AbSciCon 2022

405: Alien Ecosystems: Integrating Ecology into Astrobiology IV

1
00:00:05,349 --> 00:00:02,629
hello everyone good morning and welcome

2
00:00:07,829 --> 00:00:05,359
to the hybrid oral session for alien

3
00:00:09,750 --> 00:00:07,839
ecosystems integrating ecology into

4
00:00:12,310 --> 00:00:09,760
astrobiology

5
00:00:13,669 --> 00:00:12,320
we do have a very tight schedule today i

6
00:00:15,669 --> 00:00:13,679
wanted to give as much time to the

7
00:00:17,910 --> 00:00:15,679
speakers as possible

8
00:00:19,830 --> 00:00:17,920
the speakers will have a 15-minute slot

9
00:00:21,349 --> 00:00:19,840
each so in the hopes that they have

10
00:00:23,189 --> 00:00:21,359
about a 12-minute talk i'll give you a

11
00:00:25,349 --> 00:00:23,199
two-minute warning till the end and then

12
00:00:26,630 --> 00:00:25,359
we can have some questions after each

13
00:00:28,790 --> 00:00:26,640

talk

14
00:00:30,470 --> 00:00:28,800
so without further ado i'm going to

15
00:00:34,229 --> 00:00:30,480
introduce our first speaker

16
00:00:46,630 --> 00:00:34,239
we have mario thomas rodriguez rodrigo

17
00:00:51,910 --> 00:00:49,670
good morning atlanta hello you the world

18
00:00:54,389 --> 00:00:51,920
so my name is mario thomas rodrigo and

19
00:00:56,389 --> 00:00:54,399
i'm going to be talking about today is

20
00:00:58,549 --> 00:00:56,399
basically my coping mechanism during the

21
00:01:00,389 --> 00:00:58,559
pandemic when i was just

22
00:01:04,710 --> 00:01:00,399
looked at home and i couldn't do any lab

23
00:01:06,230 --> 00:01:04,720
work so i had this idea and we know that

24
00:01:08,710 --> 00:01:06,240
in nature

25
00:01:11,510 --> 00:01:08,720
minerals and microbes are intertwined

26
00:01:13,270 --> 00:01:11,520
they just happen to coexist together and

27
00:01:15,429 --> 00:01:13,280
they impact each other

28
00:01:17,429 --> 00:01:15,439
we know that microbes can affect

29
00:01:19,429 --> 00:01:17,439
minerals they can dissolve them they can

30
00:01:21,270 --> 00:01:19,439
modify them and they can precipitate

31
00:01:23,190 --> 00:01:21,280
them and on the other hand

32
00:01:24,870 --> 00:01:23,200
also minerals are going to shape the

33
00:01:26,630 --> 00:01:24,880
microbial communities

34
00:01:29,030 --> 00:01:26,640
so we see plenty of examples so for

35
00:01:30,390 --> 00:01:29,040
example you can take the boy out of the

36
00:01:32,789 --> 00:01:30,400
country but you can take the country out

37
00:01:35,109 --> 00:01:32,799
of the boys from spanish so rio tint is

38
00:01:36,710 --> 00:01:35,119

a massive part of my life so we have

39
00:01:37,749 --> 00:01:36,720
real tinted that basically is on top of

40
00:01:39,670 --> 00:01:37,759
pirate

41
00:01:41,270 --> 00:01:39,680
and because of the oxygen there and the

42
00:01:44,469 --> 00:01:41,280
presence of certain microbes such as

43
00:01:47,510 --> 00:01:44,479
acetyl bacillus peroxidants this pirate

44
00:01:48,950 --> 00:01:47,520
is oxidized and iron and sulfate

45
00:01:51,109 --> 00:01:48,960
accumulates on the water and that's why

46
00:01:53,749 --> 00:01:51,119
it has this very nice red color

47
00:01:55,429 --> 00:01:53,759
but also the accumulation of these

48
00:01:56,709 --> 00:01:55,439
sulfate and ion because of microbial

49
00:01:58,069 --> 00:01:56,719
activity

50
00:02:00,469 --> 00:01:58,079
contributes to the precipitation of

51
00:02:01,990 --> 00:02:00,479
certain minerals such as gerocite

52
00:02:03,670 --> 00:02:02,000
so

53
00:02:06,310 --> 00:02:03,680
when we look at modeling

54
00:02:08,869 --> 00:02:06,320
we see that there are plenty of examples

55
00:02:10,469 --> 00:02:08,879
of numerically explicit microbial models

56
00:02:13,750 --> 00:02:10,479
that address things such as microbial

57
00:02:15,830 --> 00:02:13,760
growth metabolism metabolic production

58
00:02:17,910 --> 00:02:15,840
utilization of resources and on the

59
00:02:20,229 --> 00:02:17,920
other hand we also have theoretical

60
00:02:22,470 --> 00:02:20,239
geochemical models that address things

61
00:02:24,790 --> 00:02:22,480
such as the interaction between fluids

62
00:02:26,150 --> 00:02:24,800
and water and minerals and so on and so

63
00:02:27,990 --> 00:02:26,160

forth but

64
00:02:29,830 --> 00:02:28,000
what i found is there is this massive

65
00:02:31,670 --> 00:02:29,840
gap in the middle so this is where

66
00:02:33,589 --> 00:02:31,680
gimmick which is the model i've i've

67
00:02:34,550 --> 00:02:33,599
worked i've been working with comes to

68
00:02:37,350 --> 00:02:34,560
play

69
00:02:39,270 --> 00:02:37,360
so um the aim of gimmick is actually

70
00:02:41,430 --> 00:02:39,280
numerically predict the geochemical and

71
00:02:44,309 --> 00:02:41,440
biological nature of brains of

72
00:02:47,110 --> 00:02:44,319
astrobiological interest so how does

73
00:02:51,190 --> 00:02:47,120
this work so first of all

74
00:02:53,030 --> 00:02:51,200
i've written gimmick in arm and i feed

75
00:02:55,430 --> 00:02:53,040
it a number of things so one of the

76
00:02:57,430 --> 00:02:55,440
things i feed it with is um

77
00:02:59,430 --> 00:02:57,440
the brain composition of the ground i

78
00:03:01,030 --> 00:02:59,440
want to analyze

79
00:03:02,390 --> 00:03:01,040
then a microbial community which is

80
00:03:05,350 --> 00:03:02,400
going to be basically seven different

81
00:03:07,270 --> 00:03:05,360
metabolic groups and then i can also add

82
00:03:09,350 --> 00:03:07,280
minerals to it to analyze and the

83
00:03:11,430 --> 00:03:09,360
precipitation and the solution

84
00:03:15,110 --> 00:03:11,440
and then the what the model is going to

85
00:03:16,869 --> 00:03:15,120
do is calculate um the concentration in

86
00:03:19,910 --> 00:03:16,879
the brine after the contact with the

87
00:03:21,350 --> 00:03:19,920
with the minerals using freak c and also

88
00:03:22,869 --> 00:03:21,360

it's going to give me the activity of

89
00:03:25,110 --> 00:03:22,879
the different components so then i can

90
00:03:26,789 --> 00:03:25,120
calculate gibbs free energy and finally

91
00:03:28,710 --> 00:03:26,799
the water mass in case we have things

92
00:03:30,949 --> 00:03:28,720
such as precipitation

93
00:03:32,470 --> 00:03:30,959
or freezing so we can recalculate the

94
00:03:34,229 --> 00:03:32,480
things that are not included in freak

95
00:03:36,070 --> 00:03:34,239
such as for example the microbial

96
00:03:39,030 --> 00:03:36,080
biomass

97
00:03:41,190 --> 00:03:39,040
um so how how do we model

98
00:03:42,630 --> 00:03:41,200
this this microbial evolution over time

99
00:03:44,309 --> 00:03:42,640
so we have

100
00:03:46,949 --> 00:03:44,319
that the microbial groups are going to

101
00:03:48,869 --> 00:03:46,959
be on two different types of pools we

102
00:03:51,110 --> 00:03:48,879
are going to have active cells and we're

103
00:03:52,550 --> 00:03:51,120
going to have inactive cells active

104
00:03:53,830 --> 00:03:52,560
cells are going to change over time

105
00:03:55,429 --> 00:03:53,840
because if they're active they're going

106
00:03:57,429 --> 00:03:55,439
to be reproducing

107
00:03:59,990 --> 00:03:57,439
and this is going to follow monokinetics

108
00:04:01,110 --> 00:04:00,000
and it's going to also be impacted by

109
00:04:03,670 --> 00:04:01,120
several

110
00:04:07,589 --> 00:04:03,680
physical chemical parameters such as ph

111
00:04:09,509 --> 00:04:07,599
water activity and temperature

112
00:04:11,830 --> 00:04:09,519
the next thing is that cells if they're

113
00:04:12,949 --> 00:04:11,840

alive they can die and that's a fact

114
00:04:15,509 --> 00:04:12,959
so

115
00:04:17,430 --> 00:04:15,519
how we model death is that there's going

116
00:04:19,270 --> 00:04:17,440
to be a death rate that is going to

117
00:04:21,349 --> 00:04:19,280
happen over time

118
00:04:23,510 --> 00:04:21,359
also we're going to have processes of

119
00:04:25,590 --> 00:04:23,520
activation and activation we know that

120
00:04:27,590 --> 00:04:25,600
in the labs we try to make conditions

121
00:04:29,189 --> 00:04:27,600
the best possible for microbes

122
00:04:30,790 --> 00:04:29,199
and they're going to be very happy

123
00:04:33,270 --> 00:04:30,800
they're going to be thriving but in

124
00:04:34,950 --> 00:04:33,280
nature we know that this is not a case

125
00:04:36,390 --> 00:04:34,960
and the majority of cases are we're

126
00:04:39,189 --> 00:04:36,400
going to have several small conditions

127
00:04:40,469 --> 00:04:39,199
so microbes can get into dormant states

128
00:04:41,670 --> 00:04:40,479
they are still alive but they are not

129
00:04:43,350 --> 00:04:41,680
going to be

130
00:04:45,909 --> 00:04:43,360
reproducing actively and that's where

131
00:04:48,710 --> 00:04:45,919
dormancy comes to play but what happens

132
00:04:51,110 --> 00:04:48,720
if the situation gets even worse

133
00:04:53,270 --> 00:04:51,120
in that case microbes go basically on a

134
00:04:54,950 --> 00:04:53,280
diet they're going to be consuming their

135
00:04:57,670 --> 00:04:54,960
organic matter and they're going to be

136
00:04:58,790 --> 00:04:57,680
producing um co2 as a consequence and

137
00:05:01,510 --> 00:04:58,800
this is what we're going to call

138
00:05:04,390 --> 00:05:01,520

endogenous catabolism

139
00:05:06,710 --> 00:05:04,400
but as i said my main interest is trying

140
00:05:08,710 --> 00:05:06,720
to bring together the geochemistry and

141
00:05:10,310 --> 00:05:08,720
the microbiology and we know that

142
00:05:11,270 --> 00:05:10,320
several microbes are going to be used in

143
00:05:15,110 --> 00:05:11,280
different

144
00:05:17,670 --> 00:05:15,120
are going to be an environment for their

145
00:05:19,270 --> 00:05:17,680
metabolisms and we also know that for

146
00:05:20,550 --> 00:05:19,280
some microbes

147
00:05:22,870 --> 00:05:20,560
for

148
00:05:25,189 --> 00:05:22,880
some microbes trash is going to be some

149
00:05:27,189 --> 00:05:25,199
microstructure so for example if we have

150
00:05:29,270 --> 00:05:27,199
heterotrophic bacteria they're going to

151
00:05:32,150 --> 00:05:29,280
be using this organic carbon which is

152
00:05:34,150 --> 00:05:32,160
this s that i'm i have here which is

153
00:05:36,150 --> 00:05:34,160
this um the substrate and they're going

154
00:05:37,990 --> 00:05:36,160
to be producing co2 which dissolved in

155
00:05:40,710 --> 00:05:38,000
water is going to be bicarbonate so

156
00:05:42,390 --> 00:05:40,720
that's a mineral component

157
00:05:43,990 --> 00:05:42,400
so this is these are the different

158
00:05:45,749 --> 00:05:44,000
metabolic groups that i've included in

159
00:05:47,749 --> 00:05:45,759
the model

160
00:05:49,830 --> 00:05:47,759
but yeah this is a great idea um

161
00:05:53,590 --> 00:05:49,840
whatever you want to tell me but we have

162
00:05:55,510 --> 00:05:53,600
to actually show that our model works

163
00:05:58,950 --> 00:05:55,520

so i decided to go

164
00:06:00,150 --> 00:05:58,960
to what i know which is again rio tinto

165
00:06:02,230 --> 00:06:00,160
and we know that the mineralogy of

166
00:06:03,909 --> 00:06:02,240
reutens is basically pirate and the

167
00:06:05,510 --> 00:06:03,919
community is dominated by some microbes

168
00:06:07,990 --> 00:06:05,520
such as iron oxidizers and

169
00:06:09,670 --> 00:06:08,000
sulfate-reducing bacteria and there is

170
00:06:11,189 --> 00:06:09,680
evidence that there has been anaerobic

171
00:06:13,350 --> 00:06:11,199
environments under rio tinto which are

172
00:06:15,590 --> 00:06:13,360
the ones that i'm interested in

173
00:06:17,110 --> 00:06:15,600
and there was this paper from last year

174
00:06:19,830 --> 00:06:17,120
in which they evaluated the different

175
00:06:21,590 --> 00:06:19,840
brands around the rio tinto area and

176
00:06:23,270 --> 00:06:21,600
they found that the residence time for

177
00:06:25,670 --> 00:06:23,280
this branch is around 60 years on the

178
00:06:27,749 --> 00:06:25,680
subsurface so with this information i

179
00:06:30,629 --> 00:06:27,759
decided to model the interaction between

180
00:06:32,309 --> 00:06:30,639
the water from rio tinto with a shale

181
00:06:34,390 --> 00:06:32,319
over 60 years and see what kind of

182
00:06:35,749 --> 00:06:34,400
microbes we can have there

183
00:06:38,790 --> 00:06:35,759
so this is what we found in terms of

184
00:06:41,909 --> 00:06:38,800
microbiology so we because we have the

185
00:06:45,029 --> 00:06:41,919
the um carbon leeching from the shale

186
00:06:46,790 --> 00:06:45,039
this is going to be supporting an active

187
00:06:49,029 --> 00:06:46,800
community based on heterotrophic

188
00:06:50,710 --> 00:06:49,039

metabolisms being dominated by

189
00:06:53,830 --> 00:06:50,720
sulfurides in bacteria because rio tint

190
00:06:56,469 --> 00:06:53,840
is super rich in in sulfate but also ion

191
00:06:58,950 --> 00:06:56,479
oxidizers are going to be present in in

192
00:07:01,189 --> 00:06:58,960
our model

193
00:07:03,029 --> 00:07:01,199
so if we have a bit of a

194
00:07:04,390 --> 00:07:03,039
snapshot of what is going on and how

195
00:07:06,550 --> 00:07:04,400
these different microbes are going to

196
00:07:09,589 --> 00:07:06,560
interact with the geochemistry we

197
00:07:11,589 --> 00:07:09,599
actually find that if we analyze um

198
00:07:13,430 --> 00:07:11,599
heterotrophic microbes as i said the

199
00:07:15,510 --> 00:07:13,440
community is dominated by

200
00:07:17,749 --> 00:07:15,520
srbs but also i you know oxidizes are

201
00:07:20,629 --> 00:07:17,759
going to be appearing and if we see the

202
00:07:23,029 --> 00:07:20,639
bottom um the bottom graph we can see

203
00:07:24,710 --> 00:07:23,039
that there's accumulation of um

204
00:07:26,550 --> 00:07:24,720
substrate over time and this is because

205
00:07:28,469 --> 00:07:26,560
of the leaching from the shell that i've

206
00:07:30,469 --> 00:07:28,479
modeled but also we can see that there

207
00:07:32,469 --> 00:07:30,479
is an accumulation of bicarbonate

208
00:07:34,070 --> 00:07:32,479
because of the mineralization

209
00:07:36,230 --> 00:07:34,080
of this organic carbon due to the

210
00:07:38,309 --> 00:07:36,240
activity of heterotrophs

211
00:07:40,150 --> 00:07:38,319
in terms of because obviously

212
00:07:41,749 --> 00:07:40,160
srbs are very important i decided to

213
00:07:44,390 --> 00:07:41,759

also check what happens with the cell

214
00:07:46,869 --> 00:07:44,400
recycling and we see that there is a

215
00:07:49,589 --> 00:07:46,879
small accumulation of sulfite over time

216
00:07:51,909 --> 00:07:49,599
as a product of the activity of srbs

217
00:07:55,189 --> 00:07:51,919
which is also going to allow

218
00:07:56,950 --> 00:07:55,199
the existence of sulfite oxidizers

219
00:07:58,390 --> 00:07:56,960
not as abundant as srbs but still

220
00:08:00,150 --> 00:07:58,400
they're going to have an important

221
00:08:02,230 --> 00:08:00,160
number there

222
00:08:05,029 --> 00:08:02,240
but yeah this is great okay this is

223
00:08:07,430 --> 00:08:05,039
great but um how how is our modable

224
00:08:10,309 --> 00:08:07,440
model comparable to reality so what i

225
00:08:11,749 --> 00:08:10,319
decided to do is okay we have this

226
00:08:13,830 --> 00:08:11,759
lot of brands that i said before from

227
00:08:15,510 --> 00:08:13,840
this paper from last year and i want to

228
00:08:17,110 --> 00:08:15,520
see how similar

229
00:08:18,629 --> 00:08:17,120
my results are

230
00:08:20,469 --> 00:08:18,639
to these to these brands and what i

231
00:08:21,830 --> 00:08:20,479
found is that if you see this is gimmick

232
00:08:23,589 --> 00:08:21,840
in blue

233
00:08:27,909 --> 00:08:23,599
and we have this one that is very close

234
00:08:29,670 --> 00:08:27,919
here and actually um the researchers

235
00:08:32,070 --> 00:08:29,680
um propose

236
00:08:34,310 --> 00:08:32,080
that this lhs annabelle garden actually

237
00:08:36,949 --> 00:08:34,320
comes from the interaction of rio tinto

238
00:08:38,870 --> 00:08:36,959

waters with shale aha which is exactly

239
00:08:41,029 --> 00:08:38,880
what i modeled so literally i screened

240
00:08:42,149 --> 00:08:41,039
at my computer when i saw this

241
00:08:43,990 --> 00:08:42,159
uh and what happens with the

242
00:08:45,509 --> 00:08:44,000
microbiology we compare with rio tinto

243
00:08:47,350 --> 00:08:45,519
so rioting has

244
00:08:49,110 --> 00:08:47,360
these two kinds of environments some of

245
00:08:51,590 --> 00:08:49,120
them are dominated by

246
00:08:53,190 --> 00:08:51,600
iron oxidizers such as acetic abacillus

247
00:08:56,630 --> 00:08:53,200
but then there are other environments

248
00:08:59,190 --> 00:08:56,640
that are basically hugely dominated by

249
00:09:01,350 --> 00:08:59,200
srbs such as synthobacter and

250
00:09:04,949 --> 00:09:01,360
synthophobactory is a microbe that

251
00:09:08,790 --> 00:09:04,959
reduces sulfate utilizing organic matter

252
00:09:10,550 --> 00:09:08,800
exactly what i model on gimmick as well

253
00:09:11,829 --> 00:09:10,560
so just wrapping up

254
00:09:13,990 --> 00:09:11,839
gimmick integrates your chemical and

255
00:09:15,269 --> 00:09:14,000
microbiological data which is my aim so

256
00:09:17,030 --> 00:09:15,279
that's good

257
00:09:19,990 --> 00:09:17,040
the results from gimmick reproduce

258
00:09:21,030 --> 00:09:20,000
accurately observations in rio tinto

259
00:09:22,150 --> 00:09:21,040
gimmick can be used to predict

260
00:09:23,750 --> 00:09:22,160
challenging ecosystems such as

261
00:09:24,870 --> 00:09:23,760
subsurface environments because they are

262
00:09:27,590 --> 00:09:24,880
very hard

263
00:09:29,110 --> 00:09:27,600

to drill and to get um aseptic samples

264
00:09:31,750 --> 00:09:29,120
from there because you are very exposed

265
00:09:32,790 --> 00:09:31,760
to contamination and also i've used rio

266
00:09:34,630 --> 00:09:32,800
tinto because

267
00:09:36,790 --> 00:09:34,640
apart from knowing it it's also a very

268
00:09:39,190 --> 00:09:36,800
good astrobiological um

269
00:09:40,470 --> 00:09:39,200
analog for mass in the past so actually

270
00:09:42,550 --> 00:09:40,480
the next step

271
00:09:43,509 --> 00:09:42,560
maybe it's actually using

272
00:09:46,630 --> 00:09:43,519
gimmick

273
00:09:48,829 --> 00:09:46,640
on martian brains or on icy moon brains

274
00:09:51,670 --> 00:09:48,839
but also i want to

275
00:09:53,670 --> 00:09:51,680
explore all the revenues and model other

276
00:09:54,870 --> 00:09:53,680
environments on earth such as freezing

277
00:09:56,949 --> 00:09:54,880
um

278
00:09:58,870 --> 00:09:56,959
brian as we have in blood falls which

279
00:10:01,269 --> 00:09:58,880
actually well it was what i was going to

280
00:10:02,949 --> 00:10:01,279
originally present here but

281
00:10:05,110 --> 00:10:02,959
the results were not

282
00:10:08,069 --> 00:10:05,120
quite ready yet so this is why we

283
00:10:09,750 --> 00:10:08,079
finally moved to rio tinto and that's it

284
00:10:13,140 --> 00:10:09,760
that's from me so if you have any

285
00:10:18,069 --> 00:10:13,150
questions more than happy to take them

286
00:10:21,590 --> 00:10:18,079
[Applause]

287
00:10:23,910 --> 00:10:21,600
hi tessa fisher asu great talk um once

288
00:10:26,630 --> 00:10:23,920

upon a time i was a microbial ecologist

289
00:10:28,310 --> 00:10:26,640
modeler um and the first thing that came

290
00:10:29,829 --> 00:10:28,320
to mind aside from the fact that i would

291
00:10:33,030 --> 00:10:29,839
have loved to have this back when i was

292
00:10:34,790 --> 00:10:33,040
working on my projects um

293
00:10:36,790 --> 00:10:34,800
how did you factor in

294
00:10:39,190 --> 00:10:36,800
sort of like the fundamental nutrients

295
00:10:42,069 --> 00:10:39,200
like say phosphorus availability

296
00:10:45,190 --> 00:10:42,079
so um in terms of phosphorus and such um

297
00:10:46,949 --> 00:10:45,200
so freak actually can model well freak

298
00:10:49,670 --> 00:10:46,959
doesn't really model phosphorus so we

299
00:10:51,670 --> 00:10:49,680
we've actually add some of them

300
00:10:52,949 --> 00:10:51,680
of the pizza data into the database to

301
00:10:54,949 --> 00:10:52,959
try to model it

302
00:10:57,509 --> 00:10:54,959
but also in terms of microbiology one of

303
00:10:59,350 --> 00:10:57,519
the of the things

304
00:11:01,350 --> 00:10:59,360
that we are modeling is actually the

305
00:11:03,350 --> 00:11:01,360
incorporation of phosphorus into the

306
00:11:05,269 --> 00:11:03,360
microbial cells so

307
00:11:07,750 --> 00:11:05,279
we know that there is a affinity

308
00:11:09,350 --> 00:11:07,760
constant for phosphates

309
00:11:12,710 --> 00:11:09,360
for microbial groups at the time of

310
00:11:14,630 --> 00:11:12,720
incorporating it so basically oh sorry

311
00:11:17,430 --> 00:11:14,640
basically um the dynamic is okay if

312
00:11:19,190 --> 00:11:17,440
there is organic phosphorus on the

313
00:11:21,110 --> 00:11:19,200

on the brine it's going to be absorbed

314
00:11:22,310 --> 00:11:21,120
but um heterotrophs to generate organic

315
00:11:24,790 --> 00:11:22,320
matter

316
00:11:26,710 --> 00:11:24,800
and if we have inorganic phosphorus it

317
00:11:28,389 --> 00:11:26,720
can be also absorbed by autotrophs to

318
00:11:30,870 --> 00:11:28,399
generate an organic matter

319
00:11:34,470 --> 00:11:30,880
on the other hand if we have organic

320
00:11:37,990 --> 00:11:34,480
matter it contains nitrogen it contains

321
00:11:39,910 --> 00:11:38,000
phosphorus and it contains also carbon

322
00:11:42,310 --> 00:11:39,920
so when we are actually modeling

323
00:11:45,030 --> 00:11:42,320
processes as demineralization that we

324
00:11:47,430 --> 00:11:45,040
see by heterotrophs we are actually also

325
00:11:49,110 --> 00:11:47,440
putting the phosphorous dynamics into it

326
00:11:49,990 --> 00:11:49,120
because we know the the percentage of

327
00:11:51,509 --> 00:11:50,000
them

328
00:11:53,509 --> 00:11:51,519
of the organic matter that contains

329
00:11:55,190 --> 00:11:53,519
phosphorus so that is also i've been

330
00:12:02,310 --> 00:11:55,200
mobilizing to the prime

331
00:12:02,320 --> 00:12:12,230
thank you very much any more questions

332
00:12:14,730 --> 00:12:13,829
okay a round of applause for our first

333
00:12:22,150 --> 00:12:14,740
speaker

334
00:12:26,870 --> 00:12:24,310
okay next up we're doing great on time

335
00:12:28,069 --> 00:12:26,880
we have laura facrel

336
00:12:30,350 --> 00:12:28,079
please give a round of applause for our

337
00:12:43,750 --> 00:12:30,360
second speaker

338
00:12:43,760 --> 00:12:51,430

okay

339
00:12:55,509 --> 00:12:54,230
working i can't see the things i guess

340
00:12:57,509 --> 00:12:55,519
okay perfect

341
00:12:58,790 --> 00:12:57,519
all right good morning um

342
00:13:00,550 --> 00:12:58,800
i am laura fackrill and i am a

343
00:13:01,910 --> 00:13:00,560
postdoctoral scholar at northern arizona

344
00:13:03,750 --> 00:13:01,920
university and today i'll be talking

345
00:13:05,030 --> 00:13:03,760
about a project we're working on

346
00:13:07,269 --> 00:13:05,040
where we're developing habitat

347
00:13:08,870 --> 00:13:07,279
suitability models and different species

348
00:13:11,269 --> 00:13:08,880
species distribution models for some

349
00:13:13,750 --> 00:13:11,279
taxa in some of the polar deserts and

350
00:13:15,350 --> 00:13:13,760
how we're applying that to mars

351
00:13:16,629 --> 00:13:15,360
so before i get into the details of the

352
00:13:18,389 --> 00:13:16,639
talk just some acknowledgements from my

353
00:13:19,509 --> 00:13:18,399
fellow co-authors as well as other

354
00:13:20,629 --> 00:13:19,519
collaborators and students that have

355
00:13:21,750 --> 00:13:20,639
worked with us on the project and

356
00:13:23,509 --> 00:13:21,760
several funding sources that have

357
00:13:25,110 --> 00:13:23,519
supported it

358
00:13:27,910 --> 00:13:25,120
okay so i'm going to give you a little

359
00:13:29,829 --> 00:13:27,920
bit of context first where exactly sorry

360
00:13:30,710 --> 00:13:29,839
the project is coming from um and then

361
00:13:31,990 --> 00:13:30,720
i'm going to talk about some of the

362
00:13:34,230 --> 00:13:32,000
methods and preliminary results from

363
00:13:35,269 --> 00:13:34,240

like the first steps of the project we

364
00:13:37,190 --> 00:13:35,279
are still kind of at the beginning of

365
00:13:38,870 --> 00:13:37,200
this project it's an ongoing thing and

366
00:13:40,870 --> 00:13:38,880
so we don't have any actual habitat

367
00:13:42,310 --> 00:13:40,880
suitability models finalized yet to show

368
00:13:43,590 --> 00:13:42,320
off but we do have some early results

369
00:13:45,110 --> 00:13:43,600
that are pretty cool then i'm going to

370
00:13:46,150 --> 00:13:45,120
talk the methods and the results i'm

371
00:13:48,230 --> 00:13:46,160
going to talk about we'll focus on that

372
00:13:49,829 --> 00:13:48,240
today and that will focus mostly on soil

373
00:13:51,189 --> 00:13:49,839
moisture and then we'll kind of talk

374
00:13:52,230 --> 00:13:51,199
about what's happening next and where

375
00:13:53,269 --> 00:13:52,240
that's going

376
00:13:54,470 --> 00:13:53,279
um

377
00:13:55,990 --> 00:13:54,480
all right so first some contacts of

378
00:13:57,509 --> 00:13:56,000
where this is coming from

379
00:13:59,189 --> 00:13:57,519
this is actually a project the main

380
00:14:00,870 --> 00:13:59,199
project that this is coming from is a

381
00:14:03,350 --> 00:14:00,880
project we're working on in

382
00:14:04,870 --> 00:14:03,360
mcmurdo dry valleys in antarctica and

383
00:14:06,230 --> 00:14:04,880
it's called moving beyond the margins

384
00:14:07,590 --> 00:14:06,240
and we're trying to model water

385
00:14:09,590 --> 00:14:07,600
availability and as well as different

386
00:14:11,350 --> 00:14:09,600
habitat suitability aspects of these

387
00:14:13,110 --> 00:14:11,360
polar deserts and

388
00:14:14,790 --> 00:14:13,120

some of the major goals that relate to

389
00:14:16,389 --> 00:14:14,800
specifically water

390
00:14:18,550 --> 00:14:16,399
and other aspects of the project and

391
00:14:20,069 --> 00:14:18,560
these are not all of the goals of this

392
00:14:21,269 --> 00:14:20,079
pretty large project but it's the goals

393
00:14:23,509 --> 00:14:21,279
that i'm most applicable to are talking

394
00:14:25,590 --> 00:14:23,519
about in relation to then relating that

395
00:14:27,350 --> 00:14:25,600
to mars environments today and that is

396
00:14:28,629 --> 00:14:27,360
mapping the sources and distribution and

397
00:14:30,949 --> 00:14:28,639
abundance of soil moisture in these

398
00:14:32,629 --> 00:14:30,959
soils especially cryptic sources that

399
00:14:34,069 --> 00:14:32,639
are not necessarily accounted for

400
00:14:35,829 --> 00:14:34,079
um as well as some others we'll talk

401
00:14:38,069 --> 00:14:35,839
about that in a couple of slides

402
00:14:39,670 --> 00:14:38,079
we're also going to look at the kind of

403
00:14:41,430 --> 00:14:39,680
the next steps out that are assembling

404
00:14:43,110 --> 00:14:41,440
other data sets that are geospatially

405
00:14:44,870 --> 00:14:43,120
relevant and relevant to the tax that

406
00:14:46,470 --> 00:14:44,880
lived there and that would contribute to

407
00:14:48,310 --> 00:14:46,480
understanding the habitat suitability of

408
00:14:49,509 --> 00:14:48,320
these regions

409
00:14:51,030 --> 00:14:49,519
and then taking all of this and

410
00:14:52,150 --> 00:14:51,040
developing species distribution models

411
00:14:54,069 --> 00:14:52,160
and other

412
00:14:55,670 --> 00:14:54,079
related kind of models of that to kind

413
00:14:57,430 --> 00:14:55,680

of understand better the species

414
00:14:58,470 --> 00:14:57,440
distribution of these different areas

415
00:15:00,310 --> 00:14:58,480
and how these

416
00:15:02,870 --> 00:15:00,320
more crypto cryptic water sources may be

417
00:15:04,389 --> 00:15:02,880
contributing to that um and

418
00:15:05,269 --> 00:15:04,399
as well as how climate change might be

419
00:15:07,110 --> 00:15:05,279
affecting that so that's kind of like

420
00:15:09,030 --> 00:15:07,120
the bigger project overall where this

421
00:15:10,550 --> 00:15:09,040
smaller project is coming from because

422
00:15:12,389 --> 00:15:10,560
these mcmurdo drive valleys are mars

423
00:15:13,670 --> 00:15:12,399
analog we've also wanted to see what

424
00:15:14,949 --> 00:15:13,680
what information is available and what

425
00:15:16,069 --> 00:15:14,959
data is available although we can take

426
00:15:17,430 --> 00:15:16,079
this

427
00:15:19,030 --> 00:15:17,440
approach that we're using in an earth

428
00:15:21,189 --> 00:15:19,040
ecosystem environment and then apply it

429
00:15:22,150 --> 00:15:21,199
to a potential ecosystem on another

430
00:15:24,389 --> 00:15:22,160
planet

431
00:15:25,910 --> 00:15:24,399
specifically mars

432
00:15:27,189 --> 00:15:25,920
and so why particularly soil moisture

433
00:15:28,790 --> 00:15:27,199
and why that's kind of the focus of what

434
00:15:30,230 --> 00:15:28,800
we're talking about today well it's kind

435
00:15:31,670 --> 00:15:30,240
of like that first big goal we're

436
00:15:32,870 --> 00:15:31,680
talking about and as astrobiologists we

437
00:15:34,870 --> 00:15:32,880
know the water is really important for

438
00:15:36,310 --> 00:15:34,880

life and so like following the water and

439
00:15:37,509 --> 00:15:36,320
understanding how the water behaves is a

440
00:15:39,269 --> 00:15:37,519
really important aspect of any

441
00:15:40,710 --> 00:15:39,279
environment in particular these polar

442
00:15:42,550 --> 00:15:40,720
deserts where water is extremely limited

443
00:15:45,990 --> 00:15:42,560
some of the driest places on earth

444
00:15:47,269 --> 00:15:46,000
um so dry that they actually are

445
00:15:49,350 --> 00:15:47,279
some of the best analogs we have for

446
00:15:51,110 --> 00:15:49,360
mars because of the just this nature of

447
00:15:52,150 --> 00:15:51,120
this of these deserts then we can

448
00:15:53,350 --> 00:15:52,160
actually kind of look at what are the

449
00:15:54,389 --> 00:15:53,360
different what are the behaviors of

450
00:15:55,749 --> 00:15:54,399
water in this valley and we have this

451
00:15:57,430 --> 00:15:55,759
kind of classic view of mcmurdo dry

452
00:15:59,350 --> 00:15:57,440
valleys where you have seasonal and

453
00:16:01,670 --> 00:15:59,360
glacial snow melts that are feeding

454
00:16:03,269 --> 00:16:01,680
these ephemeral streams um

455
00:16:04,870 --> 00:16:03,279
and that they are the main contributor

456
00:16:06,949 --> 00:16:04,880
to different processes that would

457
00:16:08,949 --> 00:16:06,959
involve ecosystem processes as they

458
00:16:10,230 --> 00:16:08,959
depend highly on this water and that is

459
00:16:12,310 --> 00:16:10,240
a major part of what happens in these

460
00:16:14,150 --> 00:16:12,320
ecosystems however there is a recent

461
00:16:15,749 --> 00:16:14,160
challenge to this paradigm where we're

462
00:16:17,829 --> 00:16:15,759
actually starting to find other sources

463
00:16:19,990 --> 00:16:17,839

for water that maybe have a greater

464
00:16:22,389 --> 00:16:20,000
contribution than we before realized

465
00:16:23,910 --> 00:16:22,399
in particular the detection of several

466
00:16:26,550 --> 00:16:23,920
wet patches that would be called the wet

467
00:16:28,230 --> 00:16:26,560
tracks um that are these shallow

468
00:16:29,269 --> 00:16:28,240
subsurface systems um that are

469
00:16:30,550 --> 00:16:29,279
contributing more to the environment but

470
00:16:32,550 --> 00:16:30,560
they aren't part of this major stream

471
00:16:34,230 --> 00:16:32,560
flow um and so we've been able to

472
00:16:36,949 --> 00:16:34,240
actually kind of

473
00:16:38,550 --> 00:16:36,959
not only um estimate the abundance and

474
00:16:40,069 --> 00:16:38,560
the distribution of water from streams

475
00:16:41,590 --> 00:16:40,079
but also from these cryptic sources that

476
00:16:43,670 --> 00:16:41,600
are not really very well accounted for

477
00:16:45,110 --> 00:16:43,680
and are kind of only recently been more

478
00:16:46,389 --> 00:16:45,120
studied and understood

479
00:16:48,310 --> 00:16:46,399
and that could have really potential

480
00:16:50,069 --> 00:16:48,320
importance in how ecosystem processes

481
00:16:51,509 --> 00:16:50,079
function in these environments and have

482
00:16:53,910 --> 00:16:51,519
a lot of potential for helping us

483
00:16:56,389 --> 00:16:53,920
understand um extraterrestrial

484
00:16:58,710 --> 00:16:56,399
ecosystems when we if and when we find

485
00:16:59,670 --> 00:16:58,720
them so that's kind of but they're also

486
00:17:00,710 --> 00:16:59,680
very different from the streams

487
00:17:03,030 --> 00:17:00,720
themselves because they're often more

488
00:17:04,230 --> 00:17:03,040

highly saline so this is this really

489
00:17:06,150 --> 00:17:04,240
interesting kind of approach trying to

490
00:17:07,750 --> 00:17:06,160
understand the soil moisture

491
00:17:09,990 --> 00:17:07,760
and that kind of takes us to korean soap

492
00:17:11,590 --> 00:17:10,000
linea how we want to apply that to this

493
00:17:12,789 --> 00:17:11,600
particular environment this and this is

494
00:17:14,150 --> 00:17:12,799
not the only environment that this could

495
00:17:16,870 --> 00:17:14,160
be applied to but just kind of one that

496
00:17:18,230 --> 00:17:16,880
we picked um because there's a lot of

497
00:17:19,590 --> 00:17:18,240
correlations and comparisons that could

498
00:17:22,069 --> 00:17:19,600
be made from these wet tracks that are

499
00:17:23,350 --> 00:17:22,079
in argha to recording spline but there

500
00:17:25,669 --> 00:17:23,360
are also some important distinctions and

501
00:17:27,350 --> 00:17:25,679
clarifications to remember for them and

502
00:17:29,669 --> 00:17:27,360
so we know that um occurring swiping are

503
00:17:31,750 --> 00:17:29,679
pretty familiar thing on mars now are

504
00:17:33,669 --> 00:17:31,760
these dark linear streaks that appear

505
00:17:35,990 --> 00:17:33,679
yearly along slopes and

506
00:17:37,510 --> 00:17:36,000
from on steep martian slopes and then

507
00:17:38,630 --> 00:17:37,520
they kind of tend to be seasonal where

508
00:17:40,549 --> 00:17:38,640
they appear in the warmer summer and

509
00:17:42,630 --> 00:17:40,559
then kind of disappear in colder

510
00:17:43,909 --> 00:17:42,640
temperatures

511
00:17:44,950 --> 00:17:43,919
and initial observations of these

512
00:17:47,270 --> 00:17:44,960
features

513
00:17:49,510 --> 00:17:47,280

and even some detections or preliminary

514
00:17:51,990 --> 00:17:49,520
detections of salts within them kind of

515
00:17:53,110 --> 00:17:52,000
supported the initial thoughts of them

516
00:17:54,950 --> 00:17:53,120
being these wet mechanisms that

517
00:17:56,070 --> 00:17:54,960
supported them however a lot of more

518
00:17:57,990 --> 00:17:56,080
recent observations have kind of

519
00:17:59,430 --> 00:17:58,000
clarified that and we've kind of gone

520
00:18:01,350 --> 00:17:59,440
away from the wet mechanisms and more

521
00:18:02,549 --> 00:18:01,360
towards dry mechanisms

522
00:18:03,909 --> 00:18:02,559
just because the assaults that were

523
00:18:05,669 --> 00:18:03,919
detected were not necessarily robust

524
00:18:07,909 --> 00:18:05,679
detections and so that's been highly

525
00:18:09,510 --> 00:18:07,919
disputed but there's a lot of

526
00:18:11,430 --> 00:18:09,520
different opinions in the literature and

527
00:18:12,710 --> 00:18:11,440
different things and many none of the

528
00:18:14,150 --> 00:18:12,720
mechanisms fully support all the

529
00:18:15,830 --> 00:18:14,160
features seen so there's a lot of debate

530
00:18:17,190 --> 00:18:15,840
still and there's still a lot of debate

531
00:18:18,870 --> 00:18:17,200
and whether or not they're wet or dry

532
00:18:19,909 --> 00:18:18,880
but that's not what this talk is about

533
00:18:22,150 --> 00:18:19,919
we're not trying to figure out if

534
00:18:23,270 --> 00:18:22,160
they're wet or dry um that's beyond the

535
00:18:24,950 --> 00:18:23,280
scope of what we're doing we need more

536
00:18:26,310 --> 00:18:24,960
data to really figure that out anyway

537
00:18:29,029 --> 00:18:26,320
but it's if they're wet or if there's

538
00:18:31,029 --> 00:18:29,039

any kind of wetness involved how what

539
00:18:32,870 --> 00:18:31,039
are they and what can we say about that

540
00:18:33,909 --> 00:18:32,880
and that's using some of the same

541
00:18:35,510 --> 00:18:33,919
methods that we're applying to an

542
00:18:37,190 --> 00:18:35,520
article trying to apply them to these

543
00:18:38,710 --> 00:18:37,200
methods where this wetness is an albedo

544
00:18:40,710 --> 00:18:38,720
feature that can be observed and

545
00:18:42,470 --> 00:18:40,720
measured and potentially even pulled out

546
00:18:43,830 --> 00:18:42,480
from the rest of the data so

547
00:18:45,750 --> 00:18:43,840
that's where we and then also just to

548
00:18:48,549 --> 00:18:45,760
clarify really quickly

549
00:18:49,990 --> 00:18:48,559
habitat suitability versus habitability

550
00:18:51,430 --> 00:18:50,000
and so when i'm talking in this talk i'm

551
00:18:53,669 --> 00:18:51,440
talking more about habitat suitability

552
00:18:54,789 --> 00:18:53,679
which is a pretty strict ecological term

553
00:18:56,150 --> 00:18:54,799
on which a lot of these habitat

554
00:18:58,150 --> 00:18:56,160
suitability models and distribution

555
00:19:00,150 --> 00:18:58,160
models are based and it's a little bit

556
00:19:01,590 --> 00:19:00,160
different than just habitability that we

557
00:19:03,990 --> 00:19:01,600
often talk about naturally so it's just

558
00:19:05,909 --> 00:19:04,000
a quick clarification to make about that

559
00:19:07,430 --> 00:19:05,919
all right so how are we approaching this

560
00:19:09,590 --> 00:19:07,440
and what are we doing to do this um the

561
00:19:11,750 --> 00:19:09,600
soil moisture aspects of this and then a

562
00:19:14,310 --> 00:19:11,760
little tiny bit about what's coming

563
00:19:16,870 --> 00:19:14,320

to get to the actual models in the end

564
00:19:18,950 --> 00:19:16,880
okay so first this is just an image of

565
00:19:20,549 --> 00:19:18,960
um one of the some of the lakes that are

566
00:19:21,510 --> 00:19:20,559
in these mcmurdo drive valleys and the

567
00:19:22,950 --> 00:19:21,520
changes that occur there and you can

568
00:19:24,630 --> 00:19:22,960
kind of see how dynamic it is and how

569
00:19:25,990 --> 00:19:24,640
much the surface changes and a lot of

570
00:19:27,430 --> 00:19:26,000
those changes are just these albedo

571
00:19:28,950 --> 00:19:27,440
differences that you can see in the

572
00:19:30,310 --> 00:19:28,960
background we just have this change from

573
00:19:31,750 --> 00:19:30,320
light to dark and different things

574
00:19:34,310 --> 00:19:31,760
however a lot of things can influence

575
00:19:36,150 --> 00:19:34,320
albedo from composition to topography

576
00:19:37,350 --> 00:19:36,160
and a lot of other features that just

577
00:19:38,950 --> 00:19:37,360
play into that role so how do you

578
00:19:40,950 --> 00:19:38,960
isolate the albedo changes that are from

579
00:19:42,310 --> 00:19:40,960
soil moisture specifically well we're

580
00:19:44,150 --> 00:19:42,320
fortunate we're in an area that has no

581
00:19:46,310 --> 00:19:44,160
vegetation and no animal life so we just

582
00:19:48,470 --> 00:19:46,320
have this um open canvas that we can

583
00:19:50,390 --> 00:19:48,480
kind of look at and we also have really

584
00:19:52,630 --> 00:19:50,400
detailed dem and

585
00:19:53,990 --> 00:19:52,640
topography data from lighters in this

586
00:19:55,669 --> 00:19:54,000
area as well so we can kind of isolate

587
00:19:57,190 --> 00:19:55,679
the features that are from topography

588
00:19:59,029 --> 00:19:57,200

and then separate them out and so that's

589
00:20:01,190 --> 00:19:59,039
kind of the approach that we used um so

590
00:20:04,070 --> 00:20:01,200
we took these high quality image data

591
00:20:05,830 --> 00:20:04,080
from worldview two and three um and we

592
00:20:08,149 --> 00:20:05,840
have about 57 images total from all of

593
00:20:09,430 --> 00:20:08,159
that from the years 2009 2019. we

594
00:20:10,950 --> 00:20:09,440
calibrated them and corrected them

595
00:20:12,230 --> 00:20:10,960
atmospherically and

596
00:20:14,470 --> 00:20:12,240
all the surface reflectance and all the

597
00:20:16,149 --> 00:20:14,480
different things um and then we were

598
00:20:18,149 --> 00:20:16,159
able to use the lighter data to

599
00:20:19,990 --> 00:20:18,159
construct a really accurate hill shade

600
00:20:21,990 --> 00:20:20,000
and other topography relevance i'll be

601
00:20:23,510 --> 00:20:22,000
able to model the topography of the area

602
00:20:24,630 --> 00:20:23,520
and you can use that to then subtract

603
00:20:26,070 --> 00:20:24,640
that out

604
00:20:27,430 --> 00:20:26,080
and then we get to that third image on

605
00:20:29,510 --> 00:20:27,440
the bottom and that's what you remain so

606
00:20:31,270 --> 00:20:29,520
you remain with the albedo changes that

607
00:20:32,870 --> 00:20:31,280
aren't influenced from topography and

608
00:20:34,070 --> 00:20:32,880
that leaves behind what you can then use

609
00:20:35,430 --> 00:20:34,080
to calculate okay what are the other

610
00:20:36,549 --> 00:20:35,440
things that would influence albedo in

611
00:20:37,750 --> 00:20:36,559
this area

612
00:20:39,750 --> 00:20:37,760
and because the composition is

613
00:20:41,190 --> 00:20:39,760

relatively consistent and because we

614
00:20:42,870 --> 00:20:41,200
understand the relationship of different

615
00:20:45,110 --> 00:20:42,880
salts and snow

616
00:20:47,350 --> 00:20:45,120
to this area we can kind of isolate what

617
00:20:49,110 --> 00:20:47,360
is from potentially wet patches if we

618
00:20:50,950 --> 00:20:49,120
look at it over time

619
00:20:53,190 --> 00:20:50,960
and that can kind of isolate that those

620
00:20:55,830 --> 00:20:53,200
changes in albedo occur over time

621
00:20:57,830 --> 00:20:55,840
in seasonal patterns can then be from

622
00:21:00,390 --> 00:20:57,840
these wet patches as well as streams and

623
00:21:01,669 --> 00:21:00,400
other sources of soil moisture

624
00:21:03,350 --> 00:21:01,679
and we've actually also correlated this

625
00:21:05,110 --> 00:21:03,360
to studies in the lab where we've been

626
00:21:07,029 --> 00:21:05,120
able to have there's a fairly linear

627
00:21:09,110 --> 00:21:07,039
relationship um

628
00:21:10,070 --> 00:21:09,120
before the soil becomes saturated so

629
00:21:12,710 --> 00:21:10,080
once you get saturated it gets a little

630
00:21:14,310 --> 00:21:12,720
more complicated of a spectral

631
00:21:15,430 --> 00:21:14,320
relationship but before that point you

632
00:21:16,870 --> 00:21:15,440
actually have this really nice linear

633
00:21:19,029 --> 00:21:16,880
relationship between

634
00:21:20,230 --> 00:21:19,039
the soil albedo changes and the soil

635
00:21:21,590 --> 00:21:20,240
moisture content so we're able to use

636
00:21:23,350 --> 00:21:21,600
that to actually then help to also

637
00:21:25,350 --> 00:21:23,360
estimate how much is there and because

638
00:21:26,470 --> 00:21:25,360

we have data from the ground in an

639
00:21:27,990 --> 00:21:26,480
article we can actually compare that and

640
00:21:29,750 --> 00:21:28,000
show that it is similar and so we've

641
00:21:31,270 --> 00:21:29,760
been able to do that so that's kind of

642
00:21:33,110 --> 00:21:31,280
the soil moisture aspect of it and then

643
00:21:35,590 --> 00:21:33,120
really briefly we're also integrating it

644
00:21:37,830 --> 00:21:35,600
with other meteorological data um

645
00:21:39,830 --> 00:21:37,840
different nddi index all sorts of other

646
00:21:41,270 --> 00:21:39,840
geospatially related data that helps us

647
00:21:42,870 --> 00:21:41,280
understand the habitat suitability of

648
00:21:44,549 --> 00:21:42,880
this region to incorporate into these

649
00:21:46,230 --> 00:21:44,559
species distribution models and that's

650
00:21:48,549 --> 00:21:46,240
um the lower example is just an example

651
00:21:50,070 --> 00:21:48,559
of when distribution in the area

652
00:21:51,990 --> 00:21:50,080
all right so then how do we apply that

653
00:21:53,909 --> 00:21:52,000
to rsl specifically just focusing on the

654
00:21:55,510 --> 00:21:53,919
moisture soil moisture aspects if it is

655
00:21:56,470 --> 00:21:55,520
indeed moist at all

656
00:21:58,470 --> 00:21:56,480
um

657
00:21:59,750 --> 00:21:58,480
and that's using and so we carry here

658
00:22:01,990 --> 00:21:59,760
from worldview to high-rise images and

659
00:22:04,310 --> 00:22:02,000
we do similar corrections and also we

660
00:22:05,110 --> 00:22:04,320
have um enough hierarchy images that we

661
00:22:07,510 --> 00:22:05,120
can

662
00:22:09,110 --> 00:22:07,520
produce a dem of the area that's an

663
00:22:09,990 --> 00:22:09,120

accurate it's not quite as detailed as

664
00:22:11,590 --> 00:22:10,000
what you would get in that article where

665
00:22:12,870 --> 00:22:11,600
you have this nice lidar but it's

666
00:22:14,549 --> 00:22:12,880
accurate enough that we can kind of do

667
00:22:17,350 --> 00:22:14,559
the similar workflow and then get an

668
00:22:19,190 --> 00:22:17,360
estimate for um this one if these albedo

669
00:22:21,350 --> 00:22:19,200
changes are indeed from soil moisture

670
00:22:22,630 --> 00:22:21,360
how moist is it and then we still take

671
00:22:24,390 --> 00:22:22,640
those images and just put them through a

672
00:22:26,950 --> 00:22:24,400
very similar workflow as we did for the

673
00:22:29,190 --> 00:22:26,960
worldview images and apply them to these

674
00:22:30,390 --> 00:22:29,200
rsls

675
00:22:32,230 --> 00:22:30,400
and then that will be assembled with

676
00:22:33,750 --> 00:22:32,240
other available data that's if as long

677
00:22:34,390 --> 00:22:33,760
as that data has a proper resolution and

678
00:22:35,750 --> 00:22:34,400
is

679
00:22:37,430 --> 00:22:35,760
the kind of data that we need to kind of

680
00:22:39,029 --> 00:22:37,440
that we can combine that and perform a

681
00:22:41,029 --> 00:22:39,039
more limited kind of

682
00:22:42,950 --> 00:22:41,039
habitat suitability model we don't have

683
00:22:43,909 --> 00:22:42,960
as much data to work with so we can't do

684
00:22:45,270 --> 00:22:43,919
as many things as we can do in

685
00:22:47,110 --> 00:22:45,280
antarctica but we can start to

686
00:22:49,350 --> 00:22:47,120
understand what are the contributions to

687
00:22:50,630 --> 00:22:49,360
habitat suitability from water at least

688
00:22:52,710 --> 00:22:50,640

and from other features that we actually

689
00:22:54,149 --> 00:22:52,720
have available data for and so just kind

690
00:22:55,909 --> 00:22:54,159
of take this example and apply something

691
00:22:57,350 --> 00:22:55,919
that we use all the time in ecosystems

692
00:22:59,029 --> 00:22:57,360
on earth and see what we can do with it

693
00:23:01,750 --> 00:22:59,039
in an environment on another planet so

694
00:23:02,630 --> 00:23:01,760
that's kind of um the approach there

695
00:23:04,710 --> 00:23:02,640
okay

696
00:23:06,149 --> 00:23:04,720
so just a couple of preliminary results

697
00:23:08,630 --> 00:23:06,159
um so this is just what we would see in

698
00:23:10,549 --> 00:23:08,640
antarctica so kind of just a really

699
00:23:12,470 --> 00:23:10,559
quick visual as we do want to look at

700
00:23:13,909 --> 00:23:12,480
the variation of albedo over time if

701
00:23:15,590 --> 00:23:13,919
it's just a stagnant albedo that doesn't

702
00:23:16,870 --> 00:23:15,600
change at all then that can likely be

703
00:23:18,549 --> 00:23:16,880
due to composition or other features

704
00:23:20,310 --> 00:23:18,559
that affect albedo but if you can look

705
00:23:21,590 --> 00:23:20,320
at the ones that change seasonally that

706
00:23:23,350 --> 00:23:21,600
match this pattern we can actually kind

707
00:23:26,149 --> 00:23:23,360
of understand that variation from the

708
00:23:28,630 --> 00:23:26,159
average and get an idea of soil moisture

709
00:23:30,230 --> 00:23:28,640
and so applying that same thing to mars

710
00:23:31,669 --> 00:23:30,240
this is kind of the result for a police

711
00:23:32,630 --> 00:23:31,679
or crater which is the first one we

712
00:23:33,750 --> 00:23:32,640
tried this on and we're also going to

713
00:23:35,590 --> 00:23:33,760

try it on a

714
00:23:36,789 --> 00:23:35,600
hurwitz crater kind of in the next phase

715
00:23:38,710 --> 00:23:36,799
because we have enough data there are

716
00:23:40,390 --> 00:23:38,720
enough images to actually do this

717
00:23:42,230 --> 00:23:40,400
um and so that's kind of this is that

718
00:23:43,909 --> 00:23:42,240
that result of like the estimate of

719
00:23:45,350 --> 00:23:43,919
biometric water content if that albeit

720
00:23:46,310 --> 00:23:45,360
change is from water

721
00:23:47,750 --> 00:23:46,320
um

722
00:23:49,190 --> 00:23:47,760
and so that kind of

723
00:23:51,909 --> 00:23:49,200
got us this result where we have around

724
00:23:53,029 --> 00:23:51,919
10 to 20 percent in our cells with less

725
00:23:54,950 --> 00:23:53,039
than five percent if it's not in our

726
00:23:56,710 --> 00:23:54,960
cell so we have like this range of what

727
00:23:58,789 --> 00:23:56,720
the soil moisture content would be none

728
00:24:00,470 --> 00:23:58,799
of them have been above 20 so it's not a

729
00:24:03,110 --> 00:24:00,480
lot of water that's that's a per that's

730
00:24:04,549 --> 00:24:03,120
not saturated um

731
00:24:06,230 --> 00:24:04,559
and the

732
00:24:07,750 --> 00:24:06,240
and it's but it is within a comparable

733
00:24:10,230 --> 00:24:07,760
range for what we saw for the antarctic

734
00:24:11,110 --> 00:24:10,240
soils um and combined with some of the

735
00:24:12,630 --> 00:24:11,120
other data we have in the thermal

736
00:24:14,149 --> 00:24:12,640
modeling different things it's actually

737
00:24:15,750 --> 00:24:14,159
comparable to some other results that

738
00:24:18,310 --> 00:24:15,760

people have seen using themis to try to

739
00:24:21,110 --> 00:24:18,320
estimate moisture abundance if you can

740
00:24:23,029 --> 00:24:21,120
take into account themis's resolution

741
00:24:25,190 --> 00:24:23,039
and um the fact that fetus is a

742
00:24:27,190 --> 00:24:25,200
nighttime measurement then it's within a

743
00:24:29,990 --> 00:24:27,200
comparable range that's consistent with

744
00:24:31,190 --> 00:24:30,000
other what other results have found

745
00:24:32,390 --> 00:24:31,200
and so then we want to take that and

746
00:24:34,070 --> 00:24:32,400
combine it with that other data to kind

747
00:24:35,669 --> 00:24:34,080
of get more of a habitat suitability

748
00:24:36,950 --> 00:24:35,679
approach so if you're interested in that

749
00:24:38,789 --> 00:24:36,960
i don't have we don't have those results

750
00:24:40,149 --> 00:24:38,799
to show yet but they are coming and so

751
00:24:41,669 --> 00:24:40,159
if you're interested just talk to me

752
00:24:43,990 --> 00:24:41,679
afterwards and we can kind of keep in

753
00:24:45,190 --> 00:24:44,000
contact and update when that happens but

754
00:24:47,830 --> 00:24:45,200
for now we're just really excited that

755
00:24:49,190 --> 00:24:47,840
we have um just this idea of like if

756
00:24:50,950 --> 00:24:49,200
they are wet then we can understand how

757
00:24:53,110 --> 00:24:50,960
what they might be and what implications

758
00:24:54,950 --> 00:24:53,120
that might have for habitability and so

759
00:24:58,130 --> 00:24:54,960
i'll just kind of leave up our

760
00:25:05,029 --> 00:24:58,140
conclusions and take any questions

761
00:25:08,310 --> 00:25:06,470
okay we have plenty of time for

762
00:25:13,029 --> 00:25:08,320
questions so

763
00:25:16,789 --> 00:25:13,039

hi abel mendes from phl at upr arecibo

764
00:25:19,110 --> 00:25:16,799
uh nice talk thank you and and i am glad

765
00:25:22,149 --> 00:25:19,120
that you're using habitat suitability

766
00:25:23,510 --> 00:25:22,159
instead of the general term habitability

767
00:25:25,510 --> 00:25:23,520
and uh

768
00:25:27,830 --> 00:25:25,520
we would like to help you because we are

769
00:25:30,230 --> 00:25:27,840
working on those models and trying to

770
00:25:31,830 --> 00:25:30,240
help other people incorporate a more

771
00:25:33,830 --> 00:25:31,840
standardized

772
00:25:35,830 --> 00:25:33,840
models for habitability

773
00:25:40,310 --> 00:25:35,840
that was my comment thank you very much

774
00:25:45,190 --> 00:25:42,310
hello great talk i'm garrett roberts

775
00:25:47,750 --> 00:25:45,200
kingman from ames research center um

776
00:25:49,510 --> 00:25:47,760
this is a little bit tangential to what

777
00:25:51,909 --> 00:25:49,520
you talked about but i was curious um

778
00:25:53,590 --> 00:25:51,919
because it's relevant to um

779
00:25:56,310 --> 00:25:53,600
to the

780
00:25:59,110 --> 00:25:56,320
habitats for these organisms what is do

781
00:26:01,669 --> 00:25:59,120
you have estimates on the um salinity of

782
00:26:05,110 --> 00:26:01,679
these rsls and um how that may differ

783
00:26:06,070 --> 00:26:05,120
between your antarctic modeling and um

784
00:26:07,990 --> 00:26:06,080
and that's a great question because

785
00:26:09,430 --> 00:26:08,000
that's a big part of it and that's

786
00:26:11,190 --> 00:26:09,440
probably a question that

787
00:26:12,870 --> 00:26:11,200
was more answered but has become less

788
00:26:14,470 --> 00:26:12,880

answered as we realized the original

789
00:26:16,870 --> 00:26:14,480
salt detections that they had for these

790
00:26:18,149 --> 00:26:16,880
rsls are actually not robust and so we

791
00:26:20,070 --> 00:26:18,159
don't know if there are assaults in them

792
00:26:25,750 --> 00:26:20,080
or not technically

793
00:26:29,029 --> 00:26:27,190
i'm going to piggyback off of that

794
00:26:30,070 --> 00:26:29,039
question um

795
00:26:31,909 --> 00:26:30,080
so

796
00:26:33,909 --> 00:26:31,919
i saw a talk by

797
00:26:35,909 --> 00:26:33,919
jacob shafer here

798
00:26:37,350 --> 00:26:35,919
measuring

799
00:26:43,029 --> 00:26:37,360
the

800
00:26:45,669 --> 00:26:43,039
showing that

801
00:26:47,669 --> 00:26:45,679
compared to adjacent dry patches they

802
00:26:51,190 --> 00:26:47,679
have something like a thousand five

803
00:26:52,870 --> 00:26:51,200
thousand times the conductivity so

804
00:26:55,669 --> 00:26:52,880
with your results would you expect

805
00:26:57,750 --> 00:26:55,679
something similar on mars or

806
00:26:59,350 --> 00:26:57,760
um i think if if it is a similar

807
00:27:00,549 --> 00:26:59,360
mechanism to the wet tracks then yeah i

808
00:27:02,310 --> 00:27:00,559
think we would expect something like

809
00:27:03,830 --> 00:27:02,320
that depending on what the actual actual

810
00:27:05,269 --> 00:27:03,840
assaults would be but there's a lot that

811
00:27:06,710 --> 00:27:05,279
we don't know about rsls yet there's a

812
00:27:08,630 --> 00:27:06,720
lot of assumptions that we're making but

813
00:27:10,470 --> 00:27:08,640

yeah the wet tracks are very much more

814
00:27:12,310 --> 00:27:10,480
saline um

815
00:27:13,750 --> 00:27:12,320
than the freshwater streams that are

816
00:27:15,190 --> 00:27:13,760
typically in these areas so it's a very

817
00:27:17,430 --> 00:27:15,200
different kind of wet environment than

818
00:27:18,870 --> 00:27:17,440
we would think of typically

819
00:27:20,870 --> 00:27:18,880
and

820
00:27:22,950 --> 00:27:20,880
i have a sort of secondary question to

821
00:27:27,909 --> 00:27:22,960
that um

822
00:27:29,909 --> 00:27:27,919
a lot of those um

823
00:27:31,669 --> 00:27:29,919
those wet tracks can be influenced from

824
00:27:34,310 --> 00:27:31,679
the permafrost below

825
00:27:37,269 --> 00:27:34,320
do you think that there's a similar

826
00:27:39,430 --> 00:27:37,279
mechanism on mars or there could be

827
00:27:40,710 --> 00:27:39,440
possibly but there's um

828
00:27:41,830 --> 00:27:40,720
and permafrost is definitely one of the

829
00:27:43,430 --> 00:27:41,840
mechanisms for the wet tracks but

830
00:27:44,950 --> 00:27:43,440
there's also delta questions could also

831
00:27:46,549 --> 00:27:44,960
be a mechanism and there's different

832
00:27:47,830 --> 00:27:46,559
mechanisms depending on which wet track

833
00:27:50,070 --> 00:27:47,840
and like how sailing like there's a lot

834
00:27:53,190 --> 00:27:50,080
of different places but that could be

835
00:27:54,389 --> 00:27:53,200
potentially one source for um moisture

836
00:27:55,669 --> 00:27:54,399
in the mars environment because we don't

837
00:27:56,950 --> 00:27:55,679
necessarily

838
00:27:58,149 --> 00:27:56,960

especially from the more recent

839
00:28:00,549 --> 00:27:58,159
observations we realize they're not if

840
00:28:02,710 --> 00:28:00,559
they are what they're not very wet rsls

841
00:28:04,230 --> 00:28:02,720
probably aren't being these large brine

842
00:28:05,750 --> 00:28:04,240
flows necessarily like what is the

843
00:28:08,389 --> 00:28:05,760
source for those brine flows but a

844
00:28:09,269 --> 00:28:08,399
permafrost orchestral questions maybe um

845
00:28:10,389 --> 00:28:09,279
depending on how you look at it but

846
00:28:11,669 --> 00:28:10,399
again we don't really understand how

847
00:28:12,710 --> 00:28:11,679
much salt there actually is and so

848
00:28:14,549 --> 00:28:12,720
there's a lot more data that we actually

849
00:28:16,310 --> 00:28:14,559
need to understand for but i wish we

850
00:28:17,590 --> 00:28:16,320
could just take a rover and stick an ac

851
00:28:18,630 --> 00:28:17,600
meter and just like measure it and just

852
00:28:21,350 --> 00:28:18,640
like

853
00:28:22,149 --> 00:28:21,360
yeah we need good mineralogy

854
00:28:29,269 --> 00:28:22,159
yeah

855
00:28:36,470 --> 00:28:30,389
awesome

856
00:29:03,750 --> 00:28:39,269
all right next up we have heart bathroom

857
00:29:03,760 --> 00:29:07,430
sounds good

858
00:29:12,950 --> 00:29:10,470
cool hey everyone um my name is harp

859
00:29:15,430 --> 00:29:12,960
bathur i'm at cu boulder working with

860
00:29:17,110 --> 00:29:15,440
sebastian koff and alexis templeton my

861
00:29:19,430 --> 00:29:17,120
current project is calibrating the

862
00:29:22,470 --> 00:29:19,440
hydrogen isotope biosignature of

863
00:29:24,950 --> 00:29:22,480

archaeolipids in a model methanogen

864
00:29:27,110 --> 00:29:24,960
cool so um

865
00:29:29,110 --> 00:29:27,120
life forms a bunch of different

866
00:29:31,510 --> 00:29:29,120
macromolecules that can be used as

867
00:29:34,630 --> 00:29:31,520
potential biosignatures so like proteins

868
00:29:37,350 --> 00:29:34,640
lipids carbohydrates and dna and rna

869
00:29:39,430 --> 00:29:37,360
proteins carbohydrates and dna and rna

870
00:29:41,590 --> 00:29:39,440
are really chemically fragile and

871
00:29:42,630 --> 00:29:41,600
unstable over long periods of geologic

872
00:29:45,750 --> 00:29:42,640
time

873
00:29:47,830 --> 00:29:45,760
however lipids are pretty stable

874
00:29:49,590 --> 00:29:47,840
and can persist up to like hundreds of

875
00:29:51,590 --> 00:29:49,600
millions years

876
00:29:54,230 --> 00:29:51,600
over geologic time so that's a really

877
00:29:56,389 --> 00:29:54,240
important molecule to look as a

878
00:29:58,870 --> 00:29:56,399
potential biosignature

879
00:30:01,510 --> 00:29:58,880
cool so like what even our lipids um

880
00:30:03,909 --> 00:30:01,520
lipids are nonpolar hydrocarbons in

881
00:30:05,110 --> 00:30:03,919
their most reduced form which is which

882
00:30:06,470 --> 00:30:05,120
means they're super great for like

883
00:30:08,630 --> 00:30:06,480
energy storage because once they're

884
00:30:10,950 --> 00:30:08,640
oxidized they release a bunch of energy

885
00:30:13,029 --> 00:30:10,960
that could be used by the cell

886
00:30:16,630 --> 00:30:13,039
and they form up like they form things

887
00:30:19,430 --> 00:30:16,640
such as waxes oils and cell membranes so

888
00:30:21,190 --> 00:30:19,440

this is a cell membrane

889
00:30:23,669 --> 00:30:21,200
and you can see on the bottom is an

890
00:30:25,750 --> 00:30:23,679
individual lipids it's made up of a

891
00:30:27,669 --> 00:30:25,760
polar hydrophilic head and a non-polar

892
00:30:30,630 --> 00:30:27,679
hydrophobic tail which is important to

893
00:30:33,750 --> 00:30:30,640
keep in mind when i go over my methods

894
00:30:34,789 --> 00:30:33,760
and so this is basically all the domains

895
00:30:36,870 --> 00:30:34,799
of life

896
00:30:39,750 --> 00:30:36,880
with their specific lipids that

897
00:30:41,669 --> 00:30:39,760
characterize them

898
00:30:43,029 --> 00:30:41,679
and i'm just going to go over each one

899
00:30:45,510 --> 00:30:43,039
and

900
00:30:46,710 --> 00:30:45,520
basically why what lipids are used for

901
00:30:51,190 --> 00:30:46,720
for each of them

902
00:30:53,269 --> 00:30:51,200
so lipids can be used to basically

903
00:30:55,830 --> 00:30:53,279
determine different like environmental

904
00:30:57,430 --> 00:30:55,840
and physiological factors

905
00:30:59,990 --> 00:30:57,440
regarding that organism so we're going

906
00:31:02,470 --> 00:31:00,000
to start with eukaryotes so eukaryotes

907
00:31:04,950 --> 00:31:02,480
are pretty well studied and in

908
00:31:06,950 --> 00:31:04,960
eukaryotes specifically like plant waxes

909
00:31:10,070 --> 00:31:06,960
and other photoautotrophs

910
00:31:12,389 --> 00:31:10,080
you could the d2h or hydrogen isotopes

911
00:31:14,789 --> 00:31:12,399
of the lipids can tell you about past

912
00:31:16,389 --> 00:31:14,799
hydrological cycles so this is the image

913
00:31:18,870 --> 00:31:16,399

that shows you

914
00:31:20,389 --> 00:31:18,880
on the y-axis the d2h

915
00:31:22,630 --> 00:31:20,399
of different

916
00:31:25,669 --> 00:31:22,640
plant waxes and on the y-axis you can

917
00:31:27,509 --> 00:31:25,679
see sorry x-axis this is the rainwater

918
00:31:30,470 --> 00:31:27,519
and what you see here is a pretty

919
00:31:33,190 --> 00:31:30,480
positive correlation so basically by

920
00:31:34,870 --> 00:31:33,200
looking at the d2h of these plant waxes

921
00:31:36,630 --> 00:31:34,880
you can determine

922
00:31:38,389 --> 00:31:36,640
paths like precipitation patterns and

923
00:31:40,870 --> 00:31:38,399
hydrological cycles

924
00:31:41,909 --> 00:31:40,880
bacteria are also super well studied as

925
00:31:44,149 --> 00:31:41,919
a domain

926
00:31:46,470 --> 00:31:44,159
and their due to d2h tells you about

927
00:31:49,029 --> 00:31:46,480
their metabolism so this figure shows

928
00:31:50,950 --> 00:31:49,039
you that there's different sources

929
00:31:53,110 --> 00:31:50,960
of hydrogen for

930
00:31:55,590 --> 00:31:53,120
bacterial lipids so you have water you

931
00:31:57,590 --> 00:31:55,600
have nadph which is a hydride carrier in

932
00:32:00,070 --> 00:31:57,600
the cell and you have organic substrates

933
00:32:02,310 --> 00:32:00,080
for heterotrophs and then on the bottom

934
00:32:04,389 --> 00:32:02,320
part of this image you can see that on

935
00:32:05,430 --> 00:32:04,399
the y-axis you have the lipid deuterium

936
00:32:07,350 --> 00:32:05,440
content

937
00:32:09,750 --> 00:32:07,360
and on the x-axis are different

938
00:32:11,909 --> 00:32:09,760

metabolic pathways so you have like

939
00:32:13,990 --> 00:32:11,919
autotrophic pathways and heterotrophic

940
00:32:15,509 --> 00:32:14,000
pathways and what i want you to get from

941
00:32:18,230 --> 00:32:15,519
this is you could have

942
00:32:21,029 --> 00:32:18,240
different um hydrogen composition of

943
00:32:24,149 --> 00:32:21,039
lipids based on your metabolic pathway

944
00:32:26,149 --> 00:32:24,159
and the d2h ranges over like hundreds of

945
00:32:29,029 --> 00:32:26,159
per ml which is

946
00:32:31,509 --> 00:32:29,039
large even in hydrogen space

947
00:32:33,509 --> 00:32:31,519
so archaea are

948
00:32:35,350 --> 00:32:33,519
the last domain they're not really well

949
00:32:37,509 --> 00:32:35,360
studied in terms of isotopic

950
00:32:38,870 --> 00:32:37,519
biosignatures archaea are kind of like

951
00:32:40,950 --> 00:32:38,880
bacteria but they have slightly

952
00:32:42,789 --> 00:32:40,960
different cell structures and they live

953
00:32:43,750 --> 00:32:42,799
in extreme environments

954
00:32:45,509 --> 00:32:43,760
um

955
00:32:47,990 --> 00:32:45,519
and although they're able to live in

956
00:32:49,430 --> 00:32:48,000
these like super extreme environments um

957
00:32:50,870 --> 00:32:49,440
they don't do well in like really

958
00:32:52,470 --> 00:32:50,880
comfortable labs where they're given

959
00:32:54,710 --> 00:32:52,480
everything they need they just choose

960
00:32:58,230 --> 00:32:54,720
like not to grow and stuff

961
00:33:00,230 --> 00:32:58,240
why i don't know um but basically um

962
00:33:01,509 --> 00:33:00,240
they're still really important to study

963
00:33:04,789 --> 00:33:01,519

even though there's been a lot of like

964
00:33:06,149 --> 00:33:04,799
lab and analytical techniques um

965
00:33:08,710 --> 00:33:06,159
uh they're important to study because

966
00:33:10,950 --> 00:33:08,720
they do live in these environments um

967
00:33:13,350 --> 00:33:10,960
and are important for like nutrient and

968
00:33:15,430 --> 00:33:13,360
energy transformation in really

969
00:33:17,590 --> 00:33:15,440
chronically nutrient limit limited

970
00:33:19,909 --> 00:33:17,600
environments um

971
00:33:21,350 --> 00:33:19,919
that are analogs for those like found on

972
00:33:23,669 --> 00:33:21,360
other planets

973
00:33:26,230 --> 00:33:23,679
methanogens specifically are type of

974
00:33:29,350 --> 00:33:26,240
anaerobic archaea that produce methane

975
00:33:32,149 --> 00:33:29,360
and they live in um environments that

976
00:33:35,029 --> 00:33:32,159
also like um that are also very limited

977
00:33:38,070 --> 00:33:35,039
and mimic those found in on like mars

978
00:33:40,470 --> 00:33:38,080
europa enceladus etc cetera

979
00:33:42,070 --> 00:33:40,480
methanogens specifically are a primitive

980
00:33:43,430 --> 00:33:42,080
metabolism

981
00:33:44,470 --> 00:33:43,440
that are thought to be one of the first

982
00:33:46,950 --> 00:33:44,480
forms of

983
00:33:49,350 --> 00:33:46,960
energy transduction um they contributed

984
00:33:50,470 --> 00:33:49,360
to early earth's reducing environment

985
00:33:53,350 --> 00:33:50,480
and they're thought to be super

986
00:33:55,590 --> 00:33:53,360
important in the origin and evolution of

987
00:33:58,710 --> 00:33:55,600
life on earth

988
00:34:00,230 --> 00:33:58,720

so here we have two images uh one of

989
00:34:02,630 --> 00:34:00,240
these extreme environments that

990
00:34:04,310 --> 00:34:02,640
methanogens live in our serpentinizing

991
00:34:06,149 --> 00:34:04,320
system so i'm sure you guys have heard a

992
00:34:08,230 --> 00:34:06,159
lot about serpentinizing systems at this

993
00:34:10,069 --> 00:34:08,240
conference the top images amman the

994
00:34:12,869 --> 00:34:10,079
bottom one is mars as you can see they

995
00:34:14,869 --> 00:34:12,879
look super similar um serpentinizing sys

996
00:34:16,950 --> 00:34:14,879
it's okay so oman is a low temperature

997
00:34:17,829 --> 00:34:16,960
serpentinizing system which basically

998
00:34:20,710 --> 00:34:17,839
means

999
00:34:23,829 --> 00:34:20,720
that there's water rock reactions in

1000
00:34:25,190 --> 00:34:23,839
this system that produce a bunch of

1001
00:34:27,909 --> 00:34:25,200
hydrogen

1002
00:34:30,550 --> 00:34:27,919
and also makes it really carbon limited

1003
00:34:32,629 --> 00:34:30,560
and produces alkaline to hyper alkaline

1004
00:34:34,869 --> 00:34:32,639
waters

1005
00:34:37,109 --> 00:34:34,879
and oman and other serpentinizing

1006
00:34:39,030 --> 00:34:37,119
systems are thought to be have like are

1007
00:34:41,510 --> 00:34:39,040
analogs for those found

1008
00:34:44,149 --> 00:34:41,520
on other planetary bodies so it's really

1009
00:34:46,310 --> 00:34:44,159
important to study methanogens because

1010
00:34:47,750 --> 00:34:46,320
once again primitive metabolism and also

1011
00:34:49,109 --> 00:34:47,760
they're present in environments that are

1012
00:34:51,190 --> 00:34:49,119
analogues for

1013
00:34:54,149 --> 00:34:51,200

other uh bodies that are important for

1014
00:34:55,829 --> 00:34:54,159
astrobiological exploration

1015
00:34:57,670 --> 00:34:55,839
so yeah methanogen lipids are an

1016
00:34:59,670 --> 00:34:57,680
untapped source of modern and ancient

1017
00:35:02,069 --> 00:34:59,680
environmental information

1018
00:35:04,069 --> 00:35:02,079
so that's my main point and my research

1019
00:35:05,670 --> 00:35:04,079
questions are what processes determine

1020
00:35:07,270 --> 00:35:05,680
lipid hydrogen isotope signatures and

1021
00:35:08,950 --> 00:35:07,280
methanogens

1022
00:35:11,109 --> 00:35:08,960
how are hydrogen biosignatures of

1023
00:35:13,510 --> 00:35:11,119
methanogens influenced by physical and

1024
00:35:15,190 --> 00:35:13,520
chemical environmental parameters

1025
00:35:17,430 --> 00:35:15,200
and do methanogens demonstrate

1026
00:35:19,510 --> 00:35:17,440
physiological adaptations to carbon

1027
00:35:21,829 --> 00:35:19,520
limitations in these serpentinizing

1028
00:35:23,510 --> 00:35:21,839
systems my overall goal is to create a

1029
00:35:26,150 --> 00:35:23,520
framework to understand information

1030
00:35:27,750 --> 00:35:26,160
stored in archaeolipid hydrogen isotope

1031
00:35:30,470 --> 00:35:27,760
ratios

1032
00:35:32,550 --> 00:35:30,480
so their methanogens are grouped into

1033
00:35:35,589 --> 00:35:32,560
three main groups depending on their

1034
00:35:37,589 --> 00:35:35,599
substrate usage first we have um

1035
00:35:40,550 --> 00:35:37,599
hydrogenotrophic methanogens which

1036
00:35:42,150 --> 00:35:40,560
basically use h2co2 formate or a couple

1037
00:35:44,710 --> 00:35:42,160
simple alcohols

1038
00:35:46,950 --> 00:35:44,720

to reduce co2 to methane next we have

1039
00:35:50,630 --> 00:35:46,960
acetoclastic methanogenesis which breaks

1040
00:35:52,550 --> 00:35:50,640
apart acetate to form methane and co2

1041
00:35:54,550 --> 00:35:52,560
lastly we have methylotrophic

1042
00:35:56,829 --> 00:35:54,560
methanogenesis which uses methylated

1043
00:35:58,470 --> 00:35:56,839
substrates such as methanol and

1044
00:36:01,109 --> 00:35:58,480
trimethylamine

1045
00:36:03,589 --> 00:36:01,119
to form methane i'm going to be focused

1046
00:36:05,510 --> 00:36:03,599
um on hydrogenotrophic methanogenesis

1047
00:36:07,589 --> 00:36:05,520
and acetoclastic methanogenesis because

1048
00:36:09,589 --> 00:36:07,599
these are the most common ones

1049
00:36:11,589 --> 00:36:09,599
found in nature

1050
00:36:14,150 --> 00:36:11,599
so i'm going to do this by looking at

1051
00:36:17,190 --> 00:36:14,160
three different species of methanogens

1052
00:36:19,589 --> 00:36:17,200
first we have embarked right which

1053
00:36:22,550 --> 00:36:19,599
is a super cool bug because it can

1054
00:36:24,550 --> 00:36:22,560
participate in all three pathways so

1055
00:36:26,950 --> 00:36:24,560
it's hydrogenotrophic cetoclastic and

1056
00:36:29,190 --> 00:36:26,960
methylotrophic it's well studied so it

1057
00:36:30,870 --> 00:36:29,200
has a simple fully sequenced genome a

1058
00:36:32,870 --> 00:36:30,880
bunch of lipid information and it's

1059
00:36:35,190 --> 00:36:32,880
environmentally diverse and that it can

1060
00:36:39,030 --> 00:36:35,200
be found in like fresh water as well as

1061
00:36:41,790 --> 00:36:39,040
landfills and like cow guts and stuff

1062
00:36:44,230 --> 00:36:41,800
next we have ember pollutus which is a

1063
00:36:47,990 --> 00:36:44,240

hydrogenotrophic methanogen that could

1064
00:36:50,470 --> 00:36:48,000
also use formate as both energy and a

1065
00:36:52,390 --> 00:36:50,480
carbon source it is also well studied

1066
00:36:54,630 --> 00:36:52,400
with a fully sequenced genome and is

1067
00:36:56,150 --> 00:36:54,640
found in marine environments such as

1068
00:37:00,390 --> 00:36:56,160
salt marshes

1069
00:37:02,069 --> 00:37:00,400
lastly we have methanobacterium nshq4 um

1070
00:37:04,310 --> 00:37:02,079
so this is a hydrogenotrophic and

1071
00:37:06,550 --> 00:37:04,320
fermatotrophic methanogen this is my

1072
00:37:09,270 --> 00:37:06,560
exploratory system so this is the one

1073
00:37:12,790 --> 00:37:09,280
found in those um serpentinizing systems

1074
00:37:14,550 --> 00:37:12,800
in oman not well studied at all

1075
00:37:17,030 --> 00:37:14,560
but i'm using mara pollutus as a model

1076
00:37:18,870 --> 00:37:17,040
system for this bug um and yeah so it's

1077
00:37:20,829 --> 00:37:18,880
found in the serpentinizing system which

1078
00:37:23,910 --> 00:37:20,839
is the same ophelite and

1079
00:37:26,710 --> 00:37:23,920
oman and so this is like the schematic

1080
00:37:28,470 --> 00:37:26,720
of what i plan to do um so you have the

1081
00:37:30,390 --> 00:37:28,480
super primitive metabolism

1082
00:37:33,270 --> 00:37:30,400
methanogenesis where you have the

1083
00:37:36,150 --> 00:37:33,280
production of methane as well as biomass

1084
00:37:38,790 --> 00:37:36,160
but like what makes up the lipid

1085
00:37:40,950 --> 00:37:38,800
hydrogen isotope signal is it like water

1086
00:37:42,870 --> 00:37:40,960
is it hydride carriers acetyl coa which

1087
00:37:46,150 --> 00:37:42,880
is important precursor and the formation

1088
00:37:49,349 --> 00:37:46,160

of biomass i aim to do this with

1089
00:37:51,430 --> 00:37:49,359
two different methods so aim one is

1090
00:37:53,109 --> 00:37:51,440
focused on batch cultures aim2 on

1091
00:37:54,710 --> 00:37:53,119
chemostats

1092
00:37:57,030 --> 00:37:54,720
so aim1

1093
00:37:59,109 --> 00:37:57,040
i hope to test the impact of carbon

1094
00:38:01,829 --> 00:37:59,119
source and energy availability on lipid

1095
00:38:03,510 --> 00:38:01,839
hydrogen isotope isotopic composition as

1096
00:38:05,430 --> 00:38:03,520
well as lipid production

1097
00:38:07,349 --> 00:38:05,440
so for this one i'm going to use all

1098
00:38:09,750 --> 00:38:07,359
three methanogens

1099
00:38:12,710 --> 00:38:09,760
grow them in like hydrogenotrophically

1100
00:38:15,030 --> 00:38:12,720
fromatotrophically and acetoclastically

1101
00:38:17,030 --> 00:38:15,040
by using three different

1102
00:38:19,109 --> 00:38:17,040
heavy waters so plus zero just means

1103
00:38:21,910 --> 00:38:19,119
molecule molecule water and then

1104
00:38:23,670 --> 00:38:21,920
enriched by 225 per ml and 450 per ml

1105
00:38:25,510 --> 00:38:23,680
for the hydrogenotrophic since they use

1106
00:38:27,670 --> 00:38:25,520
h2 co2 i'm going to pressurize the head

1107
00:38:29,670 --> 00:38:27,680
space with h2 co2

1108
00:38:31,990 --> 00:38:29,680
for the other

1109
00:38:34,710 --> 00:38:32,000
substrates like formate an acetate i'm

1110
00:38:36,150 --> 00:38:34,720
just going to purge with n2 because i

1111
00:38:37,430 --> 00:38:36,160
just need to keep it anaerobic or else

1112
00:38:40,069 --> 00:38:37,440
they will die

1113
00:38:42,710 --> 00:38:40,079

and so basically i grow these up in

1114
00:38:45,510 --> 00:38:42,720
batch culture experiments

1115
00:38:47,670 --> 00:38:45,520
in these continuous od readers up until

1116
00:38:50,630 --> 00:38:47,680
they reach stationary phase

1117
00:38:52,870 --> 00:38:50,640
which looks like this like growth curves

1118
00:38:55,190 --> 00:38:52,880
my next aim is to test the impact of

1119
00:38:56,390 --> 00:38:55,200
carbon availability and energy flux on

1120
00:38:58,790 --> 00:38:56,400
the hydrogen stable isotope

1121
00:39:00,630 --> 00:38:58,800
fractionation of the produced lipids um

1122
00:39:02,470 --> 00:39:00,640
so for my batch cultures they're are

1123
00:39:04,069 --> 00:39:02,480
going to be grown in like ideal

1124
00:39:05,990 --> 00:39:04,079
conditions like the temperatures they

1125
00:39:07,589 --> 00:39:06,000
like the ph's they like access

1126
00:39:09,990 --> 00:39:07,599
everything so they're happy i just want

1127
00:39:12,550 --> 00:39:10,000
them to grow um for this one i'm

1128
00:39:14,550 --> 00:39:12,560
focusing on kind of testing parameters

1129
00:39:16,870 --> 00:39:14,560
out so i'm using chemostat which is a

1130
00:39:19,910 --> 00:39:16,880
continuous culture basically you have

1131
00:39:22,630 --> 00:39:19,920
like an influx of media

1132
00:39:24,950 --> 00:39:22,640
that equals the outflow of media and

1133
00:39:27,990 --> 00:39:24,960
this is great because you can keep the

1134
00:39:30,069 --> 00:39:28,000
system in steady state by changing per

1135
00:39:32,790 --> 00:39:30,079
and keep the system in steady state but

1136
00:39:35,030 --> 00:39:32,800
you could also change parameters um to

1137
00:39:36,550 --> 00:39:35,040
see their impact on

1138
00:39:39,349 --> 00:39:36,560

the cultures and then sample it

1139
00:39:41,349 --> 00:39:39,359
immediately to do analyses so for this

1140
00:39:43,510 --> 00:39:41,359
i'm using the hydrogenotrophic pathways

1141
00:39:46,069 --> 00:39:43,520
of mare pollutus and my exploratory

1142
00:39:48,550 --> 00:39:46,079
system the methanobacterium just because

1143
00:39:49,670 --> 00:39:48,560
of time constraints chemostats are super

1144
00:39:51,829 --> 00:39:49,680
finicky

1145
00:39:53,829 --> 00:39:51,839
don't work a lot of the time so i'm

1146
00:39:54,950 --> 00:39:53,839
trying to keep my chemostat work

1147
00:39:56,230 --> 00:39:54,960
feasible

1148
00:39:58,710 --> 00:39:56,240
i'm going to test two carbon

1149
00:40:01,670 --> 00:39:58,720
availability conditions so excess carbon

1150
00:40:04,950 --> 00:40:01,680
limiting carbon two energy states excess

1151
00:40:06,150 --> 00:40:04,960
h2 and limiting h2 and two ph's neutral

1152
00:40:08,470 --> 00:40:06,160
and alkaline

1153
00:40:11,910 --> 00:40:08,480
alkaline because that's the waters that

1154
00:40:13,990 --> 00:40:11,920
the methanobacterium are found in

1155
00:40:16,150 --> 00:40:14,000
cool so once i have my cultures i'm

1156
00:40:17,670 --> 00:40:16,160
going to do a couple different analyses

1157
00:40:20,150 --> 00:40:17,680
first i'm going to measure the head

1158
00:40:23,190 --> 00:40:20,160
space so basically just like a take a

1159
00:40:26,150 --> 00:40:23,200
sample of the gas insert it into a gcfid

1160
00:40:29,670 --> 00:40:26,160
tcd to see the concentrations of methane

1161
00:40:32,710 --> 00:40:29,680
co2 and h2 and then i'm gonna take the

1162
00:40:34,790 --> 00:40:32,720
cultures and harvest the biomass

1163
00:40:37,109 --> 00:40:34,800

and then i'm gonna do a lipid extraction

1164
00:40:40,950 --> 00:40:37,119
and this is like a two-step protocol the

1165
00:40:42,309 --> 00:40:40,960
first step breaks off that head group

1166
00:40:43,670 --> 00:40:42,319
which is that polar head group if you

1167
00:40:44,630 --> 00:40:43,680
guys remember that image i showed you

1168
00:40:47,349 --> 00:40:44,640
earlier

1169
00:40:48,950 --> 00:40:47,359
and this out isolates the alcohol

1170
00:40:49,990 --> 00:40:48,960
after that i'm going to cleave the ether

1171
00:40:53,190 --> 00:40:50,000
bonds

1172
00:40:54,870 --> 00:40:53,200
in order to produce phytane and phytane

1173
00:40:56,390 --> 00:40:54,880
which is that last molecule down there

1174
00:40:58,150 --> 00:40:56,400
is something that i could run on

1175
00:41:00,790 --> 00:40:58,160
additional instruments

1176
00:41:04,069 --> 00:41:00,800
then i'm gonna run um these lipid

1177
00:41:06,550 --> 00:41:04,079
extracts on a gcfid um first and that's

1178
00:41:08,470 --> 00:41:06,560
for quantification and so basically you

1179
00:41:11,030 --> 00:41:08,480
just get some peaks

1180
00:41:12,550 --> 00:41:11,040
one is going to be your analyte peak and

1181
00:41:13,750 --> 00:41:12,560
a lights peak and then the other ones

1182
00:41:16,309 --> 00:41:13,760
are just going to be standard so you

1183
00:41:18,870 --> 00:41:16,319
just compare to see how much you have

1184
00:41:20,710 --> 00:41:18,880
second i'm going to run it on a gcms for

1185
00:41:22,710 --> 00:41:20,720
classification and so this you get a

1186
00:41:24,390 --> 00:41:22,720
bunch of peaks you pick one and then you

1187
00:41:26,470 --> 00:41:24,400
look at the fragments that the compounds

1188
00:41:28,790 --> 00:41:26,480

are broken up into and compare those of

1189
00:41:31,270 --> 00:41:28,800
your target analytes lastly i'm going to

1190
00:41:32,710 --> 00:41:31,280
run on a gc rms to do hydrogen isotope

1191
00:41:34,150 --> 00:41:32,720
fractionation

1192
00:41:37,270 --> 00:41:34,160
so i'm like supposed to have data on

1193
00:41:40,470 --> 00:41:37,280
this but our gc rms broke a couple weeks

1194
00:41:42,950 --> 00:41:40,480
ago um so i've been working on that

1195
00:41:45,030 --> 00:41:42,960
not successful and also we have a helium

1196
00:41:48,950 --> 00:41:45,040
shortage in case you guys are wondering

1197
00:41:51,270 --> 00:41:48,960
so um yeah eventually i'll have data

1198
00:41:53,750 --> 00:41:51,280
hopefully um but yeah so because i don't

1199
00:41:57,109 --> 00:41:53,760
have data here are some predicted trends

1200
00:41:59,910 --> 00:41:57,119
um so on the y-axis we have rates of

1201
00:42:02,550 --> 00:41:59,920
growth and methane production x-axis are

1202
00:42:04,230 --> 00:42:02,560
different parameters so with ph i

1203
00:42:06,470 --> 00:42:04,240
hypothesize that we're going to have the

1204
00:42:09,430 --> 00:42:06,480
greatest growth and methanogenesis

1205
00:42:11,109 --> 00:42:09,440
ideal phs so that's like neutral from

1206
00:42:13,750 --> 00:42:11,119
air pollutus embark right and slightly

1207
00:42:16,630 --> 00:42:13,760
alkaline for methanobacterium

1208
00:42:18,230 --> 00:42:16,640
in terms of carbon availability if we

1209
00:42:20,870 --> 00:42:18,240
have limiting carbon you're not going to

1210
00:42:22,950 --> 00:42:20,880
get as much growth or methane and once

1211
00:42:24,790 --> 00:42:22,960
you have saturated greatest growth in

1212
00:42:26,630 --> 00:42:24,800
methane and once you reach excess it

1213
00:42:30,230 --> 00:42:26,640

kind of plateaus out that's similar for

1214
00:42:32,870 --> 00:42:30,240
energy availability or like hydrogen

1215
00:42:34,150 --> 00:42:32,880
and then lastly carbon source so i

1216
00:42:35,910 --> 00:42:34,160
anticipate we're going to have different

1217
00:42:37,829 --> 00:42:35,920
rates based on

1218
00:42:40,069 --> 00:42:37,839
the different substrates that we use

1219
00:42:42,069 --> 00:42:40,079
acetate formate h2 co2 just because they

1220
00:42:43,589 --> 00:42:42,079
have different gibbs free energy so

1221
00:42:46,150 --> 00:42:43,599
different free energies available to

1222
00:42:47,990 --> 00:42:46,160
actually do these metabolisms

1223
00:42:49,990 --> 00:42:48,000
in terms of lipids

1224
00:42:51,910 --> 00:42:50,000
you can i anticipate that there's going

1225
00:42:55,190 --> 00:42:51,920
to be different contributing factors um

1226
00:42:57,349 --> 00:42:55,200
to the lipid h a d2h so intracellular

1227
00:42:59,510 --> 00:42:57,359
water and then hydride carriers as well

1228
00:43:01,910 --> 00:42:59,520
as acetyl-coa which is important once

1229
00:43:03,670 --> 00:43:01,920
again precursor for producing biomath

1230
00:43:04,550 --> 00:43:03,680
and biomass and that will produce these

1231
00:43:07,030 --> 00:43:04,560
different

1232
00:43:10,230 --> 00:43:07,040
classes of isoprenatal ether bonded

1233
00:43:12,710 --> 00:43:10,240
lipids in addition i expect carbon

1234
00:43:14,870 --> 00:43:12,720
availability energy availability and ph

1235
00:43:16,710 --> 00:43:14,880
to have an impact on the different

1236
00:43:18,550 --> 00:43:16,720
classes of lipids made so in certain

1237
00:43:21,190 --> 00:43:18,560
like nutrient energy limited

1238
00:43:23,670 --> 00:43:21,200

environments the methanogens may produce

1239
00:43:24,630 --> 00:43:23,680
other specific classes of lipids over

1240
00:43:26,790 --> 00:43:24,640
others

1241
00:43:28,710 --> 00:43:26,800
lastly um

1242
00:43:31,270 --> 00:43:28,720
in comparison to how like carbon

1243
00:43:33,190 --> 00:43:31,280
fractionation is impacted by nutrient

1244
00:43:36,390 --> 00:43:33,200
energy availabilities due to enzymatic

1245
00:43:38,230 --> 00:43:36,400
reactions i untest i anticipate that

1246
00:43:39,990 --> 00:43:38,240
they're also going to have an impact on

1247
00:43:41,910 --> 00:43:40,000
the hydrogen isotope signals of these

1248
00:43:43,430 --> 00:43:41,920
lipids as well

1249
00:43:45,349 --> 00:43:43,440
um so yeah this is a study looking at

1250
00:43:47,430 --> 00:43:45,359
slow growth and metabolism more commonly

1251
00:43:49,750 --> 00:43:47,440
found in natural settings um insight

1252
00:43:51,430 --> 00:43:49,760
into information stored in archaeolipids

1253
00:43:53,589 --> 00:43:51,440
and a framework to assist in future

1254
00:43:55,910 --> 00:43:53,599
inquiries into primordium metabolisms

1255
00:43:58,309 --> 00:43:55,920
and our ability to to detect life on

1256
00:44:00,870 --> 00:43:58,319
other rocky bodies in the universe

1257
00:44:03,270 --> 00:44:00,880
um and i'd like to thank my advisors

1258
00:44:05,589 --> 00:44:03,280
alexis templeton sebastian kopp members

1259
00:44:08,470 --> 00:44:05,599
of tea lab especially eric ellison

1260
00:44:11,349 --> 00:44:08,480
members of cop lab adam and jamie and

1261
00:44:13,589 --> 00:44:11,359
nsf for funding and the mars exploration

1262
00:44:14,630 --> 00:44:13,599
program at jpl for funding my trip out

1263
00:44:22,470 --> 00:44:14,640

here

1264
00:44:22,480 --> 00:44:25,910
we'll take any questions

1265
00:44:30,870 --> 00:44:28,309
hi that was a great thought i really

1266
00:44:32,309 --> 00:44:30,880
really enjoyed it and i have a question

1267
00:44:34,309 --> 00:44:32,319
i'm a saka

1268
00:44:37,109 --> 00:44:34,319
methylotropic methanogenesis

1269
00:44:38,309 --> 00:44:37,119
are you going to try um backery also

1270
00:44:41,510 --> 00:44:38,319
with um

1271
00:44:43,670 --> 00:44:41,520
trimethylamine or dmx of the

1272
00:44:46,069 --> 00:44:43,680
of the sources to see how the

1273
00:44:48,790 --> 00:44:46,079
limits change as well or not um that's a

1274
00:44:51,589 --> 00:44:48,800
good question i

1275
00:44:53,589 --> 00:44:51,599
currently do not plan to um because

1276
00:44:55,990 --> 00:44:53,599
that's kind of just not what is found in

1277
00:44:58,230 --> 00:44:56,000
nature most of the time for the barcray

1278
00:45:00,230 --> 00:44:58,240
i wanted to do hydrogenotrophic because

1279
00:45:02,309 --> 00:45:00,240
the mara pollutus and methanobacterium

1280
00:45:06,550 --> 00:45:02,319
are also hydrogenotrophic so i want to

1281
00:45:09,349 --> 00:45:06,560
see if it's like if the actual like

1282
00:45:11,750 --> 00:45:09,359
different methanogens have an impact on

1283
00:45:13,829 --> 00:45:11,760
the d2h of the lipids

1284
00:45:15,750 --> 00:45:13,839
and then i was going to do acetoclastic

1285
00:45:17,589 --> 00:45:15,760
as just a comparison because that's also

1286
00:45:19,349 --> 00:45:17,599
found in nature i wasn't going to do any

1287
00:45:21,829 --> 00:45:19,359
of the methylated

1288
00:45:24,230 --> 00:45:21,839

substrates because of like time

1289
00:45:25,910 --> 00:45:24,240
constraints but it's definitely

1290
00:45:28,150 --> 00:45:25,920
something to consider just not my

1291
00:45:29,990 --> 00:45:28,160
priority right now you know also one of

1292
00:45:32,710 --> 00:45:30,000
the things i was thinking is especially

1293
00:45:35,430 --> 00:45:32,720
in very salient environments and if you

1294
00:45:37,109 --> 00:45:35,440
have sulfates especially yeah um

1295
00:45:39,589 --> 00:45:37,119
methylotrophic methanogenesis is the one

1296
00:45:41,829 --> 00:45:39,599
that takes over the rest of the

1297
00:45:43,589 --> 00:45:41,839
other methanogenic roots yeah so that's

1298
00:45:45,670 --> 00:45:43,599
that's what i have in there in the back

1299
00:45:47,190 --> 00:45:45,680
of my mind but i perfectly understand

1300
00:45:49,750 --> 00:45:47,200
then the limitation of time especially

1301
00:45:51,910 --> 00:45:49,760
with the helios yeah exactly well thank

1302
00:45:53,430 --> 00:45:51,920
you yeah thanks

1303
00:45:55,829 --> 00:45:53,440
unfortunately we have time for just one

1304
00:45:57,750 --> 00:45:55,839
more question

1305
00:45:59,589 --> 00:45:57,760
thank you i'm katherine wright formerly

1306
00:46:01,829 --> 00:45:59,599
in the temple lab at cu boulder i

1307
00:46:03,349 --> 00:46:01,839
graduated some time ago um really great

1308
00:46:05,430 --> 00:46:03,359
talk thank you i'm just interested in

1309
00:46:06,710 --> 00:46:05,440
your choice of hydrogen fractionation

1310
00:46:08,150 --> 00:46:06,720
rather than carbon is it just that it's

1311
00:46:09,670 --> 00:46:08,160
been less well studied would be a great

1312
00:46:11,910 --> 00:46:09,680
reason or is there some other reason as

1313
00:46:14,390 --> 00:46:11,920

well oh yeah great question should have

1314
00:46:15,990 --> 00:46:14,400
mentioned that so hydrogen isotope

1315
00:46:19,190 --> 00:46:16,000
fractionation in

1316
00:46:21,910 --> 00:46:19,200
archaeolipids is not studied very well

1317
00:46:23,510 --> 00:46:21,920
there's like one paper at all 2020 and

1318
00:46:26,150 --> 00:46:23,520
they kind of focused on hydrogen

1319
00:46:28,390 --> 00:46:26,160
comparing to carbon fractionation in

1320
00:46:31,109 --> 00:46:28,400
lipids and because hydrogen fracture

1321
00:46:33,190 --> 00:46:31,119
like the hydrogen composition of like

1322
00:46:35,030 --> 00:46:33,200
eukaryotic and bacterial lipids can tell

1323
00:46:36,950 --> 00:46:35,040
us so much information about like past

1324
00:46:39,829 --> 00:46:36,960
environments or like physiological

1325
00:46:41,750 --> 00:46:39,839
adaptations of these bugs um and because

1326
00:46:43,750 --> 00:46:41,760
archaea are super important

1327
00:46:45,750 --> 00:46:43,760
to study in terms of like

1328
00:46:48,230 --> 00:46:45,760
looking at primordial metabolisms and

1329
00:46:50,150 --> 00:46:48,240
biosignatures on other planetary bodies

1330
00:46:52,790 --> 00:46:50,160
i thought that like

1331
00:46:54,790 --> 00:46:52,800
starting studying on like hydrogen

1332
00:46:57,510 --> 00:46:54,800
isotopes in archaeolipids can give us

1333
00:46:59,190 --> 00:46:57,520
like really important information

1334
00:47:00,710 --> 00:46:59,200
about the past

1335
00:47:01,990 --> 00:47:00,720
but i also

1336
00:47:03,670 --> 00:47:02,000
didn't put on here because i didn't want

1337
00:47:05,510 --> 00:47:03,680
to go into it because it's like a 10

1338
00:47:07,750 --> 00:47:05,520

minute talk but i'm gonna do carbon

1339
00:47:10,150 --> 00:47:07,760
isotopes of lipids as well as a

1340
00:47:11,670 --> 00:47:10,160
comparison

1341
00:47:13,589 --> 00:47:11,680
and as well as like i'm going to look at

1342
00:47:18,150 --> 00:47:13,599
the isotope fractionation of the methane

1343
00:47:18,160 --> 00:47:22,950
thank you very much heart bathroom

1344
00:47:22,960 --> 00:47:38,549
next up we have rachel moore

1345
00:47:38,559 --> 00:47:54,309
oh thanks

1346
00:47:57,829 --> 00:47:56,470
okay hi everyone so my name is rachel

1347
00:47:59,510 --> 00:47:57,839
moore and today i'm going to be talking

1348
00:48:01,109 --> 00:47:59,520
to you about something that i also

1349
00:48:02,710 --> 00:48:01,119
started during the pandemic similar to

1350
00:48:04,309 --> 00:48:02,720
what mario our first speaker was talking

1351
00:48:06,150 --> 00:48:04,319
about so i was excited to hear i'm not

1352
00:48:08,390 --> 00:48:06,160
the only one

1353
00:48:10,390 --> 00:48:08,400
and i i'm a post-doc here at georgia

1354
00:48:12,230 --> 00:48:10,400
tech in the planetary exploration lab

1355
00:48:14,150 --> 00:48:12,240
and today we'll be talking to you about

1356
00:48:16,390 --> 00:48:14,160
genome-scale metabolic modeling as a

1357
00:48:18,790 --> 00:48:16,400
tool and how we have used it to assess

1358
00:48:21,109 --> 00:48:18,800
the habitability or the habitable the

1359
00:48:23,910 --> 00:48:21,119
potential and production of biomarkers

1360
00:48:25,270 --> 00:48:23,920
in an early mars paleolithic gale crater

1361
00:48:27,270 --> 00:48:25,280
so pictured in the bottom right hand

1362
00:48:29,270 --> 00:48:27,280
corner of this screen is a visual

1363
00:48:30,790 --> 00:48:29,280

representation of a simple genome-scale

1364
00:48:32,390 --> 00:48:30,800
metabolic model

1365
00:48:34,470 --> 00:48:32,400
we have an organism whose genome has

1366
00:48:35,589 --> 00:48:34,480
been fully sequenced those genes have

1367
00:48:37,910 --> 00:48:35,599
been linked to proteins and those

1368
00:48:39,270 --> 00:48:37,920
proteins were linked to reactions and

1369
00:48:41,349 --> 00:48:39,280
since we have all of the reactions

1370
00:48:43,750 --> 00:48:41,359
available we can then model the flow of

1371
00:48:45,829 --> 00:48:43,760
metabolites through that model that is

1372
00:48:47,430 --> 00:48:45,839
we know where certain compounds can be

1373
00:48:49,270 --> 00:48:47,440
consumed and where they will be produced

1374
00:48:51,109 --> 00:48:49,280
and we can then constrain this model by

1375
00:48:53,349 --> 00:48:51,119
giving it certain inputs like a defined

1376
00:48:55,990 --> 00:48:53,359
media and we can compute the outputs of

1377
00:48:57,510 --> 00:48:56,000
metabolites and biomass production rates

1378
00:48:58,870 --> 00:48:57,520
um so to go through this i'm first going

1379
00:49:00,710 --> 00:48:58,880
to talk a little bit more about genome

1380
00:49:02,309 --> 00:49:00,720
scale metabolic models that process and

1381
00:49:03,990 --> 00:49:02,319
give some background there then i'm

1382
00:49:06,069 --> 00:49:04,000
going to show some preliminary results

1383
00:49:08,069 --> 00:49:06,079
from the model that we did of a lake at

1384
00:49:09,510 --> 00:49:08,079
gale crater and then i will talk a

1385
00:49:11,829 --> 00:49:09,520
little bit about predicting biomarker

1386
00:49:13,270 --> 00:49:11,839
concentrations

1387
00:49:15,349 --> 00:49:13,280
so like i said on the first slide to

1388
00:49:16,790 --> 00:49:15,359

build a genome-scale metabolic model we

1389
00:49:18,549 --> 00:49:16,800
first start with an organism whose

1390
00:49:20,230 --> 00:49:18,559
genome has been fully sequenced those

1391
00:49:22,390 --> 00:49:20,240
genes from the annotated genome are then

1392
00:49:23,910 --> 00:49:22,400
linked to reactions next all of those

1393
00:49:25,670 --> 00:49:23,920
reactions are integrated through their

1394
00:49:27,829 --> 00:49:25,680
shared metabolites so this results in a

1395
00:49:29,829 --> 00:49:27,839
construction of a metabolic network for

1396
00:49:31,589 --> 00:49:29,839
that organism of interest then the

1397
00:49:33,829 --> 00:49:31,599
metabolic network can be converted into

1398
00:49:35,270 --> 00:49:33,839
a stoichiometric matrix or s matrix for

1399
00:49:37,190 --> 00:49:35,280
short where the rows represent

1400
00:49:39,750 --> 00:49:37,200
metabolites and the columns represent

1401
00:49:41,990 --> 00:49:39,760
reactions each entry in this matrix

1402
00:49:44,150 --> 00:49:42,000
represents a reaction coefficient of a

1403
00:49:45,990 --> 00:49:44,160
particular metabolite in that reaction

1404
00:49:48,069 --> 00:49:46,000
so zeros indicate that that metabolite's

1405
00:49:49,589 --> 00:49:48,079
not present a negative number means that

1406
00:49:50,710 --> 00:49:49,599
it's being consumed in that reaction a

1407
00:49:52,710 --> 00:49:50,720
positive number means it's being

1408
00:49:54,470 --> 00:49:52,720
produced

1409
00:49:56,150 --> 00:49:54,480
this process is now fairly automated we

1410
00:49:57,670 --> 00:49:56,160
can use online tools like kbase but you

1411
00:49:59,030 --> 00:49:57,680
still have to go through the literature

1412
00:50:00,549 --> 00:49:59,040
and make sure that

1413
00:50:01,750 --> 00:50:00,559

you are only putting in things that

1414
00:50:03,270 --> 00:50:01,760
actually belong in that organism and

1415
00:50:05,990 --> 00:50:03,280
you're not creating something new unless

1416
00:50:06,790 --> 00:50:06,000
of course you're in bioengineering

1417
00:50:10,870 --> 00:50:06,800
so

1418
00:50:12,950 --> 00:50:10,880
identify key features of metabolism like

1419
00:50:15,190 --> 00:50:12,960
growth yield resource distribution gene

1420
00:50:16,069 --> 00:50:15,200
essentiality and to actually solve this

1421
00:50:17,829 --> 00:50:16,079
model

1422
00:50:19,589 --> 00:50:17,839
we use linear programming through flux

1423
00:50:22,069 --> 00:50:19,599
balance analysis to find the optimal

1424
00:50:23,910 --> 00:50:22,079
solution for a single reaction and this

1425
00:50:25,270 --> 00:50:23,920
reaction is one that the organism should

1426
00:50:26,870 --> 00:50:25,280
theoretically optimize or could

1427
00:50:29,109 --> 00:50:26,880
theoretically optimize like biomass

1428
00:50:30,470 --> 00:50:29,119
production for example

1429
00:50:32,069 --> 00:50:30,480
and we also of course need to constrain

1430
00:50:33,030 --> 00:50:32,079
this model by providing with a defined

1431
00:50:34,870 --> 00:50:33,040
medium

1432
00:50:36,710 --> 00:50:34,880
so we have used this framework to model

1433
00:50:39,270 --> 00:50:36,720
a very simple community in a very simple

1434
00:50:41,190 --> 00:50:39,280
representation of gale crater but before

1435
00:50:43,270 --> 00:50:41,200
i talk about the organisms that we chose

1436
00:50:45,190 --> 00:50:43,280
and why i wanted to mention that these

1437
00:50:46,950 --> 00:50:45,200
are by far not the only life as we know

1438
00:50:48,549 --> 00:50:46,960

it that maybe could have survived in

1439
00:50:49,589 --> 00:50:48,559
this environment um in fact there are

1440
00:50:51,270 --> 00:50:49,599
quite a few people that have written

1441
00:50:53,510 --> 00:50:51,280
about the plausible microbial

1442
00:50:54,630 --> 00:50:53,520
metabolisms for life on mars and this is

1443
00:50:56,870 --> 00:50:54,640
because there are quite a few different

1444
00:50:57,990 --> 00:50:56,880
metabolic species present there um and

1445
00:50:59,750 --> 00:50:58,000
maybe some of these people you've

1446
00:51:01,670 --> 00:50:59,760
actually heard speak this week

1447
00:51:03,030 --> 00:51:01,680
but we have to start somewhere right so

1448
00:51:05,430 --> 00:51:03,040
in our case we started by thinking about

1449
00:51:07,670 --> 00:51:05,440
this previously published experiment as

1450
00:51:09,589 --> 00:51:07,680
these two microorganisms could feasibly

1451
00:51:11,430 --> 00:51:09,599
grow in the early mars environment

1452
00:51:13,030 --> 00:51:11,440
rhodochemis pollustrus is a bacterium

1453
00:51:14,630 --> 00:51:13,040
that is capable of four different modes

1454
00:51:16,549 --> 00:51:14,640
of metabolism or using four different

1455
00:51:18,150 --> 00:51:16,559
modes of metabolism and one of those

1456
00:51:20,710 --> 00:51:18,160
that can grow photo autotrophically

1457
00:51:22,790 --> 00:51:20,720
using sunlight without oxygen geobacter

1458
00:51:25,270 --> 00:51:22,800
sulfur is an obligately anaerobic

1459
00:51:26,870 --> 00:51:25,280
bacteria meaning it will die with oxygen

1460
00:51:29,349 --> 00:51:26,880
present and it is primarily

1461
00:51:30,470 --> 00:51:29,359
heterotrophic um both of these organisms

1462
00:51:32,390 --> 00:51:30,480
are really interesting because they're

1463
00:51:34,230 --> 00:51:32,400

capable of utilizing solid phase iron

1464
00:51:35,589 --> 00:51:34,240
oxides for extracellular electron

1465
00:51:37,829 --> 00:51:35,599
transfer so they can use things like

1466
00:51:39,670 --> 00:51:37,839
magnetite so in this co-culture

1467
00:51:42,549 --> 00:51:39,680
experiment that you see on the left

1468
00:51:44,390 --> 00:51:42,559
this group burn at all in 2015

1469
00:51:46,790 --> 00:51:44,400
show that our plus stress can oxidize

1470
00:51:49,670 --> 00:51:46,800
iron 2 plus in magnetite using light

1471
00:51:52,470 --> 00:51:49,680
energy and g sulfureducins can reverse

1472
00:51:54,150 --> 00:51:52,480
that by reducing the fe3 that was made

1473
00:51:55,910 --> 00:51:54,160
turning it back into fe2 so essentially

1474
00:51:57,430 --> 00:51:55,920
they're using the solid phase magnetite

1475
00:51:59,030 --> 00:51:57,440
like a rechargeable battery and that's

1476
00:52:01,270 --> 00:51:59,040
why these organisms were of interest to

1477
00:52:05,109 --> 00:52:03,190
so these known earth organisms are the

1478
00:52:07,030 --> 00:52:05,119
basis for our preliminary model of gale

1479
00:52:08,549 --> 00:52:07,040
lake coincidentally both of these

1480
00:52:10,390 --> 00:52:08,559
organisms have already had metabolic

1481
00:52:12,309 --> 00:52:10,400
models created for them and they have

1482
00:52:14,790 --> 00:52:12,319
been validated against growth data in

1483
00:52:16,230 --> 00:52:14,800
typical laboratory conditions so we have

1484
00:52:18,069 --> 00:52:16,240
models that are accurate at predicting

1485
00:52:19,829 --> 00:52:18,079
the growth of these organisms in typical

1486
00:52:21,750 --> 00:52:19,839
laboratory media not astrological

1487
00:52:23,910 --> 00:52:21,760
conditions but that brings me to our

1488
00:52:26,150 --> 00:52:23,920

next step how do we actually define the

1489
00:52:27,750 --> 00:52:26,160
media based on real data in our case

1490
00:52:29,270 --> 00:52:27,760
from gale crater

1491
00:52:30,870 --> 00:52:29,280
so we all know of course curiosity has

1492
00:52:32,549 --> 00:52:30,880
been analyzing the chemical compositions

1493
00:52:34,309 --> 00:52:32,559
of sediments at gale crater more

1494
00:52:36,069 --> 00:52:34,319
recently groups like fukushi at all in

1495
00:52:38,309 --> 00:52:36,079
2019 have taken the chemical

1496
00:52:39,750 --> 00:52:38,319
compositions of the and the presence of

1497
00:52:41,270 --> 00:52:39,760
certain minerals

1498
00:52:43,349 --> 00:52:41,280
and used it as constraints for

1499
00:52:45,430 --> 00:52:43,359
thermodynamic modeling using react from

1500
00:52:47,750 --> 00:52:45,440
geochemist workbench to reconstruct the

1501
00:52:49,270 --> 00:52:47,760
water chemistry at gale

1502
00:52:51,190 --> 00:52:49,280
so this is one of the tables from their

1503
00:52:52,950 --> 00:52:51,200
paper you can see that they took data

1504
00:52:54,069 --> 00:52:52,960
from john klein and cumberland drill

1505
00:52:56,549 --> 00:52:54,079
sites and inferred chemical

1506
00:52:58,309 --> 00:52:56,559
concentrations for that lake water so we

1507
00:53:00,549 --> 00:52:58,319
have used utilized this information

1508
00:53:02,870 --> 00:53:00,559
along with other data sets to define our

1509
00:53:04,790 --> 00:53:02,880
in silico media so following the methods

1510
00:53:07,349 --> 00:53:04,800
of merinos at all in 2020 this is just

1511
00:53:08,870 --> 00:53:07,359
an example this is not the full um

1512
00:53:10,630 --> 00:53:08,880
in silico media that we're using but

1513
00:53:13,750 --> 00:53:10,640

what we did was we mapped the chemical

1514
00:53:16,069 --> 00:53:13,760
the chemical compounds from these data

1515
00:53:17,990 --> 00:53:16,079
sets to metabolite identifiers of the

1516
00:53:20,470 --> 00:53:18,000
metabolic model and then set the upper

1517
00:53:21,910 --> 00:53:20,480
bound flux to those concentrations

1518
00:53:23,349 --> 00:53:21,920
so this allows you then to get an

1519
00:53:26,390 --> 00:53:23,359
estimate of the maximum potential

1520
00:53:28,150 --> 00:53:26,400
biomass produced from these specific

1521
00:53:30,230 --> 00:53:28,160
metabolisms if anything grows at all of

1522
00:53:32,309 --> 00:53:30,240
course so um again this is just an

1523
00:53:34,470 --> 00:53:32,319
example image of an in silico defined

1524
00:53:36,710 --> 00:53:34,480
media and we set this all up using cobra

1525
00:53:39,270 --> 00:53:36,720
pi and python and solve these models

1526
00:53:41,349 --> 00:53:39,280
using the grobe solver um so just to

1527
00:53:43,030 --> 00:53:41,359
recap so far our simple model we have

1528
00:53:45,109 --> 00:53:43,040
two organisms that we've identified as

1529
00:53:46,710 --> 00:53:45,119
being feasible in this environment again

1530
00:53:49,030 --> 00:53:46,720
just a starting point

1531
00:53:51,109 --> 00:53:49,040
we're in this liquid water environment

1532
00:53:53,190 --> 00:53:51,119
we also know we have certain trace

1533
00:53:55,030 --> 00:53:53,200
nutrients and metals coming from from

1534
00:53:56,470 --> 00:53:55,040
that data we have from the sediments we

1535
00:53:57,750 --> 00:53:56,480
also probably have some amount of

1536
00:53:59,510 --> 00:53:57,760
hydrogen that could be coming from a

1537
00:54:02,150 --> 00:53:59,520
variety of sources maybe radiolysis

1538
00:54:04,150 --> 00:54:02,160

maybe serpentinization um we also have

1539
00:54:05,670 --> 00:54:04,160
probably a thicker atmosphere we're in

1540
00:54:07,670 --> 00:54:05,680
the late nowhere nuacci and our early

1541
00:54:09,190 --> 00:54:07,680
historian period and from that we know

1542
00:54:11,670 --> 00:54:09,200
there was probably some amount of

1543
00:54:13,750 --> 00:54:11,680
nitrogen carbon dioxide that can diffuse

1544
00:54:15,829 --> 00:54:13,760
into the system and finally since we're

1545
00:54:19,430 --> 00:54:15,839
in a lake system we also have a photon

1546
00:54:20,790 --> 00:54:19,440
flux so if these organisms are able to

1547
00:54:22,630 --> 00:54:20,800
grow in this environment they should be

1548
00:54:24,390 --> 00:54:22,640
able to cycle this iron like we saw in

1549
00:54:26,470 --> 00:54:24,400
that co-culture experiment

1550
00:54:28,630 --> 00:54:26,480
these are just some of these citations

1551
00:54:30,710 --> 00:54:28,640
um so that's exactly what we saw so

1552
00:54:32,630 --> 00:54:30,720
first we we did see that the microbes

1553
00:54:34,230 --> 00:54:32,640
grew individually

1554
00:54:35,589 --> 00:54:34,240
in the given lake media without living

1555
00:54:37,109 --> 00:54:35,599
in a community

1556
00:54:38,870 --> 00:54:37,119
so they did grow they were capable of

1557
00:54:40,470 --> 00:54:38,880
surviving with only co2 as a carbon

1558
00:54:42,470 --> 00:54:40,480
source but we found that they grew at a

1559
00:54:43,990 --> 00:54:42,480
much faster rate when combined in the

1560
00:54:45,910 --> 00:54:44,000
same environment and this indicated

1561
00:54:47,910 --> 00:54:45,920
centrophile cross feeding and we did in

1562
00:54:49,430 --> 00:54:47,920
fact see the microbes cross feeding both

1563
00:54:50,870 --> 00:54:49,440

actually produced carbon compounds and

1564
00:54:52,390 --> 00:54:50,880
exported it and the other organism was

1565
00:54:53,270 --> 00:54:52,400
capable of taking it in and utilizing

1566
00:54:54,150 --> 00:54:53,280
that

1567
00:54:56,069 --> 00:54:54,160
and these

1568
00:54:58,390 --> 00:54:56,079
these values are just the fluxes of

1569
00:55:00,710 --> 00:54:58,400
these um carbon compounds being exported

1570
00:55:02,150 --> 00:55:00,720
or imported into the cell

1571
00:55:04,069 --> 00:55:02,160
and then we also found that iron was

1572
00:55:06,549 --> 00:55:04,079
effectively cycled as well between redox

1573
00:55:08,549 --> 00:55:06,559
states so g sulfur do sins was reducing

1574
00:55:11,430 --> 00:55:08,559
iron three to produce iron two and then

1575
00:55:13,190 --> 00:55:11,440
our plustress was taking that and um

1576
00:55:15,670 --> 00:55:13,200
turning it back again so they did this

1577
00:55:17,670 --> 00:55:15,680
at identical rates hence the cycling and

1578
00:55:19,829 --> 00:55:17,680
um again these oxidation states of iron

1579
00:55:21,190 --> 00:55:19,839
can be found within magnetite so next

1580
00:55:22,710 --> 00:55:21,200
what i wanted to do was determine the

1581
00:55:24,150 --> 00:55:22,720
maximum cell concentration that could

1582
00:55:25,910 --> 00:55:24,160
actually be maintained within gale lake

1583
00:55:27,750 --> 00:55:25,920
and this is because i'm a microbiologist

1584
00:55:30,230 --> 00:55:27,760
by trade and i want to be able to

1585
00:55:32,309 --> 00:55:30,240
compare cell concentration to modern day

1586
00:55:34,150 --> 00:55:32,319
analogs of the environment

1587
00:55:36,150 --> 00:55:34,160
so to do this we used a dynamic flux

1588
00:55:37,589 --> 00:55:36,160

balance analysis which is similar to the

1589
00:55:39,270 --> 00:55:37,599
traditional flux balance analysis to

1590
00:55:41,270 --> 00:55:39,280
solve this community model

1591
00:55:43,990 --> 00:55:41,280
and a dynamic flex balance analysis that

1592
00:55:45,430 --> 00:55:44,000
simply couples a dynamic system to in

1593
00:55:47,589 --> 00:55:45,440
the external cellular

1594
00:55:49,910 --> 00:55:47,599
environment to the pseudo-steady-state

1595
00:55:52,309 --> 00:55:49,920
of the metabolic model so we basically

1596
00:55:54,069 --> 00:55:52,319
ran this model for individual time steps

1597
00:55:56,789 --> 00:55:54,079
and allowed the flux of metabolites in

1598
00:55:58,309 --> 00:55:56,799
the media to be consumed sequentially

1599
00:55:59,910 --> 00:55:58,319
um so from there then we were able to

1600
00:56:01,430 --> 00:55:59,920
predict how much biomass could grow per

1601
00:56:02,470 --> 00:56:01,440
amount of nitrogen which we found to be

1602
00:56:04,950 --> 00:56:02,480
a limiting

1603
00:56:06,789 --> 00:56:04,960
growth factor in our case and we ran

1604
00:56:08,470 --> 00:56:06,799
this dynamic analysis using both a low

1605
00:56:10,150 --> 00:56:08,480
and high bounds of mediaflux based on

1606
00:56:11,910 --> 00:56:10,160
the findings at gale crater so these

1607
00:56:13,750 --> 00:56:11,920
media bonds were defined from the high

1608
00:56:15,030 --> 00:56:13,760
and low ranges of chemical compounds or

1609
00:56:17,589 --> 00:56:15,040
chemical concentrations from that

1610
00:56:20,630 --> 00:56:17,599
fukushi paper so starting with

1611
00:56:22,470 --> 00:56:20,640
zero uh 0.1 grams of biomass you can see

1612
00:56:24,630 --> 00:56:22,480
this in the solid line we grew about

1613
00:56:27,510 --> 00:56:24,640

0.23 grams of biomass per gram of

1614
00:56:29,190 --> 00:56:27,520
nitrogen this is regardless of mediaflux

1615
00:56:31,430 --> 00:56:29,200
so using this information the amount of

1616
00:56:33,030 --> 00:56:31,440
biomass grown per gram of n2 the weight

1617
00:56:35,030 --> 00:56:33,040
of a typical cell

1618
00:56:37,190 --> 00:56:35,040
the amount of n2 that could possibly be

1619
00:56:38,630 --> 00:56:37,200
in this in this environment

1620
00:56:41,430 --> 00:56:38,640
we can then calculate an upper bound

1621
00:56:42,549 --> 00:56:41,440
concentration of microbial cells and

1622
00:56:44,549 --> 00:56:42,559
depending on the concentration of

1623
00:56:46,309 --> 00:56:44,559
nitrogen present gale lake could have

1624
00:56:48,309 --> 00:56:46,319
potentially supported again this is a

1625
00:56:50,230 --> 00:56:48,319
model as much as 10 to the fifth cells

1626
00:56:51,910 --> 00:56:50,240
per ml of lake water so again this

1627
00:56:53,430 --> 00:56:51,920
calculation is just based on the amount

1628
00:56:55,510 --> 00:56:53,440
of biomass produced and assuming that

1629
00:56:56,870 --> 00:56:55,520
cells are a picogram and weight so this

1630
00:56:58,150 --> 00:56:56,880
is incredibly similar to what we see

1631
00:56:59,750 --> 00:56:58,160
here on earth in a number of

1632
00:57:01,829 --> 00:56:59,760
oligotrophic water-based environments

1633
00:57:03,510 --> 00:57:01,839
for example eutrophic brines and solar

1634
00:57:04,950 --> 00:57:03,520
salt harvesting facilities you can find

1635
00:57:07,349 --> 00:57:04,960
anywhere from ten to the fifth to ten to

1636
00:57:09,349 --> 00:57:07,359
the seventh cells per mil and

1637
00:57:11,030 --> 00:57:09,359
sub-glacial lakes on the other hand um

1638
00:57:12,390 --> 00:57:11,040

we can find anything from like ten to

1639
00:57:14,309 --> 00:57:12,400
the fourth to 10 to the fifth cells per

1640
00:57:16,630 --> 00:57:14,319
ml so this is very promising that we're

1641
00:57:17,829 --> 00:57:16,640
finding similar overall concentrations

1642
00:57:19,430 --> 00:57:17,839
but again this is assuming that

1643
00:57:20,789 --> 00:57:19,440
everything is well mixed and distributed

1644
00:57:22,230 --> 00:57:20,799
throughout the depths of gale lake and

1645
00:57:23,829 --> 00:57:22,240
this may or may not have been the case

1646
00:57:26,150 --> 00:57:23,839
in reality but could be a good starting

1647
00:57:28,470 --> 00:57:26,160
point um so finally i mentioned on the

1648
00:57:29,829 --> 00:57:28,480
first slide that i uh we'll also be

1649
00:57:31,829 --> 00:57:29,839
talking about biomarkers and this is why

1650
00:57:34,069 --> 00:57:31,839
i was excited to see um harp talking

1651
00:57:36,390 --> 00:57:34,079
about lipids um

1652
00:57:38,150 --> 00:57:36,400
so we were interested in our case with

1653
00:57:39,430 --> 00:57:38,160
mars being a paleo lake we were really

1654
00:57:41,349 --> 00:57:39,440
interested in biomarkers that could

1655
00:57:42,950 --> 00:57:41,359
persist for billions of years

1656
00:57:44,470 --> 00:57:42,960
and certain bacterial lipids like

1657
00:57:45,829 --> 00:57:44,480
opinoids can actually be preserved in

1658
00:57:47,750 --> 00:57:45,839
the sedimentary rock record over

1659
00:57:49,990 --> 00:57:47,760
billions of years so how does this work

1660
00:57:51,589 --> 00:57:50,000
bacteria present in the water column if

1661
00:57:54,230 --> 00:57:51,599
they die they can be buried in the

1662
00:57:55,109 --> 00:57:54,240
sediment where they degrade over time

1663
00:57:57,510 --> 00:57:55,119

and

1664
00:57:59,030 --> 00:57:57,520
then uh this whole pain structure will

1665
00:58:00,950 --> 00:57:59,040
actually be preserved over billions of

1666
00:58:03,510 --> 00:58:00,960
years and this is because uh their fused

1667
00:58:05,510 --> 00:58:03,520
polycyclic structures are quite stable

1668
00:58:08,150 --> 00:58:05,520
um so we can then actually extract and

1669
00:58:10,150 --> 00:58:08,160
detect these lipids in agent sediments

1670
00:58:11,670 --> 00:58:10,160
so we used our gm scale model to predict

1671
00:58:13,270 --> 00:58:11,680
topenoid and hopeonite precursor

1672
00:58:15,589 --> 00:58:13,280
production using flux balance analysis

1673
00:58:17,589 --> 00:58:15,599
again an estimated a maximum of 10 to

1674
00:58:19,190 --> 00:58:17,599
the minus three grams of opinoid per

1675
00:58:21,270 --> 00:58:19,200
kilogram of gale crater sediment at a

1676
00:58:23,670 --> 00:58:21,280
single time point and this is assuming a

1677
00:58:25,910 --> 00:58:23,680
photic zone depth of 100 meters and

1678
00:58:28,230 --> 00:58:25,920
assuming a single preservation event

1679
00:58:30,789 --> 00:58:28,240
such as settling after a mass death of

1680
00:58:32,710 --> 00:58:30,799
100 of the cells for one generation and

1681
00:58:35,430 --> 00:58:32,720
uniform mixing of the subtle material

1682
00:58:36,549 --> 00:58:35,440
within one meter of sediment so

1683
00:58:38,309 --> 00:58:36,559
i want to point out that this

1684
00:58:39,829 --> 00:58:38,319
concentration of sedimentary hopanes is

1685
00:58:41,589 --> 00:58:39,839
very low it's pretty much at the limit

1686
00:58:44,230 --> 00:58:41,599
of detection for miniaturized gcms

1687
00:58:46,150 --> 00:58:44,240
systems which i believe is around 1ppm

1688
00:58:48,069 --> 00:58:46,160

at least to my knowledge but this could

1689
00:58:49,750 --> 00:58:48,079
mean that hopanes might be detectable or

1690
00:58:51,190 --> 00:58:49,760
at detectable levels in gale crater if

1691
00:58:52,710 --> 00:58:51,200
these events reoccurred over time for

1692
00:58:54,309 --> 00:58:52,720
example

1693
00:58:55,910 --> 00:58:54,319
so in the end this model is meant just

1694
00:58:57,589 --> 00:58:55,920
to illustrate the potential for using

1695
00:58:59,270 --> 00:58:57,599
genetic information encoded in life as

1696
00:59:00,950 --> 00:58:59,280
we know it

1697
00:59:03,030 --> 00:59:00,960
and to think more about habitable spaces

1698
00:59:05,190 --> 00:59:03,040
on other worlds for instance maybe

1699
00:59:06,950 --> 00:59:05,200
genome scale models could be useful to

1700
00:59:08,470 --> 00:59:06,960
inform what biomarkers could be present

1701
00:59:10,150 --> 00:59:08,480
and at what levels depending on nutrient

1702
00:59:11,829 --> 00:59:10,160
ranges and depending on the type of

1703
00:59:13,349 --> 00:59:11,839
microbial life that could inhabit that

1704
00:59:15,589 --> 00:59:13,359
particular environment

1705
00:59:17,109 --> 00:59:15,599
this type of modeling also allows you to

1706
00:59:18,630 --> 00:59:17,119
potentially try out an idea before

1707
00:59:21,270 --> 00:59:18,640
testing growth in the laboratory which

1708
00:59:23,510 --> 00:59:21,280
can be both costly in terms of time and

1709
00:59:26,309 --> 00:59:23,520
money we also intend to develop this

1710
00:59:27,750 --> 00:59:26,319
modeling process further in time

1711
00:59:29,270 --> 00:59:27,760
so hopefully it'll be more useful at

1712
00:59:39,430 --> 00:59:29,280
predicting and constraining scenarios of

1713
00:59:44,230 --> 00:59:42,390

excellent we'll take any questions

1714
00:59:47,349 --> 00:59:44,240
hey it's me again

1715
00:59:49,510 --> 00:59:47,359
that was taken a great talk um

1716
00:59:50,870 --> 00:59:49,520
how have you constrained the amount of

1717
00:59:54,390 --> 00:59:50,880
hydrogen that you

1718
00:59:56,069 --> 00:59:54,400
use in the model yeah so i i basically i

1719
00:59:57,990 --> 00:59:56,079
what i did everything that's going into

1720
01:00:00,230 --> 00:59:58,000
this model is based on flux so what i

1721
01:00:02,309 --> 01:00:00,240
did was utilize

1722
01:00:03,910 --> 01:00:02,319
estimates in the ranges of partial

1723
01:00:05,990 --> 01:00:03,920
pressure and converted that into

1724
01:00:08,549 --> 01:00:06,000
concentration that could diffuse into

1725
01:00:12,069 --> 01:00:08,559
the water based on henry's law

1726
01:00:13,430 --> 01:00:12,079
so it's just a simple concentration flux

1727
01:00:14,950 --> 01:00:13,440
so that's why i'm really interested in

1728
01:00:16,390 --> 01:00:14,960
your work because i think that would be

1729
01:00:18,069 --> 01:00:16,400
you know great to couple with actual

1730
01:00:19,670 --> 01:00:18,079
geochemistry models there's actually

1731
01:00:21,510 --> 01:00:19,680
hydrogen is the one i'm struggling the

1732
01:00:23,589 --> 01:00:21,520
most so you have that number and i have

1733
01:00:25,349 --> 01:00:23,599
the other numbers

1734
01:00:26,230 --> 01:00:25,359
yeah exactly exactly that's exactly what

1735
01:00:29,349 --> 01:00:26,240
i'm thinking

1736
01:00:36,789 --> 01:00:29,359
thank you

1737
01:00:44,549 --> 01:00:39,670
okay next up we have uh our online

1738
01:00:44,559 --> 01:00:48,230

all right can you guys hear me well

1739
01:00:48,240 --> 01:00:53,349
yeah yep can you hear me

1740
01:00:59,109 --> 01:00:57,349
i can't hear anyone um

1741
01:00:59,910 --> 01:00:59,119
can you hear me

1742
01:01:01,109 --> 01:00:59,920
yes

1743
01:01:02,150 --> 01:01:01,119
okay okay sorry

1744
01:01:04,230 --> 01:01:02,160
okay good

1745
01:01:06,390 --> 01:01:04,240
just making sure um so hi everyone i'm

1746
01:01:08,470 --> 01:01:06,400
tomakko fell i'm currently a postdoc at

1747
01:01:10,069 --> 01:01:08,480
michigan state university and today i'm

1748
01:01:12,390 --> 01:01:10,079
going to present some pretty preliminary

1749
01:01:14,150 --> 01:01:12,400
results on this general idea of building

1750
01:01:16,069 --> 01:01:14,160
a unifying framework for modeling the

1751
01:01:17,589 --> 01:01:16,079
emergence and the evolution of microbial

1752
01:01:19,190 --> 01:01:17,599
metabolisms

1753
01:01:21,589 --> 01:01:19,200
so before i dive in i just want to thank

1754
01:01:24,309 --> 01:01:21,599
my collaborators on this project as well

1755
01:01:26,789 --> 01:01:24,319
as my source of funding and nasa

1756
01:01:27,829 --> 01:01:26,799
so as an ecologist um i'm really

1757
01:01:29,349 --> 01:01:27,839
interested in understanding this

1758
01:01:31,750 --> 01:01:29,359
emergence of ecosystem functions right

1759
01:01:33,910 --> 01:01:31,760
like how life impacts systems and how

1760
01:01:35,750 --> 01:01:33,920
they work and we know that like it

1761
01:01:37,829 --> 01:01:35,760
relies on on microbes like kind of

1762
01:01:40,470 --> 01:01:37,839
everywhere like microbes help build soil

1763
01:01:43,109 --> 01:01:40,480

fertility on earth uh they are you know

1764
01:01:44,950 --> 01:01:43,119
fueling uh for example nitrogen cycle

1765
01:01:47,030 --> 01:01:44,960
and also they're you know created the

1766
01:01:49,190 --> 01:01:47,040
atmosphere on earth so if for example

1767
01:01:52,630 --> 01:01:49,200
you zoom in in like the nitrogen cycle

1768
01:01:53,750 --> 01:01:52,640
um it's pretty amazing to see how like

1769
01:01:55,750 --> 01:01:53,760
microbes

1770
01:01:57,589 --> 01:01:55,760
are basically present everywhere they

1771
01:01:59,910 --> 01:01:57,599
fix the nitrogen they will decompose

1772
01:02:02,069 --> 01:01:59,920
that organic matter they will nitrify

1773
01:02:04,470 --> 01:02:02,079
they will denitrify and some of these

1774
01:02:06,390 --> 01:02:04,480
bacteria or other microbes will be

1775
01:02:07,829 --> 01:02:06,400
specialized others will be more generous

1776
01:02:10,950 --> 01:02:07,839
but what's amazing is the great

1777
01:02:13,190 --> 01:02:10,960
diversity of these metabolic strategies

1778
01:02:15,670 --> 01:02:13,200
so biologists have started to understand

1779
01:02:17,910 --> 01:02:15,680
really well these microbial metabolism

1780
01:02:19,829 --> 01:02:17,920
uh pathways we just had a talk on that

1781
01:02:21,349 --> 01:02:19,839
um so it's pretty amazing the the level

1782
01:02:23,589 --> 01:02:21,359
of details we're starting to have on

1783
01:02:25,430 --> 01:02:23,599
what happens within cells as this little

1784
01:02:28,230 --> 01:02:25,440
chemical factories

1785
01:02:30,150 --> 01:02:28,240
but i would argue maybe today uh maybe

1786
01:02:31,270 --> 01:02:30,160
as an ecologist i think we still may be

1787
01:02:32,710 --> 01:02:31,280
missing a little bit of how do we

1788
01:02:34,390 --> 01:02:32,720

connect it to how do we go from you know

1789
01:02:36,789 --> 01:02:34,400
what happens within the cell and how do

1790
01:02:38,470 --> 01:02:36,799
we also smoothly uh go through these

1791
01:02:40,870 --> 01:02:38,480
levels of organization all the way to

1792
01:02:43,270 --> 01:02:40,880
what happens at the existing level

1793
01:02:45,829 --> 01:02:43,280
and i would argue that uh what we need

1794
01:02:47,430 --> 01:02:45,839
to do is find like integrative ways of

1795
01:02:48,710 --> 01:02:47,440
going through these levels of

1796
01:02:51,510 --> 01:02:48,720
organizations

1797
01:02:53,270 --> 01:02:51,520
from individuals first to population so

1798
01:02:55,029 --> 01:02:53,280
we first need to understand you know how

1799
01:02:57,029 --> 01:02:55,039
what happens within cell

1800
01:02:58,710 --> 01:02:57,039
fuels population growth then starts

1801
01:02:59,829 --> 01:02:58,720
diversifying uh these different

1802
01:03:01,270 --> 01:02:59,839
populations

1803
01:03:03,270 --> 01:03:01,280
in communities and then finally

1804
01:03:05,270 --> 01:03:03,280
connected to ecosystems and i would say

1805
01:03:07,910 --> 01:03:05,280
this is kind of one of the focus of my

1806
01:03:10,230 --> 01:03:07,920
field ecology

1807
01:03:12,230 --> 01:03:10,240
and so today i want to specifically show

1808
01:03:14,390 --> 01:03:12,240
you the first step how do we like think

1809
01:03:16,549 --> 01:03:14,400
about how to go using ecological

1810
01:03:18,950 --> 01:03:16,559
theories from what happens within cells

1811
01:03:21,349 --> 01:03:18,960
dynamics of metabolites to the growth of

1812
01:03:23,190 --> 01:03:21,359
populations using like getting inspired

1813
01:03:24,789 --> 01:03:23,200

inspiration from ecology

1814
01:03:26,390 --> 01:03:24,799
and when we can do this

1815
01:03:28,230 --> 01:03:26,400
we have a lot of tools in ecology to

1816
01:03:31,190 --> 01:03:28,240
start thinking about

1817
01:03:34,150 --> 01:03:31,200
studying like diversification or like uh

1818
01:03:35,990 --> 01:03:34,160
community ecology um by by just

1819
01:03:38,069 --> 01:03:36,000
harnessing uh the knowledge of

1820
01:03:39,670 --> 01:03:38,079
technological theories

1821
01:03:41,029 --> 01:03:39,680
and so today that's what i want to do is

1822
01:03:43,109 --> 01:03:41,039
just show you how we can use these

1823
01:03:46,069 --> 01:03:43,119
conceptual theories to scale from cell

1824
01:03:48,230 --> 01:03:46,079
metabolism to condition growth

1825
01:03:50,870 --> 01:03:48,240
so let's go back to metabolic models we

1826
01:03:53,109 --> 01:03:50,880
had a nice introduction on fba with the

1827
01:03:55,270 --> 01:03:53,119
previous talk uh so i can go quickly on

1828
01:03:57,029 --> 01:03:55,280
this um but like the standard we have

1829
01:03:59,829 --> 01:03:57,039
the standard understanding of what

1830
01:04:01,589 --> 01:03:59,839
happens within within a cell so let's

1831
01:04:03,670 --> 01:04:01,599
take this like toy model for a cell

1832
01:04:06,150 --> 01:04:03,680
where we have a bunch of external

1833
01:04:09,109 --> 01:04:06,160
extracellular resources r1r2 we have

1834
01:04:11,029 --> 01:04:09,119
some reactions within the cell and then

1835
01:04:13,190 --> 01:04:11,039
these reactants they will convert these

1836
01:04:15,109 --> 01:04:13,200
resources into this internal metabolites

1837
01:04:16,150 --> 01:04:15,119
and eventually some reactions will fuel

1838
01:04:18,549 --> 01:04:16,160

uh

1839
01:04:20,950 --> 01:04:18,559
population growth so we can formally

1840
01:04:22,630 --> 01:04:20,960
look at this by simply saying that the

1841
01:04:24,069 --> 01:04:22,640
change through time in metabolite

1842
01:04:26,549 --> 01:04:24,079
concentration is going to be

1843
01:04:27,750 --> 01:04:26,559
proportional to the reaction rates

1844
01:04:29,750 --> 01:04:27,760
and these reactions right this

1845
01:04:30,870 --> 01:04:29,760
proportionality remain proportional the

1846
01:04:33,029 --> 01:04:30,880
coefficient in between is going to be

1847
01:04:34,549 --> 01:04:33,039
this stoichiometric matrix here that

1848
01:04:37,430 --> 01:04:34,559
links the two

1849
01:04:39,109 --> 01:04:37,440
we can rewrite this as simply again this

1850
01:04:41,430 --> 01:04:39,119
product but it's important to remember

1851
01:04:43,670 --> 01:04:41,440
that these reaction rates uh they obey

1852
01:04:45,829 --> 01:04:43,680
some kinetics so they are going to be

1853
01:04:48,390 --> 01:04:45,839
functions of either the external

1854
01:04:50,470 --> 01:04:48,400
resources or the internal metabolites

1855
01:04:52,789 --> 01:04:50,480
right so the problem is not as simple as

1856
01:04:54,789 --> 01:04:52,799
simply linear because of these kinetics

1857
01:04:57,029 --> 01:04:54,799
in between

1858
01:04:59,510 --> 01:04:57,039
so now that's what happens within a cell

1859
01:05:01,670 --> 01:04:59,520
how do we understand how we can go uh to

1860
01:05:03,270 --> 01:05:01,680
the population level so

1861
01:05:05,430 --> 01:05:03,280
what i find interesting as an ecologist

1862
01:05:07,670 --> 01:05:05,440
is that so technically if you were to

1863
01:05:09,190 --> 01:05:07,680

try to model population growth you would

1864
01:05:11,750 --> 01:05:09,200
have to follow each of these cells

1865
01:05:14,230 --> 01:05:11,760
individually from their birth after cell

1866
01:05:16,230 --> 01:05:14,240
division all the way to when they divide

1867
01:05:19,430 --> 01:05:16,240
again right and as they do this they are

1868
01:05:21,510 --> 01:05:19,440
moving in this like metabolic state

1869
01:05:23,109 --> 01:05:21,520
because they are accumulating metabolize

1870
01:05:24,390 --> 01:05:23,119
before they can divide right so it's one

1871
01:05:26,950 --> 01:05:24,400
of the properties of life everything

1872
01:05:28,470 --> 01:05:26,960
needs to grow first before it can divide

1873
01:05:29,910 --> 01:05:28,480
and so this means that if you're looking

1874
01:05:32,309 --> 01:05:29,920
at a population there's going to be some

1875
01:05:33,109 --> 01:05:32,319
heterogeneity in the state of the cells

1876
01:05:35,029 --> 01:05:33,119
right

1877
01:05:36,789 --> 01:05:35,039
and technically if we want to do this

1878
01:05:37,990 --> 01:05:36,799
correctly we would have to keep track of

1879
01:05:40,150 --> 01:05:38,000
the state of each cells in the

1880
01:05:42,630 --> 01:05:40,160
population maybe by following the full

1881
01:05:44,470 --> 01:05:42,640
distribution over the metabolic state

1882
01:05:47,190 --> 01:05:44,480
this is obviously obviously extremely

1883
01:05:48,710 --> 01:05:47,200
complicated to do in practice and so for

1884
01:05:50,549 --> 01:05:48,720
today we are going to ignore this

1885
01:05:52,630 --> 01:05:50,559
virginity and focus on the average

1886
01:05:53,990 --> 01:05:52,640
metabolic state like but there are ways

1887
01:05:56,470 --> 01:05:54,000
in ecology to actually account for this

1888
01:05:57,510 --> 01:05:56,480

heterogeneity but today i will not uh

1889
01:05:59,190 --> 01:05:57,520
not

1890
01:06:00,950 --> 01:05:59,200
look for it but you can ask me questions

1891
01:06:02,870 --> 01:06:00,960
if you're curious so then when we do

1892
01:06:04,950 --> 01:06:02,880
this we find these simplified versions

1893
01:06:06,870 --> 01:06:04,960
of models where we are keeping track of

1894
01:06:08,470 --> 01:06:06,880
the total abundance in the population

1895
01:06:10,789 --> 01:06:08,480
but also the average metabolite

1896
01:06:12,470 --> 01:06:10,799
concentration in a cell and then we have

1897
01:06:14,549 --> 01:06:12,480
an equation that describes the dynamics

1898
01:06:16,630 --> 01:06:14,559
of these extracellular resources to sort

1899
01:06:18,470 --> 01:06:16,640
of the environment and we can think of

1900
01:06:20,470 --> 01:06:18,480
this as a sort of more complicated

1901
01:06:22,789 --> 01:06:20,480
versions of the classic resource

1902
01:06:24,789 --> 01:06:22,799
consumer models we use in ecology now we

1903
01:06:27,670 --> 01:06:24,799
have a population that is more uh

1904
01:06:29,589 --> 01:06:27,680
precisely described through this this

1905
01:06:31,190 --> 01:06:29,599
metabolite transformation with this

1906
01:06:32,710 --> 01:06:31,200
population

1907
01:06:34,230 --> 01:06:32,720
so when you look at these equations we

1908
01:06:35,670 --> 01:06:34,240
find again this sort of within cell

1909
01:06:37,589 --> 01:06:35,680
metabolic model i was just telling you

1910
01:06:38,950 --> 01:06:37,599
about uh but we have an extra term that

1911
01:06:41,029 --> 01:06:38,960
shows up it's called the dilution by

1912
01:06:43,510 --> 01:06:41,039
growth and it is a mechanistic

1913
01:06:45,190 --> 01:06:43,520

consequence of of of accounting

1914
01:06:47,589 --> 01:06:45,200
correctly for uh what happens when

1915
01:06:49,190 --> 01:06:47,599
population grows like metabolized gate

1916
01:06:50,710 --> 01:06:49,200
get diluted

1917
01:06:52,309 --> 01:06:50,720
as a consequence of growth and this has

1918
01:06:55,270 --> 01:06:52,319
been pointing pointed out by other

1919
01:06:57,270 --> 01:06:55,280
authors um in other sort of part of the

1920
01:07:00,630 --> 01:06:57,280
literature about metabolic models but is

1921
01:07:02,789 --> 01:07:00,640
for example not included in fba

1922
01:07:04,710 --> 01:07:02,799
now we still have to figure out what is

1923
01:07:07,190 --> 01:07:04,720
this expression for the kinetics of my

1924
01:07:10,309 --> 01:07:07,200
reaction rates as a function of resource

1925
01:07:11,990 --> 01:07:10,319
or metabolic concentrations so you could

1926
01:07:14,230 --> 01:07:12,000
tell me like let's just use the classics

1927
01:07:16,630 --> 01:07:14,240
like michaelis-menten menten to describe

1928
01:07:17,430 --> 01:07:16,640
this reaction but today i want to be i

1929
01:07:19,349 --> 01:07:17,440
want to show something a little

1930
01:07:21,430 --> 01:07:19,359
different like uh we came up with this

1931
01:07:23,750 --> 01:07:21,440
idea that we can represent these

1932
01:07:25,510 --> 01:07:23,760
chemical reactions by sort of

1933
01:07:27,589 --> 01:07:25,520
abstracting out the sort of complexity

1934
01:07:29,430 --> 01:07:27,599
of mechanism and by instead using a

1935
01:07:31,190 --> 01:07:29,440
minimum function so we're saying that

1936
01:07:32,710 --> 01:07:31,200
the reaction rate is going to be given

1937
01:07:35,270 --> 01:07:32,720
by the concentration of the most

1938
01:07:37,029 --> 01:07:35,280

limiting metabolite that is a substrate

1939
01:07:39,510 --> 01:07:37,039
for that reaction the same way that the

1940
01:07:41,750 --> 01:07:39,520
level of water in this barrel is given

1941
01:07:43,990 --> 01:07:41,760
by the shortest stave in the borough

1942
01:07:46,630 --> 01:07:44,000
okay so if you for example state take

1943
01:07:49,270 --> 01:07:46,640
this reaction here by this toy model of

1944
01:07:52,069 --> 01:07:49,280
a metabolic network v1 it has two

1945
01:07:53,589 --> 01:07:52,079
different substrates r1 or q4 here and

1946
01:07:56,390 --> 01:07:53,599
so we just write the kinetics as being

1947
01:07:58,710 --> 01:07:56,400
this minimum function and then if q4 is

1948
01:08:01,349 --> 01:07:58,720
more limiting than r1 the reaction is

1949
01:08:03,670 --> 01:08:01,359
just directly linear proportional to q4

1950
01:08:06,150 --> 01:08:03,680
with an affinity or if it's the other

1951
01:08:08,069 --> 01:08:06,160
way around r1 is limiting and then the

1952
01:08:10,789 --> 01:08:08,079
reaction rate is proportional to r1 okay

1953
01:08:13,589 --> 01:08:10,799
so it's very simple and this has a very

1954
01:08:16,070 --> 01:08:13,599
very um convenient property that this is

1955
01:08:17,669 --> 01:08:16,080
a locally linear problem

1956
01:08:19,189 --> 01:08:17,679
so the other thing is because we can

1957
01:08:22,309 --> 01:08:19,199
think of each reaction as being limited

1958
01:08:24,149 --> 01:08:22,319
by only one metabolite as a time we can

1959
01:08:25,590 --> 01:08:24,159
look at the whole metabolic network as

1960
01:08:27,910 --> 01:08:25,600
looking at the combinations of each

1961
01:08:30,229 --> 01:08:27,920
reaction all possible possibilities of

1962
01:08:31,829 --> 01:08:30,239
limitation so we can count them um and

1963
01:08:34,309 --> 01:08:31,839

then we have all the possible limitation

1964
01:08:36,870 --> 01:08:34,319
regimes for our metabolic network that

1965
01:08:38,789 --> 01:08:36,880
sort of uh qualitatively describe the

1966
01:08:40,950 --> 01:08:38,799
functioning of the network so you can do

1967
01:08:43,430 --> 01:08:40,960
this here it's only 12 but for it it

1968
01:08:44,709 --> 01:08:43,440
goes fast i'll show you um but when we

1969
01:08:47,110 --> 01:08:44,719
do this like if we go back to this

1970
01:08:48,070 --> 01:08:47,120
argument that now have this linearity of

1971
01:08:49,269 --> 01:08:48,080
of the

1972
01:08:50,870 --> 01:08:49,279
reaction rate

1973
01:08:52,789 --> 01:08:50,880
something magical happens like for

1974
01:08:54,390 --> 01:08:52,799
ecologists like suddenly we are in the

1975
01:08:56,390 --> 01:08:54,400
realm of what we call this linearly

1976
01:08:58,149 --> 01:08:56,400
structured population so we have a

1977
01:08:59,749 --> 01:08:58,159
structure for the growth of my cell

1978
01:09:02,630 --> 01:08:59,759
populations alongside their metabolite

1979
01:09:04,309 --> 01:09:02,640
concentration that is very familiar we

1980
01:09:05,669 --> 01:09:04,319
indeed recover the theory of linearly

1981
01:09:07,430 --> 01:09:05,679
structured populations that we use in

1982
01:09:09,510 --> 01:09:07,440
ecology in general to describe for

1983
01:09:11,189 --> 01:09:09,520
example the dynamics of a butterfly

1984
01:09:13,910 --> 01:09:11,199
giving laying eggs

1985
01:09:15,510 --> 01:09:13,920
birth to caterpillars crisalis etc or

1986
01:09:17,349 --> 01:09:15,520
for example the growth of like

1987
01:09:18,630 --> 01:09:17,359
site-structured publication like we

1988
01:09:20,470 --> 01:09:18,640

entered the realm of like very

1989
01:09:22,070 --> 01:09:20,480
well-known theories

1990
01:09:24,789 --> 01:09:22,080
and so if we want to compute the growth

1991
01:09:27,030 --> 01:09:24,799
rate of my uh cell populations we can

1992
01:09:28,789 --> 01:09:27,040
actually just mimic what we do usually

1993
01:09:30,390 --> 01:09:28,799
the life cycle so we can close the life

1994
01:09:32,149 --> 01:09:30,400
cycle but this time it's like a

1995
01:09:33,829 --> 01:09:32,159
metabolic lifecycle so we can actually

1996
01:09:36,149 --> 01:09:33,839
understand the way this limitation

1997
01:09:38,309 --> 01:09:36,159
reactions sort of feed on itself

1998
01:09:40,630 --> 01:09:38,319
creating this like autocatalytic loop

1999
01:09:43,669 --> 01:09:40,640
and we can use the theory to just find

2000
01:09:45,349 --> 01:09:43,679
uh this asymptotic growth rate

2001
01:09:46,709 --> 01:09:45,359
so now we we have this growth rate and

2002
01:09:48,630 --> 01:09:46,719
so i just want to show you like what we

2003
01:09:51,590 --> 01:09:48,640
do with it so let's take an example here

2004
01:09:53,430 --> 01:09:51,600
with e coli looking at the core model

2005
01:09:55,350 --> 01:09:53,440
and focusing on the glycolysis pathway

2006
01:09:57,750 --> 01:09:55,360
so i'm just going to take glycolysis um

2007
01:10:00,070 --> 01:09:57,760
and we just so that's glycolysis which

2008
01:10:02,390 --> 01:10:00,080
is going to assume it's a proxy for cell

2009
01:10:04,470 --> 01:10:02,400
growth and we have different substrates

2010
01:10:07,110 --> 01:10:04,480
here that can enter glucose fructose

2011
01:10:09,990 --> 01:10:07,120
phosphorus and uh some protons

2012
01:10:12,070 --> 01:10:10,000
if we again think of it using this like

2013
01:10:13,590 --> 01:10:12,080

combinatorics of the different way

2014
01:10:15,110 --> 01:10:13,600
reactions can be limiting

2015
01:10:16,870 --> 01:10:15,120
you can see we have like around 2000

2016
01:10:18,310 --> 01:10:16,880
possible limitation ratios it's like a

2017
01:10:20,470 --> 01:10:18,320
pretty complicated to just go through

2018
01:10:22,630 --> 01:10:20,480
all possible ways this metabolic network

2019
01:10:24,550 --> 01:10:22,640
can function but we actually can still

2020
01:10:26,310 --> 01:10:24,560
do it on the computer

2021
01:10:28,390 --> 01:10:26,320
um so let's just look now at the growth

2022
01:10:30,630 --> 01:10:28,400
rate of this metabolic network and the

2023
01:10:33,350 --> 01:10:30,640
population uh along gradients of

2024
01:10:36,070 --> 01:10:33,360
phosphorus and sugar uh glucose of

2025
01:10:37,430 --> 01:10:36,080
availability so this is the result i get

2026
01:10:38,390 --> 01:10:37,440
with this mole and so i get the growth

2027
01:10:40,470 --> 01:10:38,400
rate

2028
01:10:42,709 --> 01:10:40,480
of my population as a function of the

2029
01:10:44,790 --> 01:10:42,719
resource availability of glucose and

2030
01:10:46,630 --> 01:10:44,800
phosphate and you can see this this

2031
01:10:49,990 --> 01:10:46,640
curve um i don't know if you can see in

2032
01:10:52,229 --> 01:10:50,000
3d um basically has several sort of

2033
01:10:54,229 --> 01:10:52,239
sides there's the first side here that

2034
01:10:56,310 --> 01:10:54,239
corresponds to the glucose limited

2035
01:10:57,430 --> 01:10:56,320
growth where glucose is the only

2036
01:10:59,270 --> 01:10:57,440
limiting

2037
01:11:01,990 --> 01:10:59,280
resource for for the

2038
01:11:03,830 --> 01:11:02,000

the cell um and if you can see adding

2039
01:11:06,070 --> 01:11:03,840
phosphorus doesn't really impact growth

2040
01:11:07,830 --> 01:11:06,080
so we are only limited by glucose here

2041
01:11:09,750 --> 01:11:07,840
and here is the opposite it's phosphate

2042
01:11:11,110 --> 01:11:09,760
limited and glucose doesn't do anything

2043
01:11:12,550 --> 01:11:11,120
because we already have enough of it

2044
01:11:14,870 --> 01:11:12,560
right and so we get this like right

2045
01:11:17,430 --> 01:11:14,880
angle uh growth surface here that is

2046
01:11:18,870 --> 01:11:17,440
kind of a classic of surgical ecology

2047
01:11:20,630 --> 01:11:18,880
it's called an essential resource like

2048
01:11:23,189 --> 01:11:20,640
we need both of these resources for

2049
01:11:24,790 --> 01:11:23,199
growth to be uh possible okay and so

2050
01:11:27,270 --> 01:11:24,800
they sort of and as soon as we have

2051
01:11:28,790 --> 01:11:27,280
enough of one we only need the other

2052
01:11:31,669 --> 01:11:28,800
and you can also notice we have this

2053
01:11:33,830 --> 01:11:31,679
emergence like seedling uh in growth so

2054
01:11:36,630 --> 01:11:33,840
this is a consequence of basically the

2055
01:11:38,470 --> 01:11:36,640
sort of the yield of the reaction uh uh

2056
01:11:40,470 --> 01:11:38,480
combining with the dilution by growth

2057
01:11:42,550 --> 01:11:40,480
adding a maximal cap where as you can

2058
01:11:44,229 --> 01:11:42,560
see adding glucose or phosphate doesn't

2059
01:11:46,470 --> 01:11:44,239
really fuel growth right we've reached

2060
01:11:49,510 --> 01:11:46,480
the sort of like intrinsic uh growth

2061
01:11:51,110 --> 01:11:49,520
maximal growth of the metabolic network

2062
01:11:52,550 --> 01:11:51,120
so this is cool because we so this is

2063
01:11:54,470 --> 01:11:52,560

one example we get these essential

2064
01:11:55,830 --> 01:11:54,480
resources that emerge but we've explored

2065
01:11:57,830 --> 01:11:55,840
glycolysis a little more and we find

2066
01:11:59,750 --> 01:11:57,840
some pretty interesting uh combination

2067
01:12:02,709 --> 01:11:59,760
like interactions like between glucose

2068
01:12:04,470 --> 01:12:02,719
and fructose sometimes we get inhibition

2069
01:12:06,630 --> 01:12:04,480
when it's too much of a substrate like

2070
01:12:08,310 --> 01:12:06,640
us

2071
01:12:09,590 --> 01:12:08,320
sort of uh consuming resources that

2072
01:12:11,590 --> 01:12:09,600
could be used for something else so it's

2073
01:12:13,430 --> 01:12:11,600
like detrimental um et cetera but i

2074
01:12:14,630 --> 01:12:13,440
don't have time to talk about another

2075
01:12:16,390 --> 01:12:14,640
aspect that we found that was pretty

2076
01:12:19,270 --> 01:12:16,400
interesting is we saw the emergence of

2077
01:12:20,709 --> 01:12:19,280
antenative metabolic states so for fixed

2078
01:12:22,310 --> 01:12:20,719
uh

2079
01:12:23,910 --> 01:12:22,320
nutritional conditions like you know

2080
01:12:26,870 --> 01:12:23,920
fixed phosphate and glucose and you look

2081
01:12:29,430 --> 01:12:26,880
at this equilibria of the this growth

2082
01:12:31,270 --> 01:12:29,440
balance growth equilibrium um

2083
01:12:32,470 --> 01:12:31,280
you can eat either glucose estimator or

2084
01:12:34,709 --> 01:12:32,480
intrinsically limited and the

2085
01:12:35,430 --> 01:12:34,719
consequence of this is that this could

2086
01:12:37,590 --> 01:12:35,440
have

2087
01:12:39,270 --> 01:12:37,600
this could describe the emergence of two

2088
01:12:41,750 --> 01:12:39,280

morphs in a clonal population that has

2089
01:12:43,590 --> 01:12:41,760
the exact same metabolic network uh

2090
01:12:45,750 --> 01:12:43,600
between that grow in two different

2091
01:12:47,430 --> 01:12:45,760
phases so we can have uh basically uh

2092
01:12:49,590 --> 01:12:47,440
heterogeneity in that population that

2093
01:12:51,030 --> 01:12:49,600
emerges because of this alternative

2094
01:12:52,550 --> 01:12:51,040
stable state

2095
01:12:54,709 --> 01:12:52,560
now you're going to ask me no no now

2096
01:12:57,430 --> 01:12:54,719
what so it is pretty cute it's very

2097
01:12:58,870 --> 01:12:57,440
theoretically oriented uh work but what

2098
01:13:01,189 --> 01:12:58,880
do we do with this what do we do when we

2099
01:13:03,350 --> 01:13:01,199
have this growth rate um as a function

2100
01:13:05,030 --> 01:13:03,360
of resources then i would argue that in

2101
01:13:07,430 --> 01:13:05,040
surgical ecology this is basically the

2102
01:13:08,470 --> 01:13:07,440
cornerstone of everything else that can

2103
01:13:09,270 --> 01:13:08,480
be done

2104
01:13:11,110 --> 01:13:09,280
like

2105
01:13:12,470 --> 01:13:11,120
on top of this so we can start to think

2106
01:13:14,229 --> 01:13:12,480
about the microbial niches we can

2107
01:13:17,510 --> 01:13:14,239
quantify you know the sets of conditions

2108
01:13:19,110 --> 01:13:17,520
and which microbes could be able to grow

2109
01:13:21,350 --> 01:13:19,120
we could start doing like coexistence

2110
01:13:23,350 --> 01:13:21,360
studying the niche so using these niches

2111
01:13:25,189 --> 01:13:23,360
to understand which conditions two

2112
01:13:27,430 --> 01:13:25,199
different metabolic networks would

2113
01:13:29,350 --> 01:13:27,440

co-exist or exclude each other and we

2114
01:13:32,390 --> 01:13:29,360
can start doing uh using invasion

2115
01:13:34,630 --> 01:13:32,400
fitness to try to understand how these

2116
01:13:36,550 --> 01:13:34,640
organisms can evolve by adding or

2117
01:13:37,910 --> 01:13:36,560
removing reactions in the metabolic

2118
01:13:40,149 --> 01:13:37,920
network

2119
01:13:41,030 --> 01:13:40,159
so this brings me to my uh take a

2120
01:13:42,950 --> 01:13:41,040
message

2121
01:13:43,750 --> 01:13:42,960
so basically i hope i showed you we can

2122
01:13:45,350 --> 01:13:43,760
use

2123
01:13:47,669 --> 01:13:45,360
structural population theory to go from

2124
01:13:49,030 --> 01:13:47,679
cell metabolism to coefficient growth um

2125
01:13:51,030 --> 01:13:49,040
we've seen the emergence of purchased

2126
01:13:52,950 --> 01:13:51,040
limitation we have possibility for

2127
01:13:55,270 --> 01:13:52,960
alternative metabolic states and finally

2128
01:13:57,830 --> 01:13:55,280
this should open the door to doing like

2129
01:14:00,149 --> 01:13:57,840
standard ecology and evolution uh

2130
01:14:02,410 --> 01:14:00,159
to tackle broader questions thank you

2131
01:14:08,229 --> 01:14:02,420
for attention

2132
01:14:09,430 --> 01:14:08,239
[Applause]

2133
01:14:22,149 --> 01:14:09,440
all right we have time for some

2134
01:14:24,229 --> 01:14:23,430
all right that was a really interesting

2135
01:14:27,350 --> 01:14:24,239
talk

2136
01:14:29,110 --> 01:14:27,360
cole mathis arizona state

2137
01:14:30,709 --> 01:14:29,120
maybe you covered this and i just missed

2138
01:14:32,950 --> 01:14:30,719

it but i'm just curious if you have any

2139
01:14:35,430 --> 01:14:32,960
ideas about the best way to validate

2140
01:14:37,270 --> 01:14:35,440
this type of approach uh experimentally

2141
01:14:39,510 --> 01:14:37,280
or if you have thoughts about like what

2142
01:14:41,750 --> 01:14:39,520
the easiest sort of point of contact

2143
01:14:44,229 --> 01:14:41,760
with some observations or or some

2144
01:14:46,790 --> 01:14:44,239
experiments would be

2145
01:14:48,790 --> 01:14:46,800
that's that's a good question so i'm i'm

2146
01:14:50,950 --> 01:14:48,800
not yeah i'm not too much in the field

2147
01:14:53,510 --> 01:14:50,960
so i'm not a microbiologist myself so um

2148
01:14:55,430 --> 01:14:53,520
i i don't have too many ideas how to to

2149
01:14:58,310 --> 01:14:55,440
validate it um i'm open to two

2150
01:14:59,110 --> 01:14:58,320
suggestions if you have any um

2151
01:15:07,910 --> 01:14:59,120
yeah

2152
01:15:14,070 --> 01:15:10,950
i had a quick question um

2153
01:15:14,870 --> 01:15:14,080
i saw can you can you hear me

2154
01:15:16,070 --> 01:15:14,880
okay

2155
01:15:18,790 --> 01:15:16,080
um

2156
01:15:21,669 --> 01:15:18,800
so i saw i missed something but i saw

2157
01:15:22,830 --> 01:15:21,679
that you were looking at phosphorus and

2158
01:15:24,870 --> 01:15:22,840
glucose

2159
01:15:27,189 --> 01:15:24,880
limitation um

2160
01:15:29,830 --> 01:15:27,199
have you thought like i saw that your

2161
01:15:31,669 --> 01:15:29,840
network gets very complex uh have you

2162
01:15:34,630 --> 01:15:31,679
started to think about adding in any

2163
01:15:36,470 --> 01:15:34,640

other sort of limitations nitrogen or

2164
01:15:38,310 --> 01:15:36,480
possibly metals that would probably get

2165
01:15:39,750 --> 01:15:38,320
really complex

2166
01:15:40,870 --> 01:15:39,760
yeah it would be interesting so this was

2167
01:15:43,270 --> 01:15:40,880
like

2168
01:15:45,510 --> 01:15:43,280
we wanted to first look at e coli core

2169
01:15:47,669 --> 01:15:45,520
model which is bigger and has nitrogen

2170
01:15:49,270 --> 01:15:47,679
for example in there um it was a big

2171
01:15:51,669 --> 01:15:49,280
network um

2172
01:15:54,550 --> 01:15:51,679
to work with our methods we then we

2173
01:15:57,270 --> 01:15:54,560
started we chose to focus first on on

2174
01:15:59,510 --> 01:15:57,280
glycolysis as a sort of a proxy for the

2175
01:16:01,510 --> 01:15:59,520
whole network um which

2176
01:16:03,910 --> 01:16:01,520
here only has uh these four uh

2177
01:16:05,430 --> 01:16:03,920
limitation uh limitations but it would

2178
01:16:08,310 --> 01:16:05,440
be interesting so if this would if we

2179
01:16:09,669 --> 01:16:08,320
scaled it up to the full full core model

2180
01:16:12,070 --> 01:16:09,679
we would have other limitations that we

2181
01:16:13,590 --> 01:16:12,080
could start looking at this combine

2182
01:16:16,550 --> 01:16:13,600
multiple limitations and try to

2183
01:16:18,470 --> 01:16:16,560
understand um yeah how

2184
01:16:21,270 --> 01:16:18,480
how they how they emerge and what kind

2185
01:16:22,950 --> 01:16:21,280
of limitations do we expect um

2186
01:16:24,950 --> 01:16:22,960
yeah

2187
01:16:27,030 --> 01:16:24,960
awesome thank you thank you

2188
01:16:30,229 --> 01:16:27,040

thank you very much tama

2189
01:16:50,390 --> 01:16:32,070
all right our last speaker of this

2190
01:16:50,400 --> 01:16:55,990
thanks yeah

2191
01:16:59,350 --> 01:16:57,830
all right hi everyone uh this talk will

2192
01:17:01,590 --> 01:16:59,360
be a bit different from the other ones

2193
01:17:02,550 --> 01:17:01,600
that just happened so uh sarah walker

2194
01:17:03,669 --> 01:17:02,560
was supposed to give this talk she

2195
01:17:05,030 --> 01:17:03,679
wasn't able to be here and this is a

2196
01:17:06,310 --> 01:17:05,040
project we've been working on together

2197
01:17:09,590 --> 01:17:06,320
so i was happy to be able to take the

2198
01:17:11,030 --> 01:17:09,600
chance to to share it with y'all um

2199
01:17:12,149 --> 01:17:11,040
so before i get started i just want to

2200
01:17:13,510 --> 01:17:12,159
acknowledge everyone that's contributed

2201
01:17:15,030 --> 01:17:13,520
to this obviously sarah and i have been

2202
01:17:17,830 --> 01:17:15,040
working on this and we've been working

2203
01:17:18,950 --> 01:17:17,840
with two early career scientists uh

2204
01:17:22,070 --> 01:17:18,960
sierra

2205
01:17:23,270 --> 01:17:22,080
who just will start at a

2206
01:17:24,870 --> 01:17:23,280
phd

2207
01:17:26,310 --> 01:17:24,880
at the university of arizona in the fall

2208
01:17:28,229 --> 01:17:26,320
and pritvik who's actually a high school

2209
01:17:29,350 --> 01:17:28,239
student who will be attending university

2210
01:17:31,350 --> 01:17:29,360
it's been really great working with them

2211
01:17:33,110 --> 01:17:31,360
they've really taught us a lot um and

2212
01:17:35,750 --> 01:17:33,120
i've been talking about similar ideas

2213
01:17:37,430 --> 01:17:35,760

with harrison smith um we had a poster

2214
01:17:38,470 --> 01:17:37,440
earlier in the week about some related

2215
01:17:40,070 --> 01:17:38,480
stuff

2216
01:17:41,270 --> 01:17:40,080
so if you're curious about that you can

2217
01:17:43,110 --> 01:17:41,280
find us and we can send you the

2218
01:17:45,430 --> 01:17:43,120
pre-print or show you the poster

2219
01:17:47,510 --> 01:17:45,440
um so right so i

2220
01:17:49,510 --> 01:17:47,520
just wanted to talk today about

2221
01:17:51,110 --> 01:17:49,520
uh sort of what i think are the two main

2222
01:17:52,630 --> 01:17:51,120
pillars of astrobiology the main

2223
01:17:55,110 --> 01:17:52,640
research questions and on the one hand

2224
01:17:56,390 --> 01:17:55,120
it's how do we detect life

2225
01:17:58,310 --> 01:17:56,400
and on the other hand how do we make

2226
01:18:00,229 --> 01:17:58,320
life or rather how do we understand the

2227
01:18:01,750 --> 01:18:00,239
emergence of living systems and if you

2228
01:18:03,270 --> 01:18:01,760
take one thing away from this talk i

2229
01:18:04,709 --> 01:18:03,280
hope that you take away that these two

2230
01:18:06,870 --> 01:18:04,719
problems have to be solved sort of

2231
01:18:07,750 --> 01:18:06,880
simultaneously and together

2232
01:18:09,350 --> 01:18:07,760
because

2233
01:18:10,870 --> 01:18:09,360
our ability to understand the life we

2234
01:18:12,709 --> 01:18:10,880
find and our ability to make life in a

2235
01:18:14,709 --> 01:18:12,719
lab will depend on on answering them

2236
01:18:16,310 --> 01:18:14,719
both at the same time so to give an

2237
01:18:17,750 --> 01:18:16,320
example of what i mean by that i think

2238
01:18:19,189 --> 01:18:17,760

you can just consider

2239
01:18:21,030 --> 01:18:19,199
you know a topic that comes up at apps

2240
01:18:24,310 --> 01:18:21,040
icon a lot so if you think about

2241
01:18:26,709 --> 01:18:24,320
homochirality if i go to a session on uh

2242
01:18:27,430 --> 01:18:26,719
maybe prebiotic chemistry

2243
01:18:43,030 --> 01:18:27,440
i

2244
01:18:46,870 --> 01:18:43,040
phenomena

2245
01:18:48,390 --> 01:18:46,880
different ways suggests that there's

2246
01:18:50,229 --> 01:18:48,400
some ambiguity that we need to resolve

2247
01:18:51,590 --> 01:18:50,239
in the field to understand like how it

2248
01:18:52,790 --> 01:18:51,600
could be that a biosignature is

2249
01:18:54,950 --> 01:18:52,800
something we're expecting to happen

2250
01:18:56,310 --> 01:18:54,960
abiotically right and obviously the

2251
01:18:57,990 --> 01:18:56,320
answer to that is we expect

2252
01:18:59,110 --> 01:18:58,000
biosignatures to emerge over time

2253
01:19:00,950 --> 01:18:59,120
through the process that leads to the

2254
01:19:02,950 --> 01:19:00,960
emergence of life

2255
01:19:05,110 --> 01:19:02,960
but what this means is that we need to

2256
01:19:07,110 --> 01:19:05,120
unify sort of understanding the origins

2257
01:19:08,950 --> 01:19:07,120
of life with our approaches to detecting

2258
01:19:10,310 --> 01:19:08,960
life i mean just to give an example from

2259
01:19:12,070 --> 01:19:10,320
the history of science about why this

2260
01:19:14,470 --> 01:19:12,080
might be useful you can think about

2261
01:19:16,550 --> 01:19:14,480
particle physics in the sort of

2262
01:19:18,470 --> 01:19:16,560
early 20th century people were doing

2263
01:19:20,070 --> 01:19:18,480

experiments in accelerators and then at

2264
01:19:21,830 --> 01:19:20,080
the same time people were learning about

2265
01:19:23,669 --> 01:19:21,840
sort of inflationary cosmology and there

2266
01:19:25,270 --> 01:19:23,679
was this realization that the early

2267
01:19:25,990 --> 01:19:25,280
universe was very hot and dense and it

2268
01:19:27,910 --> 01:19:26,000
was

2269
01:19:29,110 --> 01:19:27,920
sort of experiencing similar conditions

2270
01:19:30,950 --> 01:19:29,120
to what was happening in the particle

2271
01:19:32,310 --> 01:19:30,960
accelerators and so to understand the

2272
01:19:34,390 --> 01:19:32,320
early evolution of the universe you

2273
01:19:36,229 --> 01:19:34,400
could use our theories of particle

2274
01:19:37,189 --> 01:19:36,239
physics and then at the same time by

2275
01:19:39,510 --> 01:19:37,199
under

2276
01:19:41,510 --> 01:19:39,520
of the universe you could place

2277
01:19:43,189 --> 01:19:41,520
constraints on our models of particle

2278
01:19:44,630 --> 01:19:43,199
physics so there was this sort of

2279
01:19:46,070 --> 01:19:44,640
feedback here that led to greater

2280
01:19:47,350 --> 01:19:46,080
explanatory and predictive power for

2281
01:19:49,510 --> 01:19:47,360
both fields

2282
01:19:51,270 --> 01:19:49,520
and what i'm hoping to convince you of

2283
01:19:52,870 --> 01:19:51,280
is that sort of astrobiology has this

2284
01:19:54,390 --> 01:19:52,880
large-scale cosmological question about

2285
01:19:56,390 --> 01:19:54,400
the distribution and abundance and

2286
01:19:57,590 --> 01:19:56,400
diversity of life in the universe and at

2287
01:19:58,790 --> 01:19:57,600
the same time there's this sort of

2288
01:20:00,070 --> 01:19:58,800

experimental paradigm about

2289
01:20:02,390 --> 01:20:00,080
understanding the emergence of living

2290
01:20:04,630 --> 01:20:02,400
systems and if we can couple these i i

2291
01:20:05,990 --> 01:20:04,640
do think we can make more effective

2292
01:20:08,149 --> 01:20:06,000
progress and have better explanations

2293
01:20:10,149 --> 01:20:08,159
for living phenomena

2294
01:20:11,669 --> 01:20:10,159
so one way to understand this is through

2295
01:20:13,030 --> 01:20:11,679
the framework of bayesian hypothesis

2296
01:20:14,629 --> 01:20:13,040
testing and specifically with life

2297
01:20:16,310 --> 01:20:14,639
detection so a lot of people have been

2298
01:20:18,950 --> 01:20:16,320
talking about bayesian life

2299
01:20:20,310 --> 01:20:18,960
life detection um especially since 2018

2300
01:20:21,910 --> 01:20:20,320
there was a workshop that led to two

2301
01:20:23,510 --> 01:20:21,920
papers that both sort of explored this

2302
01:20:24,790 --> 01:20:23,520
idea and there's been a lot of really

2303
01:20:27,350 --> 01:20:24,800
great work some of which has been

2304
01:20:29,110 --> 01:20:27,360
presented here subsequently um so just

2305
01:20:31,270 --> 01:20:29,120
at a very basic level

2306
01:20:32,950 --> 01:20:31,280
bayesian hypothesis testing is about how

2307
01:20:34,790 --> 01:20:32,960
much how confident should i be in a

2308
01:20:36,390 --> 01:20:34,800
hypothesis like there's life on this

2309
01:20:37,830 --> 01:20:36,400
planet conditioned on some observation

2310
01:20:40,470 --> 01:20:37,840
or some data

2311
01:20:42,470 --> 01:20:40,480
and if you can sort of quantify your

2312
01:20:44,229 --> 01:20:42,480
uncertain your confidence in a few

2313
01:20:45,750 --> 01:20:44,239

things then you can calculate this

2314
01:20:47,189 --> 01:20:45,760
pretty easily and those things are like

2315
01:20:48,470 --> 01:20:47,199
how confident were you before you had

2316
01:20:50,629 --> 01:20:48,480
that data that there was life on the

2317
01:20:52,790 --> 01:20:50,639
planet and how often does that

2318
01:20:54,470 --> 01:20:52,800
observation co-occur with data and how

2319
01:20:56,790 --> 01:20:54,480
many false positives you have so can

2320
01:20:59,430 --> 01:20:56,800
that observation occur without life and

2321
01:21:00,790 --> 01:20:59,440
how often does that happen right and so

2322
01:21:02,390 --> 01:21:00,800
um this is just like a really simple

2323
01:21:03,669 --> 01:21:02,400
schematic to show how these are related

2324
01:21:05,430 --> 01:21:03,679
um

2325
01:21:06,870 --> 01:21:05,440
this is not sort of a silver bullet for

2326
01:21:08,790 --> 01:21:06,880
life detection it doesn't solve all our

2327
01:21:10,390 --> 01:21:08,800
problems and there are some issues and

2328
01:21:11,750 --> 01:21:10,400
um there's a really great paper that's

2329
01:21:13,750 --> 01:21:11,760
coming out i think either this month or

2330
01:21:15,430 --> 01:21:13,760
next month by david kenny who's a

2331
01:21:16,629 --> 01:21:15,440
philosopher and chris kempi's and they

2332
01:21:18,070 --> 01:21:16,639
have like a really interesting critique

2333
01:21:19,830 --> 01:21:18,080
of this approach that i think the field

2334
01:21:22,550 --> 01:21:19,840
should should take seriously so check

2335
01:21:24,070 --> 01:21:22,560
out that paper when it comes out um

2336
01:21:26,149 --> 01:21:24,080
but i just want to sort of use this

2337
01:21:27,750 --> 01:21:26,159
example to illustrate the connection

2338
01:21:28,950 --> 01:21:27,760

between life detection and the origin of

2339
01:21:31,189 --> 01:21:28,960
life and first i just want to walk

2340
01:21:33,110 --> 01:21:31,199
through a super simple example of how

2341
01:21:34,709 --> 01:21:33,120
this works so let's say we're playing a

2342
01:21:36,229 --> 01:21:34,719
game and i've got two coins one of them

2343
01:21:38,229 --> 01:21:36,239
is like a biased coin and one of them is

2344
01:21:39,430 --> 01:21:38,239
fair so a fair coin turns up heads fifty

2345
01:21:41,110 --> 01:21:39,440
percent of the time and fails fifty

2346
01:21:43,750 --> 01:21:41,120
percent of the time and a bias coin

2347
01:21:45,189 --> 01:21:43,760
turns up any other ratio right i give

2348
01:21:47,030 --> 01:21:45,199
you a coin you don't know which one it

2349
01:21:49,270 --> 01:21:47,040
is and so you decide to flip it to try

2350
01:21:50,629 --> 01:21:49,280
to figure out which one you have right

2351
01:21:52,070 --> 01:21:50,639
so you can

2352
01:21:53,910 --> 01:21:52,080
calculate that if you know these

2353
01:21:55,189 --> 01:21:53,920
parameters again so maybe you know me

2354
01:21:56,629 --> 01:21:55,199
pretty well and you think like oh cole's

2355
01:21:57,990 --> 01:21:56,639
messing with me i'm pretty sure you gave

2356
01:21:59,430 --> 01:21:58,000
me the bias coin or maybe you don't know

2357
01:22:01,830 --> 01:21:59,440
me at all and you're like okay it could

2358
01:22:03,590 --> 01:22:01,840
be either i'm not sure so your prior on

2359
01:22:04,709 --> 01:22:03,600
the bias coin this like

2360
01:22:07,430 --> 01:22:04,719
pb

2361
01:22:08,950 --> 01:22:07,440
could be somewhere between zero and one

2362
01:22:10,470 --> 01:22:08,960
and then you also need to know how

2363
01:22:12,149 --> 01:22:10,480

biased the coin is so if it's the case

2364
01:22:14,790 --> 01:22:12,159
that like the bias coin always shows

2365
01:22:16,629 --> 01:22:14,800
tails then this p t condition on b would

2366
01:22:18,310 --> 01:22:16,639
be one or maybe it only shuts heads in

2367
01:22:20,310 --> 01:22:18,320
which case it would be zero but if you

2368
01:22:22,629 --> 01:22:20,320
have these two valuables variables you

2369
01:22:24,229 --> 01:22:22,639
can calculate you know how confident you

2370
01:22:25,669 --> 01:22:24,239
should be that you've got the bias coin

2371
01:22:27,270 --> 01:22:25,679
so that's on the vertical axis the

2372
01:22:28,550 --> 01:22:27,280
posterior like

2373
01:22:30,950 --> 01:22:28,560
what's my confidence that i have the

2374
01:22:33,030 --> 01:22:30,960
bias coin condition unseen tails as a

2375
01:22:34,550 --> 01:22:33,040
function of those two variables right so

2376
01:22:36,629 --> 01:22:34,560
here again you're just talking about how

2377
01:22:38,870 --> 01:22:36,639
biased the coin is so on the left hand

2378
01:22:40,550 --> 01:22:38,880
side if the coin always shows heads and

2379
01:22:42,709 --> 01:22:40,560
you see tails you know you've got a fair

2380
01:22:43,830 --> 01:22:42,719
coin but if it shows something else or

2381
01:22:45,270 --> 01:22:43,840
there's a different bias then there's

2382
01:22:47,750 --> 01:22:45,280
more ambiguity

2383
01:22:49,590 --> 01:22:47,760
um and this really strongly depends

2384
01:22:51,350 --> 01:22:49,600
depends again on your prior hypothesis

2385
01:22:53,030 --> 01:22:51,360
about that the chance that i gave you

2386
01:22:54,550 --> 01:22:53,040
that coin

2387
01:22:56,149 --> 01:22:54,560
um and this is the same data just sort

2388
01:22:57,750 --> 01:22:56,159

of switching the axes around here where

2389
01:22:59,350 --> 01:22:57,760
now i put the prior on the horizontal

2390
01:23:00,310 --> 01:22:59,360
axis and the color is how biased the

2391
01:23:01,590 --> 01:23:00,320
coin is

2392
01:23:03,030 --> 01:23:01,600
so that might seem like a sort of

2393
01:23:04,629 --> 01:23:03,040
abstract example but it's directly

2394
01:23:06,149 --> 01:23:04,639
analogous to the problem of detecting

2395
01:23:08,310 --> 01:23:06,159
life on another world based on an

2396
01:23:09,590 --> 01:23:08,320
observation right so this is like one of

2397
01:23:11,270 --> 01:23:09,600
the main questions we're interested in

2398
01:23:13,189 --> 01:23:11,280
astrobiology is if i make some

2399
01:23:15,030 --> 01:23:13,199
observation of a planet how confident

2400
01:23:16,709 --> 01:23:15,040
should i be that there's life there um

2401
01:23:18,149 --> 01:23:16,719
and this is the exact same equation with

2402
01:23:19,910 --> 01:23:18,159
like pretty much the same variables i've

2403
01:23:21,270 --> 01:23:19,920
just changed the labels from like bias

2404
01:23:23,910 --> 01:23:21,280
and tails to

2405
01:23:26,470 --> 01:23:23,920
life not life and observation

2406
01:23:28,629 --> 01:23:26,480
and i've changed the axis here on the

2407
01:23:30,470 --> 01:23:28,639
these plots to logarithmic scales

2408
01:23:32,229 --> 01:23:30,480
because our uncertainty about

2409
01:23:33,990 --> 01:23:32,239
both our prior expectation about the

2410
01:23:36,310 --> 01:23:34,000
emergence of life we're uncertain on

2411
01:23:38,950 --> 01:23:36,320
logarithmic scales we're not like oh 50

2412
01:23:40,149 --> 01:23:38,960
50 or 25 of the time it's like could be

2413
01:23:41,590 --> 01:23:40,159

one in 10 or it could be one in a

2414
01:23:42,790 --> 01:23:41,600
million or one in a trillion we don't

2415
01:23:44,550 --> 01:23:42,800
know where it is

2416
01:23:46,709 --> 01:23:44,560
um and so

2417
01:23:48,870 --> 01:23:46,719
all of this is to say that like

2418
01:23:50,470 --> 01:23:48,880
here if we plot our false positive rate

2419
01:23:51,590 --> 01:23:50,480
on the x-axis which is this graph that's

2420
01:23:53,510 --> 01:23:51,600
circled

2421
01:23:56,070 --> 01:23:53,520
which is how often does this observation

2422
01:23:57,910 --> 01:23:56,080
occur when life is not present we can

2423
01:23:59,910 --> 01:23:57,920
sort of look at how confident we can be

2424
01:24:01,510 --> 01:23:59,920
in life detection claims based on our

2425
01:24:02,390 --> 01:24:01,520
prior hypothesis of life occurring in

2426
01:24:04,149 --> 01:24:02,400
that environment

2427
01:24:07,030 --> 01:24:04,159
right so if our prior hypothesis is

2428
01:24:09,030 --> 01:24:07,040
quite low like 1 in 10 to the 4

2429
01:24:10,709 --> 01:24:09,040
we need to have very very low false

2430
01:24:12,870 --> 01:24:10,719
positive rates to make strong life

2431
01:24:14,310 --> 01:24:12,880
detection claims which is sort of being

2432
01:24:16,310 --> 01:24:14,320
at the one at the top of the graph there

2433
01:24:18,070 --> 01:24:16,320
is a strong claim

2434
01:24:20,229 --> 01:24:18,080
and another way to sort of obviously see

2435
01:24:22,310 --> 01:24:20,239
this is if you're if your

2436
01:24:23,590 --> 01:24:22,320
false positive rate is zero then this

2437
01:24:25,510 --> 01:24:23,600
term goes to zero and you've got

2438
01:24:27,590 --> 01:24:25,520

something over itself and this term is

2439
01:24:29,350 --> 01:24:27,600
one which means you don't actually need

2440
01:24:31,189 --> 01:24:29,360
to be confident in your prior hypothesis

2441
01:24:32,870 --> 01:24:31,199
about life being there in order to know

2442
01:24:34,709 --> 01:24:32,880
that it's there so another way to say

2443
01:24:36,470 --> 01:24:34,719
that is if your biosignature has any

2444
01:24:38,070 --> 01:24:36,480
false positives you need a prior

2445
01:24:40,070 --> 01:24:38,080
hypothesis about life's origin in that

2446
01:24:41,750 --> 01:24:40,080
environment but if it had if it doesn't

2447
01:24:43,510 --> 01:24:41,760
have false positives you don't need a

2448
01:24:45,030 --> 01:24:43,520
strong hypothesis or really any

2449
01:24:46,229 --> 01:24:45,040
hypothesis about life's origin in that

2450
01:24:48,070 --> 01:24:46,239
environment

2451
01:24:49,910 --> 01:24:48,080
so this sort of means that like life

2452
01:24:51,110 --> 01:24:49,920
detection there's two ways forward right

2453
01:24:52,550 --> 01:24:51,120
one is are there smoking gun

2454
01:24:53,830 --> 01:24:52,560
biosignatures

2455
01:24:55,030 --> 01:24:53,840
and the other is are there ways to

2456
01:24:56,229 --> 01:24:55,040
estimate the likelihood of life's

2457
01:24:58,310 --> 01:24:56,239
emergence given in a particular

2458
01:24:59,910 --> 01:24:58,320
environment so i do think unambiguous

2459
01:25:01,510 --> 01:24:59,920
biosignatures exist i think like an

2460
01:25:03,189 --> 01:25:01,520
intuitive example would be directed

2461
01:25:04,550 --> 01:25:03,199
radio transmission from another star

2462
01:25:06,229 --> 01:25:04,560
system right there might be some

2463
01:25:07,910 --> 01:25:06,239

ambiguity about decoding the signal and

2464
01:25:09,590 --> 01:25:07,920
exactly what they're sending us but if

2465
01:25:11,510 --> 01:25:09,600
we got a message that was like encoding

2466
01:25:13,030 --> 01:25:11,520
the digits of pi we don't have to argue

2467
01:25:14,390 --> 01:25:13,040
about the likelihood of life emerging in

2468
01:25:16,149 --> 01:25:14,400
that star system because there's no

2469
01:25:18,070 --> 01:25:16,159
other explanation besides an intelligent

2470
01:25:19,189 --> 01:25:18,080
civilization right there's no chance

2471
01:25:21,030 --> 01:25:19,199
that that's a false positive life

2472
01:25:22,390 --> 01:25:21,040
detection

2473
01:25:23,910 --> 01:25:22,400
i think that there are other ones this

2474
01:25:27,030 --> 01:25:23,920
is tentative we're trying to work out

2475
01:25:28,470 --> 01:25:27,040
the the uh sort of validation of this

2476
01:25:29,669 --> 01:25:28,480
but there's some evidence that there

2477
01:25:32,070 --> 01:25:29,679
might be ways to use chemical

2478
01:25:33,669 --> 01:25:32,080
biosignatures that are unambiguous

2479
01:25:35,510 --> 01:25:33,679
uh but the main point is that

2480
01:25:37,350 --> 01:25:35,520
identifying unambiguous biosignatures

2481
01:25:39,189 --> 01:25:37,360
requires what is and isn't possible with

2482
01:25:41,030 --> 01:25:39,199
and without life in principle not as a

2483
01:25:43,350 --> 01:25:41,040
matter of scale

2484
01:25:44,950 --> 01:25:43,360
and that requires sort of a theory and

2485
01:25:45,990 --> 01:25:44,960
experimental paradigms to test those

2486
01:25:47,270 --> 01:25:46,000
measures

2487
01:25:48,310 --> 01:25:47,280
so what about on the other side right

2488
01:25:50,470 --> 01:25:48,320

are there ways to estimate the

2489
01:25:52,709 --> 01:25:50,480
likelihood of life's emergence

2490
01:25:54,310 --> 01:25:52,719
so there was a paper in 2018 by david

2491
01:25:55,590 --> 01:25:54,320
kipping and his collaborator where they

2492
01:25:57,110 --> 01:25:55,600
asked this question about what would

2493
01:25:59,030 --> 01:25:57,120
what sort of information would best

2494
01:26:00,229 --> 01:25:59,040
constrain the prior on life and they

2495
01:26:02,310 --> 01:26:00,239
sort of said there's like basically

2496
01:26:03,830 --> 01:26:02,320
three uh pieces of information we could

2497
01:26:05,830 --> 01:26:03,840
get we could get data from large scale

2498
01:26:07,510 --> 01:26:05,840
surveys of life by trying to detect it

2499
01:26:08,870 --> 01:26:07,520
on other worlds we could collect

2500
01:26:10,550 --> 01:26:08,880
experimental data about the likelihood

2501
01:26:12,149 --> 01:26:10,560
of life's emergence in the lab or we

2502
01:26:14,310 --> 01:26:12,159
could put tighter constraints on life's

2503
01:26:16,310 --> 01:26:14,320
early emergence

2504
01:26:18,470 --> 01:26:16,320
based on the sort of phylogenetic or

2505
01:26:19,750 --> 01:26:18,480
rock record

2506
01:26:21,350 --> 01:26:19,760
large scale surveys of life are

2507
01:26:23,510 --> 01:26:21,360
difficult because again we don't have

2508
01:26:25,750 --> 01:26:23,520
unambiguous biosignatures that work for

2509
01:26:27,110 --> 01:26:25,760
uh planets outside the solar system yet

2510
01:26:28,790 --> 01:26:27,120
and we would need the prior to evaluate

2511
01:26:31,669 --> 01:26:28,800
those in the first place

2512
01:26:33,270 --> 01:26:31,679
uh this review found that uh the data

2513
01:26:34,550 --> 01:26:33,280

from better constraints on life's early

2514
01:26:36,229 --> 01:26:34,560
emergence would actually be the least

2515
01:26:37,590 --> 01:26:36,239
informative about constraining life's

2516
01:26:39,430 --> 01:26:37,600
prior and so that leaves this

2517
01:26:42,070 --> 01:26:39,440
experimental paradigm where the question

2518
01:26:43,910 --> 01:26:42,080
we now have to ask is like what's the

2519
01:26:45,430 --> 01:26:43,920
likelihood of life emerging in a given

2520
01:26:47,830 --> 01:26:45,440
planetary environment and can we make

2521
01:26:49,910 --> 01:26:47,840
chemical simulations of that to span the

2522
01:26:52,310 --> 01:26:49,920
space of possible biospheres in relation

2523
01:26:54,629 --> 01:26:52,320
to the possible planetary environments

2524
01:26:55,750 --> 01:26:54,639
and that's a gigantic question which

2525
01:26:57,510 --> 01:26:55,760
we're not really approaching in a

2526
01:26:59,430 --> 01:26:57,520
systematic way yet and the last thing i

2527
01:27:01,990 --> 01:26:59,440
want to end on is just that

2528
01:27:03,430 --> 01:27:02,000
another analogy to particle physics

2529
01:27:05,270 --> 01:27:03,440
that's a huge question that can't be

2530
01:27:06,629 --> 01:27:05,280
addressed in a single lab and there are

2531
01:27:07,910 --> 01:27:06,639
other fields in the history of science

2532
01:27:10,070 --> 01:27:07,920
that have addressed these large scale

2533
01:27:11,830 --> 01:27:10,080
questions so super common conde is a

2534
01:27:14,550 --> 01:27:11,840
detector that you're looking at here and

2535
01:27:15,990 --> 01:27:14,560
they're looking for uh proton decays um

2536
01:27:17,669 --> 01:27:16,000
and this is like a giant experiment

2537
01:27:20,310 --> 01:27:17,679
buried in japan and just to give you a

2538
01:27:21,830 --> 01:27:20,320

sense of scale that little that's a few

2539
01:27:24,149 --> 01:27:21,840
people in boats uh working on the

2540
01:27:26,070 --> 01:27:24,159
detectors there and it's not detected

2541
01:27:28,310 --> 01:27:26,080
anything yet right the whole point of

2542
01:27:29,990 --> 01:27:28,320
this experiment is to look for proton

2543
01:27:32,070 --> 01:27:30,000
decay and it's been doing this for i

2544
01:27:33,430 --> 01:27:32,080
think about a decade or more and they've

2545
01:27:35,430 --> 01:27:33,440
not detected one yet but that

2546
01:27:37,910 --> 01:27:35,440
information is still useful because it's

2547
01:27:40,390 --> 01:27:37,920
putting ever tighter constraints on the

2548
01:27:42,229 --> 01:27:40,400
parameters in that model

2549
01:27:43,669 --> 01:27:42,239
um and so i think the the thing i want

2550
01:27:45,350 --> 01:27:43,679
to end on here is like what is the

2551
01:27:46,709 --> 01:27:45,360
analog experiment for the origin of life

2552
01:27:48,629 --> 01:27:46,719
so that we can understand the emergence

2553
01:27:50,390 --> 01:27:48,639
of living systems we can make these

2554
01:27:51,910 --> 01:27:50,400
constraints right

2555
01:27:53,510 --> 01:27:51,920
and i think that it will take sort of

2556
01:27:55,189 --> 01:27:53,520
something of the scale of the lhc or

2557
01:27:56,790 --> 01:27:55,199
something like super comic econo to

2558
01:27:59,030 --> 01:27:56,800
really explore the space of possible

2559
01:28:02,310 --> 01:27:59,040
chemistries in relation to uh possible

2560
01:28:04,149 --> 01:28:02,320
biospheres right so i'll i'll end there

2561
01:28:05,830 --> 01:28:04,159
hopefully i didn't go over time

2562
01:28:07,189 --> 01:28:05,840
so the main thing again is just that our

2563
01:28:08,629 --> 01:28:07,199

search for life is not independent of

2564
01:28:10,709 --> 01:28:08,639
life's origin

2565
01:28:13,030 --> 01:28:10,719
um we need to specifically test the

2566
01:28:14,550 --> 01:28:13,040
hypothesis that life is on a planet it

2567
01:28:16,070 --> 01:28:14,560
should not be the hypothesis of last

2568
01:28:17,669 --> 01:28:16,080
resort we need to

2569
01:28:19,669 --> 01:28:17,679
collect the data and information that we

2570
01:28:21,270 --> 01:28:19,679
need to evaluate the hypothesis in its

2571
01:28:23,350 --> 01:28:21,280
own right and not try to rule out all

2572
01:28:25,430 --> 01:28:23,360
possible abiotic worlds because that's

2573
01:28:28,470 --> 01:28:25,440
as big if not bigger than the space of

2574
01:28:30,149 --> 01:28:28,480
possible biotic worlds

2575
01:28:31,990 --> 01:28:30,159
i think we can agree that there are some

2576
01:28:34,229 --> 01:28:32,000
decisive biosignatures like directed

2577
01:28:37,189 --> 01:28:34,239
radio transmissions how do we find more

2578
01:28:38,629 --> 01:28:37,199
and if we can't how do we make

2579
01:28:40,149 --> 01:28:38,639
strong prior hypotheses about the

2580
01:28:42,310 --> 01:28:40,159
emergence of life or at least specific

2581
01:28:44,229 --> 01:28:42,320
living processes in given planetary

2582
01:28:45,510 --> 01:28:44,239
environments i think for both of those

2583
01:28:46,870 --> 01:28:45,520
we need a deeper integration of origin

2584
01:28:49,030 --> 01:28:46,880
of life and astrobiology and we need

2585
01:28:50,390 --> 01:28:49,040
these sort of large scale experiments to

2586
01:28:51,350 --> 01:28:50,400
try to rule out and reduce our

2587
01:28:54,570 --> 01:28:51,360
uncertainty about the space of

2588
01:29:01,030 --> 01:28:54,580

possibilities here and that's it thanks

2589
01:29:12,790 --> 01:29:02,550
thank you so much paul do we have any

2590
01:29:16,950 --> 01:29:15,030
nice talk thanks sean dominical golden

2591
01:29:18,709 --> 01:29:16,960
nasa goddard space flight center

2592
01:29:20,470 --> 01:29:18,719
um i wouldn't argue with any of the

2593
01:29:21,590 --> 01:29:20,480
conclusions with this question i'm about

2594
01:29:23,830 --> 01:29:21,600
to ask i think we definitely need to

2595
01:29:25,750 --> 01:29:23,840
fund more origins of life research

2596
01:29:27,110 --> 01:29:25,760
my question is um

2597
01:29:28,870 --> 01:29:27,120
short of something coming from a

2598
01:29:30,950 --> 01:29:28,880
communicating civilization or evidence

2599
01:29:33,030 --> 01:29:30,960
of a artificial production from

2600
01:29:34,470 --> 01:29:33,040
something like a civilization

2601
01:29:36,390 --> 01:29:34,480
is there anything that you would allow

2602
01:29:37,669 --> 01:29:36,400
as or some combination of signals that

2603
01:29:39,110 --> 01:29:37,679
you would allow as a decisive

2604
01:29:40,070 --> 01:29:39,120
biosignature

2605
01:29:42,629 --> 01:29:40,080
yeah so i think that's a really

2606
01:29:44,229 --> 01:29:42,639
interesting question and my answer is i

2607
01:29:46,390 --> 01:29:44,239
don't know but i think the way we need

2608
01:29:48,629 --> 01:29:46,400
to go about that is understanding

2609
01:29:51,270 --> 01:29:48,639
what is possible in principle with and

2610
01:29:53,030 --> 01:29:51,280
without life right and so the reason

2611
01:29:55,350 --> 01:29:53,040
sort of starting from the like directed

2612
01:29:57,110 --> 01:29:55,360
radio transmission the reason that is

2613
01:29:59,030 --> 01:29:57,120

unambiguous is because there's no

2614
01:30:00,950 --> 01:29:59,040
configuration of the world that like

2615
01:30:03,669 --> 01:30:00,960
would lead to that without life

2616
01:30:04,550 --> 01:30:03,679
and i think that we're in a stage where

2617
01:30:06,550 --> 01:30:04,560
we

2618
01:30:08,149 --> 01:30:06,560
are sort of not approaching the problem

2619
01:30:09,510 --> 01:30:08,159
in a way where we can frame that right

2620
01:30:10,950 --> 01:30:09,520
because we know that life doesn't

2621
01:30:13,430 --> 01:30:10,960
violate any of the laws of physics or

2622
01:30:14,950 --> 01:30:13,440
chemistry and so we start to like be

2623
01:30:17,030 --> 01:30:14,960
very uncertain about what is and is

2624
01:30:18,950 --> 01:30:17,040
impossible but i do think that like

2625
01:30:20,550 --> 01:30:18,960
that's one example there may be others

2626
01:30:22,629 --> 01:30:20,560
and and i think what we need to do that

2627
01:30:24,470 --> 01:30:22,639
is develop theories that help us sort of

2628
01:30:26,149 --> 01:30:24,480
see where those might be and then figure

2629
01:30:27,830 --> 01:30:26,159
out ways where we can test them on earth

2630
01:30:29,270 --> 01:30:27,840
right i think that's like really the

2631
01:30:31,270 --> 01:30:29,280
challenging thing

2632
01:30:33,030 --> 01:30:31,280
is figuring out ways where we can build

2633
01:30:34,470 --> 01:30:33,040
a hypothesis and also test it and

2634
01:30:39,189 --> 01:30:34,480
validate it and then go look for it

2635
01:30:44,149 --> 01:30:41,830
hey cole hello lou nasa goddard space

2636
01:30:46,310 --> 01:30:44,159
flight center um my question is uh can

2637
01:30:48,629 --> 01:30:46,320
you talk a little bit more about the

2638
01:30:50,950 --> 01:30:48,639

kinds of limitations in our interpretive

2639
01:30:53,030 --> 01:30:50,960
framework of real data that's coming

2640
01:30:56,070 --> 01:30:53,040
uh from missions um that are related to

2641
01:30:57,590 --> 01:30:56,080
astrobiology and the limitations that we

2642
01:30:59,270 --> 01:30:57,600
have in our detection methods that can

2643
01:31:00,830 --> 01:30:59,280
influence your probability numbers that

2644
01:31:03,350 --> 01:31:00,840
go into the bayesian

2645
01:31:05,910 --> 01:31:03,360
um equations

2646
01:31:07,270 --> 01:31:05,920
thanks yeah yeah i'll try so um

2647
01:31:08,550 --> 01:31:07,280
obviously there's a few different levels

2648
01:31:09,990 --> 01:31:08,560
right so what i was talking about today

2649
01:31:11,669 --> 01:31:10,000
was sort of assuming you had perfect

2650
01:31:14,870 --> 01:31:11,679
data that your observation is not

2651
01:31:17,430 --> 01:31:14,880
somehow noise right um and that's like a

2652
01:31:19,110 --> 01:31:17,440
theoretical sort of jump and the reason

2653
01:31:20,550 --> 01:31:19,120
i make that is i think when it comes to

2654
01:31:22,790 --> 01:31:20,560
like instrumentation noise and things

2655
01:31:24,310 --> 01:31:22,800
like that that that's like a technical

2656
01:31:25,910 --> 01:31:24,320
question that i think specialists that

2657
01:31:27,189 --> 01:31:25,920
already exist can sort of work out and

2658
01:31:29,750 --> 01:31:27,199
it's hard like i don't want to minimize

2659
01:31:31,430 --> 01:31:29,760
it i think it's super challenging um

2660
01:31:33,430 --> 01:31:31,440
but it's sort of like i think something

2661
01:31:36,629 --> 01:31:33,440
that we already know and understand how

2662
01:31:39,030 --> 01:31:36,639
to solve i think the challenge comes uh

2663
01:31:40,950 --> 01:31:39,040

from like evaluating and related to

2664
01:31:42,629 --> 01:31:40,960
sean's question like how will we ever

2665
01:31:43,990 --> 01:31:42,639
know that there are no false positives

2666
01:31:45,189 --> 01:31:44,000
right you like it's very difficult to

2667
01:31:47,430 --> 01:31:45,199
prove a negative

2668
01:31:48,870 --> 01:31:47,440
um and so then the question becomes like

2669
01:31:51,030 --> 01:31:48,880
how can we build

2670
01:31:51,910 --> 01:31:51,040
uh sort of analysis frameworks where we

2671
01:31:54,149 --> 01:31:51,920
can

2672
01:31:55,750 --> 01:31:54,159
really try to push the limits on what it

2673
01:31:57,750 --> 01:31:55,760
you know how do we like sort of load the

2674
01:31:59,510 --> 01:31:57,760
dice in the favor so we can be like okay

2675
01:32:01,350 --> 01:31:59,520
what's the most likely false positive

2676
01:32:03,110 --> 01:32:01,360
and how do we really force that and then

2677
01:32:04,550 --> 01:32:03,120
ask the question like okay could we ever

2678
01:32:06,790 --> 01:32:04,560
actually force that if it wasn't for

2679
01:32:07,750 --> 01:32:06,800
living systems um i don't know if that

2680
01:32:09,510 --> 01:32:07,760
answers your question or if you're

2681
01:32:14,310 --> 01:32:09,520
asking something more specific we can

2682
01:32:18,390 --> 01:32:16,629
all right thank you very much cole