Ask An Astrobiologist

Episode 47: February 3rd, 2022

Dr. Mark Skidmore

NASA Astrobiology Program

1
00:00:01,120 --> 00:00:30,230
[Music]

2
00:00:35,830 --> 00:00:33,350
greetings friends fellow earthlings and

3
00:00:38,790 --> 00:00:35,840
explorers of life on earth and maybe

4
00:00:41,190 --> 00:00:38,800
beyond welcome to ask an astrobiologist

5
00:00:43,350 --> 00:00:41,200
the show that celebrates the science

6
00:00:45,110 --> 00:00:43,360
and celebrates the scientists involved

7
00:00:45,990 --> 00:00:45,120
in our quest to understand the nature of

8
00:00:48,229 --> 00:00:46,000
life

9
00:00:49,990 --> 00:00:48,239
i'm your host with the most dr graham

10
00:00:51,350 --> 00:00:50,000
the space beard lao

11
00:00:54,709 --> 00:00:51,360
and we're brought to you by the nasa

12
00:00:56,630 --> 00:00:54,719
astrobiology program and sagonet.org

13
00:00:58,790 --> 00:00:56,640

as always it's such a huge pleasure to

14
00:01:00,549 --> 00:00:58,800
be here to join all of you to be able to

15
00:01:02,310 --> 00:01:00,559
ask our world-renowned researchers in

16
00:01:04,549 --> 00:01:02,320
astrobiology the questions that we have

17
00:01:06,390 --> 00:01:04,559
about life out there we're also very

18
00:01:08,310 --> 00:01:06,400
thankful for all of you out there in the

19
00:01:10,550 --> 00:01:08,320
twitterverse and instagram and ticktalk

20
00:01:13,030 --> 00:01:10,560
and everywhere else sharing information

21
00:01:15,350 --> 00:01:13,040
about our guests about our show we want

22
00:01:17,109 --> 00:01:15,360
to highlight this month the enfold

23
00:01:19,830 --> 00:01:17,119
account that's the network for life

24
00:01:21,990 --> 00:01:19,840
detection uh the account is at life

25
00:01:24,230 --> 00:01:22,000
detection on twitter uh and a special

26
00:01:26,550 --> 00:01:24,240
thanks to joey pasterski uh for helping

27
00:01:28,710 --> 00:01:26,560
to manage and lead that account and for

28
00:01:30,789 --> 00:01:28,720
sharing information about our show with

29
00:01:32,469 --> 00:01:30,799
their audience as well

30
00:01:34,069 --> 00:01:32,479
now this month's episode is going to be

31
00:01:36,149 --> 00:01:34,079
pretty awesome especially near and dear

32
00:01:37,990 --> 00:01:36,159
to my heart since i've done research in

33
00:01:40,390 --> 00:01:38,000
polar environments and trying to

34
00:01:42,230 --> 00:01:40,400
understand how life and a glacial system

35
00:01:44,069 --> 00:01:42,240
can help us learn more about life out

36
00:01:46,310 --> 00:01:44,079
there this month we're going to be

37
00:01:47,830 --> 00:01:46,320
chatting with dr mark skidmore a

38
00:01:50,550 --> 00:01:47,840

professor in the department of earth

39
00:01:52,630 --> 00:01:50,560
sciences at montana state university

40
00:01:55,510 --> 00:01:52,640
uh dr skidmore conducts research on the

41
00:01:58,149 --> 00:01:55,520
biogeochemistry and geomicrobiology of

42
00:02:01,190 --> 00:01:58,159
glacial systems examining the cycling of

43
00:02:03,910 --> 00:02:01,200
elements such as carbon sulfur nitrogen

44
00:02:06,550 --> 00:02:03,920
and iron in these systems his research

45
00:02:09,029 --> 00:02:06,560
also considers the habitability of icy

46
00:02:11,430 --> 00:02:09,039
terrestrial environments especially

47
00:02:13,270 --> 00:02:11,440
sub-glacial systems and how this can

48
00:02:15,190 --> 00:02:13,280
guide our search for habitable

49
00:02:17,910 --> 00:02:15,200
environments elsewhere in the solar

50
00:02:20,229 --> 00:02:17,920
system dr skidmore has fueled research

51
00:02:21,589 --> 00:02:20,239
experience in numerous glaciated systems

52
00:02:23,910 --> 00:02:21,599
in the arctic

53
00:02:27,750 --> 00:02:23,920
and alpine regions and the antarctic

54
00:02:30,470 --> 00:02:27,760
over 25 years of exploration and study

55
00:02:32,229 --> 00:02:30,480
so welcome to ask an astrobiologist dr

56
00:02:33,750 --> 00:02:32,239
mark skidmore

57
00:02:35,509 --> 00:02:33,760
hi how's it going

58
00:02:37,750 --> 00:02:35,519
it's going quite well thanks for joining

59
00:02:39,589 --> 00:02:37,760
us uh it felt like a glacier environment

60
00:02:41,750 --> 00:02:39,599
in my my office here a little bit ago

61
00:02:43,190 --> 00:02:41,760
until i got my heater working um you do

62
00:02:45,509 --> 00:02:43,200
have to love those cold systems and

63
00:02:47,270 --> 00:02:45,519

being in them um i think there's a lot

64
00:02:49,750 --> 00:02:47,280
to be said for those of us who've chosen

65
00:02:51,270 --> 00:02:49,760
to go out and explore those systems um

66
00:02:52,869 --> 00:02:51,280
so i'm very glad to have you on the show

67
00:02:55,990 --> 00:02:52,879
to talk about your research in glacial

68
00:02:58,390 --> 00:02:56,000
environments yeah pleased to be here

69
00:03:00,070 --> 00:02:58,400
well so for every episode we have we

70
00:03:01,910 --> 00:03:00,080
like to start off before we talk a bit

71
00:03:03,670 --> 00:03:01,920
more about your your current research

72
00:03:06,309 --> 00:03:03,680
and and the ways your research ties into

73
00:03:07,990 --> 00:03:06,319
astrobiology we like to hear what got

74
00:03:10,710 --> 00:03:08,000
you into the science that you're doing

75
00:03:13,589 --> 00:03:10,720
what is your science origin story that

76
00:03:15,910 --> 00:03:13,599
got you from young mark skidmore to dr

77
00:03:17,110 --> 00:03:15,920
mark skidmore uh the glaciologist and

78
00:03:19,910 --> 00:03:17,120
researcher

79
00:03:22,149 --> 00:03:19,920
yeah so um i think this goes back to if

80
00:03:23,750 --> 00:03:22,159
we think about right you know formative

81
00:03:24,869 --> 00:03:23,760
years really sort of like middle and

82
00:03:26,949 --> 00:03:24,879
high school

83
00:03:29,030 --> 00:03:26,959
um i was really fortunate had you know

84
00:03:32,070 --> 00:03:29,040
good science background teachers in sort

85
00:03:33,670 --> 00:03:32,080
of like chemistry biology physics but um

86
00:03:36,070 --> 00:03:33,680
teachers

87
00:03:37,110 --> 00:03:36,080
that taught me geography this is in the

88
00:03:37,990 --> 00:03:37,120

uk

89
00:03:44,149 --> 00:03:38,000
um

90
00:03:47,589 --> 00:03:44,159
to not the no glaciers in the uk right

91
00:03:49,670 --> 00:03:47,599
now but there are glaciated environments

92
00:03:51,830 --> 00:03:49,680
so we went out and looked at these

93
00:03:53,589 --> 00:03:51,840
different glaciated environments and

94
00:03:55,589 --> 00:03:53,599
that got me kind of interested in in

95
00:03:57,190 --> 00:03:55,599
that aspect of sort of earth science or

96
00:03:59,030 --> 00:03:57,200
the earth system

97
00:04:01,670 --> 00:03:59,040
and then when i got to

98
00:04:03,750 --> 00:04:01,680
university as an undergraduate the first

99
00:04:05,990 --> 00:04:03,760
week or so i was there i talked to a

100
00:04:07,910 --> 00:04:06,000
student who was a third year like to a

101
00:04:10,470 --> 00:04:07,920
senior at the university

102
00:04:12,229 --> 00:04:10,480
and he was telling me about oh he'd been

103
00:04:15,350 --> 00:04:12,239
on this really cool glacier research

104
00:04:17,590 --> 00:04:15,360
project the past summer so then i was

105
00:04:20,390 --> 00:04:17,600
like oh okay so i went and talked to the

106
00:04:21,990 --> 00:04:20,400
professor involved and said hey

107
00:04:24,390 --> 00:04:22,000
this sounds interesting would there be

108
00:04:26,469 --> 00:04:24,400
an opportunity to join this research

109
00:04:28,070 --> 00:04:26,479
project next summer he sort of said okay

110
00:04:30,310 --> 00:04:28,080
well you know this is

111
00:04:31,990 --> 00:04:30,320
september october time we'll be figuring

112
00:04:33,670 --> 00:04:32,000
that out in the spring

113
00:04:36,310 --> 00:04:33,680

and then yeah i went and joined that

114
00:04:38,950 --> 00:04:36,320
research project for the following three

115
00:04:40,310 --> 00:04:38,960
summers uh on a glacier in the in the

116
00:04:43,350 --> 00:04:40,320
swiss alps

117
00:04:45,270 --> 00:04:43,360
and um yeah so it's cool and i really

118
00:04:47,830 --> 00:04:45,280
got into studying they were more

119
00:04:49,749 --> 00:04:47,840
interested in hydrology and chemistry of

120
00:04:52,390 --> 00:04:49,759
the environments rather than

121
00:04:54,390 --> 00:04:52,400
microbiology at that stage this was

122
00:04:55,909 --> 00:04:54,400
25 plus years ago

123
00:04:58,710 --> 00:04:55,919
but i studied the chemistry of the

124
00:04:59,670 --> 00:04:58,720
snowpack as sort of an honest thesis

125
00:05:02,310 --> 00:04:59,680
um

126
00:05:05,110 --> 00:05:02,320
and then after doing my undergraduate i

127
00:05:07,270 --> 00:05:05,120
then went on to do graduate studies the

128
00:05:09,189 --> 00:05:07,280
professor from cambridge moved to

129
00:05:12,390 --> 00:05:09,199
alberta um

130
00:05:15,189 --> 00:05:12,400
in in canada and i went there to do my

131
00:05:17,510 --> 00:05:15,199
grad research and again we were looking

132
00:05:19,909 --> 00:05:17,520
at a glacier up in the canadian high

133
00:05:21,590 --> 00:05:19,919
arctic this time upon ellesmere island

134
00:05:23,590 --> 00:05:21,600
in nunavut canada

135
00:05:24,710 --> 00:05:23,600
and that was looking again trying to

136
00:05:27,590 --> 00:05:24,720
understand

137
00:05:30,469 --> 00:05:27,600
the glacial hydrology the subglacial

138
00:05:32,870 --> 00:05:30,479

hydrology the chemistry of these systems

139
00:05:35,350 --> 00:05:32,880
and i was really trying to understand

140
00:05:37,749 --> 00:05:35,360
how carbon might be cycled in these in

141
00:05:40,469 --> 00:05:37,759
these environments and of course

142
00:05:41,990 --> 00:05:40,479
you have a good committee member and the

143
00:05:43,909 --> 00:05:42,000
committee member who was actually an

144
00:05:46,150 --> 00:05:43,919
isotope geochemist said oh well if

145
00:05:47,830 --> 00:05:46,160
you're going to study carbon cycling

146
00:05:50,230 --> 00:05:47,840
you you should really think about if

147
00:05:51,990 --> 00:05:50,240
there's a biological component and at

148
00:05:54,390 --> 00:05:52,000
that time that wasn't something that so

149
00:05:56,870 --> 00:05:54,400
many folk really thought about

150
00:05:58,710 --> 00:05:56,880
so then i went over to the department of

151
00:06:00,309 --> 00:05:58,720
uh microbiology

152
00:06:02,710 --> 00:06:00,319
talked to a prof there

153
00:06:05,430 --> 00:06:02,720
she gave me all these cool you know this

154
00:06:08,550 --> 00:06:05,440
equipment and sampling

155
00:06:09,909 --> 00:06:08,560
you know devices and enrichment media so

156
00:06:13,029 --> 00:06:09,919
then i went and took it out to the

157
00:06:15,110 --> 00:06:13,039
glacier and collected samples uh

158
00:06:18,390 --> 00:06:15,120
enriched them some of them there and

159
00:06:20,550 --> 00:06:18,400
then also collected samples to take back

160
00:06:22,950 --> 00:06:20,560
um and then yeah the the samples we

161
00:06:24,550 --> 00:06:22,960
enriched in the field you know

162
00:06:26,870 --> 00:06:24,560
once they grew wildly but there was a

163
00:06:28,629 --> 00:06:26,880

lot of biomass and growth in in you know

164
00:06:31,189 --> 00:06:28,639
the big carboy that i'd added all this

165
00:06:33,110 --> 00:06:31,199
media to from the glacier waters and so

166
00:06:36,070 --> 00:06:33,120
then we did some

167
00:06:37,510 --> 00:06:36,080
experiments on the the basal ice so

168
00:06:39,430 --> 00:06:37,520
that's the ice at the bottom of the

169
00:06:41,510 --> 00:06:39,440
glacier so where the ice flows on the

170
00:06:43,830 --> 00:06:41,520
bottom of the glacier scrapes long

171
00:06:45,749 --> 00:06:43,840
material that freezes onto the bed it's

172
00:06:48,870 --> 00:06:45,759
got lots of really fine grained

173
00:06:52,550 --> 00:06:48,880
sediments and so those fine-grained

174
00:06:55,909 --> 00:06:52,560
sediments can provide potential you know

175
00:07:00,230 --> 00:06:55,919
carbon and or energy sources uh for for

176
00:07:01,749 --> 00:07:00,240
the microbes um so yeah they um

177
00:07:05,350 --> 00:07:01,759
you know so then we ended up doing a

178
00:07:06,950 --> 00:07:05,360
whole bunch of research on uh those um

179
00:07:09,589 --> 00:07:06,960
those sediments and were able to

180
00:07:11,830 --> 00:07:09,599
demonstrate that there were a range of

181
00:07:13,350 --> 00:07:11,840
organisms so there are organisms that

182
00:07:15,029 --> 00:07:13,360
are just sort of what i would call like

183
00:07:17,110 --> 00:07:15,039
normal or

184
00:07:19,670 --> 00:07:17,120
heterotrophs organic aerobic

185
00:07:21,589 --> 00:07:19,680
heterotrophs um but then we're also able

186
00:07:24,230 --> 00:07:21,599
to uh grow

187
00:07:26,390 --> 00:07:24,240
um at cold temperatures so all of our

188
00:07:28,390 --> 00:07:26,400

experiments were done like in the fridge

189
00:07:30,710 --> 00:07:28,400
um or at fridge temperatures we're able

190
00:07:34,390 --> 00:07:30,720
to grow organisms that were capable of

191
00:07:37,029 --> 00:07:34,400
reducing nitrate or sulfate or

192
00:07:39,270 --> 00:07:37,039
producing methane so methanogens and the

193
00:07:41,749 --> 00:07:39,280
interesting thing about those organisms

194
00:07:44,230 --> 00:07:41,759
is that they basically they're they're

195
00:07:46,550 --> 00:07:44,240
anaerobes they don't require oxygen and

196
00:07:48,550 --> 00:07:46,560
these experiments that we did you take

197
00:07:51,270 --> 00:07:48,560
the ice from the base and you melt it

198
00:07:53,749 --> 00:07:51,280
down and you put it under you know an

199
00:07:56,550 --> 00:07:53,759
anaerobic head space without oxygen and

200
00:07:57,510 --> 00:07:56,560
these organisms you know grow and thrive

201
00:07:59,990 --> 00:07:57,520
so

202
00:08:03,189 --> 00:08:00,000
that's kind of how i got into it and it

203
00:08:05,189 --> 00:08:03,199
was pretty cool uh set of results

204
00:08:06,469 --> 00:08:05,199
that's such a cool pathway too

205
00:08:07,749 --> 00:08:06,479
i love you know one there's the

206
00:08:09,510 --> 00:08:07,759
connection to great teachers and

207
00:08:11,430 --> 00:08:09,520
advisors and committee members along the

208
00:08:12,869 --> 00:08:11,440
way that have kind of been there for you

209
00:08:14,629 --> 00:08:12,879
to help you along you know in developing

210
00:08:15,909 --> 00:08:14,639
your career but then also just you know

211
00:08:17,350 --> 00:08:15,919
just that thought of like the early

212
00:08:19,589 --> 00:08:17,360
geography of trying to think about these

213
00:08:21,270 --> 00:08:19,599

old glaciated systems to more modern

214
00:08:23,350 --> 00:08:21,280
systems i grew up in the great lakes

215
00:08:24,710 --> 00:08:23,360
region of north america and so as a

216
00:08:26,390 --> 00:08:24,720
young child i was always kind of just

217
00:08:28,469 --> 00:08:26,400
enthused by this idea that glaciers

218
00:08:30,150 --> 00:08:28,479
could carve the environment even though

219
00:08:32,070 --> 00:08:30,160
there aren't any glaciers present

220
00:08:33,509 --> 00:08:32,080
anymore and so i was kind of found that

221
00:08:35,269 --> 00:08:33,519
a little shocking

222
00:08:37,350 --> 00:08:35,279
i've also been fortunate to go up to

223
00:08:39,350 --> 00:08:37,360
northern canada to do research

224
00:08:41,190 --> 00:08:39,360
i once asked some people there what

225
00:08:43,110 --> 00:08:41,200
would you call a scientist uh in the

226
00:08:44,470 --> 00:08:43,120
noctituck and they didn't actually know

227
00:08:47,430 --> 00:08:44,480
but they did say that they would call me

228
00:08:48,790 --> 00:08:47,440
an umlick which is uh is enoch for a

229
00:08:50,710 --> 00:08:48,800
bearded person

230
00:08:52,070 --> 00:08:50,720
which i thought was pretty funny um but

231
00:08:54,310 --> 00:08:52,080
it is very cool to hear about you know

232
00:08:56,070 --> 00:08:54,320
this this you know sequence of research

233
00:08:57,590 --> 00:08:56,080
that you had through ella's mirror and

234
00:09:00,070 --> 00:08:57,600
now you've been in so many different

235
00:09:01,829 --> 00:09:00,080
environments around the world uh we did

236
00:09:04,230 --> 00:09:01,839
share through the nasa astrobiology

237
00:09:06,550 --> 00:09:04,240
twitter account a poll uh we said you

238
00:09:08,550 --> 00:09:06,560

know our next guest dr mark skidmore

239
00:09:10,070 --> 00:09:08,560
studies environments that are cold salty

240
00:09:12,630 --> 00:09:10,080
and lack oxygen

241
00:09:14,870 --> 00:09:12,640
which is a great analog for europa which

242
00:09:16,550 --> 00:09:14,880
is a nice astrobiology target but we

243
00:09:18,630 --> 00:09:16,560
also want to know what other world kind

244
00:09:21,350 --> 00:09:18,640
of fits that description we gave people

245
00:09:24,550 --> 00:09:21,360
the option of saturn venus mercury or

246
00:09:27,190 --> 00:09:24,560
mars and over 52 percent of our

247
00:09:28,870 --> 00:09:27,200
respondents at nearly 400 votes

248
00:09:30,790 --> 00:09:28,880
all said mars

249
00:09:33,030 --> 00:09:30,800
which is the correct answer there are

250
00:09:35,430 --> 00:09:33,040
cold salty and lacking oxygen kinds of

251
00:09:37,430 --> 00:09:35,440
environments for just that kind of

252
00:09:38,389 --> 00:09:37,440
biology that you're discussing on mars

253
00:09:39,670 --> 00:09:38,399
as well

254
00:09:41,110 --> 00:09:39,680
and so one thing i wanted to ask you

255
00:09:42,870 --> 00:09:41,120
about was

256
00:09:44,949 --> 00:09:42,880
some of your early research was

257
00:09:46,710 --> 00:09:44,959
connected to this martian polar science

258
00:09:48,550 --> 00:09:46,720
conference that you attended which was

259
00:09:50,550 --> 00:09:48,560
right around the time that the nasa

260
00:09:53,590 --> 00:09:50,560
astrobiology program was really being

261
00:09:55,509 --> 00:09:53,600
being born and created at nasa and so

262
00:09:57,269 --> 00:09:55,519
i'd love to hear the transition in your

263
00:09:59,910 --> 00:09:57,279

research from this martian polar science

264
00:10:01,670 --> 00:09:59,920
conference then to more analog kind of

265
00:10:02,630 --> 00:10:01,680
based research in glacial systems as

266
00:10:04,389 --> 00:10:02,640
well

267
00:10:07,269 --> 00:10:04,399
yeah now i was really fortunate i went

268
00:10:09,670 --> 00:10:07,279
to the uh first conference on on marsh

269
00:10:11,829 --> 00:10:09,680
polo martian polar science it was back

270
00:10:14,710 --> 00:10:11,839
in 1998

271
00:10:17,110 --> 00:10:14,720
and um yeah i was a graduate student and

272
00:10:21,350 --> 00:10:17,120
i really got exposed there to you know a

273
00:10:22,790 --> 00:10:21,360
whole plethora of um talks and everybody

274
00:10:25,670 --> 00:10:22,800
the vast majority of folks there were

275
00:10:28,389 --> 00:10:25,680
focused on you know uh much more sort of

276
00:10:30,710 --> 00:10:28,399
physical sciences of the martian polls

277
00:10:32,949 --> 00:10:30,720
and understanding the polar caps and how

278
00:10:34,310 --> 00:10:32,959
they operate and

279
00:10:36,150 --> 00:10:34,320
and yeah it was just

280
00:10:38,870 --> 00:10:36,160
a very interesting

281
00:10:40,870 --> 00:10:38,880
conference to go to

282
00:10:42,710 --> 00:10:40,880
and learn about that and also present my

283
00:10:44,710 --> 00:10:42,720
research and say hey

284
00:10:47,590 --> 00:10:44,720
these environments are not necessarily

285
00:10:48,389 --> 00:10:47,600
perfect analogues for mars but you know

286
00:10:50,949 --> 00:10:48,399
they're

287
00:10:53,430 --> 00:10:50,959
systems where we're looking at you know

288
00:10:55,030 --> 00:10:53,440

debris rich ices ices that have lots of

289
00:10:57,269 --> 00:10:55,040
debris and there are certainly

290
00:10:58,230 --> 00:10:57,279
environments on mars where one can think

291
00:11:00,310 --> 00:10:58,240
about

292
00:11:03,110 --> 00:11:00,320
there being uh environments where

293
00:11:06,069 --> 00:11:03,120
there's ice uh that contains uh a

294
00:11:08,230 --> 00:11:06,079
reasonable amount of debris um so yeah

295
00:11:10,870 --> 00:11:08,240
and then after after that that just got

296
00:11:12,949 --> 00:11:10,880
me thinking more than just focusing on

297
00:11:14,870 --> 00:11:12,959
you know on on earth one of the

298
00:11:17,110 --> 00:11:14,880
driving questions at that time was hey

299
00:11:20,230 --> 00:11:17,120
originally like are there organisms

300
00:11:22,230 --> 00:11:20,240
there yes there are how are they active

301
00:11:24,150 --> 00:11:22,240
yes they are are they active at like

302
00:11:24,949 --> 00:11:24,160
sort of in-situ temperatures yes they

303
00:11:27,110 --> 00:11:24,959
are

304
00:11:29,350 --> 00:11:27,120
um you know but then it was like okay

305
00:11:31,430 --> 00:11:29,360
well how could these systems then

306
00:11:33,509 --> 00:11:31,440
potentially guide us

307
00:11:35,910 --> 00:11:33,519
to to look for life elsewhere simply

308
00:11:38,230 --> 00:11:35,920
that you know you go out in in the in

309
00:11:40,470 --> 00:11:38,240
the solar system and you know nasa's

310
00:11:42,389 --> 00:11:40,480
manta was like follow the water

311
00:11:45,590 --> 00:11:42,399
but then it's like okay follow the water

312
00:11:48,389 --> 00:11:45,600
but also the water on a lot of um

313
00:11:52,710 --> 00:11:48,399

planets is in the form of ice or it's at

314
00:11:55,110 --> 00:11:52,720
least ice covering uh a body of water

315
00:11:57,110 --> 00:11:55,120
very cool yeah um i do so before we talk

316
00:11:58,710 --> 00:11:57,120
a bit more about these icy systems i do

317
00:12:00,230 --> 00:11:58,720
want to ask what is your coolest

318
00:12:01,590 --> 00:12:00,240
experience that you've had and you've

319
00:12:02,710 --> 00:12:01,600
been in the field so many times and have

320
00:12:04,550 --> 00:12:02,720
been to different places around the

321
00:12:06,389 --> 00:12:04,560
world what is the coolest experience

322
00:12:08,470 --> 00:12:06,399
you've had on a glacier

323
00:12:12,230 --> 00:12:08,480
yeah so i think that goes back to my

324
00:12:15,030 --> 00:12:12,240
graduate work when um we were working on

325
00:12:18,629 --> 00:12:15,040
so the the glaciers um

326
00:12:20,550 --> 00:12:18,639
the the glacier in in elsmere it's uh

327
00:12:22,230 --> 00:12:20,560
what's called a polythermal glacier so

328
00:12:25,110 --> 00:12:22,240
that means there's sort of two types of

329
00:12:27,350 --> 00:12:25,120
ice there's ice right at the margin of

330
00:12:28,949 --> 00:12:27,360
the glacier that's frozen to the bed

331
00:12:30,949 --> 00:12:28,959
because it's really cold it's about like

332
00:12:32,710 --> 00:12:30,959
80 degrees north so the

333
00:12:35,829 --> 00:12:32,720
the ice at the margin is frozen to the

334
00:12:38,069 --> 00:12:35,839
bed but the ice um behind it further

335
00:12:39,430 --> 00:12:38,079
upstream is what we call tempradis so

336
00:12:41,990 --> 00:12:39,440
that'll have a

337
00:12:43,990 --> 00:12:42,000
water at the bed of the ice

338
00:12:46,069 --> 00:12:44,000

and um so

339
00:12:48,870 --> 00:12:46,079
water comes in from the surface or water

340
00:12:51,350 --> 00:12:48,880
builds up in the subglacial environment

341
00:12:53,110 --> 00:12:51,360
and it can't break through that um that

342
00:12:54,389 --> 00:12:53,120
frozen ice barrier because it's frozen

343
00:12:56,710 --> 00:12:54,399
to the bed

344
00:12:57,750 --> 00:12:56,720
and what happens is that at some point

345
00:12:59,350 --> 00:12:57,760
in time

346
00:13:02,310 --> 00:12:59,360
there's enough water pressure builds

347
00:13:04,710 --> 00:13:02,320
back up that you end up with the water

348
00:13:06,310 --> 00:13:04,720
being sort of blasted out of the surface

349
00:13:08,629 --> 00:13:06,320
of the glacier and you can get a

350
00:13:10,550 --> 00:13:08,639
fountain right that comes up out of the

351
00:13:11,670 --> 00:13:10,560
glacier i know you're probably at least

352
00:13:14,550 --> 00:13:11,680
uh

353
00:13:17,110 --> 00:13:14,560
100 or more feet above the you know

354
00:13:19,269 --> 00:13:17,120
whether where the glacier bed is

355
00:13:20,710 --> 00:13:19,279
and so the water blasts up out of that

356
00:13:22,389 --> 00:13:20,720
and we're like cool well we can go

357
00:13:25,350 --> 00:13:22,399
sample that because that's water that's

358
00:13:28,310 --> 00:13:25,360
come in directly from the glacier bed

359
00:13:30,389 --> 00:13:28,320
but when we were doing it um the water

360
00:13:32,790 --> 00:13:30,399
has forced its way up to the glacier bed

361
00:13:34,389 --> 00:13:32,800
through pressure and fracturing and so

362
00:13:35,269 --> 00:13:34,399
when i was working there

363
00:13:37,990 --> 00:13:35,279

um

364
00:13:40,230 --> 00:13:38,000
working with a field assistant and we're

365
00:13:43,750 --> 00:13:40,240
working collecting samples and then

366
00:13:49,110 --> 00:13:46,310
zippering noise and in front of us we

367
00:13:50,230 --> 00:13:49,120
were standing next to this uh water

368
00:13:52,629 --> 00:13:50,240
fountain

369
00:13:54,790 --> 00:13:52,639
and so then the glacier in front of us

370
00:13:56,949 --> 00:13:54,800
going back up the glacier basically

371
00:13:59,189 --> 00:13:56,959
fractured in front of us hydro fractured

372
00:14:00,230 --> 00:13:59,199
and just sort of went

373
00:14:02,870 --> 00:14:00,240
and so

374
00:14:05,910 --> 00:14:02,880
we were both like okay maybe we'll just

375
00:14:07,189 --> 00:14:05,920
move a little bit to the side um

376
00:14:11,670 --> 00:14:07,199
and uh

377
00:14:12,710 --> 00:14:11,680
of that i mean the fracture wasn't big

378
00:14:14,949 --> 00:14:12,720
enough for

379
00:14:16,389 --> 00:14:14,959
uh an individual to like fall into it

380
00:14:17,590 --> 00:14:16,399
wasn't like we would be falling into the

381
00:14:19,269 --> 00:14:17,600
chasm

382
00:14:22,629 --> 00:14:19,279
but it was a very much a reminder that

383
00:14:25,750 --> 00:14:22,639
we were in a very active uh dynamic uh

384
00:14:26,870 --> 00:14:25,760
system and so i think that's probably

385
00:14:28,310 --> 00:14:26,880
um

386
00:14:31,030 --> 00:14:28,320
yeah probably the coolest or certainly

387
00:14:32,389 --> 00:14:31,040
the most surprising um you know thing

388
00:14:34,389 --> 00:14:32,399

that happened to me maybe in one of

389
00:14:36,150 --> 00:14:34,399
those things nice yeah it sounds like it

390
00:14:38,230 --> 00:14:36,160
could be a big shocker just watching the

391
00:14:40,230 --> 00:14:38,240
watching the ice unzip in front of you

392
00:14:41,670 --> 00:14:40,240
um so yes with these glacial systems i

393
00:14:43,269 --> 00:14:41,680
mean obviously so we mentioned that mars

394
00:14:45,590 --> 00:14:43,279
can be an analog you know analog for

395
00:14:47,590 --> 00:14:45,600
martian sites there's also an analog for

396
00:14:49,990 --> 00:14:47,600
europa and enceladus and these these icy

397
00:14:51,350 --> 00:14:50,000
worlds um specifically we do have sites

398
00:14:53,269 --> 00:14:51,360
you know where there are lakes

399
00:14:55,030 --> 00:14:53,279
underneath of these glaciers that can

400
00:14:56,790 --> 00:14:55,040
serve as a way for us to explore what

401
00:14:59,269 --> 00:14:56,800
it's like to drill down through the ice

402
00:15:01,990 --> 00:14:59,279
and then to access materials in a lake

403
00:15:05,189 --> 00:15:02,000
or at the base of the glacier down below

404
00:15:06,470 --> 00:15:05,199
which is a good analog for europa

405
00:15:08,629 --> 00:15:06,480
if we ever do drill through the ice of

406
00:15:10,949 --> 00:15:08,639
europa or just understanding some of the

407
00:15:13,030 --> 00:15:10,959
the the dynamics of exchange of

408
00:15:15,350 --> 00:15:13,040
materials through the ice from that that

409
00:15:17,110 --> 00:15:15,360
ocean or lake down below uh and you've

410
00:15:18,949 --> 00:15:17,120
been involved in the salsa project the

411
00:15:21,189 --> 00:15:18,959
subglacial antarctic lake scientific

412
00:15:22,870 --> 00:15:21,199
access project uh i'd love to hear more

413
00:15:25,590 --> 00:15:22,880

about that research specifically about

414
00:15:28,870 --> 00:15:25,600
drilling down into lakes like that

415
00:15:31,910 --> 00:15:28,880
yeah for sure and so um i'm involved the

416
00:15:34,389 --> 00:15:31,920
salsa project is uh sort of the latest

417
00:15:36,790 --> 00:15:34,399
iteration of uh antarctic so glacial

418
00:15:38,949 --> 00:15:36,800
drilling um i was actually involved in a

419
00:15:40,870 --> 00:15:38,959
previous project that was called wizard

420
00:15:42,150 --> 00:15:40,880
and that was just another acronym but we

421
00:15:44,790 --> 00:15:42,160
were just drilling into a different

422
00:15:46,470 --> 00:15:44,800
subglacial lake in west antarctica

423
00:15:47,990 --> 00:15:46,480
and so yeah the premise here is that

424
00:15:51,189 --> 00:15:48,000
we're drilling through

425
00:15:53,829 --> 00:15:51,199
you know a kilometer of ice to access a

426
00:15:55,670 --> 00:15:53,839
lake beneath that ice uh you know that's

427
00:15:57,590 --> 00:15:55,680
like in in the case of salsa we were

428
00:15:59,189 --> 00:15:57,600
drilling into subglacial like mercer in

429
00:16:01,670 --> 00:15:59,199
west antarctica

430
00:16:04,150 --> 00:16:01,680
uh and the lake uh when we sampled it

431
00:16:06,790 --> 00:16:04,160
was about 14 meters deep

432
00:16:08,550 --> 00:16:06,800
um and so

433
00:16:11,430 --> 00:16:08,560
one of the cool things there though is

434
00:16:13,590 --> 00:16:11,440
that a lot of work went into and people

435
00:16:17,269 --> 00:16:13,600
think about this from an astrobiological

436
00:16:20,470 --> 00:16:17,279
perspective of clean access sampling

437
00:16:21,350 --> 00:16:20,480
right so we spend a lot of time

438
00:16:23,110 --> 00:16:21,360

not

439
00:16:24,710 --> 00:16:23,120
just for the salsa project but the

440
00:16:27,189 --> 00:16:24,720
technology was really developed for the

441
00:16:31,430 --> 00:16:27,199
prior project called wizard but was to

442
00:16:33,590 --> 00:16:31,440
build um a system that cleans the water

443
00:16:36,150 --> 00:16:33,600
so we access these lakes using a hot

444
00:16:39,110 --> 00:16:36,160
water drill so that's basically like

445
00:16:39,910 --> 00:16:39,120
high temperature hot water 80 85 degrees

446
00:16:41,829 --> 00:16:39,920
c

447
00:16:43,110 --> 00:16:41,839
and you blast it down and you make a

448
00:16:44,470 --> 00:16:43,120
hole to the

449
00:16:45,590 --> 00:16:44,480
you know through the ice with the hot

450
00:16:47,910 --> 00:16:45,600
water

451
00:16:50,069 --> 00:16:47,920
but one of the key things is making sure

452
00:16:53,030 --> 00:16:50,079
that that water that you're putting down

453
00:16:55,590 --> 00:16:53,040
there is clean or as clean as you can

454
00:16:59,269 --> 00:16:55,600
possibly get it um so that you're not

455
00:17:01,829 --> 00:16:59,279
introducing like external uh microbes

456
00:17:03,590 --> 00:17:01,839
into this pristine environment and so we

457
00:17:05,350 --> 00:17:03,600
kind of get around that in two ways one

458
00:17:07,510 --> 00:17:05,360
is obviously if you take the snow from

459
00:17:09,110 --> 00:17:07,520
the surface that's the natural

460
00:17:11,990 --> 00:17:09,120
environment or that's the naturally

461
00:17:13,669 --> 00:17:12,000
occurring you know um you know material

462
00:17:15,669 --> 00:17:13,679
in that in that environment

463
00:17:20,390 --> 00:17:15,679

and then we put it through a series of

464
00:17:22,150 --> 00:17:20,400
filters um and um uv banks and so

465
00:17:24,630 --> 00:17:22,160
there's basically a big filtration

466
00:17:25,350 --> 00:17:24,640
system inside uh

467
00:17:30,390 --> 00:17:25,360
on

468
00:17:32,470 --> 00:17:30,400
we built this system tested it

469
00:17:34,470 --> 00:17:32,480
here at montana state and then shipped

470
00:17:35,990 --> 00:17:34,480
it down to antarctica and that's what

471
00:17:38,070 --> 00:17:36,000
was used on both of these drilling

472
00:17:39,590 --> 00:17:38,080
projects and so then the idea is that

473
00:17:40,870 --> 00:17:39,600
then the water that you and we would

474
00:17:43,990 --> 00:17:40,880
test it out there are all kinds of

475
00:17:46,390 --> 00:17:44,000
sampling ports uh within the system so

476
00:17:48,789 --> 00:17:46,400
you you take samples and you check that

477
00:17:51,029 --> 00:17:48,799
the the biomass or the number of cells

478
00:17:53,190 --> 00:17:51,039
that you have in that water that's going

479
00:17:55,029 --> 00:17:53,200
down is you know

480
00:17:57,190 --> 00:17:55,039
in our case like orders of magnitude

481
00:17:59,110 --> 00:17:57,200
lower than the sample that you pull up

482
00:18:00,950 --> 00:17:59,120
out of the like so then you can be

483
00:18:03,669 --> 00:18:00,960
really confident and say hey well the

484
00:18:05,669 --> 00:18:03,679
water that we put down to make the the

485
00:18:07,590 --> 00:18:05,679
drill hole um

486
00:18:09,190 --> 00:18:07,600
was not the source of the microbes that

487
00:18:10,950 --> 00:18:09,200
we're getting out of the out of our

488
00:18:12,470 --> 00:18:10,960

samples in the lake

489
00:18:14,230 --> 00:18:12,480
very cool it's almost like planetary

490
00:18:16,470 --> 00:18:14,240
protection right in this case it's right

491
00:18:18,630 --> 00:18:16,480
it's a glacial lake protection

492
00:18:20,630 --> 00:18:18,640
yeah it's it's a it's a similar it's a

493
00:18:22,789 --> 00:18:20,640
similar kind of approach in terms of

494
00:18:24,950 --> 00:18:22,799
thinking about that way of doing it and

495
00:18:27,110 --> 00:18:24,960
the similarly the like all of the

496
00:18:29,110 --> 00:18:27,120
instruments that went down once we've

497
00:18:31,350 --> 00:18:29,120
drilled the hole they were all cleaned

498
00:18:33,510 --> 00:18:31,360
with hydrogen peroxide and then if you

499
00:18:35,830 --> 00:18:33,520
go on to the the salsa website there's

500
00:18:38,549 --> 00:18:35,840
this cool photo too that once you put

501
00:18:42,310 --> 00:18:38,559
the the at the top of the drill hole

502
00:18:44,470 --> 00:18:42,320
there's a big huge uv lamp bank that we

503
00:18:46,470 --> 00:18:44,480
put down into the ice right at the top

504
00:18:48,630 --> 00:18:46,480
of the borehole so everything that went

505
00:18:51,750 --> 00:18:48,640
down through that uh borehole at the top

506
00:18:54,390 --> 00:18:51,760
of it it's been zapped on the outside by

507
00:18:57,270 --> 00:18:54,400
um you know these strong uv lamps so it

508
00:18:59,669 --> 00:18:57,280
really definitely concerned or trying as

509
00:19:02,390 --> 00:18:59,679
best as we can uh with sort of best

510
00:19:05,430 --> 00:19:02,400
practices to make the sampling you know

511
00:19:06,950 --> 00:19:05,440
as as biologically clean as we can get

512
00:19:08,549 --> 00:19:06,960
yeah which is super crucial for

513
00:19:10,310 --> 00:19:08,559

planetary exploration as well of course

514
00:19:12,870 --> 00:19:10,320
we have clean rooms where we try our

515
00:19:15,350 --> 00:19:12,880
best to sterilize you know rovers like

516
00:19:17,029 --> 00:19:15,360
perseverance and curiosity and if we do

517
00:19:19,270 --> 00:19:17,039
ever design a europa lander we'll

518
00:19:21,270 --> 00:19:19,280
certainly try to to clean that and

519
00:19:23,510 --> 00:19:21,280
sterilize it as much as possible to

520
00:19:26,150 --> 00:19:23,520
avoid contaminating some other isolated

521
00:19:27,830 --> 00:19:26,160
system with potential biology

522
00:19:29,590 --> 00:19:27,840
i will come back to something though you

523
00:19:31,350 --> 00:19:29,600
mentioned so at lake mercer where you

524
00:19:33,350 --> 00:19:31,360
were doing this research you mentioned

525
00:19:35,270 --> 00:19:33,360
the depth earlier and we actually

526
00:19:38,390 --> 00:19:35,280
reached out on twitter through nasa

527
00:19:40,710 --> 00:19:38,400
astrobiology to ask our audience uh how

528
00:19:44,789 --> 00:19:40,720
deep you had drilled to get down there

529
00:19:45,789 --> 00:19:44,799
we had options of roughly 138 meters 572

530
00:19:52,549 --> 00:19:45,799
meters

531
00:19:54,230 --> 00:19:52,559
and the audience tech 866

532
00:19:57,669 --> 00:19:54,240
rather than the actual answer which is

533
00:20:00,070 --> 00:19:57,679
just over a kilometer it's 1084 meters

534
00:20:02,390 --> 00:20:00,080
um and so that's very deep to drill into

535
00:20:04,070 --> 00:20:02,400
these lakes here on earth um of course

536
00:20:05,510 --> 00:20:04,080
drilling through europa's ice would be

537
00:20:07,669 --> 00:20:05,520
even more it's you know roughly 10

538
00:20:10,870 --> 00:20:07,679

kilometers i think is the best estimate

539
00:20:13,350 --> 00:20:10,880
right now of ice um but still like 1 000

540
00:20:15,830 --> 00:20:13,360
kilometers or 1000 meters is still a lot

541
00:20:17,909 --> 00:20:15,840
of depth how long does it take to drill

542
00:20:21,110 --> 00:20:17,919
down through that much yeah it takes a

543
00:20:23,430 --> 00:20:21,120
few days in terms of um to to drill all

544
00:20:25,990 --> 00:20:23,440
the way down and again there's a a

545
00:20:28,149 --> 00:20:26,000
system that you set up where the you

546
00:20:30,230 --> 00:20:28,159
drill a hole first and then you drill

547
00:20:33,750 --> 00:20:30,240
another parallel hole which they call a

548
00:20:35,430 --> 00:20:33,760
keyhole or a rod well rodriguez well and

549
00:20:37,669 --> 00:20:35,440
so the idea is that you set up this sort

550
00:20:39,830 --> 00:20:37,679
of loop system so that you drill down

551
00:20:42,789 --> 00:20:39,840
you connect those two at about 100 or

552
00:20:44,390 --> 00:20:42,799
120 meters depth so that then that means

553
00:20:46,710 --> 00:20:44,400
as you're drilling down

554
00:20:48,149 --> 00:20:46,720
uh into the ice in the in the borehole

555
00:20:50,710 --> 00:20:48,159
that you're drilling there's then a

556
00:20:51,669 --> 00:20:50,720
return flow and that return water is

557
00:20:53,750 --> 00:20:51,679
there's a

558
00:20:56,710 --> 00:20:53,760
ground water pump in that other well and

559
00:20:59,029 --> 00:20:56,720
that returns the flow uh back into the

560
00:21:01,510 --> 00:20:59,039
into the system for for cleaning the

561
00:21:02,549 --> 00:21:01,520
water and so yeah the drilling took a a

562
00:21:06,310 --> 00:21:02,559
few days

563
00:21:09,430 --> 00:21:06,320

uh to get down uh into the into the lake

564
00:21:12,310 --> 00:21:09,440
um and as one gets down to the lake you

565
00:21:14,630 --> 00:21:12,320
also don't do this cool idea that they

566
00:21:15,909 --> 00:21:14,640
you kind of like lower the pressure as

567
00:21:18,310 --> 00:21:15,919
possible as

568
00:21:19,830 --> 00:21:18,320
as best as possible in your drilling so

569
00:21:21,990 --> 00:21:19,840
you're still drilling down but you're

570
00:21:24,149 --> 00:21:22,000
reducing the back pressure so that as

571
00:21:26,310 --> 00:21:24,159
soon as you hit the lake then the water

572
00:21:28,870 --> 00:21:26,320
from the lake came back up the bore hole

573
00:21:31,510 --> 00:21:28,880
at the bottom by you know sort of 20 or

574
00:21:33,430 --> 00:21:31,520
30 meters so again the reason for doing

575
00:21:35,590 --> 00:21:33,440
that was again back to sort of your

576
00:21:37,830 --> 00:21:35,600
planetary protection argument that it's

577
00:21:40,870 --> 00:21:37,840
like well if water at the bottom comes

578
00:21:43,190 --> 00:21:40,880
back up the borehole then it's way less

579
00:21:44,789 --> 00:21:43,200
likely that we're able to contaminate

580
00:21:47,110 --> 00:21:44,799
that even if we've done all of our

581
00:21:49,430 --> 00:21:47,120
cleaning really well then having water

582
00:21:51,510 --> 00:21:49,440
come back up the borehole uh which is

583
00:21:54,630 --> 00:21:51,520
what happened you know that was the goal

584
00:21:56,230 --> 00:21:54,640
again of the the drilling strategy uh to

585
00:21:58,549 --> 00:21:56,240
you know

586
00:22:01,590 --> 00:21:58,559
again to make sure we we could try and

587
00:22:03,270 --> 00:22:01,600
be as clean as possible yeah very cool

588
00:22:04,470 --> 00:22:03,280

uh i do want to talk now just for a

589
00:22:06,070 --> 00:22:04,480
little bit before we open it up to our

590
00:22:07,990 --> 00:22:06,080
audience questions about some of your

591
00:22:09,110 --> 00:22:08,000
your more recent research including a

592
00:22:11,510 --> 00:22:09,120
new project that you're working on right

593
00:22:13,510 --> 00:22:11,520
now up in the arctic but before i get

594
00:22:15,590 --> 00:22:13,520
there i think for our audience a lot of

595
00:22:16,870 --> 00:22:15,600
people have never been in a glacial

596
00:22:19,669 --> 00:22:16,880
environment have never been to the

597
00:22:21,270 --> 00:22:19,679
arctic or or antarctica um like i

598
00:22:23,190 --> 00:22:21,280
mentioned i was fortunate to spend some

599
00:22:24,390 --> 00:22:23,200
time in the arctic over two weeks you

600
00:22:26,310 --> 00:22:24,400
know we brought along some special

601
00:22:28,390 --> 00:22:26,320
snacks i for one argued for pemicon

602
00:22:30,230 --> 00:22:28,400
which you know is a meat and fat with

603
00:22:32,549 --> 00:22:30,240
berries kind of mixture that you know

604
00:22:34,070 --> 00:22:32,559
old polar explorers would take um i

605
00:22:36,789 --> 00:22:34,080
wonder if you could just give us a brief

606
00:22:38,950 --> 00:22:36,799
explanation of your experiences how long

607
00:22:40,549 --> 00:22:38,960
you've spent on these glacial glacier

608
00:22:42,070 --> 00:22:40,559
systems and and maybe some of the

609
00:22:43,909 --> 00:22:42,080
special treats that your teams have

610
00:22:45,270 --> 00:22:43,919
brought along just to make things a

611
00:22:46,390 --> 00:22:45,280
little more comfortable in those cold

612
00:22:48,630 --> 00:22:46,400
systems

613
00:22:50,390 --> 00:22:48,640

yeah no for sure so i mean probably the

614
00:22:52,630 --> 00:22:50,400
longest field work was maybe as a

615
00:22:55,110 --> 00:22:52,640
graduate student up on ellesmere you

616
00:22:57,270 --> 00:22:55,120
know like nine or ten weeks in the field

617
00:22:59,430 --> 00:22:57,280
and those would be in um you know tent

618
00:23:02,070 --> 00:22:59,440
camps um

619
00:23:03,590 --> 00:23:02,080
you know uh that's probably the

620
00:23:06,230 --> 00:23:03,600
you know the sort of most maybe

621
00:23:08,710 --> 00:23:06,240
primitive and longest time in the field

622
00:23:10,630 --> 00:23:08,720
and um yeah the real treat for me was

623
00:23:12,710 --> 00:23:10,640
always like you know

624
00:23:14,549 --> 00:23:12,720
in the cold environment

625
00:23:16,549 --> 00:23:14,559
you know chocolate bars

626
00:23:19,029 --> 00:23:16,559
nothing like i mean i

627
00:23:22,070 --> 00:23:19,039
i grew up in birmingham which is pretty

628
00:23:25,590 --> 00:23:22,080
close to the you know a cadbury factory

629
00:23:27,510 --> 00:23:25,600
um in the uk and so like you know a

630
00:23:29,990 --> 00:23:27,520
couple of chocolate bars a day it's

631
00:23:31,909 --> 00:23:30,000
fantastic it's just like you know that's

632
00:23:33,990 --> 00:23:31,919
back to the treat of the environment and

633
00:23:36,070 --> 00:23:34,000
frankly when you're in such cold

634
00:23:37,430 --> 00:23:36,080
temperatures cold environments and

635
00:23:39,669 --> 00:23:37,440
you're camping

636
00:23:41,510 --> 00:23:39,679
you know you burn off the the energy

637
00:23:43,669 --> 00:23:41,520
from those chocolate bars pretty rapidly

638
00:23:46,630 --> 00:23:43,679

so certainly the thing that i always

639
00:23:48,230 --> 00:23:46,640
look forward to is that you know

640
00:23:50,070 --> 00:23:48,240
you get to at least eat one chocolate

641
00:23:52,630 --> 00:23:50,080
bar a day if and if not two chocolate

642
00:23:54,470 --> 00:23:52,640
bars a day so it's always pretty good

643
00:23:56,390 --> 00:23:54,480
yeah i will say one of our collaborators

644
00:23:58,630 --> 00:23:56,400
was thoughtful enough to bring bring

645
00:23:59,430 --> 00:23:58,640
along a lot of extra chocolate just for

646
00:24:01,510 --> 00:23:59,440
us

647
00:24:03,190 --> 00:24:01,520
um so i'd love to hear now about some of

648
00:24:05,510 --> 00:24:03,200
your more recent work you have a new

649
00:24:07,669 --> 00:24:05,520
p-star funded by nasa to do some

650
00:24:09,830 --> 00:24:07,679
research in the arctic on devon island

651
00:24:11,190 --> 00:24:09,840
with a new lake system and a paper just

652
00:24:13,110 --> 00:24:11,200
came out about this system that we

653
00:24:14,390 --> 00:24:13,120
shared through the sega net uh social

654
00:24:16,789 --> 00:24:14,400
media accounts i wonder if you could

655
00:24:19,190 --> 00:24:16,799
share with our audience um what's so

656
00:24:21,269 --> 00:24:19,200
cool about this lake and why this system

657
00:24:23,909 --> 00:24:21,279
is so appealing for research

658
00:24:26,630 --> 00:24:23,919
right so the the difference is that with

659
00:24:28,870 --> 00:24:26,640
this lake so this is an uh this is a

660
00:24:31,350 --> 00:24:28,880
lake that we uh think exists beneath the

661
00:24:33,750 --> 00:24:31,360
devon ice cap again up in the canadian

662
00:24:36,950 --> 00:24:33,760
high arctic and what makes it intriguing

663
00:24:39,750 --> 00:24:36,960

or interesting as a as a research target

664
00:24:42,470 --> 00:24:39,760
is that the lakes that have done work on

665
00:24:44,470 --> 00:24:42,480
doing exploration in uh antarctica or

666
00:24:46,710 --> 00:24:44,480
the one that's behind me

667
00:24:49,750 --> 00:24:46,720
which is in iceland uh they're they're

668
00:24:51,750 --> 00:24:49,760
freshwater lakes right so they're uh

669
00:24:53,909 --> 00:24:51,760
really dilute the water looks like you

670
00:24:56,230 --> 00:24:53,919
might find in in you know glacial runoff

671
00:24:57,669 --> 00:24:56,240
mountain streams they're not very uh not

672
00:24:59,269 --> 00:24:57,679
very salty

673
00:25:01,830 --> 00:24:59,279
um whereas

674
00:25:04,470 --> 00:25:01,840
the intriguing thing about the the the

675
00:25:07,269 --> 00:25:04,480
devon situation or the devon ice cap

676
00:25:09,190 --> 00:25:07,279
case is that

677
00:25:11,190 --> 00:25:09,200
the lakes have been discovered through

678
00:25:13,350 --> 00:25:11,200
you know through radar techniques so you

679
00:25:15,110 --> 00:25:13,360
bounce radar off the bottom and if

680
00:25:17,909 --> 00:25:15,120
there's a water body you get a different

681
00:25:20,630 --> 00:25:17,919
reflection than if you have a rock bed

682
00:25:23,510 --> 00:25:20,640
um but the interesting thing there is

683
00:25:25,669 --> 00:25:23,520
that the the temperature that one would

684
00:25:27,750 --> 00:25:25,679
predict at the bed and that people have

685
00:25:29,830 --> 00:25:27,760
drilled like further away from the lakes

686
00:25:32,070 --> 00:25:29,840
but people previously you know drilled

687
00:25:34,789 --> 00:25:32,080
ice cores to the bed of the the glacier

688
00:25:36,789 --> 00:25:34,799

where it's frozen to the bed uh that the

689
00:25:38,870 --> 00:25:36,799
the ice temperatures could be sort of in

690
00:25:40,310 --> 00:25:38,880
the range of like you know minus 10

691
00:25:41,669 --> 00:25:40,320
minus 14

692
00:25:42,630 --> 00:25:41,679
um minus

693
00:25:44,549 --> 00:25:42,640
c

694
00:25:48,390 --> 00:25:44,559
and so then that's like wow well if

695
00:25:50,470 --> 00:25:48,400
there's a body of water or fluid uh at

696
00:25:53,190 --> 00:25:50,480
that temperature it's got to be really

697
00:25:56,230 --> 00:25:53,200
salty for it to maintain you know being

698
00:25:58,230 --> 00:25:56,240
a fluid body so again that was like that

699
00:26:00,950 --> 00:25:58,240
makes it really different from these

700
00:26:03,830 --> 00:26:00,960
other subglacial lakes that have been uh

701
00:26:05,110 --> 00:26:03,840
that have been discovered and so now our

702
00:26:07,110 --> 00:26:05,120
project is

703
00:26:08,310 --> 00:26:07,120
drilling into the actual lake we

704
00:26:10,789 --> 00:26:08,320
actually don't really have the

705
00:26:13,110 --> 00:26:10,799
technology yet to do that cleanly that's

706
00:26:15,269 --> 00:26:13,120
still you know hopefully that might be

707
00:26:16,950 --> 00:26:15,279
the the source of you know future work

708
00:26:18,230 --> 00:26:16,960
but right now we were thinking about

709
00:26:21,350 --> 00:26:18,240
okay well

710
00:26:23,669 --> 00:26:21,360
those lakes uh potentially drain uh

711
00:26:25,830 --> 00:26:23,679
beneath glaciers that are feeding to the

712
00:26:28,070 --> 00:26:25,840
north and the south of the ice cap and

713
00:26:30,789 --> 00:26:28,080

so then the idea would be to go in and

714
00:26:33,110 --> 00:26:30,799
try and sample where the water comes out

715
00:26:36,789 --> 00:26:33,120
beneath those glaciers to see if we can

716
00:26:38,950 --> 00:26:36,799
see if there's um you know saline waters

717
00:26:41,269 --> 00:26:38,960
and also do some more characterization

718
00:26:44,710 --> 00:26:41,279
again with the radar system or with the

719
00:26:46,549 --> 00:26:44,720
helicopter based radar system to look uh

720
00:26:48,710 --> 00:26:46,559
at the you know at the main body of

721
00:26:50,390 --> 00:26:48,720
these outlet glaciers to try and figure

722
00:26:51,510 --> 00:26:50,400
out if we can see where there might be

723
00:26:53,990 --> 00:26:51,520
channels

724
00:26:55,909 --> 00:26:54,000
beneath it beneath the eyes

725
00:26:57,190 --> 00:26:55,919
now it's such cool research

726
00:26:59,110 --> 00:26:57,200
i think we probably have some questions

727
00:27:00,470 --> 00:26:59,120
coming in about that work and other

728
00:27:02,070 --> 00:27:00,480
research you've done

729
00:27:03,590 --> 00:27:02,080
i actually see we have a lot of audience

730
00:27:05,590 --> 00:27:03,600
questions coming in but before i get

731
00:27:06,470 --> 00:27:05,600
there i have two really quick questions

732
00:27:09,350 --> 00:27:06,480
for you

733
00:27:11,110 --> 00:27:09,360
um one is what is the most alien

734
00:27:12,549 --> 00:27:11,120
environment what is the most you know

735
00:27:14,149 --> 00:27:12,559
non-terrestrial just like out of this

736
00:27:16,390 --> 00:27:14,159
world place that you've been in these

737
00:27:19,430 --> 00:27:16,400
arctic or antarctic systems

738
00:27:21,990 --> 00:27:19,440

so i think that might be like back to um

739
00:27:24,950 --> 00:27:22,000
in antarctica i was part of a research

740
00:27:26,870 --> 00:27:24,960
team uh where um

741
00:27:30,230 --> 00:27:26,880
we chainsawed the tunnel or the team

742
00:27:32,389 --> 00:27:30,240
chainsaw to tunnel into a glacier um in

743
00:27:35,830 --> 00:27:32,399
in antarctica and so being actually

744
00:27:37,669 --> 00:27:35,840
inside a glacier um in a tunnel that's a

745
00:27:39,269 --> 00:27:37,679
pretty to me that's a fairly alien

746
00:27:41,350 --> 00:27:39,279
environment that was pretty pretty

747
00:27:43,669 --> 00:27:41,360
interesting and pretty exciting

748
00:27:45,430 --> 00:27:43,679
that's awesome um so so i do have so one

749
00:27:47,269 --> 00:27:45,440
more fun question so you shared some

750
00:27:48,630 --> 00:27:47,279
pictures with us before the show they've

751
00:27:50,710 --> 00:27:48,640
been coming up while we've been

752
00:27:52,070 --> 00:27:50,720
discussing your research and your work

753
00:27:53,830 --> 00:27:52,080
one of those pictures though our

754
00:27:55,430 --> 00:27:53,840
producer and director mike toyolan

755
00:27:57,190 --> 00:27:55,440
wanted to know a bit more about because

756
00:27:59,669 --> 00:27:57,200
he loved it so much

757
00:28:02,149 --> 00:27:59,679
it's a picture of two people yourself

758
00:28:05,430 --> 00:28:02,159
included on a glacier playing guitar and

759
00:28:06,789 --> 00:28:05,440
clarinet um maybe busking to the arctic

760
00:28:07,909 --> 00:28:06,799
um i wonder if you could give us a

761
00:28:09,430 --> 00:28:07,919
little explanation about what's

762
00:28:11,750 --> 00:28:09,440
happening in that image about playing

763
00:28:14,630 --> 00:28:11,760

some instruments on a glacier right so

764
00:28:16,870 --> 00:28:14,640
uh the the other person in that uh

765
00:28:18,710 --> 00:28:16,880
in that photo is a colleague and friend

766
00:28:20,630 --> 00:28:18,720
of mine anthony arendt he's actually out

767
00:28:23,350 --> 00:28:20,640
at university of washington as a

768
00:28:25,110 --> 00:28:23,360
researcher um and

769
00:28:26,950 --> 00:28:25,120
uh when we went to the arctic i play

770
00:28:29,510 --> 00:28:26,960
clarinet i play in a bunch of different

771
00:28:33,830 --> 00:28:29,520
bands and anthony uh you know played

772
00:28:35,590 --> 00:28:33,840
guitar and so you know going back yeah

773
00:28:37,510 --> 00:28:35,600
20 odd years ago

774
00:28:39,830 --> 00:28:37,520
there wasn't any internet there wasn't

775
00:28:41,269 --> 00:28:39,840
any sat phones there wasn't anything

776
00:28:43,350 --> 00:28:41,279
else so

777
00:28:45,750 --> 00:28:43,360
you know in the evening you know you

778
00:28:47,990 --> 00:28:45,760
could play a bit of music right you know

779
00:28:49,669 --> 00:28:48,000
sit we're in a in a tent and so then

780
00:28:51,190 --> 00:28:49,679
it's like okay we'll

781
00:28:53,750 --> 00:28:51,200
get out your guitar we've got out my

782
00:28:55,510 --> 00:28:53,760
clarinet um and you know we could jam

783
00:28:56,789 --> 00:28:55,520
along and play some tunes right because

784
00:28:59,510 --> 00:28:56,799
it's like well

785
00:29:02,230 --> 00:28:59,520
you know there wasn't a lot of well

786
00:29:04,549 --> 00:29:02,240
there wasn't a lot else uh in terms of

787
00:29:07,350 --> 00:29:04,559
um you know entertainment occasionally

788
00:29:09,190 --> 00:29:07,360

we would pick up off the hf antenna you

789
00:29:12,549 --> 00:29:09,200
can pick up the sort of like bbc world

790
00:29:14,950 --> 00:29:12,559
service news you know um but other than

791
00:29:15,990 --> 00:29:14,960
that um we were pretty much like you

792
00:29:18,870 --> 00:29:16,000
know

793
00:29:20,710 --> 00:29:18,880
short radio uh scheduled call with the

794
00:29:22,789 --> 00:29:20,720
base each day just to tell them that we

795
00:29:25,029 --> 00:29:22,799
were you know yep we're still alive

796
00:29:26,950 --> 00:29:25,039
everybody's good but other than that it

797
00:29:29,190 --> 00:29:26,960
was like oh well entertainment then was

798
00:29:31,190 --> 00:29:29,200
things like yeah playing some music

799
00:29:32,549 --> 00:29:31,200
oh fantastic yeah i i wish now in

800
00:29:34,230 --> 00:29:32,559
hindsight i'd take it along like a

801
00:29:36,070 --> 00:29:34,240
didgeridoo or harmonica or something to

802
00:29:38,310 --> 00:29:36,080
the to the arctic with me maybe next

803
00:29:39,750 --> 00:29:38,320
time

804
00:29:41,269 --> 00:29:39,760
i will open it up now so we do have a

805
00:29:43,190 --> 00:29:41,279
bunch of audience questions coming in

806
00:29:44,710 --> 00:29:43,200
especially from the youtube channel so

807
00:29:46,389 --> 00:29:44,720
uh thanks to those who are asking we're

808
00:29:47,750 --> 00:29:46,399
gonna start asking those questions now

809
00:29:48,630 --> 00:29:47,760
we'll try our best to get to as many as

810
00:29:50,950 --> 00:29:48,640
we can

811
00:29:53,350 --> 00:29:50,960
um the first question comes from

812
00:29:56,310 --> 00:29:53,360
user rending rendering reality 3d

813
00:29:58,310 --> 00:29:56,320

animations uh they ask can you compare

814
00:29:59,750 --> 00:29:58,320
processes that cycle key minerals or

815
00:30:02,710 --> 00:29:59,760
elements in glacial systems here on

816
00:30:05,190 --> 00:30:02,720
earth to possible interfaces between ice

817
00:30:07,029 --> 00:30:05,200
and subsurface oceans for europa and

818
00:30:08,870 --> 00:30:07,039
enceladus

819
00:30:10,710 --> 00:30:08,880
in terms of sorry say that question

820
00:30:12,630 --> 00:30:10,720
again yes it sounds that they're asking

821
00:30:14,870 --> 00:30:12,640
if we can compare compare the processes

822
00:30:17,190 --> 00:30:14,880
that cycle uh nutrients that cycle

823
00:30:19,190 --> 00:30:17,200
elements in our glacial systems here to

824
00:30:21,750 --> 00:30:19,200
the potential for cycling uh through the

825
00:30:23,750 --> 00:30:21,760
ice on europa or enceladus

826
00:30:25,269 --> 00:30:23,760
yeah i mean it that that becomes a

827
00:30:27,909 --> 00:30:25,279
little bit more challenging to make that

828
00:30:29,590 --> 00:30:27,919
direct analogy i think on earth we

829
00:30:31,990 --> 00:30:29,600
understand that or we're starting to

830
00:30:34,950 --> 00:30:32,000
understand those processes um a lot

831
00:30:36,950 --> 00:30:34,960
better uh on europa it would really

832
00:30:38,870 --> 00:30:36,960
depend on like hey what what do we

833
00:30:42,549 --> 00:30:38,880
actually find that stand there in the

834
00:30:44,149 --> 00:30:42,559
ocean so to sort of say that i mean i i

835
00:30:45,990 --> 00:30:44,159
can't tell you or i don't think anybody

836
00:30:48,310 --> 00:30:46,000
can really tell you what what that

837
00:30:50,630 --> 00:30:48,320
mineral assemblage will be so

838
00:30:52,230 --> 00:30:50,640

um can't really provide a definitive

839
00:30:53,750 --> 00:30:52,240
answer to that so i think it's sort of

840
00:30:55,830 --> 00:30:53,760
like that would be something that we

841
00:30:57,269 --> 00:30:55,840
would have to figure out like

842
00:30:59,110 --> 00:30:57,279
what's the

843
00:31:02,389 --> 00:30:59,120
what what are the mineral assemblages

844
00:31:04,149 --> 00:31:02,399
that are down there um and and then what

845
00:31:06,070 --> 00:31:04,159
those interactions might be i mean i

846
00:31:07,350 --> 00:31:06,080
know we don't expect them to necessarily

847
00:31:09,590 --> 00:31:07,360
be

848
00:31:12,549 --> 00:31:09,600
hugely different from uh what we might

849
00:31:15,509 --> 00:31:12,559
find uh in in terrestrial systems but

850
00:31:17,190 --> 00:31:15,519
you know um yeah i guess

851
00:31:20,070 --> 00:31:17,200
you could speculate about all kinds of

852
00:31:21,909 --> 00:31:20,080
things but um i i think it'd be

853
00:31:23,909 --> 00:31:21,919
you know probably wiser to figure it out

854
00:31:25,190 --> 00:31:23,919
when we actually see what's there yeah

855
00:31:26,230 --> 00:31:25,200
it could always change our minds a lot

856
00:31:28,870 --> 00:31:26,240
once we actually get there and start

857
00:31:31,269 --> 00:31:28,880
taking data and samples right yeah yeah

858
00:31:33,110 --> 00:31:31,279
or having a better idea again of like

859
00:31:35,669 --> 00:31:33,120
what you were describing is like well

860
00:31:38,789 --> 00:31:35,679
you know how deep is or how thick is the

861
00:31:40,789 --> 00:31:38,799
ice shell before you get down to the

862
00:31:43,430 --> 00:31:40,799
to the ocean below and i think that's

863
00:31:45,509 --> 00:31:43,440

still a reasonably open question in

864
00:31:46,710 --> 00:31:45,519
terms of the the ice step

865
00:31:48,389 --> 00:31:46,720
yeah absolutely yeah there's been a lot

866
00:31:50,149 --> 00:31:48,399
of proposals over the years for

867
00:31:52,310 --> 00:31:50,159
everything from one kilometer to 40

868
00:31:53,909 --> 00:31:52,320
kilometers of depth on the icy shell and

869
00:31:55,350 --> 00:31:53,919
so there's a lot of questions there

870
00:31:57,509 --> 00:31:55,360
europa clipper will help us answer some

871
00:31:59,269 --> 00:31:57,519
of that for europa at least we'll learn

872
00:32:00,789 --> 00:31:59,279
a lot more about the surface of europa

873
00:32:02,149 --> 00:32:00,799
and get much higher resolution imaging

874
00:32:04,230 --> 00:32:02,159
and some spectra

875
00:32:05,029 --> 00:32:04,240
but there's still a lot ahead for europa

876
00:32:06,710 --> 00:32:05,039
so

877
00:32:09,669 --> 00:32:06,720
um i do have another question here that

878
00:32:11,669 --> 00:32:09,679
came in from dan in the cave on youtube

879
00:32:14,470 --> 00:32:11,679
we get lots of questions about you know

880
00:32:16,549 --> 00:32:14,480
how do i build a career in astrobiology

881
00:32:17,909 --> 00:32:16,559
but i really like dan and the cave's

882
00:32:20,789 --> 00:32:17,919
question here

883
00:32:23,029 --> 00:32:20,799
they're hoping to start a phd this fall

884
00:32:25,509 --> 00:32:23,039
in astrobiology and with a focus in

885
00:32:27,269 --> 00:32:25,519
glacial microbial communities

886
00:32:29,590 --> 00:32:27,279
and so they want to know if you were to

887
00:32:31,990 --> 00:32:29,600
start a phd now

888
00:32:34,789 --> 00:32:32,000

what would you want to focus on

889
00:32:37,029 --> 00:32:34,799
right yeah well if i was doing that now

890
00:32:39,830 --> 00:32:37,039
um i think i would yet

891
00:32:41,750 --> 00:32:39,840
you know key in on uh some of these

892
00:32:43,430 --> 00:32:41,760
environments in terms of again it it

893
00:32:45,350 --> 00:32:43,440
sort of depends on that

894
00:32:47,909 --> 00:32:45,360
research question but i would be

895
00:32:50,389 --> 00:32:47,919
thinking for sure about

896
00:32:51,750 --> 00:32:50,399
focusing like on maybe anaerobic

897
00:32:54,870 --> 00:32:51,760
organisms

898
00:32:56,470 --> 00:32:54,880
because i think that like you know a lot

899
00:32:58,710 --> 00:32:56,480
of these environments whilst there may

900
00:33:00,549 --> 00:32:58,720
be some you know oxygen in these

901
00:33:03,509 --> 00:33:00,559
environments there's likely to be quite

902
00:33:06,870 --> 00:33:03,519
a lot of sort of anaerobic niches um you

903
00:33:09,509 --> 00:33:06,880
know in a lot of these systems um so i

904
00:33:13,190 --> 00:33:09,519
think there's probably a uh a fairly

905
00:33:15,830 --> 00:33:13,200
good you know uh range of uh anaerobic

906
00:33:18,230 --> 00:33:15,840
uh metabolisms that one could look into

907
00:33:21,190 --> 00:33:18,240
um and think about how those could

908
00:33:23,990 --> 00:33:21,200
potentially be ones that you might find

909
00:33:25,750 --> 00:33:24,000
uh whether it will be on on mars or say

910
00:33:27,830 --> 00:33:25,760
on europa

911
00:33:29,190 --> 00:33:27,840
indeed um these next two questions i'm

912
00:33:31,430 --> 00:33:29,200
going to bring them together actually so

913
00:33:35,029 --> 00:33:31,440

we have one from user tv ready on

914
00:33:37,509 --> 00:33:35,039
youtube and another from cjf on twitter

915
00:33:39,190 --> 00:33:37,519
uh so t venut first wants to know how

916
00:33:40,389 --> 00:33:39,200
psychrophiles adapt to extreme cold

917
00:33:41,990 --> 00:33:40,399
environments

918
00:33:44,870 --> 00:33:42,000
um and you know that's things like

919
00:33:46,630 --> 00:33:44,880
creating these anti-freeze proteins

920
00:33:48,630 --> 00:33:46,640
inside of cellular structures to avoid

921
00:33:49,909 --> 00:33:48,640
freezing and stuff like that

922
00:33:53,190 --> 00:33:49,919
but then

923
00:33:55,750 --> 00:33:53,200
cjf wants to know if purple phototrophic

924
00:33:56,870 --> 00:33:55,760
bacteria exist in glaciers

925
00:33:58,630 --> 00:33:56,880
specifically they want to know a bit

926
00:34:01,110 --> 00:33:58,640
more about the production of hydrogen

927
00:34:03,190 --> 00:34:01,120
from some organisms through phototrophy

928
00:34:04,710 --> 00:34:03,200
uh in glaciers and so i wonder if you

929
00:34:06,789 --> 00:34:04,720
could speak to these two kinds of things

930
00:34:08,869 --> 00:34:06,799
these organisms that are kind of adapted

931
00:34:10,629 --> 00:34:08,879
to cold systems and how they do so and

932
00:34:11,909 --> 00:34:10,639
maybe some of the unique metabolisms we

933
00:34:15,589 --> 00:34:11,919
see there

934
00:34:17,829 --> 00:34:15,599
yeah no for sure um so um the the first

935
00:34:20,069 --> 00:34:17,839
question uh the first question is about

936
00:34:22,389 --> 00:34:20,079
uh

937
00:34:24,230 --> 00:34:22,399
purple phototrophic organisms on

938
00:34:27,349 --> 00:34:24,240

glaciers and i have to say sorry i'm not

939
00:34:29,109 --> 00:34:27,359
like super familiar with uh with those

940
00:34:30,869 --> 00:34:29,119
um and so

941
00:34:32,869 --> 00:34:30,879
you know that's not really where i've

942
00:34:35,109 --> 00:34:32,879
been spending a lot of time the

943
00:34:38,230 --> 00:34:35,119
subglacial environment is one

944
00:34:40,470 --> 00:34:38,240
lacking in light and so i've not really

945
00:34:42,790 --> 00:34:40,480
focused so much on phototrophs and and

946
00:34:45,349 --> 00:34:42,800
so i'm less familiar with the the idea

947
00:34:47,030 --> 00:34:45,359
that they might produce hydrogen um

948
00:34:49,990 --> 00:34:47,040
that's not that's just not something

949
00:34:51,589 --> 00:34:50,000
i've i've researched um

950
00:34:53,190 --> 00:34:51,599
um

951
00:34:55,190 --> 00:34:53,200
and sorry and then what was the second

952
00:34:57,589 --> 00:34:55,200
question uh so the other one was really

953
00:34:59,109 --> 00:34:57,599
how do psychophiles adapt to extreme

954
00:35:00,870 --> 00:34:59,119
cold conditions

955
00:35:02,550 --> 00:35:00,880
right so again just as you'd mentioned

956
00:35:05,510 --> 00:35:02,560
there are there are different adaptive

957
00:35:08,310 --> 00:35:05,520
strategies often it's like flexibility

958
00:35:11,270 --> 00:35:08,320
in membranes that are able to adapt to

959
00:35:13,589 --> 00:35:11,280
cold environments and then also um

960
00:35:16,390 --> 00:35:13,599
people the organisms will make what i

961
00:35:18,950 --> 00:35:16,400
call some compatible solutes inside so

962
00:35:22,150 --> 00:35:18,960
that as you get colder often you find

963
00:35:24,630 --> 00:35:22,160

that some of the organisms that are cold

964
00:35:26,310 --> 00:35:24,640
tolerant may also be somewhat salt

965
00:35:28,470 --> 00:35:26,320
tolerant right because it's like once

966
00:35:29,670 --> 00:35:28,480
you get below zero

967
00:35:31,990 --> 00:35:29,680
your

968
00:35:34,470 --> 00:35:32,000
solution that you might be surviving in

969
00:35:38,230 --> 00:35:34,480
might be quite briny right so

970
00:35:40,390 --> 00:35:38,240
if i have a saline solution at -5c

971
00:35:42,790 --> 00:35:40,400
um organisms will still be able to

972
00:35:45,910 --> 00:35:42,800
thrive and survive in those but they may

973
00:35:48,310 --> 00:35:45,920
also then need to be adapted again to um

974
00:35:51,030 --> 00:35:48,320
you know uh to cope with the the the

975
00:35:52,550 --> 00:35:51,040
higher salt concentrations

976
00:35:53,910 --> 00:35:52,560
you know it's there's so many organisms

977
00:35:56,069 --> 00:35:53,920
around our planet who've adapted to

978
00:35:58,310 --> 00:35:56,079
these extreme systems uh and the

979
00:36:01,109 --> 00:35:58,320
organisms life as we know it really is

980
00:36:02,550 --> 00:36:01,119
driven by redox processes by reductance

981
00:36:04,390 --> 00:36:02,560
and oxidants in the environment and

982
00:36:06,230 --> 00:36:04,400
you've you've studied these subglacial

983
00:36:07,589 --> 00:36:06,240
systems looking at the potential sources

984
00:36:10,150 --> 00:36:07,599
of energy for these

985
00:36:13,109 --> 00:36:10,160
microbial energetics our next question

986
00:36:14,390 --> 00:36:13,119
from fannie creativa on youtube

987
00:36:16,230 --> 00:36:14,400
they want to know

988
00:36:18,310 --> 00:36:16,240

if we have any knowledge of the

989
00:36:20,630 --> 00:36:18,320
reductions in oxidants for biology on

990
00:36:22,790 --> 00:36:20,640
mars in anaerobic conditions will they

991
00:36:25,190 --> 00:36:22,800
be similar to what you were looking at

992
00:36:26,870 --> 00:36:25,200
in these subglacial systems

993
00:36:29,510 --> 00:36:26,880
yeah i mean i think broadly speaking

994
00:36:31,349 --> 00:36:29,520
you're gonna have the same um you know

995
00:36:33,589 --> 00:36:31,359
you have the same sort of uh what i

996
00:36:36,390 --> 00:36:33,599
would call it like the same ingredients

997
00:36:40,470 --> 00:36:36,400
um that you do on earth right in terms

998
00:36:41,910 --> 00:36:40,480
of you know you'd have hydrogen or co2

999
00:36:43,349 --> 00:36:41,920
or you might have different energy

1000
00:36:45,109 --> 00:36:43,359
couples so you'd have things like

1001
00:36:47,190 --> 00:36:45,119
there's potential for sulfate or

1002
00:36:48,950 --> 00:36:47,200
especially if i think about mars like

1003
00:36:50,470 --> 00:36:48,960
iron i mean

1004
00:36:53,349 --> 00:36:50,480
that's one thing that you think very

1005
00:36:57,270 --> 00:36:53,359
strongly about is the capabilities of

1006
00:36:58,550 --> 00:36:57,280
you know iron utilization um so i think

1007
00:37:00,069 --> 00:36:58,560
that you know

1008
00:37:01,190 --> 00:37:00,079
realistically you

1009
00:37:03,910 --> 00:37:01,200
you'd think that there would be a

1010
00:37:08,230 --> 00:37:03,920
similar suite of um

1011
00:37:09,829 --> 00:37:08,240
of uh of elements and or compounds

1012
00:37:12,150 --> 00:37:09,839
that you would find on mars that you

1013
00:37:14,230 --> 00:37:12,160

might find on on earth i mean they may

1014
00:37:15,910 --> 00:37:14,240
be in different concentrations and they

1015
00:37:17,510 --> 00:37:15,920
may be found in different environments

1016
00:37:19,510 --> 00:37:17,520
but i you know

1017
00:37:21,910 --> 00:37:19,520
you know if you drew out your matrix i

1018
00:37:24,470 --> 00:37:21,920
think you'd still say that a lot of them

1019
00:37:27,430 --> 00:37:24,480
are possible but again like back to mars

1020
00:37:28,390 --> 00:37:27,440
i'd be like i'd think about iron right

1021
00:37:30,470 --> 00:37:28,400
you know

1022
00:37:32,630 --> 00:37:30,480
as an important element or support

1023
00:37:34,470 --> 00:37:32,640
important in metabolism because when i

1024
00:37:36,390 --> 00:37:34,480
look around it's like hey what do i see

1025
00:37:38,470 --> 00:37:36,400
everywhere

1026
00:37:40,390 --> 00:37:38,480
yeah absolutely iron and sulfur are both

1027
00:37:41,829 --> 00:37:40,400
enriched in the martian surface and so

1028
00:37:43,030 --> 00:37:41,839
those are very good sources for us to

1029
00:37:45,030 --> 00:37:43,040
look at

1030
00:37:47,349 --> 00:37:45,040
we have another kind of martian question

1031
00:37:49,510 --> 00:37:47,359
here about the recent paper from chris

1032
00:37:52,230 --> 00:37:49,520
house and colleagues looking at a

1033
00:37:55,829 --> 00:37:52,240
depletion in carbon 13 isotopes in the

1034
00:37:57,349 --> 00:37:55,839
regolith of via curiosity um so aeronava

1035
00:37:59,030 --> 00:37:57,359
podar wants to know if that could be

1036
00:38:00,630 --> 00:37:59,040
biological i think i'll answer that one

1037
00:38:02,310 --> 00:38:00,640
myself really quickly

1038
00:38:03,510 --> 00:38:02,320

because one era nava it's really worth

1039
00:38:05,270 --> 00:38:03,520
reading the paper

1040
00:38:07,430 --> 00:38:05,280
the researchers did a great job of one

1041
00:38:09,349 --> 00:38:07,440
discounting contamination from organics

1042
00:38:11,990 --> 00:38:09,359
on the instrument from earth but they

1043
00:38:14,790 --> 00:38:12,000
also suggest three interpretations one

1044
00:38:16,550 --> 00:38:14,800
of them that that we go through a gmc a

1045
00:38:18,470 --> 00:38:16,560
giant molecular cloud every 100 million

1046
00:38:20,230 --> 00:38:18,480
years or so and it could be carbon

1047
00:38:21,829 --> 00:38:20,240
isotopes coming from that

1048
00:38:23,589 --> 00:38:21,839
another is that it could be volcanic

1049
00:38:24,870 --> 00:38:23,599
eruptions putting carbon dioxide into

1050
00:38:27,349 --> 00:38:24,880
the atmosphere that then is going

1051
00:38:28,630 --> 00:38:27,359
through photolysis breakdown via light

1052
00:38:30,870 --> 00:38:28,640
and forming these these different

1053
00:38:33,510 --> 00:38:30,880
isotope fractionations but one of the

1054
00:38:36,069 --> 00:38:33,520
other possible explanations could be

1055
00:38:37,430 --> 00:38:36,079
fractionation of isotopes due to life uh

1056
00:38:39,829 --> 00:38:37,440
and so i highly recommend reading the

1057
00:38:42,230 --> 00:38:39,839
paper it is a it's a short read but it's

1058
00:38:45,109 --> 00:38:42,240
a very good paper where they explore the

1059
00:38:47,510 --> 00:38:45,119
possibility for methanotrophy as well as

1060
00:38:50,069 --> 00:38:47,520
methanogenesis being involved in this

1061
00:38:52,230 --> 00:38:50,079
very big depletion in heavier isotopes

1062
00:38:53,589 --> 00:38:52,240
of carbon um but i actually wanted to

1063
00:38:55,829 --> 00:38:53,599

ask another question i saw come in that

1064
00:38:59,190 --> 00:38:55,839
i think is pretty fun uh this is from

1065
00:39:01,750 --> 00:38:59,200
david david cooter on youtube

1066
00:39:04,470 --> 00:39:01,760
so david says uh dr skidmore how have

1067
00:39:06,950 --> 00:39:04,480
advancements in metagenomic analysis

1068
00:39:08,950 --> 00:39:06,960
affected your research in recent years

1069
00:39:11,030 --> 00:39:08,960
uh how big of an impact do you think

1070
00:39:14,790 --> 00:39:11,040
this new generation of sequencing has on

1071
00:39:16,790 --> 00:39:14,800
astrobiology yeah well definitely so um

1072
00:39:19,670 --> 00:39:16,800
i'll tell you straight off the bat that

1073
00:39:21,349 --> 00:39:19,680
like you know i don't have a huge um you

1074
00:39:23,750 --> 00:39:21,359
know large amounts of expertise in

1075
00:39:25,829 --> 00:39:23,760
metagenomics personally but i work with

1076
00:39:28,630 --> 00:39:25,839
colleagues uh that do

1077
00:39:30,950 --> 00:39:28,640
and what the the ability of metagenomics

1078
00:39:33,589 --> 00:39:30,960
has uh has done is definitely been able

1079
00:39:37,510 --> 00:39:33,599
to take you know effectively like the

1080
00:39:39,829 --> 00:39:37,520
entire sequence for a community um and

1081
00:39:42,310 --> 00:39:39,839
start to put that together and start to

1082
00:39:45,510 --> 00:39:42,320
think about the potential metabolic

1083
00:39:47,670 --> 00:39:45,520
pathways that might exist in those uh in

1084
00:39:49,270 --> 00:39:47,680
those systems um

1085
00:39:51,670 --> 00:39:49,280
and so

1086
00:39:54,230 --> 00:39:51,680
again uh you know

1087
00:39:57,270 --> 00:39:54,240
that can be really really helpful

1088
00:40:01,349 --> 00:39:57,280

as a guide um you know towards the types

1089
00:40:04,230 --> 00:40:01,359
of metabolisms um but it there's still

1090
00:40:06,390 --> 00:40:04,240
in my humble opinion a a really good

1091
00:40:08,710 --> 00:40:06,400
role for them saying great that might be

1092
00:40:11,109 --> 00:40:08,720
the potential metabolisms now we use

1093
00:40:13,990 --> 00:40:11,119
that to then design some experiments

1094
00:40:14,950 --> 00:40:14,000
maybe to investigate the most

1095
00:40:19,430 --> 00:40:14,960
like

1096
00:40:21,270 --> 00:40:19,440
suggested through the metagenomic

1097
00:40:23,910 --> 00:40:21,280
analysis right because it's like it's

1098
00:40:25,510 --> 00:40:23,920
one piece of the puzzle um but then if

1099
00:40:27,670 --> 00:40:25,520
you really want to see if that's

1100
00:40:29,510 --> 00:40:27,680
actually what's going on then you'd want

1101
00:40:32,069 --> 00:40:29,520
to think about designing experiments

1102
00:40:34,630 --> 00:40:32,079
that that could you know that take that

1103
00:40:37,109 --> 00:40:34,640
as a guide but then you know that but

1104
00:40:38,950 --> 00:40:37,119
then take that kind of take that forward

1105
00:40:41,589 --> 00:40:38,960
absolutely and i was fortunate with my

1106
00:40:43,190 --> 00:40:41,599
research i wasn't doing metagenomics my

1107
00:40:45,349 --> 00:40:43,200
colleague chris trevetti was doing that

1108
00:40:46,710 --> 00:40:45,359
and before me katherine wright was doing

1109
00:40:48,550 --> 00:40:46,720
some metagenomics i was doing the

1110
00:40:50,630 --> 00:40:48,560
geochemistry and mineralogy because

1111
00:40:53,109 --> 00:40:50,640
these things they pair together you have

1112
00:40:55,109 --> 00:40:53,119
to understand the system itself what are

1113
00:40:56,950 --> 00:40:55,119

the inputs to the system what is the

1114
00:40:58,390 --> 00:40:56,960
chemistry of the system

1115
00:41:02,150 --> 00:40:58,400
and that kind of feeds directly into our

1116
00:41:05,270 --> 00:41:02,160
next question from cyan e4 on twitter

1117
00:41:07,109 --> 00:41:05,280
cyan says they're a phd candidate

1118
00:41:09,750 --> 00:41:07,119
and they're working on long isolated

1119
00:41:12,470 --> 00:41:09,760
subterranean hyper saline fluids go

1120
00:41:14,470 --> 00:41:12,480
figure cool um so cyan wants to know how

1121
00:41:16,870 --> 00:41:14,480
how long have systems like the devin

1122
00:41:19,109 --> 00:41:16,880
subglacial lake been isolated

1123
00:41:20,790 --> 00:41:19,119
um or if we have knowledge of how long

1124
00:41:22,230 --> 00:41:20,800
this may have been isolated and maybe

1125
00:41:23,829 --> 00:41:22,240
you can speak certainly to other lakes

1126
00:41:25,910 --> 00:41:23,839
that we have data on too that we know

1127
00:41:27,109 --> 00:41:25,920
how long they've been isolated um and

1128
00:41:29,030 --> 00:41:27,119
what can this tell us about the

1129
00:41:30,390 --> 00:41:29,040
possibility for extant life on mars or

1130
00:41:33,190 --> 00:41:30,400
icy moons

1131
00:41:35,349 --> 00:41:33,200
right no for sure yeah the the the the

1132
00:41:36,790 --> 00:41:35,359
question of isolation is is always kind

1133
00:41:38,950 --> 00:41:36,800
of challenging because that's sort of

1134
00:41:40,870 --> 00:41:38,960
like part of it's how do you define that

1135
00:41:43,030 --> 00:41:40,880
right because um

1136
00:41:45,030 --> 00:41:43,040
you know there's potential there is some

1137
00:41:46,790 --> 00:41:45,040
input but it might be very slow in these

1138
00:41:48,470 --> 00:41:46,800

subglacial environments like like ice

1139
00:41:50,630 --> 00:41:48,480
melts at the base and there is some

1140
00:41:52,230 --> 00:41:50,640
amount of throughput but most people

1141
00:41:54,470 --> 00:41:52,240
have made estimates certainly like in

1142
00:41:57,270 --> 00:41:54,480
the devon case we'd be talking about

1143
00:41:59,349 --> 00:41:57,280
like thousands of years um and then

1144
00:42:01,910 --> 00:41:59,359
places like subglacial lake vostok in

1145
00:42:03,670 --> 00:42:01,920
antarctica people have argued for

1146
00:42:07,270 --> 00:42:03,680
hundreds of thousands of years that that

1147
00:42:09,910 --> 00:42:07,280
system uh might have been isolated um

1148
00:42:13,030 --> 00:42:09,920
and so again back to what does that tell

1149
00:42:15,190 --> 00:42:13,040
us about for other environments i mean i

1150
00:42:17,190 --> 00:42:15,200
would think that somewhere like you know

1151
00:42:20,470 --> 00:42:17,200
if we can ever get to sample subglacial

1152
00:42:22,470 --> 00:42:20,480
lake vostok um you know that really

1153
00:42:24,950 --> 00:42:22,480
would be quite interesting because uh

1154
00:42:26,470 --> 00:42:24,960
that system is thought to have existed

1155
00:42:29,270 --> 00:42:26,480
uh as far as i know for at least

1156
00:42:32,069 --> 00:42:29,280
millions of years not to say isolated

1157
00:42:34,710 --> 00:42:32,079
but the system's in a big rift basin so

1158
00:42:36,390 --> 00:42:34,720
um it's been been around for a long time

1159
00:42:37,589 --> 00:42:36,400
so that would be a really

1160
00:42:40,470 --> 00:42:37,599
interesting

1161
00:42:42,790 --> 00:42:40,480
you know target to answer to address

1162
00:42:46,069 --> 00:42:42,800
that question relative to you know the

1163
00:42:47,829 --> 00:42:46,079

longevity uh of those systems and their

1164
00:42:49,589 --> 00:42:47,839
and their isolation

1165
00:42:51,589 --> 00:42:49,599
absolutely and that kind of goes into

1166
00:42:53,190 --> 00:42:51,599
the inputs into the system and how long

1167
00:42:55,670 --> 00:42:53,200
has it been you know an isolated system

1168
00:42:58,630 --> 00:42:55,680
or not um so we do have another question

1169
00:43:01,829 --> 00:42:58,640
here from space tv on youtube um asking

1170
00:43:03,430 --> 00:43:01,839
about uh if we go drilling on europa uh

1171
00:43:05,670 --> 00:43:03,440
would you would we or should we drill

1172
00:43:07,430 --> 00:43:05,680
into the fracture lines so on on europa

1173
00:43:08,870 --> 00:43:07,440
we have these linea these you know these

1174
00:43:11,510 --> 00:43:08,880
large cracks on the surface where we've

1175
00:43:13,190 --> 00:43:11,520
identified identified sulfur species in

1176
00:43:14,309 --> 00:43:13,200
the cracks they might be the place where

1177
00:43:15,829 --> 00:43:14,319
there is communication with the

1178
00:43:18,069 --> 00:43:15,839
subsurface ocean

1179
00:43:19,190 --> 00:43:18,079
and so space tv wants to know if you

1180
00:43:21,589 --> 00:43:19,200
think we should drill into those

1181
00:43:23,670 --> 00:43:21,599
fractures or if we should avoid them

1182
00:43:26,550 --> 00:43:23,680
yeah i'm not necessarily thinking that

1183
00:43:28,870 --> 00:43:26,560
we would drill into the fractures per se

1184
00:43:30,550 --> 00:43:28,880
um mainly because

1185
00:43:32,630 --> 00:43:30,560
until we know whether there are other

1186
00:43:35,750 --> 00:43:32,640
targets that's part of the idea of the

1187
00:43:36,950 --> 00:43:35,760
radar analysis um is that maybe there

1188
00:43:39,750 --> 00:43:36,960

are other

1189
00:43:40,550 --> 00:43:39,760
water bodies or brine bodies within the

1190
00:43:43,349 --> 00:43:40,560
shell

1191
00:43:44,950 --> 00:43:43,359
um that might be identified uh there may

1192
00:43:47,510 --> 00:43:44,960
be better targets than than the

1193
00:43:50,390 --> 00:43:47,520
fractures uh so i'd i'd kind of want to

1194
00:43:53,510 --> 00:43:50,400
know more about like what else there

1195
00:43:55,109 --> 00:43:53,520
exists there before saying for sure oh

1196
00:43:58,950 --> 00:43:55,119
we should definitely

1197
00:44:00,710 --> 00:43:58,960
target those uh those environments

1198
00:44:02,630 --> 00:44:00,720
absolutely yeah i mean there's so much

1199
00:44:04,230 --> 00:44:02,640
more to explore right

1200
00:44:05,510 --> 00:44:04,240
and one thing we could explore so

1201
00:44:08,790 --> 00:44:05,520
there's been some recent research

1202
00:44:10,630 --> 00:44:08,800
suggesting a potential subsurface lakes

1203
00:44:12,309 --> 00:44:10,640
on mars

1204
00:44:13,750 --> 00:44:12,319
perhaps underneath of some ice at the

1205
00:44:15,430 --> 00:44:13,760
poles but also

1206
00:44:17,109 --> 00:44:15,440
in other regions potential signs of

1207
00:44:19,430 --> 00:44:17,119
subsurface lakes so

1208
00:44:21,109 --> 00:44:19,440
user aaron gibbons on youtube wants to

1209
00:44:23,030 --> 00:44:21,119
know

1210
00:44:25,109 --> 00:44:23,040
if you have any thoughts about whether

1211
00:44:27,990 --> 00:44:25,119
subglacial lakes or subsurface lakes on

1212
00:44:29,589 --> 00:44:28,000
mars might be the best places to look as

1213
00:44:31,990 --> 00:44:29,599

habitable niches

1214
00:44:34,470 --> 00:44:32,000
for life on mars

1215
00:44:35,990 --> 00:44:34,480
yeah possibly i think that the lakes

1216
00:44:38,630 --> 00:44:36,000
that have been suggested certainly

1217
00:44:40,790 --> 00:44:38,640
beneath the ice um i think that could be

1218
00:44:42,550 --> 00:44:40,800
really challenging because a i think

1219
00:44:44,150 --> 00:44:42,560
there might be a little bit of a

1220
00:44:46,390 --> 00:44:44,160
controversy but certainly differing

1221
00:44:49,510 --> 00:44:46,400
theories about whether they are really

1222
00:44:51,430 --> 00:44:49,520
lakes uh beneath the the ice but i still

1223
00:44:53,670 --> 00:44:51,440
think even if there are i think the the

1224
00:44:58,230 --> 00:44:53,680
projected temperature is sort of like

1225
00:45:00,710 --> 00:44:58,240
minus 50 minus 60 c um and so

1226
00:45:04,230 --> 00:45:00,720
that might not be a particularly great

1227
00:45:06,069 --> 00:45:04,240
place um you know uh for for microbial

1228
00:45:08,309 --> 00:45:06,079
life based on what we know on earth in

1229
00:45:10,870 --> 00:45:08,319
terms of to the best of my knowledge

1230
00:45:13,510 --> 00:45:10,880
there hasn't been evidence of activity

1231
00:45:16,390 --> 00:45:13,520
microbial activity at temperatures that

1232
00:45:18,630 --> 00:45:16,400
that cold um but i think you might want

1233
00:45:20,790 --> 00:45:18,640
to look in the subsurface that is that

1234
00:45:23,829 --> 00:45:20,800
at some depth in the subsurface you'll

1235
00:45:26,309 --> 00:45:23,839
find um you know brine and or water

1236
00:45:28,230 --> 00:45:26,319
temperatures that will be much closer to

1237
00:45:30,470 --> 00:45:28,240
zero right if you go down into the

1238
00:45:33,510 --> 00:45:30,480

subsurface you'll find environments

1239
00:45:35,910 --> 00:45:33,520
where uh it wouldn't be quite so cold so

1240
00:45:38,230 --> 00:45:35,920
i think i might want to investigate

1241
00:45:40,470 --> 00:45:38,240
those types of systems just because i

1242
00:45:42,950 --> 00:45:40,480
think then you know that you're more

1243
00:45:43,910 --> 00:45:42,960
likely to find uh

1244
00:45:47,270 --> 00:45:43,920
find

1245
00:45:49,829 --> 00:45:47,280
looking in conditions where you might

1246
00:45:53,270 --> 00:45:49,839
find viable organisms rather than if

1247
00:45:57,829 --> 00:45:55,670
like yeah i don't know of any evidence

1248
00:46:00,230 --> 00:45:57,839
that that would be a temperature where

1249
00:46:02,069 --> 00:46:00,240
life could thrive yeah that's extremely

1250
00:46:03,910 --> 00:46:02,079
cold uh for any kind of you know

1251
00:46:05,990 --> 00:46:03,920
catalytic process as well

1252
00:46:07,750 --> 00:46:06,000
um so we're gonna go back now to devin

1253
00:46:09,829 --> 00:46:07,760
um because so because david came back

1254
00:46:12,150 --> 00:46:09,839
david cooter came back on youtube and

1255
00:46:15,349 --> 00:46:12,160
asked uh are saline subglacial pools

1256
00:46:16,950 --> 00:46:15,359
uncommon um they say i would think salt

1257
00:46:19,349 --> 00:46:16,960
exclusion due to freezing would increase

1258
00:46:20,870 --> 00:46:19,359
the abundance of saline environments and

1259
00:46:23,109 --> 00:46:20,880
so i guess they want to know like why is

1260
00:46:24,950 --> 00:46:23,119
it you know so intriguing to find a more

1261
00:46:26,390 --> 00:46:24,960
hyper saline lake

1262
00:46:29,430 --> 00:46:26,400
right so

1263
00:46:32,390 --> 00:46:29,440

beneath the ice that's the the the the

1264
00:46:34,790 --> 00:46:32,400
distinction so you can find uh saline

1265
00:46:37,270 --> 00:46:34,800
pools definitely like in sufficient

1266
00:46:39,750 --> 00:46:37,280
environments you get evaporation you get

1267
00:46:42,710 --> 00:46:39,760
saline you get brine channels in sea ice

1268
00:46:45,670 --> 00:46:42,720
so when you make sea ice every year like

1269
00:46:49,510 --> 00:46:45,680
as you freeze that sea ice you exclude

1270
00:46:51,190 --> 00:46:49,520
salt uh into the into the channels um

1271
00:46:53,589 --> 00:46:51,200
and you end up with pretty briny

1272
00:46:55,910 --> 00:46:53,599
channels right within the sea ice so

1273
00:46:59,109 --> 00:46:55,920
yeah these things exist it's just that

1274
00:47:01,990 --> 00:46:59,119
beneath um an ice mass

1275
00:47:05,750 --> 00:47:02,000
again i just haven't uh you know i've

1276
00:47:08,550 --> 00:47:05,760
never heard of a of a

1277
00:47:11,670 --> 00:47:08,560
an example on earth anyway where there's

1278
00:47:14,309 --> 00:47:11,680
actually like hyper saline fluid right

1279
00:47:15,510 --> 00:47:14,319
that um that's the bit that's unusual

1280
00:47:17,670 --> 00:47:15,520
because

1281
00:47:20,870 --> 00:47:17,680
all the other systems certainly the ones

1282
00:47:22,309 --> 00:47:20,880
that we've investigated um you know

1283
00:47:25,109 --> 00:47:22,319
we've actually drilled into they're all

1284
00:47:28,390 --> 00:47:25,119
fresh and in a lot of other environments

1285
00:47:30,390 --> 00:47:28,400
i think people would um you know predict

1286
00:47:32,790 --> 00:47:30,400
that they should be fresh based on

1287
00:47:34,470 --> 00:47:32,800
looking at like the ice depth and you

1288
00:47:37,190 --> 00:47:34,480

know the geothermal heat flux and the

1289
00:47:39,510 --> 00:47:37,200
predicted temperature and so the fact

1290
00:47:40,950 --> 00:47:39,520
that we have a lake um and the other

1291
00:47:43,670 --> 00:47:40,960
thing that's interesting right from a

1292
00:47:45,670 --> 00:47:43,680
sort of glaciological perspective is the

1293
00:47:47,990 --> 00:47:45,680
lakes are right in the center of the ice

1294
00:47:50,870 --> 00:47:48,000
cap which is

1295
00:47:52,549 --> 00:47:50,880
you know a little bit more unusual um

1296
00:47:56,710 --> 00:47:52,559
than you might find

1297
00:47:58,470 --> 00:47:56,720
in um other systems especially those um

1298
00:48:01,270 --> 00:47:58,480
where you know the lakes are temperate

1299
00:48:03,270 --> 00:48:01,280
they're they're often found maybe um

1300
00:48:04,950 --> 00:48:03,280
underneath uh outlet glaciers or going

1301
00:48:07,109 --> 00:48:04,960
towards the margins

1302
00:48:09,589 --> 00:48:07,119
but maybe not quite beneath uh right

1303
00:48:11,510 --> 00:48:09,599
beneath the ice divide

1304
00:48:13,030 --> 00:48:11,520
indeed and so yes it's just yeah so

1305
00:48:15,349 --> 00:48:13,040
there are certainly some sailing systems

1306
00:48:17,430 --> 00:48:15,359
maybe not hyper saline lakes is the is

1307
00:48:19,750 --> 00:48:17,440
the big difference there

1308
00:48:22,710 --> 00:48:19,760
right yeah and especially again to the

1309
00:48:26,069 --> 00:48:22,720
best of my knowledge beneath like a a

1310
00:48:27,589 --> 00:48:26,079
large ice mass um

1311
00:48:29,670 --> 00:48:27,599
yeah that's very cool

1312
00:48:33,190 --> 00:48:29,680
um so our next question i'm going to

1313
00:48:35,750 --> 00:48:33,200

expand a little bit uh user at a niche

1314
00:48:37,670 --> 00:48:35,760
on twitter uh one they say that that's a

1315
00:48:38,950 --> 00:48:37,680
treat to hear about your research um so

1316
00:48:40,790 --> 00:48:38,960
thank you thank you

1317
00:48:42,470 --> 00:48:40,800
thank you then they say i would like to

1318
00:48:44,309 --> 00:48:42,480
know if you were able to identify any

1319
00:48:46,150 --> 00:48:44,319
novel microorganisms within these

1320
00:48:47,910 --> 00:48:46,160
extreme cold environments

1321
00:48:49,829 --> 00:48:47,920
and i personally would expand that a

1322
00:48:52,230 --> 00:48:49,839
little bit but maybe like what is the

1323
00:48:54,870 --> 00:48:52,240
most intriguing thing that you've found

1324
00:48:56,549 --> 00:48:54,880
so far in your research

1325
00:48:58,309 --> 00:48:56,559
yeah i mean in terms of the the

1326
00:49:01,430 --> 00:48:58,319
organisms you know

1327
00:49:03,349 --> 00:49:01,440
yes we have found sort of quite novel

1328
00:49:06,390 --> 00:49:03,359
organisms ie you've isolate you've got

1329
00:49:07,190 --> 00:49:06,400
an isola that nobody else has got ever

1330
00:49:10,309 --> 00:49:07,200
or

1331
00:49:12,790 --> 00:49:10,319
has exactly that particular iceland but

1332
00:49:14,870 --> 00:49:12,800
you know there are they're related or

1333
00:49:15,589 --> 00:49:14,880
closely rated to lots of other organisms

1334
00:49:17,910 --> 00:49:15,599
so

1335
00:49:20,549 --> 00:49:17,920
at one level they're not necessarily i

1336
00:49:22,790 --> 00:49:20,559
wouldn't say that special um but i think

1337
00:49:23,990 --> 00:49:22,800
what's interesting is certainly uh

1338
00:49:26,870 --> 00:49:24,000

organism

1339
00:49:29,349 --> 00:49:26,880
uh a thiobacillus species that was that

1340
00:49:31,910 --> 00:49:29,359
was isolated out of the glacier and the

1341
00:49:35,109 --> 00:49:31,920
canadian rock is what's neat is that you

1342
00:49:37,589 --> 00:49:35,119
know the metabolism is pretty good at

1343
00:49:39,829 --> 00:49:37,599
five degrees c and it doesn't get that

1344
00:49:41,990 --> 00:49:39,839
much more efficient if you increase the

1345
00:49:43,670 --> 00:49:42,000
temperature so this is something that

1346
00:49:45,030 --> 00:49:43,680
looks like it might have a little bit

1347
00:49:46,230 --> 00:49:45,040
more

1348
00:49:47,910 --> 00:49:46,240
whether you want to say it's actually

1349
00:49:50,710 --> 00:49:47,920
adapted to that temperature maybe you

1350
00:49:54,069 --> 00:49:50,720
can't say that but certainly at sort of

1351
00:49:56,230 --> 00:49:54,079
cold like fridge like temperatures um

1352
00:49:59,349 --> 00:49:56,240
you know the organism thrives pretty

1353
00:50:01,349 --> 00:49:59,359
well and so i'm always interested in i

1354
00:50:03,750 --> 00:50:01,359
think those are the sort of organisms

1355
00:50:05,510 --> 00:50:03,760
that are interesting and again

1356
00:50:07,670 --> 00:50:05,520
it's organisms that back to what you

1357
00:50:10,630 --> 00:50:07,680
were describing is when you grow them in

1358
00:50:13,589 --> 00:50:10,640
the lab you also want to see that back

1359
00:50:16,150 --> 00:50:13,599
to if you use um you know genomic

1360
00:50:18,549 --> 00:50:16,160
techniques that if i've taken an example

1361
00:50:21,270 --> 00:50:18,559
out of the community that if i uh you

1362
00:50:23,750 --> 00:50:21,280
know extract the community dna and i do

1363
00:50:25,910 --> 00:50:23,760

sequencing of that if it's maybe 16s

1364
00:50:27,750 --> 00:50:25,920
genes at least you're like oh wow in

1365
00:50:30,309 --> 00:50:27,760
that community we find a lot of

1366
00:50:34,309 --> 00:50:30,319
phylotypes in the community or

1367
00:50:37,270 --> 00:50:34,319
so sequences that are uh closely related

1368
00:50:38,630 --> 00:50:37,280
to thiobacillus i.e the organism that

1369
00:50:40,230 --> 00:50:38,640
you uh

1370
00:50:42,069 --> 00:50:40,240
have been able to grow in the lab so

1371
00:50:43,430 --> 00:50:42,079
that then you can tie that back in and

1372
00:50:45,510 --> 00:50:43,440
say hey

1373
00:50:48,390 --> 00:50:45,520
the organism that we grew in the lab is

1374
00:50:50,470 --> 00:50:48,400
really closely related to you know

1375
00:50:51,990 --> 00:50:50,480
organisms within the the natural

1376
00:50:53,510 --> 00:50:52,000
environment

1377
00:50:55,030 --> 00:50:53,520
yeah absolutely yeah it's important to

1378
00:50:57,030 --> 00:50:55,040
have both those pieces of information

1379
00:50:59,030 --> 00:50:57,040
too because there might be a bunch that

1380
00:50:59,990 --> 00:50:59,040
we're still missing and so it can't all

1381
00:51:01,349 --> 00:51:00,000
just be what we're growing and

1382
00:51:02,950 --> 00:51:01,359
cultivating it has to be the things that

1383
00:51:04,470 --> 00:51:02,960
we're actually exploring what's what's

1384
00:51:06,309 --> 00:51:04,480
possible based on the thermodynamics of

1385
00:51:07,510 --> 00:51:06,319
the system the chemistry of the system

1386
00:51:09,430 --> 00:51:07,520
and then we can start looking for some

1387
00:51:11,030 --> 00:51:09,440
of the things that might be there

1388
00:51:12,790 --> 00:51:11,040

and when it comes to looking for things

1389
00:51:14,790 --> 00:51:12,800
that might be there our next question is

1390
00:51:16,950 --> 00:51:14,800
a kind of fun one um from ana route

1391
00:51:19,109 --> 00:51:16,960
mohanty who is not only a production

1392
00:51:20,630 --> 00:51:19,119
assistant for ask an astrobiologist he's

1393
00:51:22,790 --> 00:51:20,640
also a visiting scholar at blue marble

1394
00:51:24,950 --> 00:51:22,800
space institute of science uh in my

1395
00:51:27,109 --> 00:51:24,960
group uh and he was very fortunate this

1396
00:51:30,230 --> 00:51:27,119
past year in the summer he had a chance

1397
00:51:32,549 --> 00:51:30,240
to visit ladakh in northern india near

1398
00:51:34,950 --> 00:51:32,559
the himalaya or in the himalaya

1399
00:51:37,589 --> 00:51:34,960
it's a very high altitude site uh 4 500

1400
00:51:39,589 --> 00:51:37,599
meters um where they serve as a mars

1401
00:51:42,069 --> 00:51:39,599
analog and there's also glaciers in this

1402
00:51:43,829 --> 00:51:42,079
site and so on arup wants to know um

1403
00:51:45,589 --> 00:51:43,839
what the differences are from what we

1404
00:51:47,829 --> 00:51:45,599
call you know alpine glacial systems

1405
00:51:50,069 --> 00:51:47,839
these high altitude glacial systems to

1406
00:51:51,990 --> 00:51:50,079
low altitude glacial systems

1407
00:51:53,430 --> 00:51:52,000
are there differences in the biology of

1408
00:51:55,349 --> 00:51:53,440
these systems that maybe can teach us

1409
00:51:57,990 --> 00:51:55,359
about habitability

1410
00:51:59,510 --> 00:51:58,000
yeah um to the best of my knowledge i've

1411
00:52:02,230 --> 00:51:59,520
not really

1412
00:52:04,150 --> 00:52:02,240
seen anything about the the microbial

1413
00:52:06,950 --> 00:52:04,160

populations again in the subglacial

1414
00:52:09,910 --> 00:52:06,960
environment that really differ from you

1415
00:52:11,349 --> 00:52:09,920
know i've looked at systems uh alpine

1416
00:52:14,309 --> 00:52:11,359
systems that yeah it might be at

1417
00:52:17,510 --> 00:52:14,319
slightly higher elevations and not as

1418
00:52:19,349 --> 00:52:17,520
high as as in as in the himalaya but i

1419
00:52:20,950 --> 00:52:19,359
haven't seen any reports about that i

1420
00:52:23,910 --> 00:52:20,960
think the difference might be

1421
00:52:26,790 --> 00:52:23,920
potentially the organisms that you might

1422
00:52:27,990 --> 00:52:26,800
find um in the surface or in the

1423
00:52:29,589 --> 00:52:28,000
snowpack

1424
00:52:32,390 --> 00:52:29,599
that's potentially where you might see

1425
00:52:35,190 --> 00:52:32,400
some differences right based on both

1426
00:52:37,910 --> 00:52:35,200
altitude and potentially as well like

1427
00:52:40,230 --> 00:52:37,920
distance from you know the

1428
00:52:42,870 --> 00:52:40,240
the ocean or a marine source that might

1429
00:52:46,390 --> 00:52:42,880
give you different populations of your

1430
00:52:48,630 --> 00:52:46,400
sort of sufficient uh um you know

1431
00:52:51,430 --> 00:52:48,640
microbial communities but in the

1432
00:52:54,390 --> 00:52:51,440
subsurface i mean the organisms that are

1433
00:52:56,630 --> 00:52:54,400
working on ground up rocks um to get

1434
00:52:58,950 --> 00:52:56,640
their chemical energy whether that's in

1435
00:53:01,990 --> 00:52:58,960
the himalaya or whether that's in you

1436
00:53:04,950 --> 00:53:02,000
know alaska or the canadian rockies or

1437
00:53:06,870 --> 00:53:04,960
you know um the high arctic

1438
00:53:08,950 --> 00:53:06,880

you know those are probably going to be

1439
00:53:11,109 --> 00:53:08,960
pretty similar right because there's not

1440
00:53:12,790 --> 00:53:11,119
a big difference between you know the

1441
00:53:14,950 --> 00:53:12,800
the minerals that you find in those from

1442
00:53:16,630 --> 00:53:14,960
grounding up the rock it's the same kind

1443
00:53:18,870 --> 00:53:16,640
of suite of uh

1444
00:53:20,470 --> 00:53:18,880
of maybe minerals that you find in in in

1445
00:53:22,470 --> 00:53:20,480
those different systems

1446
00:53:24,069 --> 00:53:22,480
yeah absolutely and so like that might

1447
00:53:25,829 --> 00:53:24,079
actually answer our next question as

1448
00:53:27,510 --> 00:53:25,839
well to a degree here so dan in the cave

1449
00:53:28,870 --> 00:53:27,520
has asked another question

1450
00:53:31,750 --> 00:53:28,880
um if you think the physical

1451
00:53:34,069 --> 00:53:31,760
characteristics um from like snow versus

1452
00:53:35,750 --> 00:53:34,079
fern versus glacier

1453
00:53:37,430 --> 00:53:35,760
has a drastic effect on the micro

1454
00:53:39,270 --> 00:53:37,440
environments experienced by communities

1455
00:53:41,430 --> 00:53:39,280
there and so i think they are asking

1456
00:53:42,790 --> 00:53:41,440
kind of about these surface kind of uh

1457
00:53:44,870 --> 00:53:42,800
areas again

1458
00:53:46,390 --> 00:53:44,880
yeah so again

1459
00:53:48,630 --> 00:53:46,400
i i think that

1460
00:53:49,910 --> 00:53:48,640
for sure the the person asking the

1461
00:53:52,069 --> 00:53:49,920
question is right that it's going to

1462
00:53:57,030 --> 00:53:52,079
make a pretty big difference in terms of

1463
00:53:58,470 --> 00:53:57,040

thinking about um you know the uh the uh

1464
00:54:01,829 --> 00:53:58,480
the type of material that's on the

1465
00:54:04,069 --> 00:54:01,839
surface the inputs to that surface um

1466
00:54:06,549 --> 00:54:04,079
you know question is like how much dust

1467
00:54:09,750 --> 00:54:06,559
is blown onto that surface how close is

1468
00:54:13,430 --> 00:54:09,760
it to uh you know uh local marine

1469
00:54:15,670 --> 00:54:13,440
sources or other other potential sources

1470
00:54:17,349 --> 00:54:15,680
that potentially could you know concede

1471
00:54:20,069 --> 00:54:17,359
that environment right you can imagine

1472
00:54:21,990 --> 00:54:20,079
that there's places on earth where

1473
00:54:24,150 --> 00:54:22,000
there's not a lot of like you know

1474
00:54:26,549 --> 00:54:24,160
middle antarctica there's not a lot of

1475
00:54:29,430 --> 00:54:26,559
places that would be seeding like that

1476
00:54:31,990 --> 00:54:29,440
surface snow apart from purely like

1477
00:54:34,630 --> 00:54:32,000
atmospheric input whereas if you went to

1478
00:54:38,230 --> 00:54:34,640
the coast you'd be looking at quite a

1479
00:54:41,109 --> 00:54:38,240
different range of both microorganisms

1480
00:54:43,270 --> 00:54:41,119
and or inputs of like dust and aerosols

1481
00:54:47,030 --> 00:54:43,280
and other things um

1482
00:54:49,670 --> 00:54:47,040
so yeah you i think you end up with a a

1483
00:54:51,990 --> 00:54:49,680
really broad range of potential uh

1484
00:54:54,710 --> 00:54:52,000
environments uh on the surface of these

1485
00:54:56,630 --> 00:54:54,720
glaciers for sure yeah absolutely and i

1486
00:54:57,750 --> 00:54:56,640
i think for dan in the cave uh one thing

1487
00:54:58,870 --> 00:54:57,760
you might want to look into there's

1488
00:55:00,789 --> 00:54:58,880

these really interesting things that

1489
00:55:03,270 --> 00:55:00,799
form on glacial surfaces called kryoka

1490
00:55:05,510 --> 00:55:03,280
knight um it's material of dust uh it's

1491
00:55:06,950 --> 00:55:05,520
dr skipmore mentions is blowing in

1492
00:55:08,069 --> 00:55:06,960
they accumulate in little areas that

1493
00:55:09,910 --> 00:55:08,079
kind of start to

1494
00:55:11,349 --> 00:55:09,920
they change the albedo of the ice and so

1495
00:55:13,430 --> 00:55:11,359
how the insulation from the sun comes in

1496
00:55:15,270 --> 00:55:13,440
they melt their own little cones into

1497
00:55:17,109 --> 00:55:15,280
the surfaces of the glacier and and some

1498
00:55:19,589 --> 00:55:17,119
researchers have studied that kryokanite

1499
00:55:21,990 --> 00:55:19,599
material to see where the dust inputs

1500
00:55:23,589 --> 00:55:22,000
are coming from so far away to land on

1501
00:55:25,829 --> 00:55:23,599
these glacial surfaces all this dust

1502
00:55:26,870 --> 00:55:25,839
coming in so um it's worth looking into

1503
00:55:29,430 --> 00:55:26,880
if you're intrigued more about the

1504
00:55:31,270 --> 00:55:29,440
surface processes for sure um so dr

1505
00:55:32,789 --> 00:55:31,280
skidmore i have one more question that i

1506
00:55:34,950 --> 00:55:32,799
want to ask from the audience for those

1507
00:55:37,190 --> 00:55:34,960
i can't get to i apologize we had so

1508
00:55:39,750 --> 00:55:37,200
many awesome questions but we have one

1509
00:55:42,789 --> 00:55:39,760
time for one more i think here um so

1510
00:55:44,069 --> 00:55:42,799
from rachira pow on youtube uh richard

1511
00:55:45,510 --> 00:55:44,079
says first off it's absolutely

1512
00:55:47,030 --> 00:55:45,520
fascinating to learn about glacial

1513
00:55:49,190 --> 00:55:47,040

habitability from you

1514
00:55:50,630 --> 00:55:49,200
um and then

1515
00:55:52,710 --> 00:55:50,640
they'd be glad to know more about the

1516
00:55:55,109 --> 00:55:52,720
challenges associated with this kind of

1517
00:55:56,470 --> 00:55:55,119
field research um especially pertaining

1518
00:55:58,309 --> 00:55:56,480
to your work and trying to isolate

1519
00:56:00,390 --> 00:55:58,319
microbes or take samples from microbes

1520
00:56:01,910 --> 00:56:00,400
but i think i'd love you know in these

1521
00:56:03,990 --> 00:56:01,920
next two minutes that we have left from

1522
00:56:05,829 --> 00:56:04,000
you um just you know what are they the

1523
00:56:07,109 --> 00:56:05,839
challenges in general about the research

1524
00:56:08,549 --> 00:56:07,119
that you've done

1525
00:56:10,230 --> 00:56:08,559
yeah i mean

1526
00:56:12,150 --> 00:56:10,240
one of the the primary challenges is

1527
00:56:14,150 --> 00:56:12,160
always logistics is getting to the

1528
00:56:16,390 --> 00:56:14,160
glaciers because glaciers usually aren't

1529
00:56:19,589 --> 00:56:16,400
necessarily in relatively accessible

1530
00:56:22,390 --> 00:56:19,599
environments um and then you know the

1531
00:56:24,549 --> 00:56:22,400
often the question is well access in

1532
00:56:27,030 --> 00:56:24,559
terms of not access from a permitting

1533
00:56:28,789 --> 00:56:27,040
standpoint but physical access right so

1534
00:56:30,549 --> 00:56:28,799
you want to sample waters coming out of

1535
00:56:33,510 --> 00:56:30,559
the base of the glacier well sometimes

1536
00:56:35,750 --> 00:56:33,520
that's relatively straightforward um but

1537
00:56:37,990 --> 00:56:35,760
then when you want to get the sediments

1538
00:56:40,630 --> 00:56:38,000

um that i don't know if they were part

1539
00:56:41,990 --> 00:56:40,640
of the the images that were shared but

1540
00:56:44,870 --> 00:56:42,000
you know one of the challenges is

1541
00:56:45,910 --> 00:56:44,880
sometimes if if you can find like a cave

1542
00:56:47,990 --> 00:56:45,920
um

1543
00:56:50,150 --> 00:56:48,000
or an opening at the base of the glacier

1544
00:56:51,190 --> 00:56:50,160
that you can basically that you can get

1545
00:56:53,190 --> 00:56:51,200
into

1546
00:56:55,670 --> 00:56:53,200
and then you can take samples right at

1547
00:56:58,069 --> 00:56:55,680
the the ice bed interface that's

1548
00:57:00,470 --> 00:56:58,079
obviously the best place to sample and

1549
00:57:01,829 --> 00:57:00,480
back to the challenges of that so then a

1550
00:57:03,990 --> 00:57:01,839
good time to go

1551
00:57:06,230 --> 00:57:04,000
is like october if you're in the

1552
00:57:09,030 --> 00:57:06,240
northern hemisphere because the seasonal

1553
00:57:10,710 --> 00:57:09,040
belt um like the melt water that feeds

1554
00:57:13,109 --> 00:57:10,720
into the glacier that's pretty much

1555
00:57:15,990 --> 00:57:13,119
turned off by october no more surface

1556
00:57:18,549 --> 00:57:16,000
melting and before the ice closes down

1557
00:57:19,990 --> 00:57:18,559
through what we call plastic closure um

1558
00:57:22,309 --> 00:57:20,000
you can then potentially have the

1559
00:57:25,750 --> 00:57:22,319
opportunity to go into some of these

1560
00:57:29,829 --> 00:57:25,760
caves um beneath the ice to actually

1561
00:57:31,270 --> 00:57:29,839
to take some samples um so yeah i'd say

1562
00:57:32,630 --> 00:57:31,280
access and then obviously the other

1563
00:57:35,349 --> 00:57:32,640

thing too is that once you've got your

1564
00:57:37,589 --> 00:57:35,359
samples you have to be pretty

1565
00:57:39,750 --> 00:57:37,599
careful and also efficient of saying

1566
00:57:42,150 --> 00:57:39,760
right i want to be able to keep these

1567
00:57:44,710 --> 00:57:42,160
nice and cold um

1568
00:57:47,270 --> 00:57:44,720
and so sometimes uh back to that

1569
00:57:49,109 --> 00:57:47,280
canadian rockers example you know got

1570
00:57:52,789 --> 00:57:49,119
pretty good at carrying up a five litre

1571
00:57:54,789 --> 00:57:52,799
dura of liquid nitrogen um you know

1572
00:57:56,950 --> 00:57:54,799
so that you take your sample you put it

1573
00:57:58,390 --> 00:57:56,960
in your little tube and you flash freeze

1574
00:58:00,950 --> 00:57:58,400
it on site

1575
00:58:02,630 --> 00:58:00,960
and keep it frozen so that then uh you

1576
00:58:04,630 --> 00:58:02,640
can be pretty confident that when you

1577
00:58:06,309 --> 00:58:04,640
take it back to the lab that then

1578
00:58:09,030 --> 00:58:06,319
nothing's really changed

1579
00:58:10,549 --> 00:58:09,040
since you took your sample yeah i will

1580
00:58:12,630 --> 00:58:10,559
say one time we were bringing an ice

1581
00:58:15,270 --> 00:58:12,640
block back from the arctic and we got

1582
00:58:17,109 --> 00:58:15,280
stuck in ottawa for two days and so we

1583
00:58:18,470 --> 00:58:17,119
had the hotel manager of the hotel we

1584
00:58:20,710 --> 00:58:18,480
were staying at allow us to put our

1585
00:58:22,230 --> 00:58:20,720
samples in their freezer um while we're

1586
00:58:24,710 --> 00:58:22,240
waiting for transport back just to keep

1587
00:58:26,710 --> 00:58:24,720
those samples nice and cold um so dr

1588
00:58:29,109 --> 00:58:26,720

skidmore it has been a huge pleasure

1589
00:58:30,549 --> 00:58:29,119
having you on ask an astrobiologist

1590
00:58:32,630 --> 00:58:30,559
thank you so much for joining us and

1591
00:58:34,710 --> 00:58:32,640
just sharing so much about your work

1592
00:58:36,710 --> 00:58:34,720
well thank you very much i enjoyed the

1593
00:58:38,789 --> 00:58:36,720
opportunity and thanks to all the folks

1594
00:58:41,349 --> 00:58:38,799
out there for some really interesting

1595
00:58:43,030 --> 00:58:41,359
and intriguing questions

1596
00:58:45,030 --> 00:58:43,040
and for all of those watching if you

1597
00:58:46,789 --> 00:58:45,040
want to continue communicating with us

1598
00:58:48,870 --> 00:58:46,799
one thing i'd love to know from you is

1599
00:58:50,950 --> 00:58:48,880
what is the most alien place you've been

1600
00:58:53,030 --> 00:58:50,960
to have you been to a glacier have you

1601
00:58:54,950 --> 00:58:53,040
been to a weird system on the earth

1602
00:58:57,750 --> 00:58:54,960
why not jump over to the at nasa

1603
00:59:00,470 --> 00:58:57,760
astrobio twitter account or at saganorg

1604
00:59:01,349 --> 00:59:00,480
or me at cosmobiologist and just let us

1605
00:59:03,430 --> 00:59:01,359
know

1606
00:59:05,030 --> 00:59:03,440
what are some cool places you've been

1607
00:59:07,349 --> 00:59:05,040
if you'd like to sign up for the nasa

1608
00:59:09,349 --> 00:59:07,359
astrobiology newsletter to receive

1609
00:59:11,190 --> 00:59:09,359
further information about our show or

1610
00:59:12,950 --> 00:59:11,200
other events and opportunities through

1611
00:59:14,309 --> 00:59:12,960
nasa astrobiology

1612
00:59:15,750 --> 00:59:14,319
we are sharing the link for that with

1613
00:59:17,750 --> 00:59:15,760

you right now

1614
00:59:20,069 --> 00:59:17,760
so for everyone out there thank you so

1615
00:59:21,430 --> 00:59:20,079
much for joining us to dr mark skidmore

1616
00:59:23,430 --> 00:59:21,440
thank you so much for being on the show

1617
00:59:25,510 --> 00:59:23,440
and sharing your expertise with us and

1618
00:59:29,330 --> 00:59:25,520
for everyone please remember to stay