
MAY 22
AB
GRAD
CON
23

1
00:00:00,000 --> 00:00:08,570
foreign

2
00:00:38,710 --> 00:00:20,810
[Music]

3
00:00:51,810 --> 00:00:38,720
foreign

4
00:01:21,289 --> 00:00:58,500
[Music]

5
00:01:21,299 --> 00:01:24,460
foreign

6
00:01:52,429 --> 00:01:30,020
[Music]

7
00:01:52,439 --> 00:02:04,590
foreign

8
00:03:26,649 --> 00:02:16,870
[Music]

9
00:03:26,659 --> 00:03:36,150
thank you

10
00:05:13,850 --> 00:03:48,390
[Music]

11
00:05:13,860 --> 00:05:18,520
foreign

12
00:06:27,730 --> 00:05:32,180
[Music]

13
00:06:33,350 --> 00:06:29,130

thank you

14
00:06:41,380 --> 00:06:35,830
foreign

15
00:07:12,290 --> 00:07:03,720
[Music]

16
00:07:12,300 --> 00:07:15,960
foreign

17
00:07:40,309 --> 00:07:27,680
[Music]

18
00:07:46,980 --> 00:07:41,890
foreign

19
00:08:21,540 --> 00:07:55,610
[Music]

20
00:08:38,880 --> 00:08:21,550
foreign

21
00:09:31,990 --> 00:08:45,520
[Music]

22
00:09:32,000 --> 00:09:39,370
thank you

23
00:09:39,380 --> 00:10:10,449
[Music]

24
00:10:10,459 --> 00:10:13,970
thank you

25
00:10:13,980 --> 00:10:21,050
foreign

26
00:10:53,990 --> 00:10:31,970
[Music]

27
00:10:54,000 --> 00:11:02,930
foreign

28
00:11:35,090 --> 00:11:20,180
[Music]

29
00:12:12,600 --> 00:11:37,640
foreign

30
00:12:28,970 --> 00:12:20,570
[Music]

31
00:12:28,980 --> 00:12:47,600
foreign

32
00:12:47,610 --> 00:12:52,069
[Music]

33
00:12:52,079 --> 00:12:55,070
thank you

34
00:13:42,710 --> 00:13:04,910
[Music]

35
00:14:14,880 --> 00:13:58,730
foreign

36
00:15:04,730 --> 00:14:40,170
[Music]

37
00:15:19,730 --> 00:15:07,090
thank you

38
00:15:19,740 --> 00:15:24,690

foreign

39
00:16:26,629 --> 00:15:49,610
[Music]

40
00:16:26,639 --> 00:16:34,360
foreign

41
00:17:29,990 --> 00:16:51,830
[Music]

42
00:17:30,000 --> 00:17:34,330
thank you

43
00:18:40,909 --> 00:17:37,549
[Music]

44
00:18:48,830 --> 00:18:42,830
thank you

45
00:18:48,830 --> 00:18:48,840
[Music]

46
00:18:48,840 --> 00:18:54,010
foreign

47
00:19:44,390 --> 00:19:11,470
[Music]

48
00:19:54,860 --> 00:19:46,380
thank you

49
00:19:54,870 --> 00:19:59,870
[Music]

50
00:19:59,880 --> 00:20:03,830
foreign

51
00:21:15,890 --> 00:20:21,290
[Music]

52
00:21:15,900 --> 00:21:33,690
foreign

53
00:22:32,800 --> 00:22:01,390
[Music]

54
00:22:51,260 --> 00:22:32,810
foreign

55
00:23:55,880 --> 00:23:20,010
[Music]

56
00:24:14,650 --> 00:23:55,890
foreign

57
00:24:57,409 --> 00:24:19,840
[Music]

58
00:24:57,419 --> 00:25:00,470
thank you

59
00:26:14,350 --> 00:25:15,220
[Music]

60
00:26:30,260 --> 00:26:14,360
foreign

61
00:27:41,269 --> 00:27:01,550
[Music]

62
00:27:41,279 --> 00:28:04,490
oh

63
00:28:30,890 --> 00:28:14,350

[Music]

64
00:28:42,030 --> 00:28:32,730
foreign

65
00:29:32,740 --> 00:28:51,890
[Music]

66
00:29:47,760 --> 00:29:32,750
foreign

67
00:30:15,610 --> 00:30:02,700
[Music]

68
00:30:15,620 --> 00:30:24,690
oh yeah

69
00:30:49,450 --> 00:30:30,730
[Music]

70
00:31:13,789 --> 00:30:51,300
this is

71
00:31:26,970 --> 00:31:16,010
my life

72
00:31:53,630 --> 00:31:47,790
[Music]

73
00:32:00,230 --> 00:31:55,210
okay

74
00:32:00,240 --> 00:32:04,130
everybody hear me

75
00:32:04,140 --> 00:32:07,669
oh it's very exciting

76
00:32:12,889 --> 00:32:11,090
spent a lot of time all the organizing

77
00:32:15,230 --> 00:32:12,899
not everyone's here but you'll certainly

78
00:32:16,789 --> 00:32:15,240
throughout the con

79
00:32:19,610 --> 00:32:16,799
um but yeah it's just so exciting to see

80
00:32:21,889 --> 00:32:19,620
faces all the names so

81
00:32:24,350 --> 00:32:21,899
um thank you so much for coming

82
00:32:27,409 --> 00:32:24,360
um and we're just so happy to be here

83
00:32:29,930 --> 00:32:27,419
and glad everyone could make it

84
00:32:31,909 --> 00:32:29,940
hey everyone my name is Miguel and I'm a

85
00:32:34,010 --> 00:32:31,919
PhD student here at Scripps

86
00:32:35,990 --> 00:32:34,020
and I'm the co-lead organizer of app

87
00:32:37,250 --> 00:32:36,000
gradcon this year with this beautiful

88
00:32:39,950 --> 00:32:37,260

team

89
00:32:42,830 --> 00:32:39,960
it's been quite so you can actually

90
00:32:45,049 --> 00:32:42,840
decided to apply to host I've gradcon in

91
00:32:46,549 --> 00:32:45,059
September so it's been crazy eight

92
00:32:49,269 --> 00:32:46,559
months and most of all we're very

93
00:32:52,250 --> 00:32:49,279
excited to have all of you here today

94
00:32:55,070 --> 00:32:52,260
and that said we're already on the

95
00:32:57,169 --> 00:32:55,080
search for the host for next app gradcon

96
00:32:59,750 --> 00:32:57,179
so I've gradcon 2024 so if you're

97
00:33:01,909 --> 00:32:59,760
interested in hosting next year just

98
00:33:02,810 --> 00:33:01,919
come and chat with us in the next couple

99
00:33:05,510 --> 00:33:02,820
days

100
00:33:07,090 --> 00:33:05,520
we'll be able to give you an idea of

101
00:33:10,250 --> 00:33:07,100
what it entails

102
00:33:13,250 --> 00:33:10,260
and without further Ado I want to

103
00:33:16,610 --> 00:33:13,260
introduce tonight's keynote speaker Dr

104
00:33:18,230 --> 00:33:16,620
Karen G Lloyd who is a subsurface

105
00:33:19,370 --> 00:33:18,240
microbiologist at the University of

106
00:33:23,149 --> 00:33:19,380
Tennessee

107
00:33:24,950 --> 00:33:23,159
although in 2024 she will be the the

108
00:33:27,110 --> 00:33:24,960
Wrigley professor of Earth Sciences at

109
00:33:29,990 --> 00:33:27,120
the University of Southern California

110
00:33:31,789 --> 00:33:30,000
Dr Lloyd discovers new types of life in

111
00:33:34,549 --> 00:33:31,799
Arctic permafrost

112
00:33:37,730 --> 00:33:34,559
what kind of volcanic hot spring systems

113
00:33:40,970 --> 00:33:37,740

and deepsea environments she combines

114
00:33:43,750 --> 00:33:40,980
geochemistry with metabolomics meta

115
00:33:45,950 --> 00:33:43,760
transcriptomics metagenomics and other

116
00:33:48,470 --> 00:33:45,960
environmental measurements to infer what

117
00:33:53,810 --> 00:33:48,480
life is like in natural complex systems

118
00:33:53,820 --> 00:33:57,590
foreign

119
00:34:03,110 --> 00:34:00,769
thanks thanks for having me y'all and I

120
00:34:05,990 --> 00:34:03,120
went to AB gradcon here

121
00:34:08,810 --> 00:34:06,000
um would that have been like 2005 I

122
00:34:11,389 --> 00:34:08,820
think it's a as a attendee so it's kind

123
00:34:13,490 --> 00:34:11,399
of nice to be back um speaking

124
00:34:16,310 --> 00:34:13,500
um so I'm going to talk about

125
00:34:18,109 --> 00:34:16,320
um life inside Earth's crust but one of

126
00:34:20,030 --> 00:34:18,119
the reasons why we study life in Earth's

127
00:34:21,349 --> 00:34:20,040
crust is that we obviously the reason

128
00:34:24,470 --> 00:34:21,359
we're all here is that we want to find

129
00:34:26,089 --> 00:34:24,480
life outside of earth that is something

130
00:34:27,169 --> 00:34:26,099
that it's really kind of nice to give a

131
00:34:30,169 --> 00:34:27,179
talk here because I don't have to

132
00:34:32,329 --> 00:34:30,179
justify that like we all agree

133
00:34:33,710 --> 00:34:32,339
that is a thing worth doing

134
00:34:40,790 --> 00:34:33,720
so

135
00:34:43,310 --> 00:34:40,800
planetary bodies that seem like a place

136
00:34:45,710 --> 00:34:43,320
you could find some stuff but where in

137
00:34:47,869 --> 00:34:45,720
them do we expect to find some stuff

138
00:34:49,609 --> 00:34:47,879

well the place we know the most about on

139
00:34:51,050 --> 00:34:49,619
these planetary bodies is the surface

140
00:34:52,849 --> 00:34:51,060
and

141
00:34:55,129 --> 00:34:52,859
I'm not saying there's not life there

142
00:34:57,050 --> 00:34:55,139
definitely not I mean that would be

143
00:34:58,910 --> 00:34:57,060
ridiculous but there's not like the

144
00:35:01,010 --> 00:34:58,920
Amazon rainforest sitting up there we

145
00:35:03,710 --> 00:35:01,020
would have seen it if it was up there

146
00:35:06,710 --> 00:35:03,720
um so it doesn't seem to be like teeming

147
00:35:08,750 --> 00:35:06,720
on the surface but the subsurface if you

148
00:35:11,390 --> 00:35:08,760
think about the subsurfaces of all of

149
00:35:13,970 --> 00:35:11,400
these places it's a pretty Clement place

150
00:35:15,349 --> 00:35:13,980
to be there's often liquid water at

151
00:35:17,210 --> 00:35:15,359
least in the case of Europa and

152
00:35:18,650 --> 00:35:17,220
Enceladus there's whole oceans worth of

153
00:35:21,050 --> 00:35:18,660
water so that's cool that's a major

154
00:35:23,390 --> 00:35:21,060
thing ticked off our list

155
00:35:25,310 --> 00:35:23,400
protection from UV damage there's tons

156
00:35:26,990 --> 00:35:25,320
of stuff to build cells with it's kind

157
00:35:29,569 --> 00:35:27,000
of a nice place to be

158
00:35:31,550 --> 00:35:29,579
um and the evidence for this is that I

159
00:35:32,930 --> 00:35:31,560
don't know if you keep up with methane

160
00:35:34,370 --> 00:35:32,940
on Mars but this has been something

161
00:35:35,990 --> 00:35:34,380
that's been kind of controversial over

162
00:35:39,050 --> 00:35:36,000
the years and now is no longer

163
00:35:40,730 --> 00:35:39,060

controversial it is definitely there we

164
00:35:42,530 --> 00:35:40,740
have methane in the Martian atmosphere

165
00:35:44,329 --> 00:35:42,540
and the thing that I love the most about

166
00:35:46,670 --> 00:35:44,339
this methane is that it's not always

167
00:35:48,130 --> 00:35:46,680
there we get whiffs of it and so this

168
00:35:51,829 --> 00:35:48,140
this is something that seems very

169
00:35:53,870 --> 00:35:51,839
lifelike to me if you know Titan Titan

170
00:35:56,089 --> 00:35:53,880
is so full of methane you're like is

171
00:35:57,650 --> 00:35:56,099
that really biological but for for Mars

172
00:36:00,310 --> 00:35:57,660
it seems kind of biological so I wonder

173
00:36:02,810 --> 00:36:00,320
if right now there's a subsurface life

174
00:36:05,450 --> 00:36:02,820
ecosystem happening on Mars right now it

175
00:36:08,810 --> 00:36:05,460
could be and Europa Europa is really

176
00:36:10,550 --> 00:36:08,820
easy right like this is this lovely

177
00:36:12,650 --> 00:36:10,560
artist rendering if I had the artists

178
00:36:14,030 --> 00:36:12,660
that NASA does I would get so much

179
00:36:16,310 --> 00:36:14,040
funding

180
00:36:18,290 --> 00:36:16,320
um but they've got this ice cap and then

181
00:36:20,210 --> 00:36:18,300
these occasional Jets Enceladus

182
00:36:23,150 --> 00:36:20,220
definitely has jets and absolutely for

183
00:36:25,910 --> 00:36:23,160
100 sure there's a giant ocean of liquid

184
00:36:29,270 --> 00:36:25,920
probably saline water on Europa which is

185
00:36:31,430 --> 00:36:29,280
just very intriguing okay so a high

186
00:36:33,470 --> 00:36:31,440
probability shot for astrobiology is to

187
00:36:35,569 --> 00:36:33,480
look for life in the subsurface of

188
00:36:38,390 --> 00:36:35,579

planetary bodies so

189
00:36:41,089 --> 00:36:38,400
we've got this planet to look for so can

190
00:36:43,190 --> 00:36:41,099
we use Earth life the life we find here

191
00:36:44,630 --> 00:36:43,200
is a guide for what might be there on

192
00:36:46,609 --> 00:36:44,640
the subsurface of these other planetary

193
00:36:49,190 --> 00:36:46,619
bodies and I don't know if you guys ever

194
00:36:51,589 --> 00:36:49,200
do this view of Earth do you ever try to

195
00:36:55,010 --> 00:36:51,599
get the to get the land out you know

196
00:36:57,170 --> 00:36:55,020
it's like Hawaii and New Zealand you

197
00:36:59,390 --> 00:36:57,180
know California is fighting them to to

198
00:37:01,069 --> 00:36:59,400
gain place but I love looking at Earth

199
00:37:02,990 --> 00:37:01,079
like this because it really reminds you

200
00:37:05,089 --> 00:37:03,000
that we are an ocean planet we know that

201
00:37:07,550 --> 00:37:05,099
but you can you can look at it from the

202
00:37:09,530 --> 00:37:07,560
back side and some of my colleagues have

203
00:37:11,030 --> 00:37:09,540
added up the total number of microbial

204
00:37:12,829 --> 00:37:11,040
cells that are living underneath the

205
00:37:14,690 --> 00:37:12,839
ocean in the subsurface in the Marine

206
00:37:17,930 --> 00:37:14,700
sediments and it's literally

207
00:37:19,609 --> 00:37:17,940
astronomical it's 10 to the 29 which is

208
00:37:21,770 --> 00:37:19,619
a third of the microbes on the planet

209
00:37:23,150 --> 00:37:21,780
are buried in the subsurface underneath

210
00:37:25,670 --> 00:37:23,160
our oceans

211
00:37:27,349 --> 00:37:25,680
which is 10 000 times more than the

212
00:37:29,150 --> 00:37:27,359
number of stars in the universe

213
00:37:31,430 --> 00:37:29,160

um although that number has a big error

214
00:37:33,770 --> 00:37:31,440
bar on it too

215
00:37:36,050 --> 00:37:33,780
um so actually most of the life on Earth

216
00:37:39,290 --> 00:37:36,060
is actually inside Earth so we are a

217
00:37:40,910 --> 00:37:39,300
subsurface Planet too and if you look at

218
00:37:42,470 --> 00:37:40,920
the terrestrial environment

219
00:37:43,970 --> 00:37:42,480
um this has pretty much the same amount

220
00:37:46,370 --> 00:37:43,980
of microbes in it so it's not just the

221
00:37:48,430 --> 00:37:46,380
oceans this stuff is kind of everywhere

222
00:37:51,589 --> 00:37:48,440
um okay so but if you think about

223
00:37:54,230 --> 00:37:51,599
microbes and life inside Earth's crust

224
00:37:55,790 --> 00:37:54,240
our dominant signal is things like the

225
00:37:57,410 --> 00:37:55,800
Amazon rainforest there's no question

226
00:38:00,589 --> 00:37:57,420
that this planet has tons of surface

227
00:38:03,410 --> 00:38:00,599
life so you have to ask the question

228
00:38:04,790 --> 00:38:03,420
is it real you know like what are all

229
00:38:06,950 --> 00:38:04,800
those little creepy crawlies are they

230
00:38:08,690 --> 00:38:06,960
meant to be there or are they just like

231
00:38:10,970 --> 00:38:08,700
the leftovers

232
00:38:13,790 --> 00:38:10,980
um you know it can be dangerous to

233
00:38:15,530 --> 00:38:13,800
assume that an organism is optimized to

234
00:38:17,870 --> 00:38:15,540
live just where you found it

235
00:38:20,510 --> 00:38:17,880
um I have this really self-deprecating

236
00:38:23,750 --> 00:38:20,520
anecdote hopefully

237
00:38:26,450 --> 00:38:23,760
um you guys will get so I I did a um the

238
00:38:28,190 --> 00:38:26,460

geobiology the agaron geobiology summer

239
00:38:30,829 --> 00:38:28,200
course which is now at Penn State do you

240
00:38:31,790 --> 00:38:30,839
guys know about this it's fantastic you

241
00:38:34,069 --> 00:38:31,800
should look into it if you don't know

242
00:38:35,270 --> 00:38:34,079
about it it's a um I think it's six week

243
00:38:37,190 --> 00:38:35,280
summer course and this year it's going

244
00:38:40,130 --> 00:38:37,200
to be in Italy is anybody going

245
00:38:41,450 --> 00:38:40,140
no okay it's gonna be great Jen mcelady

246
00:38:43,010 --> 00:38:41,460
is running it it's Penn State's first

247
00:38:44,329 --> 00:38:43,020
year so maybe it's a rocky first year go

248
00:38:45,470 --> 00:38:44,339
next year

249
00:38:47,390 --> 00:38:45,480
um

250
00:38:48,829 --> 00:38:47,400
but I I did that in the second year that

251
00:38:51,349 --> 00:38:48,839
it was ever around and we went to

252
00:38:53,450 --> 00:38:51,359
Yellowstone for our field trip and I was

253
00:38:55,250 --> 00:38:53,460
just like so full of wonder and like my

254
00:38:56,810 --> 00:38:55,260
eyes were saucers and I was taking in

255
00:38:58,790 --> 00:38:56,820
everything that I could and I was

256
00:39:01,849 --> 00:38:58,800
watching in this hot spring I was

257
00:39:03,770 --> 00:39:01,859
watching a spider in a hot spring and I

258
00:39:06,349 --> 00:39:03,780
was like oh my God this place is Magic

259
00:39:07,849 --> 00:39:06,359
even the spiders are adapted to high

260
00:39:10,609 --> 00:39:07,859
temperature and I was just watching this

261
00:39:13,130 --> 00:39:10,619
spider just like you know cool just like

262
00:39:14,690 --> 00:39:13,140
chilling in this hot spring just

263
00:39:16,609 --> 00:39:14,700

thinking oh my God I need to work on

264
00:39:17,690 --> 00:39:16,619
arachnids like I gotta switch my whole

265
00:39:19,790 --> 00:39:17,700
thing

266
00:39:22,790 --> 00:39:19,800
and do you know where this story is

267
00:39:24,829 --> 00:39:22,800
going right it died I watched the thing

268
00:39:26,630 --> 00:39:24,839
died it just like curled up and then I

269
00:39:29,810 --> 00:39:26,640
was like oh my God Karen you're such an

270
00:39:31,370 --> 00:39:29,820
idiot you know but that that we have to

271
00:39:33,530 --> 00:39:31,380
be conscious of that like are we just

272
00:39:35,450 --> 00:39:33,540
looking at something that's kind of not

273
00:39:36,890 --> 00:39:35,460
really supposed to be there well I I

274
00:39:38,870 --> 00:39:36,900
would like to convince you in this talk

275
00:39:41,450 --> 00:39:38,880
that that is not true for the subsurface

276
00:39:43,550 --> 00:39:41,460
it's got a lot more going for it than a

277
00:39:45,890 --> 00:39:43,560
spider in a hot spring

278
00:39:47,750 --> 00:39:45,900
um so here's my my list of evidence that

279
00:39:50,210 --> 00:39:47,760
the Deep biosphere on Earth is real

280
00:39:52,130 --> 00:39:50,220
alive and not just leftovers from the

281
00:39:54,290 --> 00:39:52,140
sub from the surface

282
00:39:56,569 --> 00:39:54,300
first of all there's a lot of energy

283
00:39:58,250 --> 00:39:56,579
sources in the subsurface it's not just

284
00:40:02,210 --> 00:39:58,260
like Marine sediments that are sort of

285
00:40:04,430 --> 00:40:02,220
piling up so um I see this figure a lot

286
00:40:06,470 --> 00:40:04,440
um but it's nice because it encapsulates

287
00:40:09,470 --> 00:40:06,480
a lot of different environments so we've

288
00:40:11,450 --> 00:40:09,480

got polar regions underneath glaciers we

289
00:40:13,250 --> 00:40:11,460
have deep anoxic brines we have a

290
00:40:15,589 --> 00:40:13,260
hydrothermal vents we of course have

291
00:40:17,750 --> 00:40:15,599
Marine sediments which cover so much of

292
00:40:20,109 --> 00:40:17,760
the planet we have subduction zones we

293
00:40:23,170 --> 00:40:20,119
have serpentinizing environments we have

294
00:40:26,690 --> 00:40:23,180
volcanic adjacent areas and then we have

295
00:40:28,370 --> 00:40:26,700
human-made areas as well for for

296
00:40:31,930 --> 00:40:28,380
human-made environments all of these

297
00:40:34,069 --> 00:40:31,940
things are are places where you can find

298
00:40:35,870 --> 00:40:34,079
nutrients to drive a subsurface

299
00:40:37,490 --> 00:40:35,880
biosphere so that's that's one thing

300
00:40:40,010 --> 00:40:37,500
it's got going for it

301
00:40:41,870 --> 00:40:40,020
the other thing is that when we look at

302
00:40:43,310 --> 00:40:41,880
what's down there we actually see

303
00:40:45,770 --> 00:40:43,320
evidence that these things are breathing

304
00:40:48,290 --> 00:40:45,780
that they're alive because we can see

305
00:40:50,270 --> 00:40:48,300
the chemical signature that they leave

306
00:40:52,010 --> 00:40:50,280
um and if you are a marine sediment

307
00:40:54,170 --> 00:40:52,020
person like I am you live and breathe

308
00:40:56,930 --> 00:40:54,180
these kind of diagrams but if you're not

309
00:40:59,150 --> 00:40:56,940
if you look at small what is it faint

310
00:41:01,250 --> 00:40:59,160
things next to bright things in the

311
00:41:02,810 --> 00:41:01,260
atmosphere then maybe you're not used to

312
00:41:06,170 --> 00:41:02,820
looking at stuff like this but this is

313
00:41:08,030 --> 00:41:06,180

this is my life um this is up here

314
00:41:09,410 --> 00:41:08,040
that's the ocean up there this is the

315
00:41:11,210 --> 00:41:09,420
surface of the mud and we're just like

316
00:41:12,890 --> 00:41:11,220
looking down into the muck and look at

317
00:41:14,630 --> 00:41:12,900
the depth scale on this this is meters

318
00:41:17,510 --> 00:41:14,640
so this is like drilling a football

319
00:41:19,310 --> 00:41:17,520
field worth down so this is a massive

320
00:41:21,050 --> 00:41:19,320
drilling operation

321
00:41:22,910 --> 00:41:21,060
um and then if you measure you section

322
00:41:24,650 --> 00:41:22,920
this thing into sections and you measure

323
00:41:27,410 --> 00:41:24,660
the concentrations of in this case

324
00:41:28,730 --> 00:41:27,420
sulfate as you go down and then methane

325
00:41:30,890 --> 00:41:28,740
as well

326
00:41:32,750 --> 00:41:30,900
the fact that this is curved like this

327
00:41:35,089 --> 00:41:32,760
and we can measure the sedimentation

328
00:41:36,589 --> 00:41:35,099
rate we can use those two factors and

329
00:41:38,210 --> 00:41:36,599
then just what we know about diffusion

330
00:41:40,310 --> 00:41:38,220
and compaction and basic things like

331
00:41:41,930 --> 00:41:40,320
that to calculate the rate at which

332
00:41:43,670 --> 00:41:41,940
these organisms are breathing the

333
00:41:45,650 --> 00:41:43,680
sulfate and the fact that it's shaped

334
00:41:47,210 --> 00:41:45,660
that it's got this concave shape means

335
00:41:49,010 --> 00:41:47,220
that somebody was breathing it you can't

336
00:41:50,810 --> 00:41:49,020
really get that shape unless you have

337
00:41:53,569 --> 00:41:50,820
upward infection of sulfate free fluids

338
00:41:55,790 --> 00:41:53,579

which we don't have in this situation so

339
00:41:58,730 --> 00:41:55,800
um this is evidence that these things

340
00:42:01,730 --> 00:41:58,740
are breathing and they're alive

341
00:42:03,650 --> 00:42:01,740
um and it's not like the stuff we find

342
00:42:04,970 --> 00:42:03,660
down there is just surface stuff that's

343
00:42:07,430 --> 00:42:04,980
hanging on

344
00:42:09,470 --> 00:42:07,440
um it's its own thing so if you do this

345
00:42:10,910 --> 00:42:09,480
is a easiest way to show this is one of

346
00:42:13,849 --> 00:42:10,920
my colleagues papers

347
00:42:15,849 --> 00:42:13,859
um this is a non-met non multi what's

348
00:42:18,530 --> 00:42:15,859
nmds what does that stand for

349
00:42:19,790 --> 00:42:18,540
non-multi-dimensional scaling parametric

350
00:42:24,530 --> 00:42:19,800
test

351
00:42:25,970 --> 00:42:24,540
um this is a uh axis-less axes but all

352
00:42:27,890 --> 00:42:25,980
you have to know to understand these

353
00:42:29,510 --> 00:42:27,900
data are the dots that are close

354
00:42:30,950 --> 00:42:29,520
together have more similar microbial

355
00:42:32,690 --> 00:42:30,960
communities and dots that are farther

356
00:42:35,510 --> 00:42:32,700
apart have more different microbial

357
00:42:37,250 --> 00:42:35,520
communities so all the seawater grouped

358
00:42:39,470 --> 00:42:37,260
together and all the Marine sediment

359
00:42:41,329 --> 00:42:39,480
group together and anybody who works in

360
00:42:43,670 --> 00:42:41,339
seawater and sediment just knows this

361
00:42:45,170 --> 00:42:43,680
intuitively we have almost no overlap in

362
00:42:48,410 --> 00:42:45,180
the types of microbes we find in these

363
00:42:50,510 --> 00:42:48,420

places so it's its own thing and then

364
00:42:52,849 --> 00:42:50,520
the last thing is much harder to show

365
00:42:55,550 --> 00:42:52,859
and I've spent a lot of my career and my

366
00:42:57,230 --> 00:42:55,560
students in my lab have worked on this

367
00:42:59,270 --> 00:42:57,240
um how do you show they're actually

368
00:43:01,130 --> 00:42:59,280
adapted to live in this place that's

369
00:43:02,329 --> 00:43:01,140
that's been a little more I'll spend a

370
00:43:04,730 --> 00:43:02,339
little bit more time talking about this

371
00:43:06,890 --> 00:43:04,740
because it's a bit more nuanced

372
00:43:09,109 --> 00:43:06,900
um but I'll first not go into the whole

373
00:43:11,089 --> 00:43:09,119
story but just talk about one of my

374
00:43:13,670 --> 00:43:11,099
graduate students Jordan bird took

375
00:43:15,530 --> 00:43:13,680
samples from an iotp expedition on the

376
00:43:18,890 --> 00:43:15,540
great shipment Nisha not the geordie's

377
00:43:21,109 --> 00:43:18,900
resolution which which the Baltic Sea

378
00:43:23,809 --> 00:43:21,119
and drilled hundreds of meters into the

379
00:43:26,450 --> 00:43:23,819
Baltic Sea and he combined meta

380
00:43:28,910 --> 00:43:26,460
transcriptomes metabolomes if you don't

381
00:43:31,250 --> 00:43:28,920
work with those things we basically if

382
00:43:33,890 --> 00:43:31,260
you think about like a cell as a bag of

383
00:43:35,690 --> 00:43:33,900
biomolecules like DNA RNA proteins

384
00:43:37,190 --> 00:43:35,700
lipids and all that kind of stuff and

385
00:43:39,710 --> 00:43:37,200
then all the chemicals that get pushed

386
00:43:41,750 --> 00:43:39,720
Along by those processes if you take a

387
00:43:43,609 --> 00:43:41,760
natural sample and you pull all those

388
00:43:46,250 --> 00:43:43,619

chemicals out and then just say well

389
00:43:48,230 --> 00:43:46,260
what was there then you can kind of back

390
00:43:50,569 --> 00:43:48,240
calculate what that cell was doing you

391
00:43:51,890 --> 00:43:50,579
can reconstruct how these organisms were

392
00:43:54,309 --> 00:43:51,900
actually functioning and that's the kind

393
00:43:58,130 --> 00:43:54,319
of stuff we do and so from that

394
00:43:59,930 --> 00:43:58,140
we found that it looks like they do have

395
00:44:02,210 --> 00:43:59,940
some adaptations to being there so we

396
00:44:04,670 --> 00:44:02,220
can see some actual chemical evidence

397
00:44:06,170 --> 00:44:04,680
not just in genes so remember this is

398
00:44:08,150 --> 00:44:06,180
why I'm sort of harping on this is that

399
00:44:10,069 --> 00:44:08,160
you can predict a lot of things from

400
00:44:13,069 --> 00:44:10,079
genes but we saw actual evidence that

401
00:44:15,950 --> 00:44:13,079
these functions were happening we saw a

402
00:44:18,710 --> 00:44:15,960
DNA repair that consumes NAD which is a

403
00:44:20,390 --> 00:44:18,720
cofactor that gets redox cycled in a

404
00:44:22,910 --> 00:44:20,400
cell but in this case is using for

405
00:44:24,650 --> 00:44:22,920
getting used for DNA repair

406
00:44:25,849 --> 00:44:24,660
we found an accumulation of osmo

407
00:44:28,190 --> 00:44:25,859
protectants so this is not a

408
00:44:29,990 --> 00:44:28,200
particularly saline place we kind of

409
00:44:32,630 --> 00:44:30,000
think that collecting things like

410
00:44:34,970 --> 00:44:32,640
triolose inside cells is a lot about

411
00:44:37,190 --> 00:44:34,980
shutting down and slowing down the cells

412
00:44:40,250 --> 00:44:37,200
like pickling themselves

413
00:44:42,650 --> 00:44:40,260

and we were able to find we discovered

414
00:44:44,930 --> 00:44:42,660
ecology which maybe doesn't sound like

415
00:44:46,430 --> 00:44:44,940
such an exciting thing to find but when

416
00:44:48,530 --> 00:44:46,440
you're dealing with an ecosystem that

417
00:44:50,569 --> 00:44:48,540
might kind of be dead finding ecological

418
00:44:52,490 --> 00:44:50,579
niches is a great little indicator that

419
00:44:56,390 --> 00:44:52,500
they're actually alive so we found that

420
00:44:58,069 --> 00:44:56,400
microbe a eats food a and micro b eats

421
00:45:00,650 --> 00:44:58,079
food B and we've showed that with

422
00:45:02,690 --> 00:45:00,660
functional assays which still blows my

423
00:45:04,970 --> 00:45:02,700
mind that that actually worked so this

424
00:45:07,130 --> 00:45:04,980
may be something that they do to not

425
00:45:09,170 --> 00:45:07,140
fight because basically when you don't

426
00:45:11,329 --> 00:45:09,180
have a lot of resources and nobody gets

427
00:45:13,550 --> 00:45:11,339
to come in and nobody gets to leave if

428
00:45:15,950 --> 00:45:13,560
you compete then it's mutually assured

429
00:45:18,050 --> 00:45:15,960
destruction if you kill that cell it's

430
00:45:20,270 --> 00:45:18,060
never getting another one

431
00:45:22,630 --> 00:45:20,280
um and then we found this one group if

432
00:45:25,130 --> 00:45:22,640
you are a microbiologist this might

433
00:45:26,690 --> 00:45:25,140
make sense to you the atro bacteria

434
00:45:27,890 --> 00:45:26,700
which is a deeply branching uncultured

435
00:45:29,750 --> 00:45:27,900
clade

436
00:45:31,069 --> 00:45:29,760
we think it eats this thing called Alan

437
00:45:33,050 --> 00:45:31,079
toen which is a nitrogen-rich

438
00:45:35,270 --> 00:45:33,060

degradation product and we think it's

439
00:45:37,970 --> 00:45:35,280
maybe a keystone of that Community

440
00:45:40,250 --> 00:45:37,980
because it looks like of all the

441
00:45:41,390 --> 00:45:40,260
transcripts so again those are the MRNA

442
00:45:43,730 --> 00:45:41,400
that are going to turn into proteins

443
00:45:46,609 --> 00:45:43,740
that were the most highly transcribed in

444
00:45:49,670 --> 00:45:46,619
this whole 8 000 year old sediment like

445
00:45:51,109 --> 00:45:49,680
50 meters down into the seafloor the

446
00:45:53,510 --> 00:45:51,119
second most the number one most

447
00:45:55,130 --> 00:45:53,520
transcribed Gene which if you've worked

448
00:45:56,089 --> 00:45:55,140
with transcriptomes you could probably

449
00:45:57,790 --> 00:45:56,099
guess what the number one was

450
00:45:59,690 --> 00:45:57,800
transcribed Gene was

451
00:46:04,370 --> 00:45:59,700
hypothetical

452
00:46:05,990 --> 00:46:04,380
things are like the most important genes

453
00:46:08,390 --> 00:46:06,000
in the whole ecosystem and we have no

454
00:46:10,670 --> 00:46:08,400
clue what they are so the second

455
00:46:13,250 --> 00:46:10,680
thing that was most transcribed was

456
00:46:14,630 --> 00:46:13,260
actually a sharing Gene so this is a

457
00:46:16,910 --> 00:46:14,640
starving environment where they don't

458
00:46:19,069 --> 00:46:16,920
have much to eat and the second most

459
00:46:22,250 --> 00:46:19,079
highly transcribed Gene was actually a

460
00:46:23,930 --> 00:46:22,260
transporter that's used in centrifies to

461
00:46:25,670 --> 00:46:23,940
share your food with others which is

462
00:46:27,290 --> 00:46:25,680
very touching

463
00:46:29,870 --> 00:46:27,300

um but it but it also

464
00:46:31,910 --> 00:46:29,880
um you know basically feeds into one of

465
00:46:35,210 --> 00:46:31,920
my sort of ongoing theories that these

466
00:46:36,650 --> 00:46:35,220
extreme apocalyptic ecosystems are not

467
00:46:38,270 --> 00:46:36,660
dog eat dog at all because it doesn't

468
00:46:40,849 --> 00:46:38,280
make sense to compete when things are so

469
00:46:43,309 --> 00:46:40,859
limited um they actually cooperate I

470
00:46:45,230 --> 00:46:43,319
think quite a bit

471
00:46:45,829 --> 00:46:45,240
um this is another

472
00:46:47,750 --> 00:46:45,839
um

473
00:46:49,370 --> 00:46:47,760
little piece of evidence that we have

474
00:46:50,990 --> 00:46:49,380
some adaptation to this environment is

475
00:46:52,309 --> 00:46:51,000
work that came from

476
00:46:54,170 --> 00:46:52,319
um one of my another one of my PhD

477
00:46:55,849 --> 00:46:54,180
students Katie Sipes who is so

478
00:46:58,130 --> 00:46:55,859
absolutely addicted to going to the

479
00:46:59,990 --> 00:46:58,140
Arctic after going she can't stay up

480
00:47:01,250 --> 00:47:00,000
it's so funny she keeps finding more

481
00:47:04,069 --> 00:47:01,260
projects and I'm like Katie where are

482
00:47:06,349 --> 00:47:04,079
you and she's like Greenland so what she

483
00:47:08,510 --> 00:47:06,359
found in Siberia this is this beautiful

484
00:47:10,370 --> 00:47:08,520
Kalama River this is some of the oldest

485
00:47:12,290 --> 00:47:10,380
permafrost on Earth so this has been

486
00:47:14,569 --> 00:47:12,300
continuously Frozen for a million years

487
00:47:16,730 --> 00:47:14,579
which is crazy

488
00:47:18,910 --> 00:47:16,740

um she found this group which I was

489
00:47:22,910 --> 00:47:18,920
telling some folks at dinner about this

490
00:47:24,710 --> 00:47:22,920
profundalis group is um uh only ever

491
00:47:26,270 --> 00:47:24,720
found in Marine environments and she

492
00:47:29,210 --> 00:47:26,280
found it in this freshwater

493
00:47:31,190 --> 00:47:29,220
um place and a lot of these um Clays

494
00:47:33,470 --> 00:47:31,200
that she found in this deep weird old

495
00:47:34,910 --> 00:47:33,480
permafrost are very similar to what we

496
00:47:36,470 --> 00:47:34,920
find in these other subsurface

497
00:47:39,109 --> 00:47:36,480
environments so it really seems like

498
00:47:41,210 --> 00:47:39,119
there's something going on and the last

499
00:47:42,470 --> 00:47:41,220
sort of adaptational story I'll tell is

500
00:47:44,270 --> 00:47:42,480
from another one of my former students

501
00:47:46,309 --> 00:47:44,280
Joy Bongiorno

502
00:47:48,290 --> 00:47:46,319
who looked at these transcriptional

503
00:47:50,450 --> 00:47:48,300
differences she has this amazing data

504
00:47:52,790 --> 00:47:50,460
set which actually we're still analyzing

505
00:47:54,650 --> 00:47:52,800
um but depth is here this is now

506
00:47:57,349 --> 00:47:54,660
centimeters so this is like over that

507
00:47:59,030 --> 00:47:57,359
much space it's not super deep but what

508
00:48:01,190 --> 00:47:59,040
she looked at was the total amount of

509
00:48:03,290 --> 00:48:01,200
transcription of each of these genes as

510
00:48:04,910 --> 00:48:03,300
as you go with depth and this is the

511
00:48:07,069 --> 00:48:04,920
amount of transcription on the y-axis

512
00:48:09,410 --> 00:48:07,079
and you can see it's in log here so this

513
00:48:11,690 --> 00:48:09,420

is quite a huge increase so she found

514
00:48:13,730 --> 00:48:11,700
this very big ramping up of this

515
00:48:15,710 --> 00:48:13,740
transcription of this one gene which

516
00:48:18,290 --> 00:48:15,720
ended up just being a gene to basically

517
00:48:21,170 --> 00:48:18,300
turn it into a Spore it was like a sort

518
00:48:24,230 --> 00:48:21,180
of like a strange type of sporulation so

519
00:48:25,790 --> 00:48:24,240
we think that these things we think that

520
00:48:28,609 --> 00:48:25,800
there are adaptations to being in the

521
00:48:31,309 --> 00:48:28,619
subsurface you know sporulating or

522
00:48:34,250 --> 00:48:31,319
repairing basically

523
00:48:36,770 --> 00:48:34,260
the we're not done I can't say that

524
00:48:38,690 --> 00:48:36,780
definitively but all of my research sort

525
00:48:40,670 --> 00:48:38,700
of points at the fact that these things

526
00:48:43,250 --> 00:48:40,680
are actually adapted to be where they

527
00:48:46,490 --> 00:48:43,260
are so

528
00:48:48,589 --> 00:48:46,500
now maybe I've convinced you that Earth

529
00:48:50,329 --> 00:48:48,599
does have a vibrant and varied

530
00:48:51,950 --> 00:48:50,339
subsurface biosphere that's supposed to

531
00:48:53,690 --> 00:48:51,960
be there it's not just waiting to get to

532
00:48:56,089 --> 00:48:53,700
the surface again it's it means to be

533
00:48:57,650 --> 00:48:56,099
there so what can how can we use this

534
00:48:59,030 --> 00:48:57,660
how can we use this to look for life on

535
00:49:01,790 --> 00:48:59,040
Europa

536
00:49:05,150 --> 00:49:01,800
um so I think of the subsurface as being

537
00:49:08,150 --> 00:49:05,160
divided up into two main categories one

538
00:49:09,890 --> 00:49:08,160

is subsurface life that gets its

539
00:49:11,750 --> 00:49:09,900
chemicals from inside Earth so it's

540
00:49:14,870 --> 00:49:11,760
basically got its own lunch with it and

541
00:49:17,210 --> 00:49:14,880
it's you know making its own biomass so

542
00:49:18,710 --> 00:49:17,220
chemosynthesis that's making biomass

543
00:49:20,690 --> 00:49:18,720
from chemicals

544
00:49:22,190 --> 00:49:20,700
and then the second type would be those

545
00:49:24,109 --> 00:49:22,200
that are dependent on photosynthesis

546
00:49:26,150 --> 00:49:24,119
which

547
00:49:27,829 --> 00:49:26,160
um you know are sort of like uh

548
00:49:30,530 --> 00:49:27,839
dependent on the surface world to give

549
00:49:31,130 --> 00:49:30,540
them food and to feed them and

550
00:49:33,470 --> 00:49:31,140
um

551
00:49:35,150 --> 00:49:33,480
the second one maybe

552
00:49:36,530 --> 00:49:35,160
I mean it's like doesn't seem as

553
00:49:38,030 --> 00:49:36,540
exciting right if we're talking about

554
00:49:40,430 --> 00:49:38,040
subsurface life you kind of want it to

555
00:49:42,170 --> 00:49:40,440
have its own thing and like just waiting

556
00:49:44,270 --> 00:49:42,180
for for stuff to trickle down from the

557
00:49:46,309 --> 00:49:44,280
surface seems like sort of cheating or

558
00:49:48,770 --> 00:49:46,319
maybe not what we're going for here but

559
00:49:50,450 --> 00:49:48,780
I wanna I wanna argue that this second

560
00:49:52,790 --> 00:49:50,460
group is actually useful for

561
00:49:54,410 --> 00:49:52,800
astrobiology we can still work on these

562
00:49:56,329 --> 00:49:54,420
places on Earth that are dependent on

563
00:49:58,430 --> 00:49:56,339

the surface and learn some stuff from it

564
00:49:59,750 --> 00:49:58,440
and I also forgot to say since it's the

565
00:50:02,150 --> 00:49:59,760
evening and we have a lot of different

566
00:50:03,349 --> 00:50:02,160
area of expertise if I if you want to

567
00:50:04,490 --> 00:50:03,359
ask a question

568
00:50:06,770 --> 00:50:04,500
we're not going to ask too many

569
00:50:08,030 --> 00:50:06,780
questions it's for technical reasons

570
00:50:09,290 --> 00:50:08,040
that you guys can't ask a lot of

571
00:50:12,230 --> 00:50:09,300
questions right now because there's a

572
00:50:14,210 --> 00:50:12,240
microphone but if if you're lost just

573
00:50:17,150 --> 00:50:14,220
raise your hand and be like what is can

574
00:50:21,710 --> 00:50:19,190
Okay so

575
00:50:23,390 --> 00:50:21,720
one useless raster biology do we not

576
00:50:24,950 --> 00:50:23,400
want to study places like Marine

577
00:50:27,349 --> 00:50:24,960
sediments because it's you know

578
00:50:28,430 --> 00:50:27,359
dependent on having Amazon's up at the

579
00:50:31,790 --> 00:50:28,440
top

580
00:50:34,309 --> 00:50:31,800
um no I think it's useful

581
00:50:36,829 --> 00:50:34,319
um because we can get to them which

582
00:50:38,569 --> 00:50:36,839
I mean I know that's not the best reason

583
00:50:40,490 --> 00:50:38,579
to study something but it is important

584
00:50:43,370 --> 00:50:40,500
like getting a sample is very important

585
00:50:45,770 --> 00:50:43,380
and the cool thing about Marine

586
00:50:47,450 --> 00:50:45,780
sediments is that they're layered so if

587
00:50:49,250 --> 00:50:47,460
you want to run an experiment for a

588
00:50:51,109 --> 00:50:49,260

million years and I want to run an

589
00:50:53,690 --> 00:50:51,119
experiment from like I cannot tell you

590
00:50:56,150 --> 00:50:53,700
how badly I want to run an experiment

591
00:50:58,970 --> 00:50:56,160
for a million years but obviously I

592
00:51:01,670 --> 00:50:58,980
cannot but Marine sediments have already

593
00:51:05,210 --> 00:51:01,680
done it and so if you can be creative

594
00:51:07,970 --> 00:51:05,220
about how you sample them you can test

595
00:51:09,829 --> 00:51:07,980
hypotheses that have been run for a

596
00:51:12,650 --> 00:51:09,839
million years already

597
00:51:15,470 --> 00:51:12,660
that's why they're they're magical to me

598
00:51:18,470 --> 00:51:15,480
um so I want to tell you about the kind

599
00:51:21,109 --> 00:51:18,480
of life we find in them by talking about

600
00:51:23,390 --> 00:51:21,119
this first Great Expedition that we had

601
00:51:25,309 --> 00:51:23,400
off the coast of Peru with the ocean

602
00:51:27,109 --> 00:51:25,319
drilling program it was not the

603
00:51:28,849 --> 00:51:27,119
integrated ocean Discovery program back

604
00:51:31,809 --> 00:51:28,859
then it was ODP

605
00:51:33,829 --> 00:51:31,819
and it was the first sort of aseptic

606
00:51:35,150 --> 00:51:33,839
samples that we got from the deep

607
00:51:37,549 --> 00:51:35,160
subsurface

608
00:51:40,010 --> 00:51:37,559
and I'll show you what we got

609
00:51:43,010 --> 00:51:40,020
um with the simplistic not naming the

610
00:51:45,829 --> 00:51:43,020
microbes but I'll show them with boxes

611
00:51:47,089 --> 00:51:45,839
um so the dark blue boxes will be a

612
00:51:48,170 --> 00:51:47,099
strain of microbe that somebody else

613
00:51:51,049 --> 00:51:48,180

discovered

614
00:51:52,490 --> 00:51:51,059
and the gradient to White will tell you

615
00:51:53,870 --> 00:51:52,500
how far away it is from something

616
00:51:55,430 --> 00:51:53,880
somebody's discovered so like the

617
00:51:57,349 --> 00:51:55,440
novelty of it if it's totally novel

618
00:51:58,670 --> 00:51:57,359
totally new phylum that's never been

619
00:52:01,309 --> 00:51:58,680
discovered before it'll be a white box

620
00:52:04,430 --> 00:52:01,319
and then shades of blue in between

621
00:52:06,470 --> 00:52:04,440
so what we caught with DNA sequences was

622
00:52:09,230 --> 00:52:06,480
a bunch of kind of light colored boxes

623
00:52:10,670 --> 00:52:09,240
this stuff was really new it was very

624
00:52:13,670 --> 00:52:10,680
much unlike anything we'd ever seen

625
00:52:15,530 --> 00:52:13,680
before this is what I did

626
00:52:17,329 --> 00:52:15,540
um probably almost exactly at where most

627
00:52:19,370 --> 00:52:17,339
of you guys are in your careers right

628
00:52:21,710 --> 00:52:19,380
now I was pulling these sequences out

629
00:52:23,630 --> 00:52:21,720
and using far less sophisticated

630
00:52:25,430 --> 00:52:23,640
bioinformatics at the time to figure out

631
00:52:28,190 --> 00:52:25,440
how closely related they were but it was

632
00:52:31,609 --> 00:52:28,200
we we didn't know we didn't know about

633
00:52:34,190 --> 00:52:31,619
this uncultured dominance of life like

634
00:52:35,569 --> 00:52:34,200
you guys do now we were finding it we

635
00:52:38,089 --> 00:52:35,579
were like what the hell is this stuff I

636
00:52:39,890 --> 00:52:38,099
don't know so obviously the first time

637
00:52:41,750 --> 00:52:39,900
you go to a place like this you want to

638
00:52:43,370 --> 00:52:41,760

start culturing stuff and and this is

639
00:52:45,170 --> 00:52:43,380
low hanging fruit it's full of new stuff

640
00:52:47,270 --> 00:52:45,180
we should be able to grow it

641
00:52:49,130 --> 00:52:47,280
um so I'll show you the results of the

642
00:52:50,750 --> 00:52:49,140
growth experiments and every time they

643
00:52:52,609 --> 00:52:50,760
got one of these guys

644
00:52:54,410 --> 00:52:52,619
I'll show you

645
00:52:56,030 --> 00:52:54,420
um the new one underneath it and then

646
00:52:58,069 --> 00:52:56,040
any extra ones I'll show you off to the

647
00:52:59,089 --> 00:52:58,079
side so this is these are the ones of

648
00:53:01,930 --> 00:52:59,099
these that they caught when they

649
00:53:07,870 --> 00:53:05,390
do you see any overlap

650
00:53:10,309 --> 00:53:07,880
do you see any white boxes

651
00:53:12,410 --> 00:53:10,319
got the same thing that people always

652
00:53:14,329 --> 00:53:12,420
get and this is not to say that we

653
00:53:15,530 --> 00:53:14,339
shouldn't culture I really I really

654
00:53:17,329 --> 00:53:15,540
don't want to send that message at all

655
00:53:19,430 --> 00:53:17,339
that is the wrong message and there's a

656
00:53:20,690 --> 00:53:19,440
lot of novelty even in here just getting

657
00:53:22,190 --> 00:53:20,700
something that looks like something

658
00:53:25,069 --> 00:53:22,200
we've seen before out of the deep ocean

659
00:53:26,690 --> 00:53:25,079
is absolutely worthwhile but we were not

660
00:53:28,309 --> 00:53:26,700
catching these guys and there actually

661
00:53:30,950 --> 00:53:28,319
was another group that did this too and

662
00:53:34,370 --> 00:53:30,960
they got pretty much the same thing so

663
00:53:36,470 --> 00:53:34,380

this this really hit home to me and is

664
00:53:38,990 --> 00:53:36,480
is one reason why I I really stick to

665
00:53:40,790 --> 00:53:39,000
this biomolecule stuff

666
00:53:42,109 --> 00:53:40,800
um we often call this stuff have you

667
00:53:44,270 --> 00:53:42,119
guys I'm sure you've heard this term

668
00:53:47,450 --> 00:53:44,280
microbial this is controversial does

669
00:53:49,990 --> 00:53:47,460
anybody hate that term no good

670
00:53:57,290 --> 00:53:50,000
accepting

671
00:54:04,130 --> 00:54:00,530
I I actually like this term because um

672
00:54:05,809 --> 00:54:04,140
uh what it's it signifies just how

673
00:54:07,609 --> 00:54:05,819
pervasive this stuff is it's just kind

674
00:54:10,430 --> 00:54:07,619
of like oh it's not like oh we found a

675
00:54:12,170 --> 00:54:10,440
new thing it's like this is the main

676
00:54:14,750 --> 00:54:12,180
thing and we don't know what it is but

677
00:54:18,410 --> 00:54:14,760
yeah in terms of total mass it is far

678
00:54:22,730 --> 00:54:18,420
far less than astronomical dark matter

679
00:54:24,950 --> 00:54:22,740
um so since then we did a study where we

680
00:54:27,290 --> 00:54:24,960
went through and pulled out Gene

681
00:54:28,790 --> 00:54:27,300
sequences from the subsurface and asked

682
00:54:31,250 --> 00:54:28,800
the same question for all of them like

683
00:54:32,809 --> 00:54:31,260
if we divide up like how many of the

684
00:54:34,309 --> 00:54:32,819
sequences that we find are closely

685
00:54:36,589 --> 00:54:34,319
related to a culture versus something

686
00:54:38,030 --> 00:54:36,599
else new entirely and then we sort of

687
00:54:41,030 --> 00:54:38,040
put them in categories

688
00:54:44,089 --> 00:54:41,040

we find that this biggest pie wedge from

689
00:54:46,609 --> 00:54:44,099
terrestrial subsurface metagenomes is

690
00:54:48,950 --> 00:54:46,619
novel generetic class and then we get

691
00:54:50,390 --> 00:54:48,960
almost more than a third a novel phyla

692
00:54:52,430 --> 00:54:50,400
so they're really dominant in these

693
00:54:54,049 --> 00:54:52,440
environments that's the bacteria and

694
00:54:56,329 --> 00:54:54,059
that's the archaea

695
00:54:57,950 --> 00:54:56,339
um so it's not just it's not just that

696
00:54:59,510 --> 00:54:57,960
they're there and they're dominating

697
00:55:02,210 --> 00:54:59,520
diversity they're actually dominating

698
00:55:04,430 --> 00:55:02,220
the total biomass in these subsequences

699
00:55:07,670 --> 00:55:04,440
they're totally new stuff

700
00:55:10,069 --> 00:55:07,680
um and I my other soapbox about this

701
00:55:12,230 --> 00:55:10,079
is that even you know you can look at

702
00:55:14,750 --> 00:55:12,240
this little yellow pie wedge so this is

703
00:55:16,730 --> 00:55:14,760
a cultured organism this is done you can

704
00:55:18,589 --> 00:55:16,740
the things that fall into this pie wedge

705
00:55:20,750 --> 00:55:18,599
are things that you can order from a

706
00:55:23,390 --> 00:55:20,760
company and grow in your lab

707
00:55:25,250 --> 00:55:23,400
um however even these ones are probably

708
00:55:26,569 --> 00:55:25,260
going to act differently when we study

709
00:55:28,549 --> 00:55:26,579
them in the subsurface than when they

710
00:55:31,190 --> 00:55:28,559
grow in our Labs I mean if you if you

711
00:55:34,309 --> 00:55:31,200
were like a lion researcher which would

712
00:55:36,829 --> 00:55:34,319
be awesome but if you studied Lions only

713
00:55:39,950 --> 00:55:36,839

in a zoo then you wouldn't you would be

714
00:55:42,589 --> 00:55:39,960
like lions their whole deal is that they

715
00:55:44,089 --> 00:55:42,599
eat little pre-packaged things of meat

716
00:55:45,829 --> 00:55:44,099
and cellophane and that would be your

717
00:55:47,390 --> 00:55:45,839
conclusion I mean that's stupid right we

718
00:55:49,910 --> 00:55:47,400
know they hunt and they kill live things

719
00:55:52,430 --> 00:55:49,920
out in nature but this is kind of like

720
00:55:54,470 --> 00:55:52,440
studying microbes in a zoo so even for

721
00:55:56,150 --> 00:55:54,480
the for the cultured guys we still need

722
00:55:57,829 --> 00:55:56,160
to go out into nature and we still need

723
00:56:00,770 --> 00:55:57,839
to sample them where they are and see

724
00:56:02,809 --> 00:56:00,780
try to figure out how they live so

725
00:56:05,210 --> 00:56:02,819
apbox number I don't know what number

726
00:56:08,510 --> 00:56:05,220
I'm on now many

727
00:56:11,930 --> 00:56:08,520
if you take microbiology 101 which I now

728
00:56:14,750 --> 00:56:11,940
teach we call it 220 actually

729
00:56:17,210 --> 00:56:14,760
um but you know like your your basic

730
00:56:18,589 --> 00:56:17,220
microbiology class microbes grow in

731
00:56:21,410 --> 00:56:18,599
cultures that's how we learn about

732
00:56:23,030 --> 00:56:21,420
microbes and we know a lot about like

733
00:56:25,430 --> 00:56:23,040
what microbes do on this planet these

734
00:56:28,190 --> 00:56:25,440
are like basic truths

735
00:56:30,589 --> 00:56:28,200
I'm not saying they're not true but I'm

736
00:56:34,130 --> 00:56:30,599
saying this is a frame of reference I

737
00:56:36,230 --> 00:56:34,140
want all of you to not think of these

738
00:56:38,510 --> 00:56:36,240

things as necessarily true

739
00:56:40,670 --> 00:56:38,520
just

740
00:56:42,530 --> 00:56:40,680
life could be different than what we

741
00:56:44,089 --> 00:56:42,540
think and it could be that there are

742
00:56:46,190 --> 00:56:44,099
microbes that are never going to grow in

743
00:56:48,290 --> 00:56:46,200
culture and are not going to act like

744
00:56:50,030 --> 00:56:48,300
anything that we've seen before and we

745
00:56:53,510 --> 00:56:50,040
need to not limit ourselves especially

746
00:56:55,670 --> 00:56:53,520
as astrobiologists you know we can't

747
00:56:57,049 --> 00:56:55,680
think small-minded about this stuff

748
00:56:58,250 --> 00:56:57,059
because we'll miss something really

749
00:56:59,450 --> 00:56:58,260
important

750
00:57:00,049 --> 00:56:59,460
um so

751
00:57:01,430 --> 00:57:00,059
um

752
00:57:04,190 --> 00:57:01,440
so

753
00:57:07,010 --> 00:57:04,200
how how fast do these things grow in

754
00:57:09,109 --> 00:57:07,020
each sentiments that's that's this is

755
00:57:10,970 --> 00:57:09,119
part of the taking the lid off and

756
00:57:13,190 --> 00:57:10,980
seeing your frame of your implicit frame

757
00:57:14,870 --> 00:57:13,200
of reference that you may not have even

758
00:57:17,030 --> 00:57:14,880
realized you have

759
00:57:19,609 --> 00:57:17,040
um is when we think of microbes maybe we

760
00:57:22,370 --> 00:57:19,619
think fast because pathogens grow fast

761
00:57:24,829 --> 00:57:22,380
right you get sick pretty quickly

762
00:57:26,210 --> 00:57:24,839
um E coli for instance which we've all

763
00:57:28,069 --> 00:57:26,220

worked with certainly has a doubling

764
00:57:30,230 --> 00:57:28,079
time of 30 minutes it's not even the

765
00:57:31,490 --> 00:57:30,240
fastest micro but it's pretty fast but

766
00:57:32,990 --> 00:57:31,500
if you

767
00:57:34,309 --> 00:57:33,000
because we can work in Marine

768
00:57:36,049 --> 00:57:34,319
settlements we can do time scales

769
00:57:38,089 --> 00:57:36,059
because we have these layers so we can

770
00:57:40,490 --> 00:57:38,099
actually measure the doubling time so if

771
00:57:42,890 --> 00:57:40,500
you look at sediments with these ages

772
00:57:43,910 --> 00:57:42,900
ranging from 100 years down to 5 000

773
00:57:52,010 --> 00:57:43,920
years

774
00:57:55,849 --> 00:57:52,020
and at the surface in 100 year old

775
00:57:58,549 --> 00:57:55,859
sediments it's still 0.1 year so this is

776
00:58:01,670 --> 00:57:58,559
like still very very slow compared to E

777
00:58:04,490 --> 00:58:01,680
coli but if you go down even further we

778
00:58:07,430 --> 00:58:04,500
get up to the tens of years and maybe

779
00:58:10,069 --> 00:58:07,440
100 years generation time

780
00:58:12,049 --> 00:58:10,079
um which you know

781
00:58:13,910 --> 00:58:12,059
we publish papers with these numbers in

782
00:58:16,430 --> 00:58:13,920
them all the time and we throw throw

783
00:58:18,049 --> 00:58:16,440
them around all the time but it's hard

784
00:58:19,549 --> 00:58:18,059
to wrap your brain around what it's like

785
00:58:20,329 --> 00:58:19,559
for a cell to actually live for that

786
00:58:22,069 --> 00:58:20,339
long

787
00:58:24,049 --> 00:58:22,079
um because this is a generation time

788
00:58:25,609 --> 00:58:24,059

this isn't necessarily dividing this

789
00:58:27,589 --> 00:58:25,619
could be just replacing itself like a

790
00:58:31,010 --> 00:58:27,599
turnover total carbon turnover for these

791
00:58:33,230 --> 00:58:31,020
cells so um so you know the number of

792
00:58:35,750 --> 00:58:33,240
cumulative Generations doesn't really

793
00:58:38,270 --> 00:58:35,760
increase at some point so what we have

794
00:58:40,670 --> 00:58:38,280
are a bunch of organisms that seem to

795
00:58:43,430 --> 00:58:40,680
just be hanging out for

796
00:58:48,289 --> 00:58:43,440
how how long can an individual live does

797
00:58:53,750 --> 00:58:51,049
one one

798
00:58:57,289 --> 00:58:53,760
I don't know nematode

799
00:59:00,410 --> 00:58:59,329
does anybody have a feel like what do

800
00:59:05,750 --> 00:59:00,420
you think of when you think of a

801
00:59:11,809 --> 00:59:07,370
you guys are all astrobiologists you'll

802
00:59:15,829 --> 00:59:13,670
thousands yeah

803
00:59:17,450 --> 00:59:15,839
yeah I mean even saying like thousands

804
00:59:19,849 --> 00:59:17,460
or five thousand years for a lifespan

805
00:59:22,309 --> 00:59:19,859
for one thing is already like utre right

806
00:59:25,190 --> 00:59:22,319
that is really long like we have um

807
00:59:26,990 --> 00:59:25,200
Sequoias are what 300 Bristlecone Pines

808
00:59:28,670 --> 00:59:27,000
or maybe a thousand do you have a

809
00:59:31,150 --> 00:59:28,680
thought

810
00:59:36,530 --> 00:59:31,160
Aspens

811
00:59:44,030 --> 00:59:39,829
10 million how about

812
00:59:46,490 --> 00:59:44,040
does that but but even in right and so

813
00:59:48,950 --> 00:59:46,500

those guys so it's like clonal right and

814
00:59:51,349 --> 00:59:48,960
then even like the Sequoia that's not

815
00:59:53,329 --> 00:59:51,359
clonal it still has that living tissue

816
00:59:55,370 --> 00:59:53,339
and the living tissue certainly like

817
00:59:58,609 --> 00:59:55,380
those cells a living cell doesn't last

818
01:00:01,309 --> 00:59:58,619
as long as the whole tree so

819
01:00:03,109 --> 01:00:01,319
yeah we've got things that what I'm

820
01:00:05,930 --> 01:00:03,119
saying are lasting for a hundred

821
01:00:09,289 --> 01:00:05,940
thousand years one cell one like little

822
01:00:12,349 --> 01:00:09,299
precious tiny little lipid sack is

823
01:00:14,690 --> 01:00:12,359
hanging out intact

824
01:00:16,250 --> 01:00:14,700
for a hundred thousand years and I'm

825
01:00:18,170 --> 01:00:16,260
gonna venture to say also a million

826
01:00:21,650 --> 01:00:18,180
because why not

827
01:00:24,890 --> 01:00:21,660
and and I don't I don't know man like

828
01:00:27,170 --> 01:00:24,900
it's crazy but they might

829
01:00:28,309 --> 01:00:27,180
extra evidence for this because it's

830
01:00:31,370 --> 01:00:28,319
crazy

831
01:00:34,970 --> 01:00:31,380
Biz if you add up a total power so

832
01:00:37,130 --> 01:00:34,980
remember back to physics power is energy

833
01:00:38,569 --> 01:00:37,140
over time it's the flow rate of how much

834
01:00:40,789 --> 01:00:38,579
energy you can feed something because

835
01:00:43,970 --> 01:00:40,799
you can have a very nice Quantum of

836
01:00:46,190 --> 01:00:43,980
energy like you can a pizza will be just

837
01:00:47,690 --> 01:00:46,200
fine for me for a day but a pizza is not

838
01:00:50,569 --> 01:00:47,700

going to last me for my lifetime I'll

839
01:00:52,789 --> 01:00:50,579
die so the delivery rate of your food

840
01:00:54,470 --> 01:00:52,799
really matters so if you add up the

841
01:00:57,049 --> 01:00:54,480
total power per cell because we know

842
01:00:58,910 --> 01:00:57,059
pretty much how many cells there are out

843
01:01:01,190 --> 01:00:58,920
in in Marine sediments

844
01:01:03,289 --> 01:01:01,200
um this right here is the lowest

845
01:01:05,870 --> 01:01:03,299
measured power per cell that somebody

846
01:01:08,329 --> 01:01:05,880
has measured in a non-growing chemostat

847
01:01:09,770 --> 01:01:08,339
have you heard of retento stats I really

848
01:01:12,710 --> 01:01:09,780
love retento stats but people don't work

849
01:01:14,210 --> 01:01:12,720
in them a chemostat is a sort of a

850
01:01:16,430 --> 01:01:14,220
normal thing to do where you're passing

851
01:01:17,750 --> 01:01:16,440
fluids through a population and you have

852
01:01:19,130 --> 01:01:17,760
them grow at a certain rate and you're

853
01:01:21,530 --> 01:01:19,140
constantly feeding them and growing them

854
01:01:23,809 --> 01:01:21,540
a retentostat just has a filter at the

855
01:01:25,190 --> 01:01:23,819
end so you're not nothing is leaving so

856
01:01:27,589 --> 01:01:25,200
they're not regrowing so you just keep

857
01:01:28,970 --> 01:01:27,599
them there so in a retentive stat they

858
01:01:30,890 --> 01:01:28,980
get down to this extremely

859
01:01:32,450 --> 01:01:30,900
extraordinarily low power but then if

860
01:01:34,549 --> 01:01:32,460
you look if you integrate the total

861
01:01:37,069 --> 01:01:34,559
power available from sulfate reduction

862
01:01:38,390 --> 01:01:37,079
and from methanogenesis all underneath

863
01:01:41,510 --> 01:01:38,400

the world's oceans

864
01:01:44,030 --> 01:01:41,520
it is orders of magnitude less than what

865
01:01:45,950 --> 01:01:44,040
it takes to just keep a cell going not

866
01:01:47,990 --> 01:01:45,960
growing growing is like way out here

867
01:01:51,170 --> 01:01:48,000
growing is not even on this chart this

868
01:01:54,710 --> 01:01:51,180
is just like existing so

869
01:01:57,049 --> 01:01:54,720
it's weird man it's real weird and and

870
01:01:59,510 --> 01:01:57,059
this is the reason I'm emphasizing this

871
01:02:01,789 --> 01:01:59,520
to you guys is that this means that

872
01:02:04,430 --> 01:02:01,799
there's basically a lot more energetic

873
01:02:06,950 --> 01:02:04,440
space for life in this universe than we

874
01:02:09,650 --> 01:02:06,960
think about in our daily lives we can we

875
01:02:11,990 --> 01:02:09,660
can imagine more for where life exists

876
01:02:14,690 --> 01:02:12,000
than you know

877
01:02:16,130 --> 01:02:14,700
just you know my dog and cat my kids and

878
01:02:17,630 --> 01:02:16,140
stuff

879
01:02:18,950 --> 01:02:17,640
um so

880
01:02:20,870 --> 01:02:18,960
um what we've learned from Marine

881
01:02:22,430 --> 01:02:20,880
sediments is that life in the subsurface

882
01:02:24,650 --> 01:02:22,440
may be fundamentally mentally different

883
01:02:27,230 --> 01:02:24,660
than what we've studied before

884
01:02:29,270 --> 01:02:27,240
and we can survive on much less power

885
01:02:30,890 --> 01:02:29,280
than we experience in the sub in the

886
01:02:33,049 --> 01:02:30,900
surface world

887
01:02:34,609 --> 01:02:33,059
and this Hundred Year lifespan thing

888
01:02:36,710 --> 01:02:34,619

which we're kind of intrinsically stuck

889
01:02:38,630 --> 01:02:36,720
within our brains is an assumption it's

890
01:02:39,289 --> 01:02:38,640
not a requirement

891
01:02:42,349 --> 01:02:39,299
um

892
01:02:45,109 --> 01:02:42,359
Okay so

893
01:02:47,690 --> 01:02:45,119
I want to switch gears how far on this

894
01:02:50,390 --> 01:02:47,700
I'm 37 minutes into this well no it's

895
01:02:51,770 --> 01:02:50,400
not quite 37 minutes

896
01:02:53,089 --> 01:02:51,780
I guess the bar is closed I can't tell

897
01:02:55,970 --> 01:02:53,099
you guys to get a drink

898
01:02:57,650 --> 01:02:55,980
does anybody need I'm gonna drink does

899
01:03:04,910 --> 01:02:57,660
anybody have a question before I go to

900
01:03:07,910 --> 01:03:05,589
cool

901
01:03:11,030 --> 01:03:07,920
like what's going on with like why

902
01:03:12,950 --> 01:03:11,040
they're but they photosynthesize oh

903
01:03:13,910 --> 01:03:12,960
that's a good one so for those of you

904
01:03:15,650 --> 01:03:13,920
who didn't hear that because the

905
01:03:17,150 --> 01:03:15,660
microphone wasn't there oh sorry why are

906
01:03:18,829 --> 01:03:17,160
there so many chloroflexy there are they

907
01:03:20,990 --> 01:03:18,839
adapted to the subsurface because they

908
01:03:22,670 --> 01:03:21,000
are photosynthesizers or at least

909
01:03:25,809 --> 01:03:22,680
phototrophic they are not all

910
01:03:33,470 --> 01:03:30,230
is a Genus within there's a lot but um

911
01:03:34,789 --> 01:03:33,480
the halogen nators I guess you could

912
01:03:36,710 --> 01:03:34,799
call them so

913
01:03:38,030 --> 01:03:36,720

um that's where a lot of the chloroflexi

914
01:03:39,710 --> 01:03:38,040
research has been done just because

915
01:03:41,270 --> 01:03:39,720
that's funded because it's

916
01:03:42,770 --> 01:03:41,280
bioremediation because we use

917
01:03:43,789 --> 01:03:42,780
chlorinated compounds to clean planes

918
01:03:46,010 --> 01:03:43,799
and stuff

919
01:03:47,690 --> 01:03:46,020
um so those are fascinating organisms in

920
01:03:50,329 --> 01:03:47,700
and of themselves but most of the

921
01:03:52,370 --> 01:03:50,339
chlorophy that we find are in our linear

922
01:03:54,589 --> 01:03:52,380
I don't know if you know that group it's

923
01:03:56,809 --> 01:03:54,599
not well cultured

924
01:04:00,890 --> 01:03:56,819
um we don't have any phototrophic genes

925
01:04:02,569 --> 01:04:00,900
in them but yeah there's a lot but I

926
01:04:04,190 --> 01:04:02,579
it's cool that you bring up the

927
01:04:05,569 --> 01:04:04,200
chloroflexy because they are one of the

928
01:04:07,910 --> 01:04:05,579
most mysterious

929
01:04:08,569 --> 01:04:07,920
phyla do you work on chloroflexy um I'm

930
01:04:11,870 --> 01:04:08,579
working

931
01:04:13,130 --> 01:04:11,880
uh steam vents and like I'm in uh

932
01:04:14,630 --> 01:04:13,140
Jimmy's laws group so we do a lot of

933
01:04:16,549 --> 01:04:14,640
thermophiles and stuff

934
01:04:18,770 --> 01:04:16,559
um yeah yeah

935
01:04:20,569 --> 01:04:18,780
um so chlorofloxacy keep popping up and

936
01:04:22,010 --> 01:04:20,579
there's a lot of them and I just keep

937
01:04:23,630 --> 01:04:22,020
looking at my genomes and I'm like yeah

938
01:04:25,609 --> 01:04:23,640

so the study that we did where we

939
01:04:27,710 --> 01:04:25,619
Quantified the uncultured things all

940
01:04:32,329 --> 01:04:27,720
around the world of all the we looked at

941
01:04:34,190 --> 01:04:32,339
all environments it the only clade that

942
01:04:35,750 --> 01:04:34,200
showed up in the most uncultured that

943
01:04:38,390 --> 01:04:35,760
showed up as sorry as one of the most

944
01:04:40,849 --> 01:04:38,400
abundant clades in every environment

945
01:04:45,289 --> 01:04:40,859
you know animal guts engineered places

946
01:04:47,690 --> 01:04:45,299
human guts snow everything was annaolini

947
01:04:49,430 --> 01:04:47,700
it's that chlorophy group like

948
01:04:51,230 --> 01:04:49,440
everything else like shifts and you have

949
01:04:53,150 --> 01:04:51,240
some things in some places but

950
01:04:54,950 --> 01:04:53,160
annerolini I don't know if that's how

951
01:04:58,130 --> 01:04:54,960
you pronounce it they're everywhere they

952
01:05:02,870 --> 01:04:58,140
drive me nuts I don't know what they do

953
01:05:02,880 --> 01:05:11,329
this microphone javelin's a bad idea

954
01:05:15,530 --> 01:05:13,010
um do you think it's just the the

955
01:05:17,450 --> 01:05:15,540
doubling time or is it nutrients and

956
01:05:19,069 --> 01:05:17,460
potentially like physical structure

957
01:05:20,990 --> 01:05:19,079
that's a problem for culturing microbes

958
01:05:22,250 --> 01:05:21,000
in the sediments oh why don't we get

959
01:05:22,970 --> 01:05:22,260
cultures

960
01:05:25,309 --> 01:05:22,980
um

961
01:05:27,950 --> 01:05:25,319
I wish I knew that I think it's all

962
01:05:29,690 --> 01:05:27,960
those things I mean it's like

963
01:05:32,770 --> 01:05:29,700

if you think about what culturing is

964
01:05:35,450 --> 01:05:32,780
it's Limitless access to Abundant

965
01:05:37,309 --> 01:05:35,460
substrate which is a problem if you

966
01:05:39,230 --> 01:05:37,319
don't have like running your metabolism

967
01:05:41,150 --> 01:05:39,240
really hot is actually dangerous for a

968
01:05:42,950 --> 01:05:41,160
cell and those of us who run at a very

969
01:05:44,930 --> 01:05:42,960
high level like have all kinds of

970
01:05:46,970 --> 01:05:44,940
reactive oxygen species defenses and

971
01:05:49,069 --> 01:05:46,980
things like that but if you're not set

972
01:05:51,230 --> 01:05:49,079
up to go fast then being forced to go

973
01:05:53,210 --> 01:05:51,240
fast can kill you so that's one thing

974
01:05:55,370 --> 01:05:53,220
too much too much food you need your

975
01:05:58,670 --> 01:05:55,380
friends you need your enemies you need

976
01:06:00,049 --> 01:05:58,680
vitamins you need minerals that you're

977
01:06:01,849 --> 01:06:00,059
lacking you need them in the right

978
01:06:03,650 --> 01:06:01,859
crystalline structure

979
01:06:04,309 --> 01:06:03,660
pressure

980
01:06:06,049 --> 01:06:04,319
um

981
01:06:07,849 --> 01:06:06,059
I don't know if it's self-congratulatory

982
01:06:11,450 --> 01:06:07,859
to talk about my TED talk but I gave

983
01:06:16,670 --> 01:06:14,210
whatever it happened I um

984
01:06:19,250 --> 01:06:16,680
I gave this Ted talk about culturing

985
01:06:21,829 --> 01:06:19,260
things in the deep sea and I get an

986
01:06:23,270 --> 01:06:21,839
email like probably it's slowed down now

987
01:06:24,770 --> 01:06:23,280
but it was like hot and heavy when the

988
01:06:26,510 --> 01:06:24,780

first thing came out thing first came

989
01:06:27,590 --> 01:06:26,520
out somebody being like have you

990
01:06:29,470 --> 01:06:27,600
considered pressure

991
01:06:32,210 --> 01:06:29,480
[Music]

992
01:06:34,430 --> 01:06:32,220
yes I've considered pressure it's like I

993
01:06:36,109 --> 01:06:34,440
forgot to mention it in the talk but

994
01:06:37,430 --> 01:06:36,119
um people are thinking it's good there's

995
01:06:39,109 --> 01:06:37,440
a lot there's a lot of reasons why

996
01:06:44,750 --> 01:06:39,119
things are not on culture but I I think

997
01:06:50,150 --> 01:06:47,690
uh hypothetical I think I guess

998
01:06:51,589 --> 01:06:50,160
philosophical question do you think a

999
01:06:54,710 --> 01:06:51,599
cell could

1000
01:06:56,089 --> 01:06:54,720
possibly never die or is it possible

1001
01:06:58,609 --> 01:06:56,099
that the lifespan could just be

1002
01:07:00,049 --> 01:06:58,619
essentially infinite we have a we have a

1003
01:07:01,250 --> 01:07:00,059
limiter on that

1004
01:07:05,870 --> 01:07:01,260
and it's

1005
01:07:10,430 --> 01:07:08,089
but that's it I mean but that's a huge I

1006
01:07:12,650 --> 01:07:10,440
mean that's a lot to play with and then

1007
01:07:14,029 --> 01:07:12,660
if you if you invoke panspermia which I

1008
01:07:15,950 --> 01:07:14,039
don't know if you know this theory that

1009
01:07:18,410 --> 01:07:15,960
life formed outside of which I wanted to

1010
01:07:22,609 --> 01:07:18,420
switch to pan ovia but then I don't know

1011
01:07:24,650 --> 01:07:22,619
whatever pan pan movie of

1012
01:07:26,750 --> 01:07:24,660
um of life then you know you could have

1013
01:07:28,309 --> 01:07:26,760

a living cell that was like when the

1014
01:07:29,690 --> 01:07:28,319
Milwaukee and period on Mars was you

1015
01:07:32,029 --> 01:07:29,700
probably know better than me like five

1016
01:07:34,609 --> 01:07:32,039
billion years ago six

1017
01:07:36,650 --> 01:07:34,619
anyway Mars is older than Earth so

1018
01:07:37,730 --> 01:07:36,660
that may be our limiter I don't know but

1019
01:07:42,770 --> 01:07:37,740
that's crazy

1020
01:07:46,970 --> 01:07:44,930
so you mentioned about um the abundance

1021
01:07:48,049 --> 01:07:46,980
of centrify in the Deep subsurface

1022
01:07:49,010 --> 01:07:48,059
communities

1023
01:07:50,329 --> 01:07:49,020
um do you think

1024
01:07:52,069 --> 01:07:50,339
um are there any like interesting

1025
01:07:53,510 --> 01:07:52,079
patterns in the distribution of like

1026
01:07:59,150 --> 01:07:53,520
microbes that are typically associated

1027
01:08:03,349 --> 01:08:01,309
um or is it always just nutrient

1028
01:08:05,510 --> 01:08:03,359
limitation you mean like physically

1029
01:08:10,789 --> 01:08:05,520
where cells sit really to each other do

1030
01:08:15,890 --> 01:08:13,250
yeah like do we see more Center fees in

1031
01:08:17,150 --> 01:08:15,900
some areas and then others um I don't I

1032
01:08:19,309 --> 01:08:17,160
don't think we have that kind of

1033
01:08:20,930 --> 01:08:19,319
knowledge like that resolution like you

1034
01:08:23,150 --> 01:08:20,940
could maybe do that project but I don't

1035
01:08:25,370 --> 01:08:23,160
think we have that like just concluding

1036
01:08:29,749 --> 01:08:25,380
centrify from like the transcription of

1037
01:08:36,950 --> 01:08:29,759
some genes is already kind of sketch so

1038
01:08:42,229 --> 01:08:39,289

okay hi I really like your talk so far

1039
01:08:45,169 --> 01:08:42,239
uh so I I haven't done research in the

1040
01:08:46,070 --> 01:08:45,179
Deep subsurface as well and so you had a

1041
01:08:48,530 --> 01:08:46,080
slide that showed the different

1042
01:08:50,090 --> 01:08:48,540
adaptations for the subsurface microbes

1043
01:08:52,430 --> 01:08:50,100
and I think you mentioned that you had

1044
01:08:55,430 --> 01:08:52,440
transcriptomic data genomic data yeah

1045
01:08:57,229 --> 01:08:55,440
metabolomic data so it's a lot of data

1046
01:08:59,329 --> 01:08:57,239
um and I only work with

1047
01:09:01,010 --> 01:08:59,339
um genomic data and already I'm so

1048
01:09:03,590 --> 01:09:01,020
overwhelmed by the different things that

1049
01:09:05,090 --> 01:09:03,600
I can analyze so I was just curious I

1050
01:09:06,349 --> 01:09:05,100
mean I could read the paper but you're

1051
01:09:07,990 --> 01:09:06,359
here now

1052
01:09:10,090 --> 01:09:08,000
um how do you

1053
01:09:16,370 --> 01:09:10,100
how do you

1054
01:09:18,169 --> 01:09:16,380
mess of data yeah and how does it

1055
01:09:20,450 --> 01:09:18,179
compare so you mentioned DNA repair

1056
01:09:22,370 --> 01:09:20,460
mechanisms and all of this like how does

1057
01:09:24,769 --> 01:09:22,380
that compare to the terrestrial

1058
01:09:25,849 --> 01:09:24,779
counterparts yeah that's those are

1059
01:09:26,930 --> 01:09:25,859
really good questions I mean I think

1060
01:09:29,090 --> 01:09:26,940
this is something that we all face

1061
01:09:31,729 --> 01:09:29,100
there's like in every project and I've

1062
01:09:33,709 --> 01:09:31,739
seen it happen to all my students you

1063
01:09:35,689 --> 01:09:33,719

work so hard to get that giant data set

1064
01:09:37,729 --> 01:09:35,699
and then you get it and you're like what

1065
01:09:39,950 --> 01:09:37,739
do I do with this fire of information

1066
01:09:41,809 --> 01:09:39,960
and it's not like how you analyze it

1067
01:09:43,010 --> 01:09:41,819
there's no prescribed path through it

1068
01:09:44,150 --> 01:09:43,020
which I think is a wonderful thing

1069
01:09:45,530 --> 01:09:44,160
because it means somebody could take

1070
01:09:47,329 --> 01:09:45,540
your same data set and draw completely

1071
01:09:49,490 --> 01:09:47,339
different conclusions from it but in the

1072
01:09:51,110 --> 01:09:49,500
case of the stuff I was talking about we

1073
01:09:53,689 --> 01:09:51,120
started with our smallest data set and

1074
01:09:54,830 --> 01:09:53,699
our most valuable so we did metabolites

1075
01:09:56,450 --> 01:09:54,840
which

1076
01:09:58,550 --> 01:09:56,460
if you haven't worked with these this is

1077
01:10:00,890 --> 01:09:58,560
like you do liquid chromatography

1078
01:10:02,750 --> 01:10:00,900
coupled to mass spectrometry coupled to

1079
01:10:04,790 --> 01:10:02,760
another Mass spectrometry to sort of

1080
01:10:06,350 --> 01:10:04,800
spread things out and get monomers so

1081
01:10:08,570 --> 01:10:06,360
you can basically get things at the

1082
01:10:10,850 --> 01:10:08,580
amino as like monomeric amino acid level

1083
01:10:13,250 --> 01:10:10,860
and you kind of get what you you get and

1084
01:10:15,050 --> 01:10:13,260
so I I only did it because my buddy does

1085
01:10:17,030 --> 01:10:15,060
this like down the hall and he was like

1086
01:10:18,650 --> 01:10:17,040
let me put some of your weird samples in

1087
01:10:20,090 --> 01:10:18,660
the machine and I was like that's insane

1088
01:10:21,649 --> 01:10:20,100

because you're just going to get the

1089
01:10:23,630 --> 01:10:21,659
organic matter that's around like the

1090
01:10:25,430 --> 01:10:23,640
stuff is not necessarily connected to

1091
01:10:26,570 --> 01:10:25,440
the living microbes and he's like let's

1092
01:10:27,770 --> 01:10:26,580
just try it

1093
01:10:30,290 --> 01:10:27,780
and

1094
01:10:32,030 --> 01:10:30,300
he was like it totally failed it didn't

1095
01:10:33,649 --> 01:10:32,040
work and I was like well yeah nothing

1096
01:10:35,390 --> 01:10:33,659
ever works in the subsurface it doesn't

1097
01:10:38,930 --> 01:10:35,400
surprise me but he was like I only got

1098
01:10:43,130 --> 01:10:38,940
20 metabolites and I was like 20s a lot

1099
01:10:45,169 --> 01:10:43,140
so we took our 20 and just backed off of

1100
01:10:47,510 --> 01:10:45,179
them we said okay we've got nicotinate

1101
01:10:49,490 --> 01:10:47,520
and I I was like what in the world is

1102
01:10:50,750 --> 01:10:49,500
like I Googled it I was like what is

1103
01:10:52,850 --> 01:10:50,760
this and what is it used for and it's

1104
01:10:55,490 --> 01:10:52,860
like oh it's a precursor to NAD and then

1105
01:10:57,470 --> 01:10:55,500
we also had quinlanate it's like never

1106
01:11:00,050 --> 01:10:57,480
heard of that organ of that that

1107
01:11:01,430 --> 01:11:00,060
compound before and it's also an

1108
01:11:03,290 --> 01:11:01,440
intermediate in the pathway for the

1109
01:11:04,729 --> 01:11:03,300
creation of NAD and so then because we

1110
01:11:07,189 --> 01:11:04,739
had the transcripts we were able to say

1111
01:11:09,530 --> 01:11:07,199
who is producing the biosynthetic

1112
01:11:12,530 --> 01:11:09,540
pathways for these molecules that we see

1113
01:11:14,570 --> 01:11:12,540

and so that was a nice way to do a data

1114
01:11:16,189 --> 01:11:14,580
reduction those may not be the most

1115
01:11:18,470 --> 01:11:16,199
important stories in those

1116
01:11:20,149 --> 01:11:18,480
ecosystems in fact they probably are not

1117
01:11:22,310 --> 01:11:20,159
right like we probably missed the

1118
01:11:24,350 --> 01:11:22,320
biggest story that's there

1119
01:11:25,729 --> 01:11:24,360
but that was just the one we found I

1120
01:11:28,450 --> 01:11:25,739
don't know if that's helpful that's

1121
01:11:30,530 --> 01:11:28,460
super helpful metabolomics are great

1122
01:11:32,149 --> 01:11:30,540
they can be great they can be confusing

1123
01:11:34,070 --> 01:11:32,159
too but but it's also like when you're

1124
01:11:35,510 --> 01:11:34,080
dealing with a gigantic data set like I

1125
01:11:37,250 --> 01:11:35,520
guess just don't worry about getting the

1126
01:11:39,410 --> 01:11:37,260
perfect story like if you can find that

1127
01:11:40,910 --> 01:11:39,420
it says something like run with it

1128
01:11:41,770 --> 01:11:40,920
and publish it so we can know about it

1129
01:11:48,590 --> 01:11:41,780
too

1130
01:11:53,510 --> 01:11:50,630
um hi thank you for your talk I you talk

1131
01:11:54,830 --> 01:11:53,520
about these cells that live for hundreds

1132
01:11:57,290 --> 01:11:54,840
of thousands of years or like millions

1133
01:11:59,570 --> 01:11:57,300
of years or billions of years but maybe

1134
01:12:01,370 --> 01:11:59,580
philosophically speaking what do you

1135
01:12:04,070 --> 01:12:01,380
consider to be an individual like when

1136
01:12:06,890 --> 01:12:04,080
all the bioplasts kind of re like you

1137
01:12:09,169 --> 01:12:06,900
know like we

1138
01:12:10,970 --> 01:12:09,179

regenerate or whatever recycles thank

1139
01:12:12,709 --> 01:12:10,980
you is it the same um is that still the

1140
01:12:14,870 --> 01:12:12,719
same individual like how do you work

1141
01:12:16,610 --> 01:12:14,880
around that yeah I don't know I mean I

1142
01:12:18,470 --> 01:12:16,620
guess that is a truly philosophical

1143
01:12:21,770 --> 01:12:18,480
question there's like the philosophical

1144
01:12:23,090 --> 01:12:21,780
point about like my grandfather's ax do

1145
01:12:24,530 --> 01:12:23,100
you know about my grandfather's acts

1146
01:12:26,209 --> 01:12:24,540
there's something in like this is my

1147
01:12:28,070 --> 01:12:26,219
grandfather's ax it's you know he had it

1148
01:12:29,810 --> 01:12:28,080
and it's like well the I replaced the

1149
01:12:31,070 --> 01:12:29,820
blade a little while ago well I replaced

1150
01:12:32,810 --> 01:12:31,080
the handle a little while ago I replace

1151
01:12:34,729 --> 01:12:32,820
the like the leather strapping on it

1152
01:12:37,010 --> 01:12:34,739
it's like okay no molecule of that ax

1153
01:12:38,870 --> 01:12:37,020
was ever held by your grandfather but

1154
01:12:40,610 --> 01:12:38,880
it's my grandfather's ax so then that

1155
01:12:41,810 --> 01:12:40,620
that's a purely philosophical question

1156
01:12:43,189 --> 01:12:41,820
but I think there's a second

1157
01:12:44,930 --> 01:12:43,199
philosophical question which I find

1158
01:12:47,149 --> 01:12:44,940
interesting which is what is an

1159
01:12:48,649 --> 01:12:47,159
individual which is what you said first

1160
01:12:51,709 --> 01:12:48,659
which is like

1161
01:12:53,330 --> 01:12:51,719
when we talk about microbes we tend to

1162
01:12:54,890 --> 01:12:53,340
talk about the individual as a

1163
01:12:57,110 --> 01:12:54,900

collection of cells we talk about a

1164
01:12:58,990 --> 01:12:57,120
strain you know we don't talk about a

1165
01:13:02,510 --> 01:12:59,000
cell like an individual cell is

1166
01:13:04,130 --> 01:13:02,520
pointless in in real normal microbiology

1167
01:13:06,950 --> 01:13:04,140
because they're constantly regenerating

1168
01:13:08,810 --> 01:13:06,960
and we have cell lines and stuff but in

1169
01:13:11,390 --> 01:13:08,820
this environment where you can't have a

1170
01:13:13,010 --> 01:13:11,400
cell line suddenly the individual takes

1171
01:13:15,350 --> 01:13:13,020
on great importance

1172
01:13:17,870 --> 01:13:15,360
this is almost akin to like our lives

1173
01:13:20,090 --> 01:13:17,880
like we care about an individual dying

1174
01:13:22,490 --> 01:13:20,100
and we don't care about a cell of a

1175
01:13:28,729 --> 01:13:22,500
microbe dying ever makes research a lot

1176
01:13:34,510 --> 01:13:30,290
should I continue

1177
01:13:37,250 --> 01:13:34,520
okay if you're bored take a nap

1178
01:13:38,990 --> 01:13:37,260
it's warm in here I gave a talk once on

1179
01:13:41,030 --> 01:13:39,000
a ship and everybody fell asleep it

1180
01:13:42,470 --> 01:13:41,040
actually happened it was nice they

1181
01:13:45,290 --> 01:13:42,480
looked very comfortable so I just kept

1182
01:13:51,229 --> 01:13:49,370
so now that we know that we've got all

1183
01:13:52,790 --> 01:13:51,239
this weird stuff down there

1184
01:13:55,550 --> 01:13:52,800
um

1185
01:13:57,350 --> 01:13:55,560
how you know how can you sustain a

1186
01:13:58,669 --> 01:13:57,360
subsurface biosphere we know that there

1187
01:14:00,770 --> 01:13:58,679
aren't a bunch of plants at the surface

1188
01:14:02,890 --> 01:14:00,780

of these other planetary bodies but can

1189
01:14:05,330 --> 01:14:02,900
we work on this planet where we are

1190
01:14:07,610 --> 01:14:05,340
blessed with all these wonderful plants

1191
01:14:10,130 --> 01:14:07,620
up here and find things that are

1192
01:14:12,050 --> 01:14:10,140
independent of that dominant signal and

1193
01:14:14,030 --> 01:14:12,060
so one this isn't the only way to go

1194
01:14:15,350 --> 01:14:14,040
about this hopefully you're a room full

1195
01:14:17,630 --> 01:14:15,360
of people who will find other ways to

1196
01:14:19,790 --> 01:14:17,640
answer this question too but

1197
01:14:21,229 --> 01:14:19,800
um one way that my colleagues and I

1198
01:14:23,570 --> 01:14:21,239
thought of doing this is to go to a

1199
01:14:26,450 --> 01:14:23,580
subduction zone which are fascinating

1200
01:14:28,669 --> 01:14:26,460
geological places because in a case of

1201
01:14:30,770 --> 01:14:28,679
an ocean Continental subduction zone you

1202
01:14:33,229 --> 01:14:30,780
have an oceanic tectonic plate that

1203
01:14:35,750 --> 01:14:33,239
basically just gets shoved very slowly

1204
01:14:37,970 --> 01:14:35,760
into a continental tectonic plate an

1205
01:14:39,709 --> 01:14:37,980
oceanic plate is just denser than

1206
01:14:41,390 --> 01:14:39,719
continental plate so it sinks and it

1207
01:14:43,250 --> 01:14:41,400
goes down and this is one of the major

1208
01:14:45,890 --> 01:14:43,260
ways that we get recycling between the

1209
01:14:47,270 --> 01:14:45,900
deep Earth and the surface Earth but

1210
01:14:49,070 --> 01:14:47,280
what also happens

1211
01:14:51,649 --> 01:14:49,080
is that you get this build up this

1212
01:14:54,050 --> 01:14:51,659
bunching up in the forearch so this is

1213
01:14:56,810 --> 01:14:54,060

the ocean plate going down that pushes

1214
01:15:00,110 --> 01:14:56,820
water out of all these areas and if you

1215
01:15:01,850 --> 01:15:00,120
draw this 150 degrees C isotherm which

1216
01:15:03,350 --> 01:15:01,860
is kind of the limit of Life although I

1217
01:15:05,390 --> 01:15:03,360
definitely won't say that because it

1218
01:15:06,770 --> 01:15:05,400
could be much higher but currently you

1219
01:15:09,050 --> 01:15:06,780
know we think that it life has to be

1220
01:15:11,270 --> 01:15:09,060
under this value there's actually a lot

1221
01:15:13,430 --> 01:15:11,280
of real estate in here that's probably

1222
01:15:16,790 --> 01:15:13,440
getting fleshed out passively by these

1223
01:15:19,189 --> 01:15:16,800
hot springs and um so we thought you

1224
01:15:21,169 --> 01:15:19,199
know it'd be nice to drill 10 million

1225
01:15:23,510 --> 01:15:21,179
dollar boreholes all the way across this

1226
01:15:25,189 --> 01:15:23,520
entire thing but there is literally no

1227
01:15:26,810 --> 01:15:25,199
one who will ever fund me to do that and

1228
01:15:29,930 --> 01:15:26,820
also I don't want to get a permit to

1229
01:15:31,729 --> 01:15:29,940
drill holes all over Costa Rica so we

1230
01:15:35,450 --> 01:15:31,739
use these Hot Springs as like passive

1231
01:15:37,070 --> 01:15:35,460
sampling ports and um this is uh the

1232
01:15:38,630 --> 01:15:37,080
most interdisciplinary collaborative

1233
01:15:40,910 --> 01:15:38,640
group of people that I possibly work

1234
01:15:42,950 --> 01:15:40,920
with and this is not everybody who's

1235
01:15:45,169 --> 01:15:42,960
involved but I just want to thank them

1236
01:15:48,290 --> 01:15:45,179
up front originally these are my lab

1237
01:15:50,510 --> 01:15:48,300
crew TJ Rogers is going to turn in his

1238
01:15:52,750 --> 01:15:50,520

dissertation in a week and a half he is

1239
01:15:57,110 --> 01:15:52,760
texting me constantly

1240
01:16:00,470 --> 01:15:58,790
um and then Joy's finished up and and

1241
01:16:02,209 --> 01:16:00,480
Kate did her Masters and she did

1242
01:16:04,130 --> 01:16:02,219
wonderful work on this and then we had

1243
01:16:06,110 --> 01:16:04,140
all these International collaborators

1244
01:16:08,689 --> 01:16:06,120
from all over the place some of whom

1245
01:16:10,970 --> 01:16:08,699
y'all probably know including lots of

1246
01:16:12,350 --> 01:16:10,980
people in Costa Rica because that is

1247
01:16:13,970 --> 01:16:12,360
where science has to come from when

1248
01:16:15,890 --> 01:16:13,980
you're doing work on you know I started

1249
01:16:17,630 --> 01:16:15,900
out in oceanography and you just go to

1250
01:16:19,790 --> 01:16:17,640
oceans and drop things in them because

1251
01:16:21,830 --> 01:16:19,800
it's all big oceans but when you're

1252
01:16:22,910 --> 01:16:21,840
working on land you do not go in a

1253
01:16:24,530 --> 01:16:22,920
country that is not your country and

1254
01:16:27,169 --> 01:16:24,540
take samples which I'm sure you all know

1255
01:16:29,330 --> 01:16:27,179
but um it's not just is it morally wrong

1256
01:16:30,350 --> 01:16:29,340
but you miss the local knowledge you

1257
01:16:32,149 --> 01:16:30,360
miss the understanding of what's

1258
01:16:34,370 --> 01:16:32,159
actually happening there so this is

1259
01:16:37,189 --> 01:16:34,380
driven largely by my colleagues in Costa

1260
01:16:40,729 --> 01:16:37,199
Rica so we sampled this is pretty much

1261
01:16:41,990 --> 01:16:40,739
the whole country of Costa Rica so you

1262
01:16:44,030 --> 01:16:42,000
can see we covered some pretty good

1263
01:16:46,550 --> 01:16:44,040

ground this is their line of volcanoes

1264
01:16:49,430 --> 01:16:46,560
volcanoes pop up because this down going

1265
01:16:50,870 --> 01:16:49,440
plate basically runs into mantle and all

1266
01:16:53,330 --> 01:16:50,880
the water that on this down going plate

1267
01:16:54,830 --> 01:16:53,340
exaltvates the mantle and makes it sort

1268
01:16:55,910 --> 01:16:54,840
of have this runaway liquidification

1269
01:16:58,070 --> 01:16:55,920
that

1270
01:17:00,830 --> 01:16:58,080
shows up in volcanoes

1271
01:17:03,290 --> 01:17:00,840
and our d our idea was to sample all

1272
01:17:04,970 --> 01:17:03,300
these red dots or hot springs and see if

1273
01:17:06,770 --> 01:17:04,980
we could get a difference in the

1274
01:17:09,470 --> 01:17:06,780
progression of the subsurface biosphere

1275
01:17:11,570 --> 01:17:09,480
is it moves from early subduction into

1276
01:17:13,010 --> 01:17:11,580
the volcanoes and late subduction and

1277
01:17:17,930 --> 01:17:13,020
just to show you what some of the sites

1278
01:17:22,010 --> 01:17:20,689
Spanish speakers I apologize I'm trying

1279
01:17:25,729 --> 01:17:22,020
to learn a language and I'm really bad

1280
01:17:28,850 --> 01:17:25,739
at it but there was all this uh iron uh

1281
01:17:30,470 --> 01:17:28,860
oxidate uh iron ferry hydroxides that

1282
01:17:32,570 --> 01:17:30,480
were produced from these subsurface

1283
01:17:34,370 --> 01:17:32,580
microbes so we're sampling gases there's

1284
01:17:36,410 --> 01:17:34,380
gases bubbling out of here but it's at

1285
01:17:38,810 --> 01:17:36,420
the edge of a river so we're fighting

1286
01:17:41,630 --> 01:17:38,820
the surface stuff all the time some of

1287
01:17:43,550 --> 01:17:41,640
the samples look like this boiling mud

1288
01:17:45,770 --> 01:17:43,560

pots so this is looking quite

1289
01:17:47,390 --> 01:17:45,780
inhospitable for science

1290
01:17:49,130 --> 01:17:47,400
whatever I don't have to point to that

1291
01:17:51,169 --> 01:17:49,140
it's in the picture

1292
01:17:53,810 --> 01:17:51,179
um and some of them were in the middle

1293
01:17:55,910 --> 01:17:53,820
of volcanoes so this is pois volcano

1294
01:18:00,290 --> 01:17:55,920
which is um this Caldera you can tell

1295
01:18:02,450 --> 01:18:00,300
that it erupts a lot obviously because

1296
01:18:04,610 --> 01:18:02,460
okay you see Department there are trees

1297
01:18:07,310 --> 01:18:04,620
right I don't have to laser point to it

1298
01:18:09,470 --> 01:18:07,320
oh I can point like this all around this

1299
01:18:11,330 --> 01:18:09,480
this Central so this right here this eye

1300
01:18:13,310 --> 01:18:11,340
of it is basically the throat of the

1301
01:18:14,750 --> 01:18:13,320
volcano this is the part where um the

1302
01:18:16,370 --> 01:18:14,760
eruptions start

1303
01:18:18,830 --> 01:18:16,380
um and you can see that it erupts a lot

1304
01:18:20,090 --> 01:18:18,840
because the plants would love to use all

1305
01:18:21,830 --> 01:18:20,100
this good iron

1306
01:18:23,689 --> 01:18:21,840
um but they can't because every time

1307
01:18:25,550 --> 01:18:23,699
they get in there they get blown up

1308
01:18:28,430 --> 01:18:25,560
um so this is me sampling next to this

1309
01:18:30,890 --> 01:18:28,440
Lake I am so this is Donato he's reading

1310
01:18:33,830 --> 01:18:30,900
the numbers out to me and it was 0.85 pH

1311
01:18:36,229 --> 01:18:33,840
this is very very acidic um basically

1312
01:18:38,689 --> 01:18:36,239
sulfuric acid then you can see the fumes

1313
01:18:40,130 --> 01:18:38,699

this is a very uncomfortable picture the

1314
01:18:43,430 --> 01:18:40,140
ground is

1315
01:18:46,850 --> 01:18:43,440
um 100 degrees Celsius and it's really

1316
01:18:50,090 --> 01:18:46,860
like bad Rock so if you slip you fall

1317
01:18:51,770 --> 01:18:50,100
into a battery acid lake so but the most

1318
01:18:53,590 --> 01:18:51,780
dangerous things about volcanoes is

1319
01:18:57,590 --> 01:18:53,600
about

1320
01:18:58,250 --> 01:18:57,600
54 56 days after we were in it

1321
01:19:01,570 --> 01:18:58,260
um

1322
01:19:05,649 --> 01:19:03,950
so that you can see the shore where I

1323
01:19:08,570 --> 01:19:05,659
was it was like right there

1324
01:19:10,189 --> 01:19:08,580
and you can look as it continues

1325
01:19:11,870 --> 01:19:10,199
erupting it's not like it just blows up

1326
01:19:14,030 --> 01:19:11,880
once you can see this stuff kind of

1327
01:19:16,130 --> 01:19:14,040
shooting out here again you should be

1328
01:19:17,270 --> 01:19:16,140
able to see it and it's like if that

1329
01:19:18,229 --> 01:19:17,280
happened while you were there there's

1330
01:19:19,970 --> 01:19:18,239
some more

1331
01:19:23,450 --> 01:19:19,980
if that happened while you're there it's

1332
01:19:25,430 --> 01:19:23,460
like you would go up and down then you

1333
01:19:27,649 --> 01:19:25,440
go up again then you get a bunch of

1334
01:19:29,510 --> 01:19:27,659
rocks on your head

1335
01:19:31,850 --> 01:19:29,520
it would be very bad

1336
01:19:32,570 --> 01:19:31,860
um my colleague one of my colleagues

1337
01:19:34,010 --> 01:19:32,580
um

1338
01:19:36,830 --> 01:19:34,020

one of my

1339
01:19:39,229 --> 01:19:36,840
worst decision-making colleagues send us

1340
01:19:41,810 --> 01:19:39,239
videos from that Creator the day before

1341
01:19:44,570 --> 01:19:41,820
this and it was like the ground was like

1342
01:19:46,850 --> 01:19:44,580
popping in front of him oh

1343
01:19:49,450 --> 01:19:46,860
he's not I got other colleagues who are

1344
01:19:53,510 --> 01:19:52,250
he's I worry about I worry about that

1345
01:19:54,229 --> 01:19:53,520
guy

1346
01:19:56,330 --> 01:19:54,239
um

1347
01:19:58,010 --> 01:19:56,340
but you know it's fun to go in these

1348
01:19:59,630 --> 01:19:58,020
dangerous places but we also have to

1349
01:20:01,550 --> 01:19:59,640
mitigate our danger I don't know I I've

1350
01:20:03,709 --> 01:20:01,560
got kids I don't I don't do this stuff

1351
01:20:05,450 --> 01:20:03,719
if it had been nasty like that I would

1352
01:20:06,410 --> 01:20:05,460
not have gone in any time around this

1353
01:20:08,590 --> 01:20:06,420
area

1354
01:20:11,390 --> 01:20:08,600
um I just went in because it was such a

1355
01:20:13,550 --> 01:20:11,400
calm time but um

1356
01:20:15,590 --> 01:20:13,560
fieldwork does doesn't involve some

1357
01:20:17,990 --> 01:20:15,600
risks so

1358
01:20:20,090 --> 01:20:18,000
um the way we think about the subsurface

1359
01:20:23,209 --> 01:20:20,100
when we get these semi-dangerous samples

1360
01:20:25,130 --> 01:20:23,219
is we don't know how deep we're getting

1361
01:20:26,330 --> 01:20:25,140
them from we are going we are driving

1362
01:20:27,950 --> 01:20:26,340
all over this country and we were

1363
01:20:30,110 --> 01:20:27,960

sampling tons and tons of Hot Springs

1364
01:20:31,490 --> 01:20:30,120
they're in people's backyards it's the

1365
01:20:33,110 --> 01:20:31,500
coolest thing we like walk up to people

1366
01:20:34,250 --> 01:20:33,120
we're like hey and they recognize my

1367
01:20:35,570 --> 01:20:34,260
colleagues from TV because they talk

1368
01:20:36,890 --> 01:20:35,580
about volcanoes a lot and we're like can

1369
01:20:41,390 --> 01:20:36,900
we sample your hot springs they're like

1370
01:20:42,470 --> 01:20:41,400
absolutely so we um uh we sample this

1371
01:20:44,510 --> 01:20:42,480
stuff and we don't know how deep it's

1372
01:20:46,610 --> 01:20:44,520
coming from so one of the things we want

1373
01:20:47,630 --> 01:20:46,620
to know is how do we blank out all this

1374
01:20:53,090 --> 01:20:47,640
crap

1375
01:20:55,610 --> 01:20:53,100
don't want to study so all of the

1376
01:20:57,050 --> 01:20:55,620
dissolved organic carbon has a carbon

1377
01:20:58,970 --> 01:20:57,060
isotope I'm not going to explain what

1378
01:21:00,649 --> 01:20:58,980
they are some of you know intimately

1379
01:21:02,510 --> 01:21:00,659
about carbon Isotopes and the other

1380
01:21:04,610 --> 01:21:02,520
two-thirds of you are like I don't know

1381
01:21:07,610 --> 01:21:04,620
what this is but that's okay just know

1382
01:21:09,350 --> 01:21:07,620
that this value ranges everything up

1383
01:21:12,229 --> 01:21:09,360
here at the surface ranges from minus 23

1384
01:21:14,750 --> 01:21:12,239
to minus 30. and our inorganic carbon so

1385
01:21:16,490 --> 01:21:14,760
this is carbon dioxide is like zero-ish

1386
01:21:17,810 --> 01:21:16,500
and this should be the similar in all

1387
01:21:20,090 --> 01:21:17,820
Springs

1388
01:21:23,209 --> 01:21:20,100

so when we measure these things the DIC

1389
01:21:26,030 --> 01:21:23,219
which at the for atmosphere should be

1390
01:21:28,070 --> 01:21:26,040
sort of around hereish it got quite

1391
01:21:30,590 --> 01:21:28,080
negative it got quite light and it had

1392
01:21:32,870 --> 01:21:30,600
this pattern with its concentration and

1393
01:21:35,450 --> 01:21:32,880
that was sort of intriguing to us and so

1394
01:21:36,649 --> 01:21:35,460
my colleagues who are gastiochemists

1395
01:21:39,590 --> 01:21:36,659
looked at this and they said oh my God

1396
01:21:42,229 --> 01:21:39,600
this is a Rayleigh distillation this is

1397
01:21:44,570 --> 01:21:42,239
what happens with Isotopes f is the

1398
01:21:48,110 --> 01:21:44,580
reaction extent so this is like how far

1399
01:21:49,669 --> 01:21:48,120
the reaction has progressed is you have

1400
01:21:51,590 --> 01:21:49,679
the reaction happening in an open system

1401
01:21:53,570 --> 01:21:51,600
so that the Isotopes can be removed and

1402
01:21:56,030 --> 01:21:53,580
there's a fractionation of of the

1403
01:21:59,149 --> 01:21:56,040
Isotopes as as this progresses you get

1404
01:22:01,790 --> 01:21:59,159
this extreme push of the fraction of the

1405
01:22:04,729 --> 01:22:01,800
Del C 13 of the values and so they

1406
01:22:06,169 --> 01:22:04,739
modeled this stuff and found that

1407
01:22:08,149 --> 01:22:06,179
actually this was a Rayleigh

1408
01:22:10,790 --> 01:22:08,159
fractionation

1409
01:22:13,070 --> 01:22:10,800
um that uh differed between early and

1410
01:22:14,990 --> 01:22:13,080
subduction closer to the volcanoes and

1411
01:22:17,209 --> 01:22:15,000
in the volcanoes and these are the

1412
01:22:19,310 --> 01:22:17,219
volcanic gases themselves so the offset

1413
01:22:21,590 --> 01:22:19,320

between this end member and the volcanic

1414
01:22:23,090 --> 01:22:21,600
gases was basically showed that this

1415
01:22:25,550 --> 01:22:23,100
stuff was entirely

1416
01:22:27,290 --> 01:22:25,560
um from from Deep gases this was not

1417
01:22:28,310 --> 01:22:27,300
carbon dioxide from the atmosphere at

1418
01:22:31,250 --> 01:22:28,320
all

1419
01:22:33,229 --> 01:22:31,260
um so I don't know if you have ever done

1420
01:22:35,330 --> 01:22:33,239
this with your data sets you might call

1421
01:22:37,669 --> 01:22:35,340
it P hacking but I don't want to call it

1422
01:22:39,229 --> 01:22:37,679
that we don't do that in jail I don't I

1423
01:22:40,729 --> 01:22:39,239
swear that's like just the medical thing

1424
01:22:43,430 --> 01:22:40,739
I think we shouldn't limit ourselves

1425
01:22:46,850 --> 01:22:43,440
does anybody see two little rainbows

1426
01:22:48,590 --> 01:22:46,860
right there do you see two like I got

1427
01:22:50,450 --> 01:22:48,600
this data set and I was like I swear

1428
01:22:51,649 --> 01:22:50,460
there's two of them and I was like but I

1429
01:22:53,090 --> 01:22:51,659
shouldn't do that because that's reading

1430
01:22:55,130 --> 01:22:53,100
too much into my data

1431
01:22:56,450 --> 01:22:55,140
but I stared at it for long enough and I

1432
01:22:58,850 --> 01:22:56,460
finally figured out what was driving

1433
01:23:00,709 --> 01:22:58,860
those two if you divide them and you say

1434
01:23:02,149 --> 01:23:00,719
okay this one's on the top curve and I'm

1435
01:23:03,470 --> 01:23:02,159
making it blue and that one's on the

1436
01:23:06,050 --> 01:23:03,480
bottom curve and I'm making it orange

1437
01:23:07,729 --> 01:23:06,060
and I tried to figure out are they

1438
01:23:10,250 --> 01:23:07,739

different temperatures were they

1439
01:23:12,470 --> 01:23:10,260
different ph's none of it nothing was

1440
01:23:13,370 --> 01:23:12,480
making sense and then I put them on a

1441
01:23:16,669 --> 01:23:13,380
map

1442
01:23:18,410 --> 01:23:16,679
and they fall down a line and I was

1443
01:23:21,530 --> 01:23:18,420
giving this talk the Carnegie Institute

1444
01:23:24,470 --> 01:23:21,540
in DC before we published this paper and

1445
01:23:26,990 --> 01:23:24,480
I said yeah and we have no idea for some

1446
01:23:28,310 --> 01:23:27,000
reason everything up there is on the

1447
01:23:30,290 --> 01:23:28,320
upper line and everything down here is

1448
01:23:32,570 --> 01:23:30,300
on the lower line but it's real because

1449
01:23:33,530 --> 01:23:32,580
it's not randomly distributed and I

1450
01:23:36,110 --> 01:23:33,540
don't know maybe there's something out

1451
01:23:37,490 --> 01:23:36,120
here in this geophysicist like ran up to

1452
01:23:39,530 --> 01:23:37,500
me after the talk and who is like

1453
01:23:41,390 --> 01:23:39,540
there's a plate boundary that divides

1454
01:23:42,830 --> 01:23:41,400
those two samples and he just knew

1455
01:23:44,630 --> 01:23:42,840
because he knew the plates really well

1456
01:23:47,209 --> 01:23:44,640
and so this is

1457
01:23:49,370 --> 01:23:47,219
the East Pacific Rise and the Coco's

1458
01:23:52,010 --> 01:23:49,380
Nazca spreading Center originating

1459
01:23:54,410 --> 01:23:52,020
things so basically this me this means

1460
01:23:56,990 --> 01:23:54,420
that the stuff we're getting coming out

1461
01:23:58,729 --> 01:23:57,000
of these Hot Springs like literally next

1462
01:24:01,130 --> 01:23:58,739
to two cans and monkeys like driving

1463
01:24:05,209 --> 01:24:01,140

around like sipping pina colada coladas

1464
01:24:07,310 --> 01:24:05,219
all over Costa Rica is so connected to

1465
01:24:09,470 --> 01:24:07,320
this stuff that is subducting offshore

1466
01:24:11,209 --> 01:24:09,480
that we can see the isotopic difference

1467
01:24:14,390 --> 01:24:11,219
in the carbon that's coming in from

1468
01:24:17,149 --> 01:24:14,400
these down going slabs which is gives us

1469
01:24:18,530 --> 01:24:17,159
great power to say that yeah this stuff

1470
01:24:20,510 --> 01:24:18,540
is deep subsurface this is actually

1471
01:24:23,149 --> 01:24:20,520
connected to this stuff

1472
01:24:25,010 --> 01:24:23,159
um so so now how do we use this power we

1473
01:24:26,630 --> 01:24:25,020
know all this carbon this inorganic

1474
01:24:28,790 --> 01:24:26,640
carbon which is the starting point for

1475
01:24:30,649 --> 01:24:28,800
chemosynthesis we know all this stuff is

1476
01:24:33,050 --> 01:24:30,659
coming from the deep Earth how do we

1477
01:24:35,149 --> 01:24:33,060
show that that microbes are turning it

1478
01:24:37,130 --> 01:24:35,159
into to life or are they just using the

1479
01:24:40,070 --> 01:24:37,140
the plants and cow poop and stuff like

1480
01:24:43,250 --> 01:24:40,080
that so now if we put in the organic

1481
01:24:45,830 --> 01:24:43,260
matter and put it on the same plot the

1482
01:24:48,530 --> 01:24:45,840
Del C 13 of the organic matter we see it

1483
01:24:51,110 --> 01:24:48,540
follows along this same line and it's

1484
01:24:53,649 --> 01:24:51,120
always offset from what the inorganic

1485
01:24:55,790 --> 01:24:53,659
carbon were and the value of that offset

1486
01:24:57,770 --> 01:24:55,800
is roughly the fractionation that we

1487
01:25:00,770 --> 01:24:57,780
would expect to see if it was all being

1488
01:25:03,169 --> 01:25:00,780

made by chemosynthesizers in situ and so

1489
01:25:06,410 --> 01:25:03,179
for this reason we were able to conclude

1490
01:25:11,030 --> 01:25:08,930
all you can never say all pretty much

1491
01:25:13,010 --> 01:25:11,040
everything that's living there seems to

1492
01:25:14,930 --> 01:25:13,020
be made from the chemicals that are

1493
01:25:16,850 --> 01:25:14,940
there from the deep Earth so this is a

1494
01:25:18,350 --> 01:25:16,860
despite all the jungles despite this

1495
01:25:19,970 --> 01:25:18,360
huge surface signal we're getting

1496
01:25:22,070 --> 01:25:19,980
something that's truly in the subsurface

1497
01:25:23,750 --> 01:25:22,080
and it's only from there and we have a

1498
01:25:25,189 --> 01:25:23,760
positive control because it's nice to

1499
01:25:26,450 --> 01:25:25,199
have those

1500
01:25:29,030 --> 01:25:26,460
um can we control for Jungle Farm

1501
01:25:31,130 --> 01:25:29,040
surface world and yes we can we scooped

1502
01:25:33,229 --> 01:25:31,140
up sediments where we were across the

1503
01:25:35,450 --> 01:25:33,239
Ark in the same places and there the

1504
01:25:37,850 --> 01:25:35,460
carbon is photosynthetic so we can see

1505
01:25:38,630 --> 01:25:37,860
the photosynthetic stuff there

1506
01:25:40,189 --> 01:25:38,640
um

1507
01:25:47,750 --> 01:25:40,199
so

1508
01:25:50,270 --> 01:25:47,760
to say that this subsurface of the

1509
01:25:52,550 --> 01:25:50,280
subduction zone is dominated by

1510
01:25:53,870 --> 01:25:52,560
chemosynthesis of chemicals so this is

1511
01:25:55,490 --> 01:25:53,880
something that could be happening on

1512
01:25:57,590 --> 01:25:55,500
another planet that has no

1513
01:26:01,070 --> 01:25:57,600

photosynthesis at all

1514
01:26:03,830 --> 01:26:01,080
um and now we're at 60 minutes and I

1515
01:26:06,290 --> 01:26:03,840
have meta genomes to talk about

1516
01:26:09,590 --> 01:26:06,300
but

1517
01:26:12,110 --> 01:26:09,600
welcome do you guys want to

1518
01:26:13,430 --> 01:26:12,120
do you know what a metagenome is

1519
01:26:14,810 --> 01:26:13,440
wait raise your hand if you know what a

1520
01:26:17,330 --> 01:26:14,820
metagenome is

1521
01:26:19,430 --> 01:26:17,340
oh my God it's so many people it's

1522
01:26:21,770 --> 01:26:19,440
beautiful is that like does it make you

1523
01:26:24,229 --> 01:26:21,780
want to cry thinking about yeah yeah

1524
01:26:25,970 --> 01:26:24,239
there's a lot of pain for those of you

1525
01:26:28,490 --> 01:26:25,980
who didn't raise your hands metagenomes

1526
01:26:30,229 --> 01:26:28,500
are all the DNA in a sample like all of

1527
01:26:31,850 --> 01:26:30,239
it just sequence it

1528
01:26:33,649 --> 01:26:31,860
um so what you get is this like garbled

1529
01:26:36,050 --> 01:26:33,659
mess of every Gene from every organism

1530
01:26:38,209 --> 01:26:36,060
doing God knows what and so one thing we

1531
01:26:40,070 --> 01:26:38,219
do with them is that we can knit them

1532
01:26:41,629 --> 01:26:40,080
back together through the magic of

1533
01:26:44,030 --> 01:26:41,639
bioinformatics and I'm not going to tell

1534
01:26:46,129 --> 01:26:44,040
you how but I will if you want to know

1535
01:26:48,169 --> 01:26:46,139
not right now nobody wants to hear that

1536
01:26:50,450 --> 01:26:48,179
but I did not think this could be done

1537
01:26:52,310 --> 01:26:50,460
at all but now it can and it can be done

1538
01:26:54,229 --> 01:26:52,320

so well that I actually use it

1539
01:26:56,270 --> 01:26:54,239
and what this does is it gives you

1540
01:26:57,890 --> 01:26:56,280
genomes basically you can get like a

1541
01:27:02,810 --> 01:26:57,900
whole genome and say what a thing can be

1542
01:27:04,189 --> 01:27:02,820
doing so my student TJ caught 403 of

1543
01:27:07,189 --> 01:27:04,199
these things that were pretty complete

1544
01:27:09,709 --> 01:27:07,199
and so now

1545
01:27:11,990 --> 01:27:09,719
think about what you do all right you've

1546
01:27:14,450 --> 01:27:12,000
got like 20 samples across Costa Rica

1547
01:27:17,810 --> 01:27:14,460
you know they're something special

1548
01:27:20,330 --> 01:27:17,820
they're not a bunch of cow poop so

1549
01:27:21,649 --> 01:27:20,340
now you have 400 mags and you can figure

1550
01:27:23,030 --> 01:27:21,659
out their distribution because you can

1551
01:27:24,169 --> 01:27:23,040
recruit those reads I know some of y'all

1552
01:27:26,450 --> 01:27:24,179
know what that means but basically you

1553
01:27:28,729 --> 01:27:26,460
can see the prevalence of each of those

1554
01:27:30,709 --> 01:27:28,739
mags all these data sets how do you

1555
01:27:32,930 --> 01:27:30,719
visualize that data how do you deal that

1556
01:27:34,729 --> 01:27:32,940
fire hose you know like

1557
01:27:36,169 --> 01:27:34,739
so anyway what we thought of to do which

1558
01:27:38,629 --> 01:27:36,179
may not be the only thing is to make a

1559
01:27:40,490 --> 01:27:38,639
heat map I love making heat Maps just

1560
01:27:43,310 --> 01:27:40,500
show you like what the color of it shows

1561
01:27:44,810 --> 01:27:43,320
you how much of it is there and this is

1562
01:27:46,910 --> 01:27:44,820
what part of it looks like this is a

1563
01:27:50,629 --> 01:27:46,920

third of this heat map and what this is

1564
01:27:54,590 --> 01:27:50,639
is each column running vertically here

1565
01:27:59,330 --> 01:27:54,600
is a hot spring and every row is a

1566
01:28:01,490 --> 01:27:59,340
microbe and so if it's yellow here then

1567
01:28:04,490 --> 01:28:01,500
that microbe was present in that hot

1568
01:28:06,950 --> 01:28:04,500
spring so look at that big black part

1569
01:28:09,770 --> 01:28:06,960
right there this is a whole slew of hot

1570
01:28:12,350 --> 01:28:09,780
springs that did not have those microbes

1571
01:28:14,090 --> 01:28:12,360
present at all and so we we organized it

1572
01:28:15,590 --> 01:28:14,100
I mean we this isn't just randomly

1573
01:28:18,050 --> 01:28:15,600
distributed we said put things together

1574
01:28:20,209 --> 01:28:18,060
that have more similar distributions and

1575
01:28:21,770 --> 01:28:20,219
what we were really surprised to see is

1576
01:28:23,510 --> 01:28:21,780
that it came out to be so completely

1577
01:28:24,770 --> 01:28:23,520
organized

1578
01:28:27,530 --> 01:28:24,780
so

1579
01:28:30,350 --> 01:28:27,540
this just happens to be all of the

1580
01:28:32,990 --> 01:28:30,360
volcanic samples came out here and then

1581
01:28:34,430 --> 01:28:33,000
all of these um sort of like Technicolor

1582
01:28:36,709 --> 01:28:34,440
things over here are there different

1583
01:28:39,590 --> 01:28:36,719
metabolisms so this is just like a

1584
01:28:41,209 --> 01:28:39,600
ridiculously complex data set visualized

1585
01:28:42,290 --> 01:28:41,219
as best as we can so you can kind of see

1586
01:28:43,669 --> 01:28:42,300
what they're breathing and I know you

1587
01:28:45,470 --> 01:28:43,679
can't really see but this is their

1588
01:28:47,750 --> 01:28:45,480

respiration and whether they fix carbon

1589
01:28:48,709 --> 01:28:47,760
whether they're chemo the autotrophs or

1590
01:28:51,470 --> 01:28:48,719
not

1591
01:28:53,629 --> 01:28:51,480
and then this is the same heat map just

1592
01:28:57,410 --> 01:28:53,639
cut and moved up there so this is not a

1593
01:28:59,689 --> 01:28:57,420
separate run now all these ones that

1594
01:29:02,990 --> 01:28:59,699
were black over here are now yellow

1595
01:29:04,610 --> 01:29:03,000
because these are these set of microbes

1596
01:29:06,709 --> 01:29:04,620
are the ones that are present only in

1597
01:29:08,930 --> 01:29:06,719
the early subduction so things filtered

1598
01:29:12,050 --> 01:29:08,940
out really really distinctly and then we

1599
01:29:13,490 --> 01:29:12,060
had a third group of things that were

1600
01:29:15,890 --> 01:29:13,500
just kind of everywhere

1601
01:29:17,570 --> 01:29:15,900
and so when we looked at what these

1602
01:29:19,129 --> 01:29:17,580
things were we wanted to see are these

1603
01:29:21,169 --> 01:29:19,139
the cumulus are these the ones that are

1604
01:29:24,709 --> 01:29:21,179
making the energy for everybody else

1605
01:29:27,530 --> 01:29:24,719
yes they were we found that about 30

1606
01:29:30,590 --> 01:29:27,540
percent of the community could do carbon

1607
01:29:32,570 --> 01:29:30,600
fixation both in this this is just the

1608
01:29:35,450 --> 01:29:32,580
same heat map just cut up into pieces

1609
01:29:38,510 --> 01:29:35,460
both in the volcanoes and at the beach

1610
01:29:41,209 --> 01:29:38,520
and then less of them were distributed

1611
01:29:43,250 --> 01:29:41,219
everywhere and these ones used this oxic

1612
01:29:45,229 --> 01:29:43,260
carbon fixation pathway everywhere so

1613
01:29:46,490 --> 01:29:45,239

we're starting the side eye the ones

1614
01:29:49,370 --> 01:29:46,500
that are everywhere

1615
01:29:51,110 --> 01:29:49,380
as you should be as well

1616
01:29:53,510 --> 01:29:51,120
um but what is it that distinguished

1617
01:29:55,370 --> 01:29:53,520
them between these different places

1618
01:29:56,629 --> 01:29:55,380
um so can you see

1619
01:29:59,390 --> 01:29:56,639
it's another

1620
01:30:02,030 --> 01:29:59,400
test if you look at the color things the

1621
01:30:03,649 --> 01:30:02,040
color strips do you see differences does

1622
01:30:05,390 --> 01:30:03,659
the left hand color strip look like

1623
01:30:07,310 --> 01:30:05,400
different colors than the middle color

1624
01:30:09,649 --> 01:30:07,320
strip to you and the right hand color

1625
01:30:11,030 --> 01:30:09,659
strip you can kind of see them I kind of

1626
01:30:12,410 --> 01:30:11,040
this is one reason why I like looking at

1627
01:30:14,149 --> 01:30:12,420
complex data out like this because you

1628
01:30:16,490 --> 01:30:14,159
can really see patterns like for

1629
01:30:18,590 --> 01:30:16,500
instance this green line here

1630
01:30:21,169 --> 01:30:18,600
doesn't really it's not as complete over

1631
01:30:23,149 --> 01:30:21,179
here it's like more of a going concern

1632
01:30:26,149 --> 01:30:23,159
here and there's more of this purple

1633
01:30:28,310 --> 01:30:26,159
stuff here than there is over here so

1634
01:30:30,110 --> 01:30:28,320
what this all boils down to if you stare

1635
01:30:33,169 --> 01:30:30,120
at it for months and months

1636
01:30:34,669 --> 01:30:33,179
is that this volcano stuff liked a

1637
01:30:36,110 --> 01:30:34,679
little bit of oxygen they did a lot of

1638
01:30:37,490 --> 01:30:36,120

sulfur oxidation and they did nitrate

1639
01:30:39,410 --> 01:30:37,500
reduction

1640
01:30:41,270 --> 01:30:39,420
the things out at the coast were totally

1641
01:30:42,649 --> 01:30:41,280
different they were breathing totally

1642
01:30:44,629 --> 01:30:42,659
different things they were doing sulfate

1643
01:30:47,629 --> 01:30:44,639
reduction and hydrogen oxidation

1644
01:30:49,669 --> 01:30:47,639
and these guys that were everywhere were

1645
01:30:52,490 --> 01:30:49,679
aerobic and sulfur oxidizers and they

1646
01:30:55,250 --> 01:30:52,500
basically depended on oxygen so what we

1647
01:30:57,110 --> 01:30:55,260
concluded from this is that these are

1648
01:30:59,510 --> 01:30:57,120
the microbial communities that show up

1649
01:31:01,550 --> 01:30:59,520
late in subduction because there's a lot

1650
01:31:04,610 --> 01:31:01,560
of hydrothermal alteration of their

1651
01:31:07,070 --> 01:31:04,620
Waters that add sulfur so they have a

1652
01:31:09,050 --> 01:31:07,080
ton of CO2 there's very little calcite

1653
01:31:10,669 --> 01:31:09,060
precipitation and they get lots of

1654
01:31:12,350 --> 01:31:10,679
oxidized substrates because they have a

1655
01:31:13,790 --> 01:31:12,360
shallow geothermal gradient that sucks

1656
01:31:16,550 --> 01:31:13,800
in oxygen

1657
01:31:17,689 --> 01:31:16,560
these guys were early in subduction they

1658
01:31:20,030 --> 01:31:17,699
didn't have a lot of hydrothermal

1659
01:31:21,890 --> 01:31:20,040
alteration but they had lots of reduced

1660
01:31:24,229 --> 01:31:21,900
sulfur compounds so they were very

1661
01:31:26,270 --> 01:31:24,239
carbon dioxide limited but they still

1662
01:31:28,550 --> 01:31:26,280
did chemo they still managed to like fix

1663
01:31:30,470 --> 01:31:28,560

the carbon and make the ecosystem go but

1664
01:31:33,110 --> 01:31:30,480
it was fundamentally different than what

1665
01:31:34,669 --> 01:31:33,120
we saw at the volcanoes and then I don't

1666
01:31:36,169 --> 01:31:34,679
know does anybody have any theories for

1667
01:31:40,990 --> 01:31:36,179
what's going on with these guys who show

1668
01:31:46,310 --> 01:31:44,090
primary producers maybe oh like a

1669
01:31:48,350 --> 01:31:46,320
photosynthetic primary producers if

1670
01:31:49,070 --> 01:31:48,360
that's what you're implying then yes

1671
01:31:51,169 --> 01:31:49,080
because

1672
01:31:53,629 --> 01:31:51,179
[Laughter]

1673
01:31:56,510 --> 01:31:53,639
these are the this is the crap this is

1674
01:31:58,189 --> 01:31:56,520
the soil stuff this is the surface World

1675
01:32:00,770 --> 01:31:58,199
um the identities of these microbes are

1676
01:32:02,270 --> 01:32:00,780
like common soil things and they liked

1677
01:32:03,530 --> 01:32:02,280
oxygen and so and they showed up

1678
01:32:05,209 --> 01:32:03,540
everywhere they didn't really care where

1679
01:32:07,910 --> 01:32:05,219
they were in subduction

1680
01:32:09,830 --> 01:32:07,920
um so what this means is that the redox

1681
01:32:12,830 --> 01:32:09,840
couples that fuel this chemo

1682
01:32:14,570 --> 01:32:12,840
chemosynthetic primary production are

1683
01:32:16,250 --> 01:32:14,580
distributed they're everywhere so if

1684
01:32:20,030 --> 01:32:16,260
we're going to go looking somewhere else

1685
01:32:22,250 --> 01:32:20,040
for this subsurface Community

1686
01:32:25,490 --> 01:32:22,260
um it's likely to be there as long as we

1687
01:32:27,110 --> 01:32:25,500
have some sort of energy we're likely to

1688
01:32:29,030 --> 01:32:27,120

find it

1689
01:32:30,770 --> 01:32:29,040
conclusion slide

1690
01:32:33,290 --> 01:32:30,780
subsurface life is different than

1691
01:32:35,530 --> 01:32:33,300
surface life it seems simplistic but we

1692
01:32:38,450 --> 01:32:35,540
know it for for sure

1693
01:32:40,370 --> 01:32:38,460
they can survive on extort this is an

1694
01:32:42,470 --> 01:32:40,380
understatement very little power and

1695
01:32:45,830 --> 01:32:42,480
very long time skills

1696
01:32:47,570 --> 01:32:45,840
um and at least on Earth we got a whole

1697
01:32:49,930 --> 01:32:47,580
world down there that is doing its own

1698
01:32:52,370 --> 01:32:49,940
thing and it does not need the Sun

1699
01:32:53,870 --> 01:32:52,380
and they're large enough to really leave

1700
01:32:55,310 --> 01:32:53,880
a mark on the subsurface landscape they

1701
01:32:58,790 --> 01:32:55,320
are precipitating calcite they're

1702
01:33:01,550 --> 01:32:58,800
leaving iron Ferry hydroxides we can see

1703
01:33:05,090 --> 01:33:01,560
them so I will end with a question for

1704
01:33:06,649 --> 01:33:05,100
y'all and I use y'all advisedly I'm from

1705
01:33:08,990 --> 01:33:06,659
North Carolina I live in Tennessee I'm

1706
01:33:11,290 --> 01:33:09,000
moving to California but um don't give

1707
01:33:14,930 --> 01:33:11,300
up on the south

1708
01:33:17,530 --> 01:33:14,940
seriously I know it's easy to vilify the

1709
01:33:21,050 --> 01:33:17,540
South we are gerrymandered all to hell

1710
01:33:24,350 --> 01:33:21,060
so we are a fantastic place and we have

1711
01:33:25,430 --> 01:33:24,360
very oppressed people and um we deserve

1712
01:33:26,090 --> 01:33:25,440
your attention

1713
01:33:29,530 --> 01:33:26,100

um

1714
01:33:33,830 --> 01:33:29,540
so question for y'all

1715
01:33:35,510 --> 01:33:33,840
if we have this robust of a chemo litho

1716
01:33:38,270 --> 01:33:35,520
autotrophic this chemosynthetic

1717
01:33:40,610 --> 01:33:38,280
subsurface Community here on this place

1718
01:33:42,830 --> 01:33:40,620
where we have this dominant signal what

1719
01:33:44,149 --> 01:33:42,840
will it be like on a planetary body that

1720
01:33:46,430 --> 01:33:44,159
doesn't have all that stuff at the

1721
01:33:48,110 --> 01:33:46,440
surface it will it be different will it

1722
01:33:50,330 --> 01:33:48,120
be the same and how do we look for it

1723
01:33:51,830 --> 01:33:50,340
and I got to thank the funders and I

1724
01:33:54,169 --> 01:33:51,840
have a pretty place to work for the next

1725
01:33:56,450 --> 01:33:54,179
year and I'll take more questions if you

1726
01:34:14,410 --> 01:33:56,460
want or you can do that in that thing

1727
01:34:18,229 --> 01:34:16,430
I was wondering how different the

1728
01:34:20,030 --> 01:34:18,239
mineralogy was because you I knew you

1729
01:34:21,649 --> 01:34:20,040
had a section that had these hydrogen

1730
01:34:23,030 --> 01:34:21,659
supported and I'm assuming that it was

1731
01:34:24,649 --> 01:34:23,040
geologic hydrogen from the

1732
01:34:26,390 --> 01:34:24,659
serpentization like how different was

1733
01:34:28,430 --> 01:34:26,400
the mineralogy like could you tell the

1734
01:34:29,990 --> 01:34:28,440
difference and what led to in terms of

1735
01:34:33,410 --> 01:34:30,000
like the type of enzymes that they were

1736
01:34:34,910 --> 01:34:33,420
able to have in their like biology based

1737
01:34:36,229 --> 01:34:34,920
on the metals that were around like was

1738
01:34:38,330 --> 01:34:36,239

that some kind of connection that you

1739
01:34:40,070 --> 01:34:38,340
could make or I don't know I just want

1740
01:34:42,229 --> 01:34:40,080
more collaboration I'm sorry yeah I want

1741
01:34:44,209 --> 01:34:42,239
more elaboration on the minerals too um

1742
01:34:47,390 --> 01:34:44,219
Shauna Morrison did all the mineralogy

1743
01:34:50,030 --> 01:34:47,400
for this and she found pyrite framboids

1744
01:34:51,890 --> 01:34:50,040
in the it's very altered hydrothermal so

1745
01:34:53,090 --> 01:34:51,900
that's feeding into our hypothesis of

1746
01:34:55,970 --> 01:34:53,100
why there's so much iron and sulfur

1747
01:34:58,250 --> 01:34:55,980
cycling in the volcanoes but

1748
01:35:00,110 --> 01:34:58,260
picking apart how the metals influence

1749
01:35:01,729 --> 01:35:00,120
and you know the crystalline form of the

1750
01:35:04,910 --> 01:35:01,739
metals influence all these communities

1751
01:35:06,110 --> 01:35:04,920
is a bit of a fine scale thing and so I

1752
01:35:07,970 --> 01:35:06,120
think that's going to be more apparent

1753
01:35:10,370 --> 01:35:07,980
in our global data set is this because

1754
01:35:12,070 --> 01:35:10,380
this project has

1755
01:35:20,209 --> 01:35:12,080
metastasized

1756
01:35:25,550 --> 01:35:22,490
so my question is coming from very

1757
01:35:27,530 --> 01:35:25,560
limited background in biology so yeah so

1758
01:35:28,970 --> 01:35:27,540
when you talk about lifespan uh why do

1759
01:35:31,790 --> 01:35:28,980
different organisms have different

1760
01:35:36,050 --> 01:35:31,800
lifespans like different species have

1761
01:35:40,930 --> 01:35:37,850
why do different species have different

1762
01:35:40,940 --> 01:35:47,030
[Laughter]

1763
01:35:52,430 --> 01:35:49,510

somebody want to answer that

1764
01:35:56,030 --> 01:35:52,440
Kelly do you want to yell down for us

1765
01:35:56,040 --> 01:36:00,530
that looks good

1766
01:36:00,540 --> 01:36:03,490
um

1767
01:36:09,290 --> 01:36:07,370
so you have this group that is kind of

1768
01:36:12,590 --> 01:36:09,300
like surface derived that that you say

1769
01:36:15,709 --> 01:36:12,600
is everywhere and is likely eating so

1770
01:36:17,330 --> 01:36:15,719
the communities in the subsurface so on

1771
01:36:18,890 --> 01:36:17,340
I don't think they're feeding the rest

1772
01:36:21,830 --> 01:36:18,900
of the communities

1773
01:36:24,110 --> 01:36:21,840
no I think they're just really angry to

1774
01:36:26,629 --> 01:36:24,120
have been washed into a hot spring

1775
01:36:27,950 --> 01:36:26,639
yeah there I I don't want to use the

1776
01:36:29,810 --> 01:36:27,960
word contamination because that kind of

1777
01:36:32,209 --> 01:36:29,820
means that implies something from our

1778
01:36:35,090 --> 01:36:32,219
bodies or like our coughs

1779
01:36:36,950 --> 01:36:35,100
um it's more like just not the things we

1780
01:36:38,570 --> 01:36:36,960
were looking for because you you know

1781
01:36:40,430 --> 01:36:38,580
hot spring is coming up through layers

1782
01:36:42,169 --> 01:36:40,440
of rock and so there's gonna be some

1783
01:36:44,570 --> 01:36:42,179
soil stuff washed in

1784
01:36:45,830 --> 01:36:44,580
yeah I don't they could be or did you

1785
01:36:48,350 --> 01:36:45,840
have a thought I mean they could be

1786
01:36:57,070 --> 01:36:48,360
feeding them no

1787
01:37:01,129 --> 01:36:59,810
I think the chemo synthesizers are I

1788
01:37:03,410 --> 01:37:01,139

mean they're basically taking carbon

1789
01:37:05,450 --> 01:37:03,420
that's coming from that slab so that's

1790
01:37:08,149 --> 01:37:05,460
carbon that got buried in the Pacific

1791
01:37:14,149 --> 01:37:11,209
10 million years ago and it gets buried

1792
01:37:15,950 --> 01:37:14,159
and gets volatilized however it gets

1793
01:37:18,050 --> 01:37:15,960
from high pressure and temperature and

1794
01:37:33,050 --> 01:37:18,060
then comes back up and that's that's

1795
01:37:37,250 --> 01:37:36,229
clear thank you for your talk I was

1796
01:37:41,209 --> 01:37:37,260
wondering

1797
01:37:43,070 --> 01:37:41,219
um so you talk a lot about the

1798
01:37:46,010 --> 01:37:43,080
unculturable that's what you work on

1799
01:37:48,290 --> 01:37:46,020
actually never say that word okay

1800
01:37:51,709 --> 01:37:48,300
let's get in trouble when I do

1801
01:37:55,790 --> 01:37:51,719
so a lot of these organisms or most of

1802
01:37:58,610 --> 01:37:55,800
them are uncultured uncultured yeah

1803
01:38:01,070 --> 01:37:58,620
um so what are your thoughts on you are

1804
01:38:03,350 --> 01:38:01,080
annotating a lot of this stuff from

1805
01:38:07,070 --> 01:38:03,360
stuff that is also uncultured do you

1806
01:38:09,770 --> 01:38:07,080
think there is a it just like

1807
01:38:13,129 --> 01:38:09,780
that hypothetical protein sort of idea

1808
01:38:17,510 --> 01:38:13,139
where this is most related to this which

1809
01:38:18,470 --> 01:38:17,520
is most related to this how do you think

1810
01:38:22,370 --> 01:38:18,480
um

1811
01:38:23,870 --> 01:38:22,380
potential issue you mean the issue of

1812
01:38:25,189 --> 01:38:23,880
the game of telephone where you think

1813
01:38:27,290 --> 01:38:25,199

something's a one thing and it's

1814
01:38:28,970 --> 01:38:27,300
actually not right um

1815
01:38:31,129 --> 01:38:28,980
I think that we have to be really

1816
01:38:31,970 --> 01:38:31,139
careful about what we conclude like if

1817
01:38:34,370 --> 01:38:31,980
you're

1818
01:38:36,050 --> 01:38:34,380
at least in my research like if I if my

1819
01:38:37,370 --> 01:38:36,060
story really depends on a particular

1820
01:38:42,229 --> 01:38:37,380
annotation

1821
01:38:44,390 --> 01:38:42,239
make a multiple species alignment of the

1822
01:38:46,490 --> 01:38:44,400
multiple sequence alignment of that Gene

1823
01:38:48,050 --> 01:38:46,500
and show that there's more evidence for

1824
01:38:50,930 --> 01:38:48,060
it being what I think it is than just

1825
01:38:52,550 --> 01:38:50,940
like proka annotates it as X

1826
01:38:54,470 --> 01:38:52,560
um and you can look you know you can

1827
01:38:55,970 --> 01:38:54,480
look for the P fans you can look for the

1828
01:38:57,470 --> 01:38:55,980
active site you can do all sorts of

1829
01:38:59,930 --> 01:38:57,480
things to sort of prove to yourself you

1830
01:39:01,430 --> 01:38:59,940
can look for the flanking genes the gene

1831
01:39:03,169 --> 01:39:01,440
syntony all these things you can use to

1832
01:39:05,570 --> 01:39:03,179
build up a case you're not going to do

1833
01:39:08,270 --> 01:39:05,580
that for a whole genome or much less 400

1834
01:39:10,310 --> 01:39:08,280
genomes but you can do that for the

1835
01:39:11,950 --> 01:39:10,320
thing that you want to talk about

1836
01:39:14,270 --> 01:39:11,960
um but I mean I just think that like

1837
01:39:16,970 --> 01:39:14,280
there's so much to be gained in that

1838
01:39:19,610 --> 01:39:16,980

hypothetical space and

1839
01:39:21,950 --> 01:39:19,620
sorry another soapbox about this is that

1840
01:39:24,050 --> 01:39:21,960
you know cool we free ourselves from

1841
01:39:26,450 --> 01:39:24,060
cultures we're free what's the first

1842
01:39:29,030 --> 01:39:26,460
thing we do when we get this genome say

1843
01:39:38,510 --> 01:39:29,040
how similar is it to a culture

1844
01:39:41,510 --> 01:39:39,229
um

1845
01:39:43,610 --> 01:39:41,520
great talk I should preface this by

1846
01:39:45,010 --> 01:39:43,620
saying that I'm an astronomer so I did

1847
01:39:48,590 --> 01:39:45,020
my best

1848
01:39:50,990 --> 01:39:48,600
well the last one just stumped me so

1849
01:39:55,729 --> 01:39:52,870
Mars and

1850
01:39:58,070 --> 01:39:55,739
Europa and Enceladus and those icy moons

1851
01:40:00,110 --> 01:39:58,080
have a very different environmental

1852
01:40:00,770 --> 01:40:00,120
conditions than the earth

1853
01:40:04,149 --> 01:40:00,780
um

1854
01:40:08,709 --> 01:40:04,159
and it seemed like a lot of this was

1855
01:40:12,830 --> 01:40:08,719
predicated on subduction yeah and

1856
01:40:16,790 --> 01:40:12,840
not some sort of subscribe for instance

1857
01:40:20,689 --> 01:40:16,800
yeah so yeah I just wonder how

1858
01:40:21,590 --> 01:40:20,699
how you develop a subsurface

1859
01:40:24,350 --> 01:40:21,600
um

1860
01:40:26,750 --> 01:40:24,360
biological World in a static-lit

1861
01:40:28,669 --> 01:40:26,760
environment or in a subsurface ocean

1862
01:40:30,770 --> 01:40:28,679
environment I'm writing an EXO Grant

1863
01:40:32,090 --> 01:40:30,780

about that right now actually but but I

1864
01:40:33,830 --> 01:40:32,100
mean not that I know the answer to it

1865
01:40:36,350 --> 01:40:33,840
but I mean that is that is basically

1866
01:40:38,570 --> 01:40:36,360
like the Fatal flaw of my entire or my

1867
01:40:40,610 --> 01:40:38,580
second half of my talk it but it's a

1868
01:40:42,770 --> 01:40:40,620
relevant one because there's no plate

1869
01:40:43,550 --> 01:40:42,780
tectonics in our solar system except on

1870
01:40:46,610 --> 01:40:43,560
Earth

1871
01:40:49,129 --> 01:40:46,620
in the entire history you know the fact

1872
01:40:50,689 --> 01:40:49,139
that Olympus Mons is so enormous is

1873
01:40:52,550 --> 01:40:50,699
simply because at hot spot's been

1874
01:40:54,590 --> 01:40:52,560
sitting there like for however long it's

1875
01:40:56,570 --> 01:40:54,600
been sitting there so I think that the

1876
01:40:58,010 --> 01:40:56,580
grant that I'm writing right now is you

1877
01:40:59,689 --> 01:40:58,020
know we may not get it is to basically

1878
01:41:01,790 --> 01:40:59,699
try to get out of subduction zones and

1879
01:41:03,890 --> 01:41:01,800
do our same style of sampling in our

1880
01:41:05,450 --> 01:41:03,900
same style of work around hot spots here

1881
01:41:07,250 --> 01:41:05,460
on Earth or at least plume influenced

1882
01:41:08,930 --> 01:41:07,260
environments but you can't get away from

1883
01:41:09,950 --> 01:41:08,940
plate tectonics on Earth just the same

1884
01:41:12,770 --> 01:41:09,960
way you can't get away from the

1885
01:41:14,450 --> 01:41:12,780
photosynthes so um we're going to have

1886
01:41:16,550 --> 01:41:14,460
to deal with Hawaii

1887
01:41:26,149 --> 01:41:16,560
so are you suggesting there's no life

1888
01:41:26,159 --> 01:41:29,750

I love that yeah

1889
01:41:34,070 --> 01:41:31,250
I think the answer to that is going to

1890
01:41:40,609 --> 01:41:38,270
I guess this is this is kind of to

1891
01:41:44,090 --> 01:41:40,619
uh so

1892
01:41:46,550 --> 01:41:44,100
is is there something like why do we

1893
01:41:47,629 --> 01:41:46,560
have plate tectonics sorry this is

1894
01:41:49,669 --> 01:41:47,639
something this is almost the song no

1895
01:41:51,709 --> 01:41:49,679
that's the question is a great question

1896
01:41:53,990 --> 01:41:51,719
I don't know why do do people know that

1897
01:42:00,490 --> 01:41:54,000
I feel like people know that

1898
01:42:05,450 --> 01:42:03,290
I don't know it maybe has something to

1899
01:42:06,770 --> 01:42:05,460
do with our size you know our size and

1900
01:42:09,229 --> 01:42:06,780
relative heat I mean because it's all

1901
01:42:11,330 --> 01:42:09,239
heat convection that's driving it so you

1902
01:42:13,490 --> 01:42:11,340
need the right brittleness versus Heat

1903
01:42:15,830 --> 01:42:13,500
to break it apart and move them but that

1904
01:42:17,450 --> 01:42:15,840
may not be the right answer I don't know

1905
01:42:23,149 --> 01:42:17,460
I would say I'm a microbiologist but I

1906
01:42:34,910 --> 01:42:24,709
I think you raise your hand you raise

1907
01:42:40,970 --> 01:42:38,270
is this on whoa all right let's see if

1908
01:42:42,890 --> 01:42:40,980
this makes sense so hi I'm Emily I study

1909
01:42:45,050 --> 01:42:42,900
the limits of life in Saline

1910
01:42:47,689 --> 01:42:45,060
environments and there's some research

1911
01:42:50,149 --> 01:42:47,699
on like thermodynamic limits to certain

1912
01:42:51,649 --> 01:42:50,159
metabolisms including

1913
01:42:54,890 --> 01:42:51,659

um autotrophy that's not driven by

1914
01:42:56,870 --> 01:42:54,900
oxygenic things and so I was wondering

1915
01:42:59,030 --> 01:42:56,880
given that you found a lot of chemo

1916
01:43:00,950 --> 01:42:59,040
autotrophs in the Deep subsurface that

1917
01:43:03,050 --> 01:43:00,960
are in incredibly energy limited

1918
01:43:04,729 --> 01:43:03,060
environments do you think there actually

1919
01:43:07,910 --> 01:43:04,739
is a limit to life

1920
01:43:10,129 --> 01:43:07,920
or is this like yeah I don't know you

1921
01:43:12,290 --> 01:43:10,139
mean an energetic limit yeah sure like

1922
01:43:13,790 --> 01:43:12,300
you know in a in an extreme environment

1923
01:43:15,950 --> 01:43:13,800
you have to like use a lot of energy to

1924
01:43:17,270 --> 01:43:15,960
like survive there right so

1925
01:43:18,649 --> 01:43:17,280
yeah even places where you get your

1926
01:43:19,790 --> 01:43:18,659
protons for free like an acidic

1927
01:43:22,910 --> 01:43:19,800
environment you still spend a lot of

1928
01:43:25,490 --> 01:43:22,920
energy baling yeah

1929
01:43:26,870 --> 01:43:25,500
is there a limit for life

1930
01:43:28,910 --> 01:43:26,880
yes

1931
01:43:31,250 --> 01:43:28,920
yeah there has to be like a Gibbs free

1932
01:43:33,470 --> 01:43:31,260
energy of zero is equilibrium and you

1933
01:43:38,209 --> 01:43:33,480
can't have life with equilibrium there

1934
01:43:42,830 --> 01:43:40,910
but the but the interesting question is

1935
01:43:47,810 --> 01:43:42,840
where is that line and that's what we

1936
01:43:47,820 --> 01:43:51,649
did you want to ask your question

1937
01:43:56,149 --> 01:43:54,410
hi I'm also an astronomer and I wanted

1938
01:43:57,590 --> 01:43:56,159

to kind of move even further out than

1939
01:43:59,750 --> 01:43:57,600
Nick did

1940
01:44:02,090 --> 01:43:59,760
um so something we think about a lot as

1941
01:44:04,189 --> 01:44:02,100
astronomers is like habitable zone and

1942
01:44:06,169 --> 01:44:04,199
like you know what temperature planets

1943
01:44:07,430 --> 01:44:06,179
might have to be to host life but I'm

1944
01:44:08,689 --> 01:44:07,440
wondering what your thoughts are about

1945
01:44:10,189 --> 01:44:08,699
the prospects for life on like

1946
01:44:12,229 --> 01:44:10,199
free-floating planets that aren't

1947
01:44:13,609 --> 01:44:12,239
associated with a star there are free

1948
01:44:17,990 --> 01:44:13,619
floating planets that are not associated

1949
01:44:21,290 --> 01:44:19,850
Kepler finder

1950
01:44:22,430 --> 01:44:21,300
finding is a lot it's more of a

1951
01:44:23,450 --> 01:44:22,440
microwave do we know about them from

1952
01:44:25,430 --> 01:44:23,460
Kepler or what do we know about them

1953
01:44:26,570 --> 01:44:25,440
even Hubble

1954
01:44:28,010 --> 01:44:26,580
okay

1955
01:44:29,209 --> 01:44:28,020
I have a lot of thoughts about this I'd

1956
01:44:31,970 --> 01:44:29,219
be happy to talk about it sometimes

1957
01:44:33,709 --> 01:44:31,980
that's crazy we've been how do they have

1958
01:44:35,810 --> 01:44:33,719
I mean do they have their own heat

1959
01:44:37,070 --> 01:44:35,820
Source internally or they I mean because

1960
01:44:38,870 --> 01:44:37,080
you got to have some kind of gradient

1961
01:44:40,790 --> 01:44:38,880
that's all you gotta have something like

1962
01:44:43,490 --> 01:44:40,800
some heat from formation probably yeah

1963
01:44:45,109 --> 01:44:43,500

fading over time or like some tidal

1964
01:44:47,870 --> 01:44:45,119
forcing from somebody nearby or they

1965
01:44:51,109 --> 01:44:47,880
just like totally lonely got nothing wow

1966
01:44:52,310 --> 01:44:51,119
radio radiogenic Decay yeah yeah so I

1967
01:44:54,229 --> 01:44:52,320
mean you gotta have something right

1968
01:44:57,530 --> 01:44:54,239
there's got to be a gradient there's got

1969
01:44:58,189 --> 01:44:57,540
to be if not redox just something

1970
01:45:00,530 --> 01:44:58,199
um

1971
01:45:01,490 --> 01:45:00,540
I don't know clearly I don't know the

1972
01:45:03,050 --> 01:45:01,500
answer to that because I didn't know

1973
01:45:04,729 --> 01:45:03,060
that they were there but you know we

1974
01:45:06,890 --> 01:45:04,739
talk about the Habit like when you think

1975
01:45:08,209 --> 01:45:06,900
of the habitable zone do you think about

1976
01:45:10,490 --> 01:45:08,219
distance from the Star and brightness

1977
01:45:12,649 --> 01:45:10,500
from the star of the star

1978
01:45:14,450 --> 01:45:12,659
um also think about the depth of that

1979
01:45:17,149 --> 01:45:14,460
planet because that'll really expand

1980
01:45:18,830 --> 01:45:17,159
your Capital Zone quite a bit if you can

1981
01:45:21,169 --> 01:45:18,840
go inside the planet

1982
01:45:30,050 --> 01:45:21,179
it gets better

1983
01:45:35,209 --> 01:45:32,450
free floating plants

1984
01:45:36,950 --> 01:45:35,219
hi um first off I'm also from North

1985
01:45:39,109 --> 01:45:36,960
Carolina so hello where where are you

1986
01:45:42,530 --> 01:45:39,119
from uh Raleigh

1987
01:45:44,990 --> 01:45:42,540
I'm from Beaufort oh nice I was just

1988
01:45:46,970 --> 01:45:45,000

curious um what do you think is the uh

1989
01:45:48,950 --> 01:45:46,980
stability of these subsurface ecologies

1990
01:45:51,830 --> 01:45:48,960
through both like geological time and

1991
01:45:53,689 --> 01:45:51,840
like planetary scales and if there's any

1992
01:45:55,310 --> 01:45:53,699
like way to like have like a fossilized

1993
01:45:57,590 --> 01:45:55,320
record of their presence at all that we

1994
01:45:59,270 --> 01:45:57,600
could detect yeah I mean the carbonates

1995
01:46:01,189 --> 01:45:59,280
like the minerals that they leave behind

1996
01:46:03,830 --> 01:46:01,199
the waste products are probably the best

1997
01:46:05,390 --> 01:46:03,840
in microfossils of course and lipids are

1998
01:46:07,910 --> 01:46:05,400
are good ways to look for these sorts of

1999
01:46:10,129 --> 01:46:07,920
things but in terms of like the time

2000
01:46:13,070 --> 01:46:10,139
span of this stuff you know we're just

2001
01:46:14,030 --> 01:46:13,080
looking at the Modern stuff now and so I

2002
01:46:15,770 --> 01:46:14,040
think that

2003
01:46:19,129 --> 01:46:15,780
I don't know as much as I should about

2004
01:46:20,870 --> 01:46:19,139
that but there's a lot to be done

2005
01:46:21,810 --> 01:46:20,880
all right let's give one last round of

2006
01:46:44,030 --> 01:46:21,820
applause for Karen

2007
01:46:50,629 --> 01:46:48,109
oh and just a few housekeeping things so

2008
01:46:53,090 --> 01:46:50,639
uh tomorrow morning we'll have breakfast

2009
01:46:55,550 --> 01:46:53,100
at the grad student lounge so those of

2010
01:46:58,609 --> 01:46:55,560
you who didn't come it's a few doors

2011
01:47:00,410 --> 01:46:58,619
down if you look at the FAQ we sent out

2012
01:47:01,970 --> 01:47:00,420
all the information's in there if

2013
01:47:04,850 --> 01:47:01,980

there's any questions that are not

2014
01:47:06,470 --> 01:47:04,860
answered just message Miguel orai but

2015
01:47:10,250 --> 01:47:06,480
that will start at 8 A.M and then we'll

2016
01:47:13,310 --> 01:47:10,260
promptly start this talks right at nine

2017
01:47:15,050 --> 01:47:13,320
great oh yeah and okay I just want to

2018
01:47:17,689 --> 01:47:15,060
add one thing for those of you that

2019
01:47:20,209 --> 01:47:17,699
checked in and got your awesome swag bag

2020
01:47:22,669 --> 01:47:20,219
that's great but if you did not get the

2021
01:47:24,229 --> 01:47:22,679
plastic NASA bag and you want one come

2022
01:47:25,550 --> 01:47:24,239
see me at the check-in desk before you

2023
01:47:47,080 --> 01:47:25,560
go okay guys

2024
01:48:44,570 --> 01:48:13,220
[Music]

2025
01:48:44,580 --> 01:48:51,440
foreign

2026
01:48:51,450 --> 01:49:19,250
[Music]