 --> 00:16:22,019
um biomass so chemosynthesis that's

447
00:16:26,449 --> 00:16:24,540
making biomass from chemicals

448
00:16:27,949 --> 00:16:26,459
and then the second type would be those

449
00:16:29,870 --> 00:16:27,959
that are dependent on photosynthesis

450
00:16:32,030 --> 00:16:29,880
which

451
00:16:33,650 --> 00:16:32,040
um you know are sort of like uh

452
00:16:36,410 --> 00:16:33,660
dependent on the surface world to give

453
00:16:36,949 --> 00:16:36,420
them food and to feed them and

454
00:16:39,290 --> 00:16:36,959
um

455
00:16:40,730 --> 00:16:39,300
the second one maybe

456
00:16:41,990 --> 00:16:40,740
I mean it's like

457
00:16:42,949 --> 00:16:42,000
it's like exciting right if we're

458
00:16:44,269 --> 00:16:42,959
talking about 7

459
00:16:46,670 --> 00:16:44,279
you kind of want it to have its own

460
00:16:48,170 --> 00:16:46,680
thing and like just waiting for for

461
00:16:50,509 --> 00:16:48,180
stuff to trickle down from the surface

462
00:16:52,790 --> 00:16:50,519
seems like sort of cheating or maybe not

463
00:16:55,430 --> 00:16:52,800

what we're going for here but I wanna I

464
00:16:57,350 --> 00:16:55,440
wanna argue that this second group is

465
00:16:59,389 --> 00:16:57,360
actually useful for astrobiology we can

466
00:17:01,370 --> 00:16:59,399
still work on these places on Earth that

467
00:17:03,290 --> 00:17:01,380
are dependent on the surface and learn

468
00:17:05,210 --> 00:17:03,300
some stuff from it and I also forgot to

469
00:17:07,309 --> 00:17:05,220
say since it's the evening and we have a

470
00:17:09,230 --> 00:17:07,319
lot of different area of expertise if I

471
00:17:10,370 --> 00:17:09,240
if you want to ask a question

472
00:17:12,590 --> 00:17:10,380
we're not going to ask too many

473
00:17:13,850 --> 00:17:12,600
questions it's for technical reasons

474
00:17:15,169 --> 00:17:13,860
that you guys can't ask a lot of

475
00:17:18,409 --> 00:17:15,179
questions right now because there's a

476
00:17:20,270 --> 00:17:18,419
microphone but if if you're lost raise

477
00:17:21,829 --> 00:17:20,280
your hand and be like what is can you

478
00:17:25,069 --> 00:17:21,839
explain this one thing okay so anyway

479
00:17:27,470 --> 00:17:25,079
say that in the beginning so

480
00:17:29,150 --> 00:17:27,480
one useless faster biology do we not

481
00:17:30,710 --> 00:17:29,160
want to study places like Marine

482
00:17:33,110 --> 00:17:30,720
sediments because it's you know

483
00:17:34,190 --> 00:17:33,120
dependent on having Amazons up at the

484
00:17:38,330 --> 00:17:34,200
top

485
00:17:40,130 --> 00:17:38,340
um no I think it's useful because we can

486
00:17:42,529 --> 00:17:40,140
get to them which

487
00:17:44,270 --> 00:17:42,539
I mean I know that's not the best reason

488
00:17:46,250 --> 00:17:44,280

to study something but it is important

489
00:17:49,130 --> 00:17:46,260
like getting a sample is very important

490
00:17:51,529 --> 00:17:49,140
and the cool thing about Marine

491
00:17:53,210 --> 00:17:51,539
sediments is that they're layered so if

492
00:17:55,070 --> 00:17:53,220
you want to run an experiment for a

493
00:17:56,870 --> 00:17:55,080
million years and I want to run an

494
00:17:59,450 --> 00:17:56,880
experiment from like I cannot tell you

495
00:18:01,970 --> 00:17:59,460
how badly I want to run an experiment

496
00:18:04,789 --> 00:18:01,980
for a million years but obviously I

497
00:18:07,490 --> 00:18:04,799
cannot but Marine sediments have already

498
00:18:11,029 --> 00:18:07,500
done it and so if you can be creative

499
00:18:13,730 --> 00:18:11,039
about how you sample them you can test

500
00:18:15,650 --> 00:18:13,740
hypotheses that have been run for a

501
00:18:18,409 --> 00:18:15,660
million years already

502
00:18:21,230 --> 00:18:18,419
that's why they're they're magical to me

503
00:18:23,210 --> 00:18:21,240
um so I want to tell you about the kind

504
00:18:25,250 --> 00:18:23,220
of life we find in them

505
00:18:27,770 --> 00:18:25,260
um by talking about this first Great

506
00:18:30,590 --> 00:18:27,780
Expedition that we had off the coast of

507
00:18:32,330 --> 00:18:30,600
Peru with the ocean drilling program it

508
00:18:35,750 --> 00:18:32,340
was not the integrated ocean Discovery

509
00:18:38,930 --> 00:18:35,760
program back then it was ODP and it was

510
00:18:40,970 --> 00:18:38,940
the first sort of aseptic samples that

511
00:18:43,490 --> 00:18:40,980
we got from the deep subsurface

512
00:18:45,830 --> 00:18:43,500
and I'll show you what we got

513
00:18:48,890 --> 00:18:45,840

um with the simplistic not naming the

514
00:18:51,710 --> 00:18:48,900
microbes but I'll show them with boxes

515
00:18:52,970 --> 00:18:51,720
um so the dark blue boxes will be a

516
00:18:53,990 --> 00:18:52,980
strain of microbe that somebody else

517
00:18:56,750 --> 00:18:54,000
discovered

518
00:18:58,190 --> 00:18:56,760
and the gradient to White will tell you

519
00:18:59,630 --> 00:18:58,200
how far away it is from something

520
00:19:01,190 --> 00:18:59,640
somebody's discovered so like the

521
00:19:03,110 --> 00:19:01,200
novelty of it if it's totally novel

522
00:19:04,490 --> 00:19:03,120
totally new phylum that's never been

523
00:19:07,130 --> 00:19:04,500
discovered before it'll be a white box

524
00:19:10,310 --> 00:19:07,140
and then shades of blue in between

525
00:19:12,289 --> 00:19:10,320
so what we caught with DNA sequences was

526
00:19:15,049 --> 00:19:12,299
a bunch of kind of light colored boxes

527
00:19:16,549 --> 00:19:15,059
this stuff was really new it was very

528
00:19:19,430 --> 00:19:16,559
much unlike anything we'd ever seen

529
00:19:21,350 --> 00:19:19,440
before this is what I did

530
00:19:23,090 --> 00:19:21,360
um probably almost exactly at where most

531
00:19:25,190 --> 00:19:23,100
of you guys are in your careers right

532
00:19:27,529 --> 00:19:25,200
now I was pulling these sequences out

533
00:19:29,450 --> 00:19:27,539
and using far less sophisticated

534
00:19:31,250 --> 00:19:29,460
bioinformatics at the time to figure out

535
00:19:33,950 --> 00:19:31,260
how closely related they were but it was

536
00:19:37,430 --> 00:19:33,960
we we didn't know we didn't know about

537
00:19:40,010 --> 00:19:37,440
this uncultured dominance of life like

538
00:19:41,390 --> 00:19:40,020

you guys do now we were finding it we

539
00:19:43,909 --> 00:19:41,400
were like what the hell is this stuff I

540
00:19:45,710 --> 00:19:43,919
don't know so obviously the first time

541
00:19:47,570 --> 00:19:45,720
you go to a place like this you want to

542
00:19:49,190 --> 00:19:47,580
start culturing stuff and and this is

543
00:19:50,990 --> 00:19:49,200
low hanging fruit it's full of new stuff

544
00:19:53,090 --> 00:19:51,000
we should be able to grow it

545
00:19:55,010 --> 00:19:53,100
um so I'll show you the results of the

546
00:19:56,510 --> 00:19:55,020
growth experiments and every time they

547
00:19:58,430 --> 00:19:56,520
got one of these guys

548
00:20:00,230 --> 00:19:58,440
I'll show you

549
00:20:01,850 --> 00:20:00,240
um the new one underneath it and then

550
00:20:03,890 --> 00:20:01,860
any extra ones I'll show you off to the

551
00:20:04,909 --> 00:20:03,900
side so this is these are the ones of

552
00:20:08,270 --> 00:20:04,919
these that they caught when they

553
00:20:13,570 --> 00:20:12,110
do you see any overlap oh do you see any

554
00:20:16,070 --> 00:20:13,580
white boxes

555
00:20:18,169 --> 00:20:16,080
got the same thing that people always

556
00:20:20,150 --> 00:20:18,179
get and this is not to say that we

557
00:20:21,350 --> 00:20:20,160
shouldn't culture I really I really

558
00:20:23,150 --> 00:20:21,360
don't want to send that message at all

559
00:20:25,250 --> 00:20:23,160
that is a wrong message and there's a

560
00:20:26,510 --> 00:20:25,260
lot of novelty even in here just getting

561
00:20:28,010 --> 00:20:26,520
something that looks like something

562
00:20:30,890 --> 00:20:28,020
we've seen before out of the deep ocean

563
00:20:32,510 --> 00:20:30,900

is absolutely worthwhile but we were not

564
00:20:34,130 --> 00:20:32,520
catching these guys and there actually

565
00:20:36,830 --> 00:20:34,140
was another group that did this too and

566
00:20:40,190 --> 00:20:36,840
they got pretty much the same thing so

567
00:20:42,289 --> 00:20:40,200
this this really hit home to me and is

568
00:20:44,810 --> 00:20:42,299
is one reason why I I really stick to

569
00:20:46,610 --> 00:20:44,820
this biomolecule stuff

570
00:20:47,930 --> 00:20:46,620
um we often call this stuff have you

571
00:20:50,090 --> 00:20:47,940
guys I'm sure you've heard this term

572
00:20:53,270 --> 00:20:50,100
microbial this is controversial does

573
00:20:56,390 --> 00:20:53,280
anybody hate that term no good

574
00:21:03,110 --> 00:20:58,789
maybe the astronomers don't like it

575
00:21:09,950 --> 00:21:06,049
I I actually like this term because

576
00:21:11,690 --> 00:21:09,960
um uh what it's it signifies just how

577
00:21:13,430 --> 00:21:11,700
pervasive this stuff is it's just kind

578
00:21:16,250 --> 00:21:13,440
of like oh it's not like oh we found a

579
00:21:17,990 --> 00:21:16,260
new thing it's like this is the main

580
00:21:20,630 --> 00:21:18,000
thing and we don't know what it is but

581
00:21:24,230 --> 00:21:20,640
yeah in terms of total mass it is far

582
00:21:25,070 --> 00:21:24,240
far less than astronomical dark matter

583
00:21:28,669 --> 00:21:25,080
um

584
00:21:30,830 --> 00:21:28,679
so since then we did a study where we

585
00:21:33,169 --> 00:21:30,840
went through and pulled out Gene

586
00:21:34,669 --> 00:21:33,179
sequences from the subsurface and asked

587
00:21:37,070 --> 00:21:34,679
the same question for all of them like

588
00:21:38,630 --> 00:21:37,080

if we divide up like how many of the

589
00:21:40,130 --> 00:21:38,640
sequences that we find are closely

590
00:21:42,409 --> 00:21:40,140
related to a culture versus something

591
00:21:43,850 --> 00:21:42,419
else new entirely and then we sort of

592
00:21:46,789 --> 00:21:43,860
put them in categories

593
00:21:49,850 --> 00:21:46,799
we find that this biggest pie wedge from

594
00:21:52,370 --> 00:21:49,860
terrestrial subsurface metagenomes is

595
00:21:54,710 --> 00:21:52,380
novel generetic class and then we get

596
00:21:56,210 --> 00:21:54,720
almost more than a third a novel phyla

597
00:21:58,310 --> 00:21:56,220
so they're really dominant in these

598
00:22:01,370 --> 00:21:58,320
environments that's the bacteria and

599
00:22:03,470 --> 00:22:01,380
that's the archaea so it's not just it's

600
00:22:04,850 --> 00:22:03,480
not just that they're there and they're

601
00:22:07,669 --> 00:22:04,860
dominating diversity they're actually

602
00:22:10,190 --> 00:22:07,679
dominating the total biomass and these

603
00:22:13,490 --> 00:22:10,200
subsets they're totally new stuff

604
00:22:15,890 --> 00:22:13,500
um and I my other soapbox about this

605
00:22:18,049 --> 00:22:15,900
is that even you know you can look at

606
00:22:20,570 --> 00:22:18,059
this little yellow pie wedge so this is

607
00:22:22,490 --> 00:22:20,580
a cultured organism this is done you can

608
00:22:24,409 --> 00:22:22,500
the things that fall into this pie wedge

609
00:22:26,510 --> 00:22:24,419
are things that you can order from a

610
00:22:29,149 --> 00:22:26,520
company and grow in your lab

611
00:22:31,070 --> 00:22:29,159
um however even these ones are probably

612
00:22:32,330 --> 00:22:31,080
going to act differently when we study

613
00:22:34,310 --> 00:22:32,340

them in the subsurface than when they

614
00:22:37,010 --> 00:22:34,320
grow in our Labs I mean if you if you

615
00:22:40,130 --> 00:22:37,020
were like a lion researcher which would

616
00:22:42,590 --> 00:22:40,140
be awesome but if you studied Lions only

617
00:22:45,770 --> 00:22:42,600
in a zoo then you wouldn't you would be

618
00:22:48,350 --> 00:22:45,780
like lions their whole deal is that they

619
00:22:49,909 --> 00:22:48,360
eat little pre-packaged things of meat

620
00:22:51,590 --> 00:22:49,919
and cellophane and that would be your

621
00:22:53,149 --> 00:22:51,600
conclusion I mean that's stupid right we

622
00:22:55,730 --> 00:22:53,159
know they hunt and they kill live things

623
00:22:58,190 --> 00:22:55,740
out in nature but this is kind of like

624
00:23:00,230 --> 00:22:58,200
studying microbes in a zoo so even for

625
00:23:01,909 --> 00:23:00,240
the for the cultured guys we still need

626
00:23:03,649 --> 00:23:01,919
to go out into nature and we still need

627
00:23:05,210 --> 00:23:03,659
to sample them where they are and see

628
00:23:06,590 --> 00:23:05,220
try to figure out how they live

629
00:23:08,630 --> 00:23:06,600
so

630
00:23:11,090 --> 00:23:08,640
apbox number I don't know what number

631
00:23:14,330 --> 00:23:11,100
I'm on now many

632
00:23:17,870 --> 00:23:14,340
if you take microbiology 101 which I now

633
00:23:20,630 --> 00:23:17,880
teach we call it 220 actually

634
00:23:23,029 --> 00:23:20,640
um but you know like your your basic

635
00:23:24,409 --> 00:23:23,039
microbiology class microbes grow in

636
00:23:27,230 --> 00:23:24,419
cultures that's how we learn about

637
00:23:28,850 --> 00:23:27,240
microbes and we know a lot about like

638
00:23:31,250 --> 00:23:28,860

what microbes do on this planet these

639
00:23:34,010 --> 00:23:31,260
are like basic truths

640
00:23:36,409 --> 00:23:34,020
I'm not saying they're not true but I'm

641
00:23:39,950 --> 00:23:36,419
saying this is a frame of reference I

642
00:23:41,990 --> 00:23:39,960
want all of you to not think of these

643
00:23:44,330 --> 00:23:42,000
things as necessarily true

644
00:23:46,549 --> 00:23:44,340
just

645
00:23:48,350 --> 00:23:46,559
life could be different than what we

646
00:23:49,909 --> 00:23:48,360
think and it could be that there are

647
00:23:52,010 --> 00:23:49,919
microbes that are never going to grow in

648
00:23:54,110 --> 00:23:52,020
culture and are not going to act like

649
00:23:55,909 --> 00:23:54,120
anything that we've seen before and we

650
00:23:59,330 --> 00:23:55,919
need to not limit ourselves especially

651
00:24:01,490 --> 00:23:59,340
as astrobiologists you know we can't

652
00:24:02,870 --> 00:24:01,500
think small-minded about this stuff

653
00:24:05,270 --> 00:24:02,880
because we'll miss something really

654
00:24:05,870 --> 00:24:05,280
important so

655
00:24:07,190 --> 00:24:05,880
um

656
00:24:10,010 --> 00:24:07,200
so

657
00:24:12,830 --> 00:24:10,020
how how fast do these things grow and

658
00:24:14,930 --> 00:24:12,840
you need sediments that's that's this is

659
00:24:16,850 --> 00:24:14,940
part of the taking the lid off and

660
00:24:19,010 --> 00:24:16,860
seeing your frame of your implicit frame

661
00:24:20,690 --> 00:24:19,020
of reference that you may not have even

662
00:24:22,850 --> 00:24:20,700
realized you have

663
00:24:25,490 --> 00:24:22,860

um is when we think of microbes maybe we

664
00:24:28,190 --> 00:24:25,500
think fast because pathogens grow fast

665
00:24:30,649 --> 00:24:28,200
right you get sick pretty quickly

666
00:24:32,090 --> 00:24:30,659
um E coli for instance which we've all

667
00:24:33,950 --> 00:24:32,100
worked with certainly has a doubling

668
00:24:36,110 --> 00:24:33,960
time of 30 minutes it's not even the

669
00:24:38,690 --> 00:24:36,120
fastest microbe but it's pretty fast but

670
00:24:40,070 --> 00:24:38,700
if you because we can work in Marine

671
00:24:41,870 --> 00:24:40,080
settlements we can do time scales

672
00:24:43,909 --> 00:24:41,880
because we have these layers so we can

673
00:24:46,250 --> 00:24:43,919
actually measure the doubling time so if

674
00:24:48,710 --> 00:24:46,260
you look at sediments with these ages

675
00:24:49,730 --> 00:24:48,720
ranging from 100 years down to 5 000

676
00:24:57,830 --> 00:24:49,740
years

677
00:25:01,610 --> 00:24:57,840
and at the surface in 100 year old

678
00:25:04,310 --> 00:25:01,620
sediments it's still 0.1 year so this is

679
00:25:07,430 --> 00:25:04,320
like still very very slow compared to E

680
00:25:10,490 --> 00:25:07,440
coli but if you go down even further we

681
00:25:13,250 --> 00:25:10,500
get up to the tens of years and maybe a

682
00:25:15,890 --> 00:25:13,260
hundred years generation time

683
00:25:17,870 --> 00:25:15,900
um which you know

684
00:25:19,730 --> 00:25:17,880
we publish papers with these numbers in

685
00:25:22,250 --> 00:25:19,740
them all the time and we throw throw

686
00:25:23,870 --> 00:25:22,260
them around all the time but it's hard

687
00:25:25,370 --> 00:25:23,880
to wrap your brain around what it's like

688
00:25:26,149 --> 00:25:25,380

for a cell to actually live for that

689
00:25:27,890 --> 00:25:26,159
long

690
00:25:29,870 --> 00:25:27,900
um because this is a generation time

691
00:25:31,430 --> 00:25:29,880
this isn't necessarily dividing this

692
00:25:33,409 --> 00:25:31,440
could be just replacing itself like a

693
00:25:36,830 --> 00:25:33,419
turnover total carbon turnover for these

694
00:25:39,049 --> 00:25:36,840
cells so um so you know the number of

695
00:25:41,570 --> 00:25:39,059
cumulative Generations doesn't really

696
00:25:44,090 --> 00:25:41,580
increase at some point so what we have

697
00:25:46,490 --> 00:25:44,100
are a bunch of organisms that seem to

698
00:25:49,310 --> 00:25:46,500
just be hanging out for

699
00:25:54,110 --> 00:25:49,320
how how long can an individual live does

700
00:25:56,930 --> 00:25:54,850
one one

701
00:25:59,090 --> 00:25:56,940
[Music]

702
00:26:01,090 --> 00:25:59,100
I don't know nematode

703
00:26:03,110 --> 00:26:01,100
tardigrade

704
00:26:05,149 --> 00:26:03,120
[Music]

705
00:26:06,230 --> 00:26:05,159
does anybody have a feel like what do

706
00:26:11,510 --> 00:26:06,240
you think of when you think of a

707
00:26:17,210 --> 00:26:13,250
you guys are all astrologists you'll be

708
00:26:22,549 --> 00:26:20,990
thousands yeah yeah I mean even saying

709
00:26:24,590 --> 00:26:22,559
like thousands or five thousand years

710
00:26:27,230 --> 00:26:24,600
for a lifespan for one thing is already

711
00:26:30,169 --> 00:26:27,240
like utre right that is really long like

712
00:26:32,510 --> 00:26:30,179
we have um Sequoias are what 300

713
00:26:34,430 --> 00:26:32,520

Bristlecone Pines or maybe a thousand do

714
00:26:37,029 --> 00:26:34,440
you have a thought

715
00:26:42,350 --> 00:26:37,039
Aspens

716
00:26:49,789 --> 00:26:45,649
10 million how about

717
00:26:52,250 --> 00:26:49,799
does that but but even in right and so

718
00:26:54,830 --> 00:26:52,260
those guys so it's like clonal right and

719
00:26:57,110 --> 00:26:54,840
then even like the Sequoia that's not

720
00:26:59,149 --> 00:26:57,120
clonal it still has that living tissue

721
00:27:01,190 --> 00:26:59,159
and the living tissue certainly like

722
00:27:04,490 --> 00:27:01,200
those cells a living cell doesn't last

723
00:27:07,130 --> 00:27:04,500
as long as the whole tree so

724
00:27:08,930 --> 00:27:07,140
yeah we've got things that what I'm

725
00:27:11,810 --> 00:27:08,940
saying are lasting for a hundred

726
00:27:15,049 --> 00:27:11,820
thousand years one cell one like little

727
00:27:18,169 --> 00:27:15,059
precious tiny little lipid sack is

728
00:27:20,510 --> 00:27:18,179
hanging out intact

729
00:27:22,070 --> 00:27:20,520
for a hundred thousand years and I'm

730
00:27:23,830 --> 00:27:22,080
gonna venture to say also a million

731
00:27:27,470 --> 00:27:23,840
because why not

732
00:27:30,710 --> 00:27:27,480
and and I don't I don't know man like

733
00:27:33,049 --> 00:27:30,720
it's crazy but they might

734
00:27:34,130 --> 00:27:33,059
extra evidence for this because it's

735
00:27:37,250 --> 00:27:34,140
crazy

736
00:27:40,789 --> 00:27:37,260
is if you add up a total power so

737
00:27:43,010 --> 00:27:40,799
remember back to physics power is energy

738
00:27:44,450 --> 00:27:43,020

over time it's the flow rate of how much

739
00:27:46,610 --> 00:27:44,460
energy you can feed something because

740
00:27:49,789 --> 00:27:46,620
you can have a very nice Quantum of

741
00:27:52,070 --> 00:27:49,799
energy like you can a pizza will be just

742
00:27:53,510 --> 00:27:52,080
fine for me for a day but a pizza is not

743
00:27:56,450 --> 00:27:53,520
going to last me for my lifetime I'll

744
00:27:58,669 --> 00:27:56,460
die so the delivery rate of your food

745
00:28:00,350 --> 00:27:58,679
really matters so if you add up the

746
00:28:02,930 --> 00:28:00,360
total power per cell because we know

747
00:28:04,730 --> 00:28:02,940
pretty much how many cells there are out

748
00:28:07,010 --> 00:28:04,740
in Marine sediments

749
00:28:09,110 --> 00:28:07,020
um this right here is the lowest

750
00:28:11,750 --> 00:28:09,120
measured power per cell that somebody

751
00:28:14,149 --> 00:28:11,760
has measured in a non-growing chemostat

752
00:28:15,649 --> 00:28:14,159
have you heard of retentostats I really

753
00:28:18,529 --> 00:28:15,659
love retento stats but people don't work

754
00:28:20,090 --> 00:28:18,539
in them um a chemostat is a sort of a

755
00:28:22,310 --> 00:28:20,100
normal thing to do where you're passing

756
00:28:23,570 --> 00:28:22,320
fluids through a population and you have

757
00:28:24,950 --> 00:28:23,580
them grow at a certain rate and you're

758
00:28:27,350 --> 00:28:24,960
constantly feeding them and growing them

759
00:28:29,630 --> 00:28:27,360
a retentostat just has a filter at the

760
00:28:31,010 --> 00:28:29,640
end so you're not nothing is leaving so

761
00:28:33,470 --> 00:28:31,020
they're not regrowing so you just keep

762
00:28:34,850 --> 00:28:33,480
them there so in a retentive stat they

763
00:28:36,710 --> 00:28:34,860

get down to this extremely

764
00:28:38,330 --> 00:28:36,720
extraordinarily low power but then if

765
00:28:40,370 --> 00:28:38,340
you look if you integrate the total

766
00:28:42,890 --> 00:28:40,380
power available from sulfate reduction

767
00:28:44,269 --> 00:28:42,900
and from methanogenesis all underneath

768
00:28:47,330 --> 00:28:44,279
the world's oceans

769
00:28:49,850 --> 00:28:47,340
it is orders of magnitude less than what

770
00:28:51,769 --> 00:28:49,860
it takes to just keep a cell going not

771
00:28:53,810 --> 00:28:51,779
growing growing is like way out here

772
00:28:56,990 --> 00:28:53,820
growing is not even on this chart this

773
00:29:00,529 --> 00:28:57,000
is just like existing so

774
00:29:02,870 --> 00:29:00,539
it's weird man it's real weird and and

775
00:29:05,330 --> 00:29:02,880
this is the reason I'm emphasizing this

776
00:29:07,610 --> 00:29:05,340
to you guys is that this means that

777
00:29:10,190 --> 00:29:07,620
there's basically a lot more energetic

778
00:29:12,769 --> 00:29:10,200
space for life in this universe than we

779
00:29:15,409 --> 00:29:12,779
think about in our daily lives we can we

780
00:29:17,870 --> 00:29:15,419
can imagine more for where life exists

781
00:29:20,510 --> 00:29:17,880
than you know

782
00:29:21,950 --> 00:29:20,520
just you know my dog and cat my kids and

783
00:29:23,450 --> 00:29:21,960
stuff

784
00:29:24,769 --> 00:29:23,460
um so

785
00:29:26,690 --> 00:29:24,779
um what we've learned from Marine

786
00:29:28,250 --> 00:29:26,700
sediments is that life in the subsurface

787
00:29:30,470 --> 00:29:28,260
may be fundamentally mentally different

788
00:29:33,049 --> 00:29:30,480

than what we've studied before

789
00:29:35,090 --> 00:29:33,059
and we can survive on much less power

790
00:29:36,710 --> 00:29:35,100
than we experience in the sub in the

791
00:29:38,870 --> 00:29:36,720
surface world

792
00:29:40,430 --> 00:29:38,880
and this Hundred Year lifespan thing

793
00:29:42,470 --> 00:29:40,440
which we're kind of intrinsically stuck

794
00:29:44,450 --> 00:29:42,480
within our brains is an assumption it's

795
00:29:45,110 --> 00:29:44,460
not a requirement

796
00:29:48,169 --> 00:29:45,120
um

797
00:29:50,930 --> 00:29:48,179
Okay so

798
00:29:53,450 --> 00:29:50,940
I want to switch gears how far on this

799
00:29:56,149 --> 00:29:53,460
I'm 37 minutes into this well no it's

800
00:29:57,590 --> 00:29:56,159
not quite 37 minutes

801
00:29:59,870 --> 00:29:57,600
I guess the bar is closed I can't tell

802
00:30:02,450 --> 00:29:59,880
you guys to get a drink does anybody

803
00:30:03,769 --> 00:30:02,460
need I'm gonna drink does anybody have a

804
00:30:04,780 --> 00:30:03,779
question before I go to the second

805
00:30:10,730 --> 00:30:04,790
section of this yeah

806
00:30:16,909 --> 00:30:13,490
cool what like what's going on with like

807
00:30:18,830 --> 00:30:16,919
why they're birthday photosynthesize oh

808
00:30:19,730 --> 00:30:18,840
that's a good one so for those of you

809
00:30:21,529 --> 00:30:19,740
who didn't hear that because the

810
00:30:22,970 --> 00:30:21,539
microphone wasn't there oh sorry why are

811
00:30:24,710 --> 00:30:22,980
there so many chloroflexy there are they

812
00:30:26,870 --> 00:30:24,720
adapted to the subsurface because they

813
00:30:28,490 --> 00:30:26,880

are photosynthesizers or at least

814
00:30:30,110 --> 00:30:28,500
phototrophic they are not all

815
00:30:33,470 --> 00:30:30,120
phototrophic

816
00:30:37,370 --> 00:30:33,480
yeah yeah so dahalica coitus is a Genus

817
00:30:39,289 --> 00:30:37,380
within there's a lot but um the

818
00:30:40,610 --> 00:30:39,299
um D halogen naders I guess you could

819
00:30:42,470 --> 00:30:40,620
call them so

820
00:30:43,850 --> 00:30:42,480
um that's where a lot of the chloroflexy

821
00:30:45,590 --> 00:30:43,860
research has been done just because

822
00:30:47,090 --> 00:30:45,600
that's funded because it's

823
00:30:48,590 --> 00:30:47,100
bioremediation because we use

824
00:30:49,610 --> 00:30:48,600
chlorinated compounds to clean planes

825
00:30:51,830 --> 00:30:49,620
and stuff

826
00:30:53,510 --> 00:30:51,840
um so those are fascinating organisms in

827
00:30:56,630 --> 00:30:53,520
and of themselves but most of the

828
00:30:58,190 --> 00:30:56,640
chlorophy that we find are anerelinea I

829
00:31:00,350 --> 00:30:58,200
don't know if you know that group it's

830
00:31:02,630 --> 00:31:00,360
not well cultured

831
00:31:06,769 --> 00:31:02,640
um we don't have any phototrophic genes

832
00:31:08,389 --> 00:31:06,779
in them but yeah there's a lot but I

833
00:31:10,010 --> 00:31:08,399
it's cool that you bring up the

834
00:31:12,470 --> 00:31:10,020
chloroflexy because they are one of the

835
00:31:13,669 --> 00:31:12,480
most mysterious phyla do you work on

836
00:31:16,310 --> 00:31:13,679
chloroflexy

837
00:31:18,649 --> 00:31:16,320
um I'm working with uh steam vents and

838
00:31:20,450 --> 00:31:18,659

like I'm in uh Jimmy's law script so we

839
00:31:22,310 --> 00:31:20,460
do a lot of thermophiles and stuff

840
00:31:24,590 --> 00:31:22,320
um yeah yeah

841
00:31:26,389 --> 00:31:24,600
um so chloroflexi keep popping up and

842
00:31:27,769 --> 00:31:26,399
there's a lot of them and I just keep

843
00:31:29,450 --> 00:31:27,779
looking at my genomes and I'm like yeah

844
00:31:31,430 --> 00:31:29,460
so the study that we did where we

845
00:31:33,470 --> 00:31:31,440
Quantified the uncultured things all

846
00:31:38,090 --> 00:31:33,480
around the world of all the we looked at

847
00:31:40,010 --> 00:31:38,100
all environments it the only clade that

848
00:31:41,570 --> 00:31:40,020
showed up in the most uncultured that

849
00:31:44,210 --> 00:31:41,580
showed up as sorry as one of the most

850
00:31:46,610 --> 00:31:44,220
abundant clades in every environment

851
00:31:51,110 --> 00:31:46,620
you know animal guts engineered places

852
00:31:53,450 --> 00:31:51,120
human guts snow everything was anaolini

853
00:31:55,250 --> 00:31:53,460
it's that chloroflexy group like

854
00:31:57,110 --> 00:31:55,260
everything else like shifts and you have

855
00:31:59,029 --> 00:31:57,120
some things in some places and then the

856
00:32:00,710 --> 00:31:59,039
anarolini I don't know if that's how you

857
00:32:08,630 --> 00:32:00,720
pronounce it they're everywhere they

858
00:32:08,640 --> 00:32:17,210
microphone javelin's a bad idea

859
00:32:21,409 --> 00:32:18,889
um do you think it's just the the

860
00:32:23,330 --> 00:32:21,419
doubling time or is it nutrients and

861
00:32:24,950 --> 00:32:23,340
potentially like physical structure

862
00:32:26,870 --> 00:32:24,960
that's a problem for culturing microbes

863
00:32:28,070 --> 00:32:26,880

in the sediments oh why don't we get

864
00:32:28,789 --> 00:32:28,080
cultures

865
00:32:31,130 --> 00:32:28,799
um

866
00:32:33,649 --> 00:32:31,140
I wish I knew that I think it's all

867
00:32:35,510 --> 00:32:33,659
those things I mean it's like

868
00:32:38,570 --> 00:32:35,520
if you think about what culturing is

869
00:32:41,269 --> 00:32:38,580
it's Limitless access to Abundant

870
00:32:43,130 --> 00:32:41,279
substrate which is a problem if you

871
00:32:45,049 --> 00:32:43,140
don't have like running your metabolism

872
00:32:46,909 --> 00:32:45,059
really hot is actually dangerous for a

873
00:32:48,710 --> 00:32:46,919
cell and those of us who run at a very

874
00:32:50,690 --> 00:32:48,720
high level like have all kinds of

875
00:32:52,730 --> 00:32:50,700
reactive oxygen species defenses and

876
00:32:54,830 --> 00:32:52,740
things like that but if you're not set

877
00:32:56,990 --> 00:32:54,840
up to go fast then being forced to go

878
00:32:59,029 --> 00:32:57,000
fast can kill you so that's one thing

879
00:33:01,130 --> 00:32:59,039
too much too much food you need your

880
00:33:04,430 --> 00:33:01,140
friends you need your enemies you need

881
00:33:05,870 --> 00:33:04,440
vitamins you need minerals that you're

882
00:33:07,669 --> 00:33:05,880
lacking you need them in the right

883
00:33:09,529 --> 00:33:07,679
crystalline structure

884
00:33:10,130 --> 00:33:09,539
pressure

885
00:33:11,870 --> 00:33:10,140
um

886
00:33:13,669 --> 00:33:11,880
I don't know if it's self-congratulatory

887
00:33:17,269 --> 00:33:13,679
to talk about my TED talk but I gave

888
00:33:22,490 --> 00:33:20,029

whatever it happened I um

889
00:33:25,070 --> 00:33:22,500
I gave this Ted talk about culturing

890
00:33:27,710 --> 00:33:25,080
things in the deep sea and I get an

891
00:33:29,090 --> 00:33:27,720
email like probably it's slowed down now

892
00:33:30,590 --> 00:33:29,100
but it was like hot and heavy when the

893
00:33:32,330 --> 00:33:30,600
first thing came out thing first came

894
00:33:35,230 --> 00:33:32,340
out somebody being like have you

895
00:33:40,190 --> 00:33:37,789
yes I have considered pressure it's like

896
00:33:41,870 --> 00:33:40,200
I forgot to mention it in the talk but

897
00:33:43,190 --> 00:33:41,880
um people are thinking it's good there's

898
00:33:44,870 --> 00:33:43,200
a lot there's a lot of reasons why

899
00:33:48,730 --> 00:33:44,880
things are not on culture but I I think

900
00:33:53,509 --> 00:33:51,009
foreign

901
00:33:55,909 --> 00:33:53,519
hypothetical I think I guess

902
00:33:57,409 --> 00:33:55,919
philosophical question do you think a

903
00:34:00,470 --> 00:33:57,419
cell could

904
00:34:02,750 --> 00:34:00,480
possibly never die or is it possible

905
00:34:04,909 --> 00:34:02,760
that lifespan could just be essentially

906
00:34:05,810 --> 00:34:04,919
infinite we have a we have a limiter on

907
00:34:07,070 --> 00:34:05,820
that

908
00:34:11,109 --> 00:34:07,080
and it's

909
00:34:16,250 --> 00:34:13,849
but that's it I mean but that's a huge I

910
00:34:18,409 --> 00:34:16,260
mean that's a lot to play with and then

911
00:34:19,790 --> 00:34:18,419
if you if you invoke panspermia which I

912
00:34:21,710 --> 00:34:19,800
don't know if you know this theory that

913
00:34:24,649 --> 00:34:21,720

life formed outside which I wanted to

914
00:34:28,369 --> 00:34:24,659
switch to panovia but then I don't know

915
00:34:30,530 --> 00:34:28,379
whatever pan pan movie of

916
00:34:32,570 --> 00:34:30,540
um of life then you know you could have

917
00:34:34,190 --> 00:34:32,580
a living cell that was like when the

918
00:34:35,510 --> 00:34:34,200
milwaukeean period on Mars was you

919
00:34:37,609 --> 00:34:35,520
probably know better than me like five

920
00:34:40,369 --> 00:34:37,619
billion years ago six somebody else

921
00:34:42,409 --> 00:34:40,379
anyway Mars is older than Earth so

922
00:34:43,550 --> 00:34:42,419
that may be our limiter I don't know but

923
00:34:48,530 --> 00:34:43,560
that's crazy

924
00:34:52,849 --> 00:34:50,990
so you mentioned about the abundance of

925
00:34:53,930 --> 00:34:52,859
centrify in the Deep subsurface

926
00:34:54,889 --> 00:34:53,940
communities

927
00:34:56,210 --> 00:34:54,899
um do you think

928
00:34:57,890 --> 00:34:56,220
um are there any like interesting

929
00:34:59,329 --> 00:34:57,900
patterns in the distribution of like

930
00:35:02,930 --> 00:34:59,339
microbes that are typically associated

931
00:35:04,970 --> 00:35:02,940
with like centrify or kind of central

932
00:35:07,130 --> 00:35:04,980
communities yeah yeah

933
00:35:09,170 --> 00:35:07,140
um or is it always just nutrient

934
00:35:10,970 --> 00:35:09,180
limitation you mean like physically

935
00:35:15,349 --> 00:35:10,980
where cells sit relative to each other

936
00:35:19,069 --> 00:35:16,609
service

937
00:35:21,650 --> 00:35:19,079
yeah like do we see more Center fees in

938
00:35:22,910 --> 00:35:21,660

some areas and then others um I don't I

939
00:35:25,130 --> 00:35:22,920
don't think we have that kind of

940
00:35:26,750 --> 00:35:25,140
knowledge like that resolution like you

941
00:35:28,910 --> 00:35:26,760
could maybe do that project but I don't

942
00:35:31,069 --> 00:35:28,920
think we have that like just concluding

943
00:35:35,569 --> 00:35:31,079
centrify from like the transcription of

944
00:35:42,770 --> 00:35:35,579
some genes is already kind of sketch so

945
00:35:48,230 --> 00:35:45,770
hey hi I really like your talk so far uh

946
00:35:50,930 --> 00:35:48,240
so I I've done researching The Deep

947
00:35:51,829 --> 00:35:50,940
subsurface as well and so you had a

948
00:35:54,349 --> 00:35:51,839
slide that showed the different

949
00:35:55,910 --> 00:35:54,359
adaptations for the subsurface microbes

950
00:35:58,250 --> 00:35:55,920
and I think he mentioned that you had

951
00:36:01,730 --> 00:35:58,260
transcriptomic data genomic data yeah

952
00:36:03,050 --> 00:36:01,740
metabolism so it's a lot of data and I

953
00:36:05,150 --> 00:36:03,060
only work with

954
00:36:06,829 --> 00:36:05,160
um genomic data and already I'm so

955
00:36:09,410 --> 00:36:06,839
overwhelmed by the different things that

956
00:36:10,970 --> 00:36:09,420
I can analyze so I was just curious I

957
00:36:12,170 --> 00:36:10,980
mean I could read the paper but you're

958
00:36:14,270 --> 00:36:12,180
here now

959
00:36:16,370 --> 00:36:14,280
um How do you

960
00:36:22,190 --> 00:36:16,380
how do you

961
00:36:24,050 --> 00:36:22,200
mess of data yeah and how does it

962
00:36:26,270 --> 00:36:24,060
compare so you mentioned DNA repair

963
00:36:28,190 --> 00:36:26,280

mechanisms and all of this like how does

964
00:36:30,530 --> 00:36:28,200
that compare to the terrestrial

965
00:36:31,609 --> 00:36:30,540
counterparts yeah that's those are

966
00:36:32,750 --> 00:36:31,619
really good questions I mean I think

967
00:36:34,910 --> 00:36:32,760
this is something that we all face

968
00:36:37,550 --> 00:36:34,920
there's like in every project and I've

969
00:36:39,470 --> 00:36:37,560
seen it happen to all my students you

970
00:36:41,510 --> 00:36:39,480
work so hard to get that giant data set

971
00:36:43,250 --> 00:36:41,520
and then you get it and you're like what

972
00:36:45,050 --> 00:36:43,260
do I do with this fire hose of

973
00:36:47,150 --> 00:36:45,060
information and it's not like how you

974
00:36:48,530 --> 00:36:47,160
analyze it there's no prescribed path

975
00:36:49,730 --> 00:36:48,540
through it which I think is a wonderful

976
00:36:50,990 --> 00:36:49,740
thing because it means somebody could

977
00:36:52,370 --> 00:36:51,000
take your same data set and draw

978
00:36:54,170 --> 00:36:52,380
completely different conclusions from it

979
00:36:56,030 --> 00:36:54,180
but in the case of the stuff I was

980
00:36:57,710 --> 00:36:56,040
talking about we started with our

981
00:37:00,710 --> 00:36:57,720
smallest data set and our most valuable

982
00:37:02,270 --> 00:37:00,720
so we did metabolites which

983
00:37:04,370 --> 00:37:02,280
if you haven't worked with these this is

984
00:37:06,710 --> 00:37:04,380
like you do liquid chromatography

985
00:37:08,569 --> 00:37:06,720
coupled to mass spectrometry coupled to

986
00:37:10,670 --> 00:37:08,579
another Mass spectrometry to sort of

987
00:37:12,170 --> 00:37:10,680
spread things out and get monomers so

988
00:37:14,390 --> 00:37:12,180

you can basically get things at the

989
00:37:16,670 --> 00:37:14,400
amino as like monomeric amino acid level

990
00:37:19,130 --> 00:37:16,680
and you kind of get what you you get and

991
00:37:20,930 --> 00:37:19,140
so I I only did it because my buddy does

992
00:37:22,849 --> 00:37:20,940
this like down the hall and he was like

993
00:37:24,530 --> 00:37:22,859
let me put some of your weird samples in

994
00:37:25,910 --> 00:37:24,540
the machine and I was like that's insane

995
00:37:27,470 --> 00:37:25,920
because you're just going to get the

996
00:37:29,510 --> 00:37:27,480
organic matter that's around like the

997
00:37:31,250 --> 00:37:29,520
stuff is not necessarily connected to

998
00:37:32,329 --> 00:37:31,260
the living microbes and he's like let's

999
00:37:35,870 --> 00:37:32,339
just try it

1000
00:37:37,550 --> 00:37:35,880
and he was like it totally failed it

1001
00:37:39,290 --> 00:37:37,560
didn't work and I was like well yeah

1002
00:37:40,790 --> 00:37:39,300
nothing ever works on the subsurface it

1003
00:37:43,790 --> 00:37:40,800
doesn't surprise me but he was like I

1004
00:37:47,990 --> 00:37:43,800
only got 20 metabolites and I was like

1005
00:37:50,030 --> 00:37:48,000
20s a lot so we took our 20 and just

1006
00:37:52,849 --> 00:37:50,040
backed off of them we said okay we've

1007
00:37:54,770 --> 00:37:52,859
got nicotinate and I I was like what in

1008
00:37:56,150 --> 00:37:54,780
the world is like I Googled it I was

1009
00:37:57,650 --> 00:37:56,160
like what is this and what is it used

1010
00:38:00,349 --> 00:37:57,660
for and it's like oh it's a precursor to

1011
00:38:02,630 --> 00:38:00,359
NAD and then we also had quinlanate it's

1012
00:38:05,870 --> 00:38:02,640
like never heard of that organ of that

1013
00:38:07,250 --> 00:38:05,880

that compound before and it's also an

1014
00:38:09,109 --> 00:38:07,260
intermediate in the pathway for the

1015
00:38:10,550 --> 00:38:09,119
creation of NAD and so then because we

1016
00:38:12,950 --> 00:38:10,560
had the transcripts we were able to say

1017
00:38:15,349 --> 00:38:12,960
who is producing the biosynthetic

1018
00:38:18,349 --> 00:38:15,359
pathways for these molecules that we see

1019
00:38:20,450 --> 00:38:18,359
and so that was a nice way to do a data

1020
00:38:22,970 --> 00:38:20,460
reduction those may not be the most

1021
00:38:25,069 --> 00:38:22,980
important stories in those ecosystems in

1022
00:38:26,630 --> 00:38:25,079
fact they probably are not right like we

1023
00:38:28,069 --> 00:38:26,640
probably missed the biggest story that's

1024
00:38:30,170 --> 00:38:28,079
there

1025
00:38:31,550 --> 00:38:30,180
but that was just the one we found I

1026
00:38:35,270 --> 00:38:31,560
don't know if that's helpful that's

1027
00:38:36,530 --> 00:38:35,280
super helpful metabolomics are great it

1028
00:38:38,030 --> 00:38:36,540
can be great they can be confusing too

1029
00:38:39,829 --> 00:38:38,040
but but it's also like when you're

1030
00:38:41,270 --> 00:38:39,839
dealing with a gigantic data set like I

1031
00:38:42,950 --> 00:38:41,280
guess just don't worry about getting the

1032
00:38:45,230 --> 00:38:42,960
perfect story like if you can find that

1033
00:38:46,849 --> 00:38:45,240
it says something like run with it

1034
00:38:47,589 --> 00:38:46,859
and publish it so we can know about it

1035
00:38:52,430 --> 00:38:47,599
too

1036
00:38:56,450 --> 00:38:54,349
[Music]

1037
00:38:58,730 --> 00:38:56,460
um hi thank you for your talk I you talk

1038
00:39:00,349 --> 00:38:58,740

about the these cells that live for

1039
00:39:01,730 --> 00:39:00,359
hundreds of thousands of years or like

1040
00:39:05,210 --> 00:39:01,740
millions of years of billions of years

1041
00:39:06,950 --> 00:39:05,220
but maybe philosophically speaking what

1042
00:39:09,589 --> 00:39:06,960
do you consider to be an individual like

1043
00:39:12,710 --> 00:39:09,599
when all the Bible is kind of re like

1044
00:39:14,930 --> 00:39:12,720
you know like we

1045
00:39:15,950 --> 00:39:14,940
regenerate the original recycles thank

1046
00:39:17,390 --> 00:39:15,960
you

1047
00:39:19,609 --> 00:39:17,400
um is that still the same individual

1048
00:39:21,530 --> 00:39:19,619
like how do you work around that yeah I

1049
00:39:22,970 --> 00:39:21,540
don't know I mean I guess that is a

1050
00:39:25,190 --> 00:39:22,980
truly philosophical question there's

1051
00:39:27,230 --> 00:39:25,200
like the philosophical point about like

1052
00:39:28,970 --> 00:39:27,240
my grandfather's ax

1053
00:39:30,349 --> 00:39:28,980
do you know about my grandfather's acts

1054
00:39:32,030 --> 00:39:30,359
there's something in like this is my

1055
00:39:33,950 --> 00:39:32,040
grandfather's ax it's you know he had it

1056
00:39:35,630 --> 00:39:33,960
and it's like well the I replaced the

1057
00:39:36,890 --> 00:39:35,640
blade a little while ago well I replaced

1058
00:39:38,690 --> 00:39:36,900
the handle a little while ago I replace

1059
00:39:40,550 --> 00:39:38,700
the like the leather strapping on it

1060
00:39:42,890 --> 00:39:40,560
it's like okay no molecule of that ax

1061
00:39:44,690 --> 00:39:42,900
was ever held by your grandfather but

1062
00:39:46,430 --> 00:39:44,700
it's my grandfather's ax so then that

1063
00:39:47,690 --> 00:39:46,440

that's a purely philosophical question

1064
00:39:49,069 --> 00:39:47,700
but I think there's a second

1065
00:39:50,810 --> 00:39:49,079
philosophical question which I find

1066
00:39:53,030 --> 00:39:50,820
interesting which is what is an

1067
00:39:54,470 --> 00:39:53,040
individual which is what you said first

1068
00:39:57,530 --> 00:39:54,480
which is like

1069
00:39:59,150 --> 00:39:57,540
when we talk about microbes we tend to

1070
00:40:00,710 --> 00:39:59,160
talk about the individual as a

1071
00:40:02,990 --> 00:40:00,720
collection of cells we talk about a

1072
00:40:04,870 --> 00:40:03,000
strain you know we don't talk about a

1073
00:40:08,329 --> 00:40:04,880
cell like an individual cell is

1074
00:40:10,010 --> 00:40:08,339
pointless in in real normal microbiology

1075
00:40:12,829 --> 00:40:10,020
because they're constantly regenerating

1076
00:40:14,690 --> 00:40:12,839
and we have cell lines and stuff but in

1077
00:40:17,210 --> 00:40:14,700
this environment where you can't have a

1078
00:40:18,829 --> 00:40:17,220
cell line suddenly the individual takes

1079
00:40:21,230 --> 00:40:18,839
on great importance

1080
00:40:23,750 --> 00:40:21,240
this is almost akin to like our lives

1081
00:40:25,910 --> 00:40:23,760
like we care about an individual dying

1082
00:40:28,310 --> 00:40:25,920
and we don't care about a cell of a

1083
00:40:30,010 --> 00:40:28,320
microbe dying ever makes research a lot

1084
00:40:34,550 --> 00:40:30,020
easier

1085
00:40:40,390 --> 00:40:38,089
should I continue okay if you're bored

1086
00:40:43,130 --> 00:40:40,400
take a nap

1087
00:40:44,810 --> 00:40:43,140
it's warm in here I gave a talk once on

1088
00:40:46,849 --> 00:40:44,820

a ship and everybody fell asleep it

1089
00:40:48,290 --> 00:40:46,859
actually happened it was nice they

1090
00:40:51,170 --> 00:40:48,300
looked very comfortable so I just kept

1091
00:40:57,050 --> 00:40:55,250
so now that we know that we've got all

1092
00:40:58,450 --> 00:40:57,060
this weird stuff down there

1093
00:41:01,490 --> 00:40:58,460
um

1094
00:41:03,230 --> 00:41:01,500
how you know how can you sustain a

1095
00:41:04,550 --> 00:41:03,240
subsurface biosphere we know that there

1096
00:41:06,770 --> 00:41:04,560
aren't a bunch of plants at the surface

1097
00:41:08,770 --> 00:41:06,780
of these other planetary bodies but can

1098
00:41:11,150 --> 00:41:08,780
we work on this planet where we are

1099
00:41:13,370 --> 00:41:11,160
blessed with all these wonderful plants

1100
00:41:15,950 --> 00:41:13,380
up here and find things that are

1101
00:41:17,870 --> 00:41:15,960
independent of that dominant signal and

1102
00:41:19,849 --> 00:41:17,880
so one this isn't the only way to go

1103
00:41:21,170 --> 00:41:19,859
about this hopefully you're a room full

1104
00:41:23,450 --> 00:41:21,180
of people who will find other ways to

1105
00:41:25,609 --> 00:41:23,460
answer this question too but

1106
00:41:27,050 --> 00:41:25,619
um one way that my colleagues and I

1107
00:41:29,390 --> 00:41:27,060
thought of doing this is to go to a

1108
00:41:32,270 --> 00:41:29,400
subduction zone which are fascinating

1109
00:41:34,490 --> 00:41:32,280
geological places because in the case of

1110
00:41:36,589 --> 00:41:34,500
an ocean Continental subduction zone you

1111
00:41:39,050 --> 00:41:36,599
have an oceanic tectonic plate that

1112
00:41:41,630 --> 00:41:39,060
basically just gets shoved very slowly

1113
00:41:43,730 --> 00:41:41,640

into a continental tectonic plate an

1114
00:41:45,530 --> 00:41:43,740
oceanic plate is just denser than

1115
00:41:47,210 --> 00:41:45,540
continental plate so it sinks and it

1116
00:41:49,069 --> 00:41:47,220
goes down and this is one of the major

1117
00:41:51,770 --> 00:41:49,079
ways that we get recycling between the

1118
00:41:53,089 --> 00:41:51,780
deep Earth and the surface Earth but

1119
00:41:54,890 --> 00:41:53,099
what also happens

1120
00:41:57,410 --> 00:41:54,900
is that you get this build up this

1121
00:41:59,870 --> 00:41:57,420
bunching up in the forearch so this is

1122
00:42:02,630 --> 00:41:59,880
the ocean plate going down that pushes

1123
00:42:05,930 --> 00:42:02,640
water out of all these areas and if you

1124
00:42:07,670 --> 00:42:05,940
draw this 150 degrees C isotherm which

1125
00:42:09,170 --> 00:42:07,680
is kind of the limit of Life although I

1126
00:42:11,210 --> 00:42:09,180
definitely won't say that because it

1127
00:42:12,589 --> 00:42:11,220
could be much higher but currently you

1128
00:42:14,870 --> 00:42:12,599
know we think that it life has to be

1129
00:42:17,089 --> 00:42:14,880
under this value there's actually a lot

1130
00:42:19,250 --> 00:42:17,099
of real estate in here that's probably

1131
00:42:22,609 --> 00:42:19,260
getting fleshed out passively by these

1132
00:42:25,010 --> 00:42:22,619
hot springs and um so we thought you

1133
00:42:26,990 --> 00:42:25,020
know it'd be nice to drill 10 million

1134
00:42:29,329 --> 00:42:27,000
dollar boreholes all the way across this

1135
00:42:31,010 --> 00:42:29,339
entire thing but there is literally no

1136
00:42:32,630 --> 00:42:31,020
one who will ever fund me to do that and

1137
00:42:35,750 --> 00:42:32,640
also I don't want to get a permit to

1138
00:42:37,550 --> 00:42:35,760

drill holes all over Costa Rica so we

1139
00:42:41,270 --> 00:42:37,560
use these Hot Springs as like passive

1140
00:42:42,890 --> 00:42:41,280
sampling ports and um this is uh the

1141
00:42:44,450 --> 00:42:42,900
most interdisciplinary collaborative

1142
00:42:46,730 --> 00:42:44,460
group of people that I possibly work

1143
00:42:48,770 --> 00:42:46,740
with and this is not everybody who's

1144
00:42:50,990 --> 00:42:48,780
involved but I just want to thank them

1145
00:42:54,109 --> 00:42:51,000
up front uh originally these are my lab

1146
00:42:56,329 --> 00:42:54,119
crew TJ Rogers is going to turn in his

1147
00:42:58,569 --> 00:42:56,339
dissertation in a week and a half he is

1148
00:43:00,890 --> 00:42:58,579
texting me constantly

1149
00:43:03,050 --> 00:43:00,900
he's doing great he's gonna pull through

1150
00:43:05,030 --> 00:43:03,060
[Laughter]

1151
00:43:06,650 --> 00:43:05,040
um and enjoys finished up and and Kate

1152
00:43:08,750 --> 00:43:06,660
uh did her Masters and she did wonderful

1153
00:43:10,309 --> 00:43:08,760
work on this and then we had um all

1154
00:43:12,290 --> 00:43:10,319
these International collaborators from

1155
00:43:13,609 --> 00:43:12,300
all over the place um some of whom y'all

1156
00:43:15,230 --> 00:43:13,619
probably know

1157
00:43:15,890 --> 00:43:15,240
um including lots of people in Costa

1158
00:43:17,750 --> 00:43:15,900
Rica

1159
00:43:19,190 --> 00:43:17,760
um because that is where science has to

1160
00:43:21,050 --> 00:43:19,200
come from when you're doing work on you

1161
00:43:22,970 --> 00:43:21,060
know I started out in oceanography and

1162
00:43:25,130 --> 00:43:22,980
you just go to oceans and drop things in

1163
00:43:26,990 --> 00:43:25,140

them because it's all big oceans but

1164
00:43:28,490 --> 00:43:27,000
when you're working on land you do not

1165
00:43:30,170 --> 00:43:28,500
go in a country that is not your country

1166
00:43:32,690 --> 00:43:30,180
and take samples which I'm sure you all

1167
00:43:34,730 --> 00:43:32,700
know but um it's not just is it morally

1168
00:43:36,109 --> 00:43:34,740
wrong but you miss um the local

1169
00:43:37,849 --> 00:43:36,119
knowledge you miss the understanding of

1170
00:43:39,950 --> 00:43:37,859
what's actually happening there so this

1171
00:43:42,950 --> 00:43:39,960
is driven largely by my colleagues in

1172
00:43:44,569 --> 00:43:42,960
Costa Rica so we sampled this is pretty

1173
00:43:46,849 --> 00:43:44,579
much the whole

1174
00:43:48,770 --> 00:43:46,859
um country of Costa Rica so you can see

1175
00:43:50,990 --> 00:43:48,780
we covered some pretty good ground this

1176
00:43:52,910 --> 00:43:51,000
is their line of volcanoes volcanoes pop

1177
00:43:55,430 --> 00:43:52,920
up because this down going plate

1178
00:43:56,750 --> 00:43:55,440
basically runs into mantle and all the

1179
00:43:59,210 --> 00:43:56,760
water that on this down going plate

1180
00:44:00,710 --> 00:43:59,220
exaltvates the mantle and makes it sort

1181
00:44:01,790 --> 00:44:00,720
of have this runaway liquidification

1182
00:44:03,890 --> 00:44:01,800
that

1183
00:44:06,650 --> 00:44:03,900
shows up in volcanoes

1184
00:44:09,050 --> 00:44:06,660
and our d our idea was to sample all

1185
00:44:10,730 --> 00:44:09,060
these red dots or hot springs and see if

1186
00:44:12,530 --> 00:44:10,740
we could get a difference in the

1187
00:44:15,230 --> 00:44:12,540
progression of the subsurface biosphere

1188
00:44:17,390 --> 00:44:15,240

as it moves from early subduction into

1189
00:44:18,829 --> 00:44:17,400
the volcanoes and late subduction and

1190
00:44:19,910 --> 00:44:18,839
just to show you what some of the sites

1191
00:44:23,750 --> 00:44:19,920
looked like

1192
00:44:27,829 --> 00:44:26,510
Spanish speakers I apologize I'm trying

1193
00:44:31,550 --> 00:44:27,839
to learn a language and I'm really bad

1194
00:44:34,670 --> 00:44:31,560
at it but there was all this uh iron uh

1195
00:44:36,290 --> 00:44:34,680
oxidate uh iron ferry hydroxides that

1196
00:44:38,390 --> 00:44:36,300
were produced from these subsurface

1197
00:44:40,190 --> 00:44:38,400
microbes so we're sampling gases there's

1198
00:44:42,230 --> 00:44:40,200
gases bubbling out of here but it's at

1199
00:44:44,210 --> 00:44:42,240
the edge of a river so we're fighting

1200
00:44:46,089 --> 00:44:44,220
the surface stuff all the time

1201
00:44:48,710 --> 00:44:46,099
um some of the samples look like this

1202
00:44:51,589 --> 00:44:48,720
boiling mud pots so this is looking

1203
00:44:53,210 --> 00:44:51,599
quite inhospitable for science

1204
00:44:54,950 --> 00:44:53,220
whatever I don't have to point to that

1205
00:44:56,990 --> 00:44:54,960
it's in the picture

1206
00:44:59,630 --> 00:44:57,000
um and some of them were in the middle

1207
00:45:01,730 --> 00:44:59,640
of volcanoes so this is pois volcano

1208
00:45:06,109 --> 00:45:01,740
which is um this Caldera you can tell

1209
00:45:08,270 --> 00:45:06,119
that it erupts a lot obviously because

1210
00:45:10,430 --> 00:45:08,280
okay you see Department there are trees

1211
00:45:13,130 --> 00:45:10,440
right I don't have to laser point to it

1212
00:45:15,290 --> 00:45:13,140
oh I can point like this all around this

1213
00:45:17,150 --> 00:45:15,300

this Central so this right here this eye

1214
00:45:19,130 --> 00:45:17,160
of it is basically the throat of the

1215
00:45:20,569 --> 00:45:19,140
volcano this is the part where um the

1216
00:45:22,190 --> 00:45:20,579
eruptions start

1217
00:45:24,650 --> 00:45:22,200
um and you can see that it erupts a lot

1218
00:45:25,910 --> 00:45:24,660
because the plants would love to use all

1219
00:45:27,650 --> 00:45:25,920
this good iron

1220
00:45:29,510 --> 00:45:27,660
um but they can't because every time

1221
00:45:31,370 --> 00:45:29,520
they get in there they get blown up

1222
00:45:34,250 --> 00:45:31,380
um so this is me sampling next to this

1223
00:45:36,710 --> 00:45:34,260
Lake I am so this is Donato he's reading

1224
00:45:39,650 --> 00:45:36,720
the numbers out to me and it was 0.85 pH

1225
00:45:42,050 --> 00:45:39,660
this is very very acidic um basically

1226
00:45:44,510 --> 00:45:42,060
sulfuric acid then you can see the fumes

1227
00:45:45,950 --> 00:45:44,520
this is a very uncomfortable picture the

1228
00:45:49,250 --> 00:45:45,960
ground is

1229
00:45:52,670 --> 00:45:49,260
um 100 degrees Celsius and it's really

1230
00:45:55,910 --> 00:45:52,680
like bad Rock so if you slip you fall

1231
00:45:57,589 --> 00:45:55,920
into a battery acid lake so but the most

1232
00:45:58,670 --> 00:45:57,599
dangerous things about volcanoes is

1233
00:45:59,470 --> 00:45:58,680
about

1234
00:46:03,530 --> 00:45:59,480
um

1235
00:46:07,270 --> 00:46:03,540
54 56 days after we were in it

1236
00:46:11,990 --> 00:46:09,710
so that you can see the shore of where I

1237
00:46:14,329 --> 00:46:12,000
was it was like right there

1238
00:46:15,950 --> 00:46:14,339

and you can look as it continues

1239
00:46:17,690 --> 00:46:15,960
erupting it's not like it just blows up

1240
00:46:19,910 --> 00:46:17,700
once you can see this stuff kind of

1241
00:46:21,950 --> 00:46:19,920
shooting out here again you should be

1242
00:46:23,089 --> 00:46:21,960
able to see it and it's like if that

1243
00:46:25,250 --> 00:46:23,099
happened while you were there there's

1244
00:46:28,309 --> 00:46:25,260
some more if that happened while you're

1245
00:46:31,010 --> 00:46:28,319
there it's like you would go up and down

1246
00:46:33,410 --> 00:46:31,020
then you go up again then you get a

1247
00:46:35,390 --> 00:46:33,420
bunch of rocks on your head

1248
00:46:38,329 --> 00:46:35,400
it would be very bad

1249
00:46:39,829 --> 00:46:38,339
um my colleague one of my colleagues um

1250
00:46:42,770 --> 00:46:39,839
one of my

1251
00:46:45,109 --> 00:46:42,780
worst decision-making colleagues send us

1252
00:46:47,690 --> 00:46:45,119
videos from that Creator the day before

1253
00:46:50,329 --> 00:46:47,700
this and it was like the ground was like

1254
00:46:52,609 --> 00:46:50,339
popping in front of him oh

1255
00:46:55,270 --> 00:46:52,619
he's not I got other colleagues who are

1256
00:46:59,210 --> 00:46:58,010
he's I worry about I worry about that

1257
00:46:59,990 --> 00:46:59,220
guy

1258
00:47:02,210 --> 00:47:00,000
um

1259
00:47:03,890 --> 00:47:02,220
but you know it's fun to go in these

1260
00:47:05,510 --> 00:47:03,900
dangerous places but we also have to

1261
00:47:07,370 --> 00:47:05,520
mitigate our danger I don't know I I've

1262
00:47:09,530 --> 00:47:07,380
got kids I don't I don't do this stuff

1263
00:47:11,270 --> 00:47:09,540

if it had been nasty like that I would

1264
00:47:12,230 --> 00:47:11,280
not have gone in any time around this

1265
00:47:14,290 --> 00:47:12,240
area

1266
00:47:17,150 --> 00:47:14,300
um I just went in because it was such a

1267
00:47:19,309 --> 00:47:17,160
calm time but um

1268
00:47:21,349 --> 00:47:19,319
field work does doesn't involve some

1269
00:47:23,750 --> 00:47:21,359
risks so

1270
00:47:25,849 --> 00:47:23,760
um the way we think about the subsurface

1271
00:47:27,410 --> 00:47:25,859
when we get these semi-dangerous samples

1272
00:47:29,150 --> 00:47:27,420
is

1273
00:47:31,069 --> 00:47:29,160
we don't know how deep we're getting

1274
00:47:32,270 --> 00:47:31,079
them from we are going we are driving

1275
00:47:33,829 --> 00:47:32,280
all over this country and we are

1276
00:47:35,990 --> 00:47:33,839
sampling tons and tons of Hot Springs

1277
00:47:37,370 --> 00:47:36,000
they're in people's backyards it's the

1278
00:47:38,930 --> 00:47:37,380
coolest thing we like walk up to people

1279
00:47:40,069 --> 00:47:38,940
who are like hey and they recognize my

1280
00:47:41,390 --> 00:47:40,079
colleagues from TV because they talk

1281
00:47:42,650 --> 00:47:41,400
about volcanoes a lot and we're like can

1282
00:47:47,270 --> 00:47:42,660
we sample your hot springs they're like

1283
00:47:48,290 --> 00:47:47,280
absolutely so we um uh we sample this

1284
00:47:50,390 --> 00:47:48,300
stuff and we don't know how deep it's

1285
00:47:52,490 --> 00:47:50,400
coming from so one of the things we want

1286
00:47:53,329 --> 00:47:52,500
to know is how do we blank out all this

1287
00:47:58,849 --> 00:47:53,339
crap

1288
00:48:01,370 --> 00:47:58,859

don't want to study so all of the

1289
00:48:02,809 --> 00:48:01,380
dissolved organic carbon has a carbon

1290
00:48:04,730 --> 00:48:02,819
isotope I'm not going to explain what

1291
00:48:06,410 --> 00:48:04,740
they are some of you know intimately

1292
00:48:08,270 --> 00:48:06,420
about carbon Isotopes and the other

1293
00:48:10,370 --> 00:48:08,280
two-thirds of you are like I don't know

1294
00:48:13,370 --> 00:48:10,380
what this is but that's okay just know

1295
00:48:15,109 --> 00:48:13,380
that this value ranges everything up

1296
00:48:18,050 --> 00:48:15,119
here at the surface ranges from minus 23

1297
00:48:20,569 --> 00:48:18,060
to minus 30. and our inorganic carbon so

1298
00:48:22,250 --> 00:48:20,579
this is carbon dioxide is like zero-ish

1299
00:48:23,569 --> 00:48:22,260
and this should be the similar in all

1300
00:48:25,910 --> 00:48:23,579
Springs

1301
00:48:27,890 --> 00:48:25,920
so when we measured these things the DIC

1302
00:48:29,510 --> 00:48:27,900
which at the

1303
00:48:32,450 --> 00:48:29,520
um for atmosphere should be sort of

1304
00:48:34,550 --> 00:48:32,460
around here-ish it got quite negative it

1305
00:48:37,010 --> 00:48:34,560
got quite light and it had this pattern

1306
00:48:39,410 --> 00:48:37,020
with its concentration and that was sort

1307
00:48:41,630 --> 00:48:39,420
of intriguing to us and so my colleagues

1308
00:48:42,890 --> 00:48:41,640
who are gastiochemists looked at this

1309
00:48:44,809 --> 00:48:42,900
and they said oh my God this is a

1310
00:48:47,569 --> 00:48:44,819
Rayleigh distillation

1311
00:48:49,670 --> 00:48:47,579
um this is what happens with Isotopes f

1312
00:48:52,550 --> 00:48:49,680
is the reaction extent so this is like

1313
00:48:55,130 --> 00:48:52,560

how far the reaction has progressed is

1314
00:48:56,930 --> 00:48:55,140
you have the reaction happening in an

1315
00:48:58,490 --> 00:48:56,940
open system so that the Isotopes can be

1316
00:49:01,130 --> 00:48:58,500
removed and there's a fractionation of

1317
00:49:03,770 --> 00:49:01,140
of the Isotopes as as this progresses

1318
00:49:06,890 --> 00:49:03,780
you get this extreme push of the

1319
00:49:10,010 --> 00:49:06,900
fraction of the Del C13 of the values

1320
00:49:11,990 --> 00:49:10,020
and so they modeled this stuff and found

1321
00:49:13,970 --> 00:49:12,000
that actually this was a Rayleigh

1322
00:49:16,609 --> 00:49:13,980
fractionation

1323
00:49:18,890 --> 00:49:16,619
um that uh differed between early and

1324
00:49:20,809 --> 00:49:18,900
subduction closer to the volcanoes and

1325
00:49:23,030 --> 00:49:20,819
in the volcanoes and these are the

1326
00:49:25,130 --> 00:49:23,040
volcanic gases themselves so the offset

1327
00:49:27,410 --> 00:49:25,140
between this end member and the volcanic

1328
00:49:28,910 --> 00:49:27,420
gases was basically showed that this

1329
00:49:31,370 --> 00:49:28,920
stuff was entirely

1330
00:49:33,109 --> 00:49:31,380
um from from Deep gases this was not

1331
00:49:34,130 --> 00:49:33,119
carbon dioxide from the atmosphere at

1332
00:49:37,069 --> 00:49:34,140
all

1333
00:49:38,930 --> 00:49:37,079
um so I don't know if you have ever done

1334
00:49:40,609 --> 00:49:38,940
this with your data sets um you might

1335
00:49:43,190 --> 00:49:40,619
call it P hacking but I don't want to

1336
00:49:44,510 --> 00:49:43,200
call it that we don't do that in jail I

1337
00:49:46,010 --> 00:49:44,520
don't I swear that's like just the

1338
00:49:48,650 --> 00:49:46,020

medical thing I think we shouldn't limit

1339
00:49:51,710 --> 00:49:48,660
ourselves does anybody see two little

1340
00:49:54,109 --> 00:49:51,720
rainbows right there do you see two like

1341
00:49:55,970 --> 00:49:54,119
I got this data set and I was like I

1342
00:49:57,109 --> 00:49:55,980
swear there's two of them and I was like

1343
00:49:58,910 --> 00:49:57,119
but I shouldn't do that because that's

1344
00:50:00,950 --> 00:49:58,920
reading too much into my data

1345
00:50:02,210 --> 00:50:00,960
but I stared at it for long enough and I

1346
00:50:04,670 --> 00:50:02,220
finally figured out what was driving

1347
00:50:06,530 --> 00:50:04,680
those two if you divide them and you say

1348
00:50:07,970 --> 00:50:06,540
okay this one's on the top curve and I'm

1349
00:50:09,290 --> 00:50:07,980
making it blue and that one's on the

1350
00:50:11,870 --> 00:50:09,300
bottom curve and I'm making it orange

1351
00:50:13,550 --> 00:50:11,880
and I tried to figure out are they

1352
00:50:16,069 --> 00:50:13,560
different temperatures were they

1353
00:50:18,230 --> 00:50:16,079
different ph's none of it nothing was

1354
00:50:19,130 --> 00:50:18,240
making sense and then I put them on a

1355
00:50:22,490 --> 00:50:19,140
map

1356
00:50:24,230 --> 00:50:22,500
and they fall down a line and I was

1357
00:50:27,349 --> 00:50:24,240
giving this talk the Carnegie Institute

1358
00:50:30,290 --> 00:50:27,359
in DC before we published this paper and

1359
00:50:32,809 --> 00:50:30,300
I said yeah and we have no idea for some

1360
00:50:34,130 --> 00:50:32,819
reason everything up there is on the

1361
00:50:36,109 --> 00:50:34,140
upper line and everything down here is

1362
00:50:38,390 --> 00:50:36,119
on the lower line but it's real because

1363
00:50:39,349 --> 00:50:38,400

it's not randomly distributed and I

1364
00:50:41,930 --> 00:50:39,359
don't know maybe there's something out

1365
00:50:43,309 --> 00:50:41,940
here in this geophysicist like ran up to

1366
00:50:45,349 --> 00:50:43,319
me after the talk and who is like

1367
00:50:47,210 --> 00:50:45,359
there's a plate boundary that divides

1368
00:50:48,650 --> 00:50:47,220
those two samples and he just knew

1369
00:50:50,510 --> 00:50:48,660
because he knew the plates really well

1370
00:50:52,970 --> 00:50:50,520
and so this is

1371
00:50:55,190 --> 00:50:52,980
the East Pacific Rise and the Cocos

1372
00:50:57,890 --> 00:50:55,200
Nazca spreading Center originating

1373
00:51:00,290 --> 00:50:57,900
things so basically this me this means

1374
00:51:02,809 --> 00:51:00,300
that the stuff we're getting coming out

1375
00:51:04,549 --> 00:51:02,819
of these Hot Springs like literally next

1376
00:51:07,250 --> 00:51:04,559
to two cans and monkeys like driving

1377
00:51:11,210 --> 00:51:07,260
around like sipping pina coladas all

1378
00:51:13,670 --> 00:51:11,220
over Costa Rica is so connected to this

1379
00:51:15,710 --> 00:51:13,680
stuff that is subducting offshore that

1380
00:51:17,210 --> 00:51:15,720
we can see the isotopic difference in

1381
00:51:20,569 --> 00:51:17,220
the carbon that's coming in from these

1382
00:51:23,210 --> 00:51:20,579
down going slabs which is gives us great

1383
00:51:24,349 --> 00:51:23,220
power to say that yeah this stuff is

1384
00:51:26,390 --> 00:51:24,359
deep subsurface this is actually

1385
00:51:28,970 --> 00:51:26,400
connected to this stuff

1386
00:51:30,829 --> 00:51:28,980
um so so now how do we use this power we

1387
00:51:32,450 --> 00:51:30,839
know all this carbon this inorganic

1388
00:51:34,609 --> 00:51:32,460

carbon which is the starting point for

1389
00:51:36,530 --> 00:51:34,619
chemosynthesis we know all this stuff is

1390
00:51:38,870 --> 00:51:36,540
coming from the deep Earth how do we

1391
00:51:41,150 --> 00:51:38,880
show that the microbes are turning it

1392
00:51:42,950 --> 00:51:41,160
into to life are they just using the the

1393
00:51:45,890 --> 00:51:42,960
plants and and cow poop and stuff like

1394
00:51:46,609 --> 00:51:45,900
that so now if we put in the organic

1395
00:51:49,670 --> 00:51:46,619
matter

1396
00:51:51,950 --> 00:51:49,680
and put it on the same plot the Del C 13

1397
00:51:54,589 --> 00:51:51,960
of the organic matter we see it follows

1398
00:51:57,290 --> 00:51:54,599
along the same line and it's always

1399
00:52:00,410 --> 00:51:57,300
offset from what the inorganic carbon

1400
00:52:01,670 --> 00:52:00,420
were and the value of that offset is

1401
00:52:03,890 --> 00:52:01,680
roughly the fractionation that we would

1402
00:52:06,829 --> 00:52:03,900
expect to see if it was all being made

1403
00:52:08,990 --> 00:52:06,839
by chemosynthesizers in situ and so for

1404
00:52:12,230 --> 00:52:09,000
this reason we were able to conclude

1405
00:52:16,790 --> 00:52:14,690
all you can never say all pretty much

1406
00:52:18,770 --> 00:52:16,800
everything that's living there seems to

1407
00:52:20,750 --> 00:52:18,780
be made from the chemicals that are

1408
00:52:22,609 --> 00:52:20,760
there from the deep Earth so this is a

1409
00:52:24,109 --> 00:52:22,619
despite all the jungles despite this

1410
00:52:25,730 --> 00:52:24,119
huge surface signal we're getting

1411
00:52:27,829 --> 00:52:25,740
something that's truly in the subsurface

1412
00:52:29,510 --> 00:52:27,839
and it's only from there and we have a

1413
00:52:32,089 --> 00:52:29,520

positive control because it's nice to

1414
00:52:34,430 --> 00:52:32,099
have those can we control for Jungle

1415
00:52:35,990 --> 00:52:34,440
Farm surface world and yes we can we

1416
00:52:38,630 --> 00:52:36,000
scooped up sediments where we were

1417
00:52:41,030 --> 00:52:38,640
across the Ark in the same places and

1418
00:52:43,609 --> 00:52:41,040
there the carbon is photosynthetic so we

1419
00:52:44,390 --> 00:52:43,619
can see the photosynthetic stuff there

1420
00:52:45,950 --> 00:52:44,400
um

1421
00:52:53,569 --> 00:52:45,960
so

1422
00:52:56,030 --> 00:52:53,579
to say that this subsurface of the

1423
00:52:58,309 --> 00:52:56,040
subduction zone is dominated by

1424
00:52:59,630 --> 00:52:58,319
chemosynthesis of chemicals so this is

1425
00:53:01,250 --> 00:52:59,640
something that could be happening on

1426
00:53:03,349 --> 00:53:01,260
another planet that has no

1427
00:53:06,410 --> 00:53:03,359
photosynthesis at all

1428
00:53:08,530 --> 00:53:06,420
um and now we're at 60 minutes

1429
00:53:12,109 --> 00:53:08,540
and I have meta genomes to talk about

1430
00:53:15,470 --> 00:53:12,119
[Laughter]

1431
00:53:17,930 --> 00:53:15,480
welcome do you guys want to

1432
00:53:19,309 --> 00:53:17,940
do you know what a metagenome is

1433
00:53:21,829 --> 00:53:19,319
wait raise your hand if you know what a

1434
00:53:24,589 --> 00:53:21,839
metagenome is oh my God it's so many

1435
00:53:26,569 --> 00:53:24,599
people it's beautiful is that like does

1436
00:53:27,710 --> 00:53:26,579
it make you want to cry thinking about

1437
00:53:29,990 --> 00:53:27,720
yeah

1438
00:53:31,730 --> 00:53:30,000

there's a lot of pain for those of you

1439
00:53:34,309 --> 00:53:31,740
who didn't raise your hands metagenomes

1440
00:53:36,890 --> 00:53:34,319
are all the DNA in a sample like all of

1441
00:53:38,690 --> 00:53:36,900
it just sequence it so what you get is

1442
00:53:40,670 --> 00:53:38,700
this like garbled mess of every Gene

1443
00:53:42,829 --> 00:53:40,680
from every organism doing God knows what

1444
00:53:45,109 --> 00:53:42,839
and so one thing we do with them is that

1445
00:53:47,089 --> 00:53:45,119
we can knit them back together through

1446
00:53:49,549 --> 00:53:47,099
the magic of bioinformatics and I'm not

1447
00:53:51,589 --> 00:53:49,559
going to tell you how but I will if you

1448
00:53:53,510 --> 00:53:51,599
want to know not right now nobody wants

1449
00:53:55,730 --> 00:53:53,520
to hear that but I did not think this

1450
00:53:56,990 --> 00:53:55,740
could be done at all but now it can and

1451
00:53:59,809 --> 00:53:57,000
it can be done so well that I actually

1452
00:54:02,030 --> 00:53:59,819
use it and what this does is it gives

1453
00:54:03,710 --> 00:54:02,040
you genomes basically you can get like a

1454
00:54:08,630 --> 00:54:03,720
whole genome and say what a thing can be

1455
00:54:10,010 --> 00:54:08,640
doing so my student TJ caught 403 of

1456
00:54:13,010 --> 00:54:10,020
these things that were pretty complete

1457
00:54:15,530 --> 00:54:13,020
and so now

1458
00:54:17,870 --> 00:54:15,540
think about what you do all right you've

1459
00:54:20,270 --> 00:54:17,880
got like 20 samples across Costa Rica

1460
00:54:23,630 --> 00:54:20,280
you know they're something special

1461
00:54:26,210 --> 00:54:23,640
they're not a bunch of cow poop so

1462
00:54:27,530 --> 00:54:26,220
now you have 400 mags and you can figure

1463
00:54:28,910 --> 00:54:27,540

out their distribution because you can

1464
00:54:30,049 --> 00:54:28,920
recruit those reads I know some of y'all

1465
00:54:31,130 --> 00:54:30,059
know what that means but basically you

1466
00:54:32,690 --> 00:54:31,140
can see

1467
00:54:34,609 --> 00:54:32,700
um the prevalence of each of those mags

1468
00:54:36,530 --> 00:54:34,619
and all these data sets how do you

1469
00:54:38,390 --> 00:54:36,540
visualize that data how do you deal that

1470
00:54:40,430 --> 00:54:38,400
fire hose you know like

1471
00:54:41,930 --> 00:54:40,440
so anyway what we thought of to do which

1472
00:54:44,390 --> 00:54:41,940
may not be the only thing is to make a

1473
00:54:46,309 --> 00:54:44,400
heat map I love making heat Maps just

1474
00:54:49,190 --> 00:54:46,319
show you like what the color of it shows

1475
00:54:50,690 --> 00:54:49,200
you how much of it is there and this is

1476
00:54:52,790 --> 00:54:50,700
what part of it looks like this is a

1477
00:54:56,450 --> 00:54:52,800
third of this heat map and what this is

1478
00:54:58,190 --> 00:54:56,460
is each column running vertically here

1479
00:55:02,089 --> 00:54:58,200
is a hot spring

1480
00:55:06,170 --> 00:55:02,099
and every row is a microbe and so if

1481
00:55:08,630 --> 00:55:06,180
it's yellow here then that microbe was

1482
00:55:11,569 --> 00:55:08,640
present in that hot spring so look at

1483
00:55:14,150 --> 00:55:11,579
that big black part right there this is

1484
00:55:17,030 --> 00:55:14,160
a whole slew of hot springs that did not

1485
00:55:19,069 --> 00:55:17,040
have those microbes present at all and

1486
00:55:20,690 --> 00:55:19,079
so we we organized it I mean we this

1487
00:55:22,069 --> 00:55:20,700
isn't just randomly distributed we said

1488
00:55:24,410 --> 00:55:22,079

put things together that have more

1489
00:55:26,510 --> 00:55:24,420
similar distributions and what we were

1490
00:55:29,329 --> 00:55:26,520
really surprised to see is that it came

1491
00:55:30,589 --> 00:55:29,339
out to be so completely organized

1492
00:55:33,349 --> 00:55:30,599
so

1493
00:55:36,170 --> 00:55:33,359
this just happens to be all of the

1494
00:55:38,870 --> 00:55:36,180
volcanic samples came out here and then

1495
00:55:40,250 --> 00:55:38,880
all of these um sort of like Technicolor

1496
00:55:42,589 --> 00:55:40,260
things over here are there different

1497
00:55:45,349 --> 00:55:42,599
metabolisms so this is just like a

1498
00:55:47,030 --> 00:55:45,359
ridiculously complex data set visualized

1499
00:55:48,109 --> 00:55:47,040
as best as we can so you can kind of see

1500
00:55:49,549 --> 00:55:48,119
what they're breathing and I know you

1501
00:55:51,349 --> 00:55:49,559
can't really see but this is their

1502
00:55:53,510 --> 00:55:51,359
respiration and whether they fix carbon

1503
00:55:54,589 --> 00:55:53,520
whether they're chemo little autotrophs

1504
00:55:57,230 --> 00:55:54,599
or not

1505
00:55:59,450 --> 00:55:57,240
and then this is the same heat map just

1506
00:56:03,230 --> 00:55:59,460
cut and moved up there so this is not a

1507
00:56:05,510 --> 00:56:03,240
separate run now all these ones that

1508
00:56:08,870 --> 00:56:05,520
were black over here are now yellow

1509
00:56:10,430 --> 00:56:08,880
because these are these set of microbes

1510
00:56:12,530 --> 00:56:10,440
are the ones that are present only in

1511
00:56:14,809 --> 00:56:12,540
the early subduction so things filtered

1512
00:56:17,930 --> 00:56:14,819
out really really distinctly and then we

1513
00:56:19,370 --> 00:56:17,940

had a third group of things that were

1514
00:56:21,710 --> 00:56:19,380
just kind of everywhere

1515
00:56:23,390 --> 00:56:21,720
and so when we looked at what these

1516
00:56:24,890 --> 00:56:23,400
things were we wanted to see are these

1517
00:56:27,049 --> 00:56:24,900
the cumulative are these the ones that

1518
00:56:31,730 --> 00:56:27,059
are making the energy for everybody else

1519
00:56:33,770 --> 00:56:31,740
yes they were we found that about 30 of

1520
00:56:36,950 --> 00:56:33,780
the community could do carbon fixation

1521
00:56:39,530 --> 00:56:36,960
both in this this is just the same heat

1522
00:56:42,829 --> 00:56:39,540
map just cut up into pieces both in the

1523
00:56:44,930 --> 00:56:42,839
volcanoes and at the beach and then less

1524
00:56:47,450 --> 00:56:44,940
of them were distributed everywhere and

1525
00:56:49,309 --> 00:56:47,460
these ones used this oxic carbon

1526
00:56:51,349 --> 00:56:49,319
fixation pathway everywhere so we're

1527
00:56:52,309 --> 00:56:51,359
starting the side eye the ones that are

1528
00:56:55,250 --> 00:56:52,319
everywhere

1529
00:56:56,990 --> 00:56:55,260
as you should be as well

1530
00:56:59,390 --> 00:56:57,000
um but what is it that distinguished

1531
00:57:03,109 --> 00:56:59,400
them between these different places

1532
00:57:05,030 --> 00:57:03,119
um so can you see it's another

1533
00:57:07,250 --> 00:57:05,040
um test if you look at the color things

1534
00:57:09,530 --> 00:57:07,260
the color strips do you see differences

1535
00:57:11,270 --> 00:57:09,540
does the left hand color strip look like

1536
00:57:13,130 --> 00:57:11,280
different colors than the middle color

1537
00:57:15,530 --> 00:57:13,140
strip to you and the right hand color

1538
00:57:16,970 --> 00:57:15,540

strip you can kind of see them I kind of

1539
00:57:18,290 --> 00:57:16,980
this is one reason why I like looking at

1540
00:57:20,030 --> 00:57:18,300
complex data out like this because you

1541
00:57:22,370 --> 00:57:20,040
can really see patterns like for

1542
00:57:24,470 --> 00:57:22,380
instance this green line here

1543
00:57:26,990 --> 00:57:24,480
doesn't really it's not as complete over

1544
00:57:28,970 --> 00:57:27,000
here it's like more of a going concern

1545
00:57:31,970 --> 00:57:28,980
here and there's more of this purple

1546
00:57:34,130 --> 00:57:31,980
stuff here than there is over here so

1547
00:57:35,930 --> 00:57:34,140
what this all boils down to if you stare

1548
00:57:38,990 --> 00:57:35,940
at it for months and months

1549
00:57:40,490 --> 00:57:39,000
is that this volcano stuff liked a

1550
00:57:41,990 --> 00:57:40,500
little bit of oxygen they did a lot of

1551
00:57:43,309 --> 00:57:42,000
sulfur oxidation and they did nitrate

1552
00:57:45,230 --> 00:57:43,319
reduction

1553
00:57:47,089 --> 00:57:45,240
the things out at the coast were totally

1554
00:57:48,410 --> 00:57:47,099
different they were breathing totally

1555
00:57:50,390 --> 00:57:48,420
different things they were doing sulfate

1556
00:57:53,450 --> 00:57:50,400
reduction and hydrogen oxidation

1557
00:57:55,490 --> 00:57:53,460
and these guys that were everywhere were

1558
00:57:58,309 --> 00:57:55,500
aerobic and sulfur oxidizers and they

1559
00:58:01,069 --> 00:57:58,319
basically depended on oxygen so what we

1560
00:58:02,930 --> 00:58:01,079
concluded from this is that these are

1561
00:58:04,609 --> 00:58:02,940
the microbial communities that show up

1562
00:58:05,930 --> 00:58:04,619
late in subduction

1563
00:58:08,630 --> 00:58:05,940

um because there's a lot of hydrothermal

1564
00:58:12,109 --> 00:58:08,640
alteration of their Waters that add

1565
00:58:14,210 --> 00:58:12,119
sulfur so they have a ton of CO2 there's

1566
00:58:15,770 --> 00:58:14,220
very little calcite precipitation and

1567
00:58:17,450 --> 00:58:15,780
they get lots of oxidized substrates

1568
00:58:19,549 --> 00:58:17,460
because they have a shallow geothermal

1569
00:58:22,370 --> 00:58:19,559
gradient that sucks in oxygen

1570
00:58:23,510 --> 00:58:22,380
these guys were early in subduction they

1571
00:58:25,849 --> 00:58:23,520
didn't have a lot of hydrothermal

1572
00:58:27,650 --> 00:58:25,859
alteration but they had lots of reduced

1573
00:58:29,990 --> 00:58:27,660
sulfur compounds so they were very

1574
00:58:32,089 --> 00:58:30,000
carbon dioxide limited but they still

1575
00:58:34,309 --> 00:58:32,099
did chemo they still managed to like fix

1576
00:58:36,289 --> 00:58:34,319
the carbon and make the ecosystem go but

1577
00:58:38,870 --> 00:58:36,299
it was fundamentally different than what

1578
00:58:40,430 --> 00:58:38,880
we saw at the volcanoes and then I don't

1579
00:58:41,930 --> 00:58:40,440
know does anybody have any theories for

1580
00:58:46,690 --> 00:58:41,940
what's going on with these guys who show

1581
00:58:52,010 --> 00:58:49,789
primer producers maybe oh like a

1582
00:58:54,109 --> 00:58:52,020
photosynthetic primary producers if

1583
00:58:56,530 --> 00:58:54,119
that's what you're implying then yes

1584
00:58:59,510 --> 00:58:56,540
because

1585
00:59:01,690 --> 00:58:59,520
these are the this is the crap this is

1586
00:59:04,010 --> 00:59:01,700
the soil stuff this is the surface world

1587
00:59:06,530 --> 00:59:04,020
the identities of these microbes are

1588
00:59:08,089 --> 00:59:06,540

like common soil things and they liked

1589
00:59:09,349 --> 00:59:08,099
oxygen and so and they showed up

1590
00:59:11,030 --> 00:59:09,359
everywhere they didn't really care where

1591
00:59:13,730 --> 00:59:11,040
they were in seduction

1592
00:59:15,650 --> 00:59:13,740
um so what this means is that the redox

1593
00:59:18,650 --> 00:59:15,660
couples that fuel this chemo

1594
00:59:20,390 --> 00:59:18,660
chemosynthetic primary production are

1595
00:59:22,069 --> 00:59:20,400
distributed they're everywhere so if

1596
00:59:25,849 --> 00:59:22,079
we're gonna go looking somewhere else

1597
00:59:28,069 --> 00:59:25,859
for this subsurface Community

1598
00:59:31,309 --> 00:59:28,079
um it's likely to be there as long as we

1599
00:59:32,870 --> 00:59:31,319
have some sort of energy we're likely to

1600
00:59:34,809 --> 00:59:32,880
find it

1601
00:59:36,589 --> 00:59:34,819
conclusion slide

1602
00:59:39,170 --> 00:59:36,599
subsurface life is different than

1603
00:59:41,510 --> 00:59:39,180
surface life it seems simplistic but we

1604
00:59:44,270 --> 00:59:41,520
know it for for sure

1605
00:59:46,190 --> 00:59:44,280
um they can survive on extort this is an

1606
00:59:48,289 --> 00:59:46,200
understatement very little power and

1607
00:59:51,650 --> 00:59:48,299
very long time skills

1608
00:59:53,390 --> 00:59:51,660
um and at least on Earth we got a whole

1609
00:59:55,730 --> 00:59:53,400
world down there that is doing its own

1610
00:59:58,010 --> 00:59:55,740
thing and it does not need the Sun

1611
00:59:59,569 --> 00:59:58,020
and they're large enough to really leave

1612
01:00:01,010 --> 00:59:59,579
a mark on the subsurface landscape they

1613
01:00:04,549 --> 01:00:01,020

are precipitating calcite they're

1614
01:00:07,309 --> 01:00:04,559
leaving iron Ferry hydroxides we can see

1615
01:00:10,910 --> 01:00:07,319
them so I will end with a question for

1616
01:00:12,410 --> 01:00:10,920
y'all and I use y'all advisedly I'm from

1617
01:00:14,870 --> 01:00:12,420
North Carolina I live in Tennessee I'm

1618
01:00:17,049 --> 01:00:14,880
moving to California but don't give up

1619
01:00:20,690 --> 01:00:17,059
on the south

1620
01:00:23,289 --> 01:00:20,700
seriously I know it's easy to vilify the

1621
01:00:26,809 --> 01:00:23,299
South we are gerrymandered all to hell

1622
01:00:30,109 --> 01:00:26,819
so we are a fantastic place and we have

1623
01:00:31,190 --> 01:00:30,119
very oppressed people and um we deserve

1624
01:00:31,849 --> 01:00:31,200
your attention

1625
01:00:35,569 --> 01:00:31,859
um

1626
01:00:39,230 --> 01:00:35,579
so question for y'all

1627
01:00:41,329 --> 01:00:39,240
um if we have this robust of a chemo

1628
01:00:44,089 --> 01:00:41,339
litho autotrophic this chemosynthetic

1629
01:00:46,370 --> 01:00:44,099
subsurface Community here on this place

1630
01:00:48,650 --> 01:00:46,380
where we have this dominant signal what

1631
01:00:50,030 --> 01:00:48,660
will it be like on a planetary body that

1632
01:00:52,190 --> 01:00:50,040
doesn't have all that stuff at the

1633
01:00:54,589 --> 01:00:52,200
surface it will it be different will it

1634
01:00:56,150 --> 01:00:54,599
be the same and how do we look for it

1635
01:00:57,650 --> 01:00:56,160
um and I got to thank the funders and I

1636
01:00:59,990 --> 01:00:57,660
have a pretty place to work for the next

1637
01:01:06,049 --> 01:01:00,000
year and I'll take more questions if you

1638
01:01:06,059 --> 01:01:20,170

foreign

1639
01:01:23,990 --> 01:01:22,190
I was wondering how different the

1640
01:01:25,789 --> 01:01:24,000
mineralogy was because you I knew you

1641
01:01:27,410 --> 01:01:25,799
had a section that had these hydrogen

1642
01:01:28,789 --> 01:01:27,420
supported and I'm assuming that it was

1643
01:01:30,470 --> 01:01:28,799
geologic hydrogen from the

1644
01:01:32,150 --> 01:01:30,480
serpentinization like how different was

1645
01:01:34,190 --> 01:01:32,160
the mineralogy like could you tell the

1646
01:01:36,410 --> 01:01:34,200
difference and what led to in terms of

1647
01:01:39,230 --> 01:01:36,420
like the type of enzymes they were able

1648
01:01:40,670 --> 01:01:39,240
to have in their like biology based on

1649
01:01:41,990 --> 01:01:40,680
the metals that were around like was

1650
01:01:44,150 --> 01:01:42,000
that some kind of connection that you

1651
01:01:45,829 --> 01:01:44,160
could make or I don't know I just want

1652
01:01:48,049 --> 01:01:45,839
more collaboration I'm sorry yeah I want

1653
01:01:50,030 --> 01:01:48,059
more elaboration on the minerals too um

1654
01:01:53,210 --> 01:01:50,040
Shauna Morrison did all the mineralogy

1655
01:01:55,849 --> 01:01:53,220
for this and she found pyrite framboids

1656
01:01:57,650 --> 01:01:55,859
in the it's very altered hydrothermal so

1657
01:01:58,849 --> 01:01:57,660
that's feeding into our hypothesis of

1658
01:02:01,789 --> 01:01:58,859
why there's so much iron and sulfur

1659
01:02:04,069 --> 01:02:01,799
cycling in the volcanoes but

1660
01:02:05,990 --> 01:02:04,079
picking apart how the metals influence

1661
01:02:07,549 --> 01:02:06,000
and you know the crystalline form of the

1662
01:02:10,730 --> 01:02:07,559
metals influence all these communities

1663
01:02:11,990 --> 01:02:10,740

is a bit of a fine scale thing and so I

1664
01:02:13,789 --> 01:02:12,000
think that's going to be more apparent

1665
01:02:16,190 --> 01:02:13,799
in our global data set is this because

1666
01:02:26,030 --> 01:02:16,200
this project has

1667
01:02:31,309 --> 01:02:28,250
so my question is coming from very

1668
01:02:33,349 --> 01:02:31,319
limited background in biology so yeah so

1669
01:02:34,730 --> 01:02:33,359
when you talk about lifespan uh why do

1670
01:02:37,549 --> 01:02:34,740
different organisms have different

1671
01:02:41,930 --> 01:02:37,559
lifespans like different species have

1672
01:02:46,530 --> 01:02:43,730
why do different species have different

1673
01:02:46,920 --> 01:02:46,540
lifespans yep

1674
01:02:52,789 --> 01:02:46,930
[Laughter]

1675
01:02:58,309 --> 01:02:55,270
somebody want to answer that

1676
01:03:06,349 --> 01:02:58,319
Kelly do you want to yell down for us

1677
01:03:06,359 --> 01:03:09,309
um

1678
01:03:15,289 --> 01:03:13,190
so you have this root that is kind of

1679
01:03:16,910 --> 01:03:15,299
like surface derived that you say is

1680
01:03:19,430 --> 01:03:16,920
everywhere like

1681
01:03:22,490 --> 01:03:19,440
like eating the rest of the communities

1682
01:03:23,390 --> 01:03:22,500
in the subsurface so on I don't think

1683
01:03:24,650 --> 01:03:23,400
they're feeding the rest of the

1684
01:03:27,650 --> 01:03:24,660
communities

1685
01:03:30,410 --> 01:03:27,660
no I think they're just really angry to

1686
01:03:32,450 --> 01:03:30,420
have been washed into a hot spring yeah

1687
01:03:33,950 --> 01:03:32,460
there I I don't want to use the word

1688
01:03:35,930 --> 01:03:33,960

contamination because that kind of means

1689
01:03:38,089 --> 01:03:35,940
that implies something from our bodies

1690
01:03:40,970 --> 01:03:38,099
or like our coughs

1691
01:03:42,890 --> 01:03:40,980
um it's more like just not the things we

1692
01:03:44,450 --> 01:03:42,900
were looking for because you you know a

1693
01:03:46,250 --> 01:03:44,460
hot spring is coming up through layers

1694
01:03:47,990 --> 01:03:46,260
of rock and so there's going to be some

1695
01:03:50,390 --> 01:03:48,000
soil stuff washed in

1696
01:03:51,650 --> 01:03:50,400
yeah I don't they could be or did you

1697
01:03:54,049 --> 01:03:51,660
have a thought I mean they could be

1698
01:04:02,829 --> 01:03:54,059
feeding them no

1699
01:04:06,890 --> 01:04:05,569
I think the chemo synthesizers are I

1700
01:04:09,170 --> 01:04:06,900
mean they're basically taking carbon

1701
01:04:11,210 --> 01:04:09,180
that's coming from that slab so that's

1702
01:04:13,970 --> 01:04:11,220
carbon that got buried in the Pacific

1703
01:04:20,089 --> 01:04:17,089
10 million years ago and it gets buried

1704
01:04:21,829 --> 01:04:20,099
and gets volatilized however it gets

1705
01:04:23,990 --> 01:04:21,839
from high pressure and temperature and

1706
01:04:38,930 --> 01:04:24,000
then comes back up and that's that's

1707
01:04:43,130 --> 01:04:42,170
clear thank you for your talk I was

1708
01:04:47,089 --> 01:04:43,140
wondering

1709
01:04:48,950 --> 01:04:47,099
um so you talk a lot about the

1710
01:04:50,750 --> 01:04:48,960
unculturable that's what you work on

1711
01:04:53,829 --> 01:04:50,760
actually never say that word okay I'm

1712
01:04:57,470 --> 01:04:53,839
sorry I'll get in trouble when I do

1713
01:05:01,730 --> 01:04:57,480

so a lot of these organisms or most of

1714
01:05:04,549 --> 01:05:01,740
them are uncultured uncultured yeah

1715
01:05:07,010 --> 01:05:04,559
um so what are your thoughts on you are

1716
01:05:09,230 --> 01:05:07,020
annotating a lot of this stuff from

1717
01:05:12,950 --> 01:05:09,240
stuff that is also uncultured do you

1718
01:05:15,589 --> 01:05:12,960
think there is a it just like

1719
01:05:18,950 --> 01:05:15,599
that hypothetical protein sort of idea

1720
01:05:23,390 --> 01:05:18,960
where this is most related to this which

1721
01:05:24,230 --> 01:05:23,400
is most related to this how do you think

1722
01:05:28,069 --> 01:05:24,240
um

1723
01:05:29,630 --> 01:05:28,079
potential issue you mean the issue of

1724
01:05:30,950 --> 01:05:29,640
the game of telephone where you think

1725
01:05:33,109 --> 01:05:30,960
something's a one thing and it's

1726
01:05:34,789 --> 01:05:33,119
actually not right um

1727
01:05:36,950 --> 01:05:34,799
I think that we have to be really

1728
01:05:37,910 --> 01:05:36,960
careful about what we conclude like if

1729
01:05:40,250 --> 01:05:37,920
you're

1730
01:05:41,870 --> 01:05:40,260
at least in my research like if I if my

1731
01:05:43,190 --> 01:05:41,880
story really depends on a particular

1732
01:05:47,930 --> 01:05:43,200
annotation

1733
01:05:50,210 --> 01:05:47,940
make a multiple species alignment of the

1734
01:05:52,250 --> 01:05:50,220
multiple sequence alignment of that Gene

1735
01:05:53,870 --> 01:05:52,260
and show that there's more evidence for

1736
01:05:56,750 --> 01:05:53,880
it being what I think it is than just

1737
01:05:58,370 --> 01:05:56,760
like proka annotates it as X

1738
01:06:00,289 --> 01:05:58,380

um and you can look you know you can

1739
01:06:01,789 --> 01:06:00,299
look for the P fans you can look for the

1740
01:06:03,289 --> 01:06:01,799
active site you can do all sorts of

1741
01:06:05,750 --> 01:06:03,299
things to sort of prove to yourself you

1742
01:06:07,250 --> 01:06:05,760
can look for the flanking genes the gene

1743
01:06:08,990 --> 01:06:07,260
syntony all these things you can use to

1744
01:06:11,390 --> 01:06:09,000
build up a case you're not going to do

1745
01:06:14,089 --> 01:06:11,400
that for a whole genome or much less 400

1746
01:06:16,130 --> 01:06:14,099
genomes but you can do that for the

1747
01:06:17,770 --> 01:06:16,140
thing that you want to talk about

1748
01:06:20,089 --> 01:06:17,780
um but I mean I just think that like

1749
01:06:22,849 --> 01:06:20,099
there's so much to be gained in that

1750
01:06:25,490 --> 01:06:22,859
hypothetical space in

1751
01:06:27,829 --> 01:06:25,500
sorry another soapbox about this is that

1752
01:06:29,930 --> 01:06:27,839
you know cool we free ourselves from

1753
01:06:32,210 --> 01:06:29,940
cultures we're free what's the first

1754
01:06:34,910 --> 01:06:32,220
thing we do when we get this genome say

1755
01:06:44,329 --> 01:06:34,920
how similar is it to a culture

1756
01:06:47,329 --> 01:06:44,990
um

1757
01:06:49,430 --> 01:06:47,339
great talk I should preface this by

1758
01:06:50,829 --> 01:06:49,440
saying that I'm an astronomer so I did

1759
01:06:56,270 --> 01:06:50,839
my best

1760
01:07:01,370 --> 01:06:58,670
um Mars and

1761
01:07:03,109 --> 01:07:01,380
um Europa and Enceladus and those icy

1762
01:07:05,990 --> 01:07:03,119
moons have a very different

1763
01:07:06,589 --> 01:07:06,000

environmental conditions than the earth

1764
01:07:09,910 --> 01:07:06,599
um

1765
01:07:14,809 --> 01:07:09,920
and it seemed like a lot of this was

1766
01:07:18,470 --> 01:07:14,819
predicated on subduction yeah and

1767
01:07:22,670 --> 01:07:18,480
um not some sort of surface solution for

1768
01:07:26,510 --> 01:07:22,680
instance yeah so yeah I just wonder how

1769
01:07:27,349 --> 01:07:26,520
how you develop a subsurface

1770
01:07:30,170 --> 01:07:27,359
um

1771
01:07:32,569 --> 01:07:30,180
biological World in a static-lit

1772
01:07:34,490 --> 01:07:32,579
environment or in a subsurface ocean

1773
01:07:36,589 --> 01:07:34,500
environment I'm writing an EXO Grant

1774
01:07:37,910 --> 01:07:36,599
about that right now actually but but I

1775
01:07:39,650 --> 01:07:37,920
mean not that I know the answer to it

1776
01:07:42,230 --> 01:07:39,660
but I mean that is that is basically

1777
01:07:44,390 --> 01:07:42,240
like the Fatal flaw of my entire or my

1778
01:07:46,430 --> 01:07:44,400
second half of my talk it but it's a

1779
01:07:48,589 --> 01:07:46,440
relevant one because there's no plate

1780
01:07:49,309 --> 01:07:48,599
tectonics in our solar system except on

1781
01:07:52,309 --> 01:07:49,319
Earth

1782
01:07:54,950 --> 01:07:52,319
it in the entire history you know the

1783
01:07:56,450 --> 01:07:54,960
fact that Olympus Mons is so enormous is

1784
01:07:58,309 --> 01:07:56,460
simply because at hot spot's been

1785
01:08:00,349 --> 01:07:58,319
sitting there like for however long it's

1786
01:08:02,329 --> 01:08:00,359
been sitting there so I think that the

1787
01:08:03,770 --> 01:08:02,339
grant that I'm writing right now is you

1788
01:08:05,510 --> 01:08:03,780

know we may not get it is to basically

1789
01:08:07,549 --> 01:08:05,520
try to get out of subduction zones and

1790
01:08:09,650 --> 01:08:07,559
do our same style of sampling and our

1791
01:08:11,210 --> 01:08:09,660
same style of work around hot spots here

1792
01:08:13,010 --> 01:08:11,220
on Earth or at least plume influenced

1793
01:08:14,690 --> 01:08:13,020
environments but you can't get away from

1794
01:08:15,770 --> 01:08:14,700
plate tectonics on Earth just the same

1795
01:08:18,590 --> 01:08:15,780
way you can't get away from the

1796
01:08:20,450 --> 01:08:18,600
photosynthes so um we're going to have

1797
01:08:22,309 --> 01:08:20,460
to deal with Hawaii

1798
01:08:25,490 --> 01:08:22,319
so are you suggesting there's no life

1799
01:08:31,570 --> 01:08:25,500
elsewhere is that no

1800
01:08:37,070 --> 01:08:35,570
I love that yeah

1801
01:08:39,590 --> 01:08:37,080
I think the answer to that is going to

1802
01:08:46,450 --> 01:08:42,650
I I guess this is this is kind of to

1803
01:08:49,910 --> 01:08:46,460
that kind of effect uh so

1804
01:08:52,309 --> 01:08:49,920
is is there something like why do we

1805
01:08:54,769 --> 01:08:52,319
have plate tectonics sorry this is

1806
01:08:56,930 --> 01:08:54,779
something no that's another question is

1807
01:08:58,490 --> 01:08:56,940
a great question I don't know why do do

1808
01:08:59,749 --> 01:08:58,500
people know that I feel like people know

1809
01:09:06,309 --> 01:08:59,759
that

1810
01:09:11,329 --> 01:09:09,169
I don't know it maybe has something to

1811
01:09:12,650 --> 01:09:11,339
do with our size you know our size and

1812
01:09:15,050 --> 01:09:12,660
relative heat I mean because it's all

1813
01:09:17,209 --> 01:09:15,060

heat convection that's driving it so you

1814
01:09:19,309 --> 01:09:17,219
need the right brittleness versus Heat

1815
01:09:21,650 --> 01:09:19,319
to break it apart and move them but that

1816
01:09:23,269 --> 01:09:21,660
may not be the right answer I don't know

1817
01:09:28,910 --> 01:09:23,279
I would say I'm a microbiologist but I

1818
01:09:40,789 --> 01:09:30,530
I think you raise your hand you raise

1819
01:09:46,789 --> 01:09:44,150
is this on whoa all right let's see if

1820
01:09:48,769 --> 01:09:46,799
this makes sense so hi I'm Emily I study

1821
01:09:50,990 --> 01:09:48,779
the limits of life in Saline

1822
01:09:53,570 --> 01:09:51,000
environments and there's some research

1823
01:09:56,870 --> 01:09:53,580
on like thermodynamic limits to certain

1824
01:10:00,229 --> 01:09:56,880
metabolisms including autotrophy that's

1825
01:10:02,150 --> 01:10:00,239
not driven by oxygenic things and so I

1826
01:10:03,950 --> 01:10:02,160
was wondering given that you found a lot

1827
01:10:06,229 --> 01:10:03,960
of chemo autotrophs in the Deep

1828
01:10:08,750 --> 01:10:06,239
subsurface that are in incredibly energy

1829
01:10:10,490 --> 01:10:08,760
limited environments do you think there

1830
01:10:13,729 --> 01:10:10,500
actually is a limit to life

1831
01:10:15,950 --> 01:10:13,739
or is this like yeah I don't know you

1832
01:10:18,110 --> 01:10:15,960
mean an energetic limit yeah sure like

1833
01:10:19,550 --> 01:10:18,120
you know in a in an extreme environment

1834
01:10:21,770 --> 01:10:19,560
you have to like use a lot of energy to

1835
01:10:23,510 --> 01:10:21,780
like survive there right yeah so

1836
01:10:25,130 --> 01:10:23,520
even places where you get your protons

1837
01:10:28,729 --> 01:10:25,140
for free like an acidic environment you

1838
01:10:31,310 --> 01:10:28,739

still spend a lot of energy baling yeah

1839
01:10:32,689 --> 01:10:31,320
is there a limit for life

1840
01:10:34,790 --> 01:10:32,699
yes

1841
01:10:37,070 --> 01:10:34,800
yeah there has to be like a Gibbs free

1842
01:10:39,290 --> 01:10:37,080
energy of zero is equilibrium and you

1843
01:10:44,090 --> 01:10:39,300
can't have life with equilibrium there

1844
01:10:48,649 --> 01:10:46,669
but the but the interesting question is

1845
01:10:53,689 --> 01:10:48,659
where is that line and that's what we

1846
01:10:53,699 --> 01:10:57,890
did you want to ask your questions

1847
01:11:02,149 --> 01:11:00,350
hi I'm also an astronomer and I wanted

1848
01:11:03,470 --> 01:11:02,159
to kind of move even further out than

1849
01:11:05,689 --> 01:11:03,480
Nick did

1850
01:11:08,030 --> 01:11:05,699
um so something we think about a lot as

1851
01:11:10,130 --> 01:11:08,040
astronomers is like habitable zone and

1852
01:11:12,050 --> 01:11:10,140
like you know what temperature planets

1853
01:11:13,250 --> 01:11:12,060
might have to be to host life but I'm

1854
01:11:14,570 --> 01:11:13,260
wondering what your thoughts are about

1855
01:11:16,070 --> 01:11:14,580
the prospects for life on like

1856
01:11:18,110 --> 01:11:16,080
free-floating planets that aren't

1857
01:11:19,490 --> 01:11:18,120
associated with a star there are free

1858
01:11:21,229 --> 01:11:19,500
floating planets that are not associated

1859
01:11:22,910 --> 01:11:21,239
with stars yes

1860
01:11:28,870 --> 01:11:22,920
seriously

1861
01:11:32,330 --> 01:11:31,310
even Hubble

1862
01:11:33,890 --> 01:11:32,340
okay

1863
01:11:35,890 --> 01:11:33,900

I have a lot of thoughts about this I'd

1864
01:11:38,570 --> 01:11:35,900
be happy to talk about it that's crazy

1865
01:11:40,070 --> 01:11:38,580
we've been how do they have I mean do

1866
01:11:41,870 --> 01:11:40,080
they have their own heat Source

1867
01:11:43,189 --> 01:11:41,880
internally are they I mean because you

1868
01:11:44,930 --> 01:11:43,199
got to have some kind of gradient that's

1869
01:11:47,570 --> 01:11:44,940
all you gotta have something like some

1870
01:11:49,669 --> 01:11:47,580
heat from formation probably yeah fading

1871
01:11:51,290 --> 01:11:49,679
over time or like some tidal forcing

1872
01:11:54,350 --> 01:11:51,300
from somebody nearby or they just like

1873
01:11:57,050 --> 01:11:54,360
totally lonely got nothing wow the radio

1874
01:11:58,550 --> 01:11:57,060
radiogenic Decay yeah yeah so I mean you

1875
01:12:00,950 --> 01:11:58,560
gotta have something right there's got

1876
01:12:03,410 --> 01:12:00,960
to be a gradient there's got to be if

1877
01:12:06,350 --> 01:12:03,420
not redox just something

1878
01:12:07,250 --> 01:12:06,360
um I don't know clearly I don't know the

1879
01:12:08,810 --> 01:12:07,260
answer to that because I didn't know

1880
01:12:10,550 --> 01:12:08,820
that they were there but you know we

1881
01:12:12,649 --> 01:12:10,560
talk about the Habit like when you think

1882
01:12:13,970 --> 01:12:12,659
of the habitable zone do you think about

1883
01:12:16,250 --> 01:12:13,980
distance from the Star and brightness

1884
01:12:18,410 --> 01:12:16,260
from the star of the star

1885
01:12:20,209 --> 01:12:18,420
um also think about the depth of that

1886
01:12:22,910 --> 01:12:20,219
planet because that'll really expand

1887
01:12:24,649 --> 01:12:22,920
your Capital Zone quite a bit if you can

1888
01:12:26,930 --> 01:12:24,659

go inside the planet

1889
01:12:36,470 --> 01:12:26,940
it gets better

1890
01:12:40,970 --> 01:12:38,270
leading plants

1891
01:12:43,669 --> 01:12:40,980
hi um first off I'm also from North

1892
01:12:47,169 --> 01:12:43,679
Carolina so hello where are you from uh

1893
01:12:49,850 --> 01:12:47,179
Raleigh sweet I'm from Beaufort oh nice

1894
01:12:52,250 --> 01:12:49,860
I was just curious um what do you think

1895
01:12:54,110 --> 01:12:52,260
is the stability of these subsurface

1896
01:12:57,290 --> 01:12:54,120
ecologies through both like geological

1897
01:12:58,910 --> 01:12:57,300
time and like planetary scales um and if

1898
01:13:00,709 --> 01:12:58,920
there's any like way to like have like a

1899
01:13:02,930 --> 01:13:00,719
fossilized record of their presence at

1900
01:13:04,610 --> 01:13:02,940
all that we could detect yeah I mean the

1901
01:13:06,229 --> 01:13:04,620
carbonates like the minerals that they

1902
01:13:08,450 --> 01:13:06,239
leave behind the waste products are

1903
01:13:10,550 --> 01:13:08,460
probably the best in microfossils of

1904
01:13:12,590 --> 01:13:10,560
course and lipids are good ways to look

1905
01:13:15,530 --> 01:13:12,600
for these sorts of things but in terms

1906
01:13:16,669 --> 01:13:15,540
of like the time span of this stuff you

1907
01:13:19,790 --> 01:13:16,679
know we're just looking at the Modern

1908
01:13:21,530 --> 01:13:19,800
stuff now and so I think that

1909
01:13:22,550 --> 01:13:21,540
I don't know as much as I should about

1910
01:13:25,010 --> 01:13:22,560
that but

1911
01:13:26,689 --> 01:13:25,020
there's a lot to be done

1912
01:13:31,790 --> 01:13:26,699
all right let's give one last round of