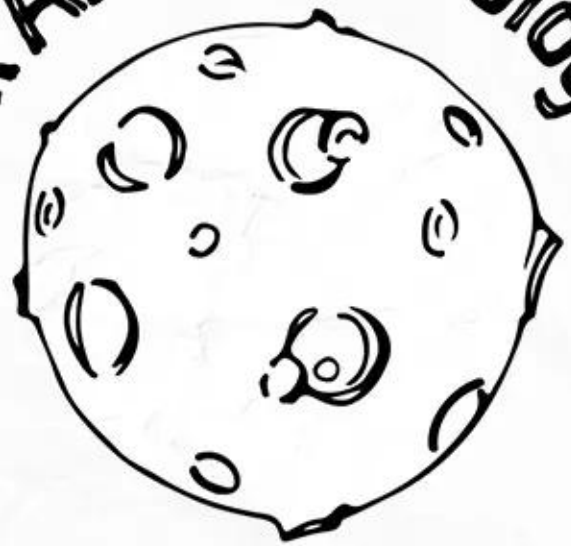
# Ask An Astrobiologist



Episode 6: May 30th, 2017

# Dr. Eric Boyd

NASA Astrobiology Program

1
00:00:00,510 --> 00:00:30,160
[Music]

2
00:00:34,610 --> 00:00:32,450
greetings friends of astrobiology

3
00:00:37,100 --> 00:00:34,620
welcome back to a brand new episode of

4
00:00:38,900 --> 00:00:37,110
ask an astrobiologist my name is Sandra

5
00:00:40,880 --> 00:00:38,910
um and this show is made possible by

6
00:00:43,700 --> 00:00:40,890
contributions from the NASA Astrobiology

7
00:00:45,500 --> 00:00:43,710
Program Elsi the earth Life Science

8
00:00:47,690 --> 00:00:45,510
Institute at Tokyo Tech and the

9
00:00:49,639 --> 00:00:47,700
nonprofit blue marble space this month

10
00:00:51,549 --> 00:00:49,649
we have a special guest again it is dr.

11
00:00:55,279 --> 00:00:51,559
Eric Boyd of Montana State University

12
00:00:58,459 --> 00:00:55,289
but first here's your monthly background

13
00:01:00,889 --> 00:00:58,469

quiz so what is behind me this month

14
00:01:03,290 --> 00:01:00,899
it's a fantastic site and tells a lot or

15
00:01:07,219 --> 00:01:03,300
not much about potential life on the

16
00:01:11,510 --> 00:01:07,229
early Earth but if you Mike if you could

17
00:01:14,420 --> 00:01:11,520
put up the picture from last month which

18
00:01:17,929 --> 00:01:14,430
was of the background when we talked

19
00:01:20,120 --> 00:01:17,939
last months it is did anybody guess it

20
00:01:25,070 --> 00:01:20,130
right if you did you have five seconds

21
00:01:28,249 --> 00:01:25,080
to put it on hashtag ask Astro bio it is

22
00:01:30,080 --> 00:01:28,259
the site of Quatro Sienna gas in Mexico

23
00:01:33,560 --> 00:01:30,090
and it's a pretty cool site because it

24
00:01:35,630 --> 00:01:33,570
hosts in those Springs microbial mats so

25
00:01:37,429 --> 00:01:35,640
this is actually living mats of bacteria

26
00:01:40,010 --> 00:01:37,439
stuck stacked on top of each other and

27
00:01:41,990 --> 00:01:40,020
they form some of the modern analog is a

28
00:01:43,700 --> 00:01:42,000
very ancient life on Earth so studying

29
00:01:45,920 --> 00:01:43,710
them in extreme environments on earth

30
00:01:49,219 --> 00:01:45,930
can give us a picture of what life was

31
00:01:52,310 --> 00:01:49,229
like in its infancy on earth and who

32
00:01:54,350 --> 00:01:52,320
knows potentially elsewhere so if you

33
00:01:56,630 --> 00:01:54,360
have any questions during the show make

34
00:01:59,690 --> 00:01:56,640
sure you ask them on either the Signet

35
00:02:01,700 --> 00:01:59,700
chat or use hashtag ask as for bio on

36
00:02:03,530 --> 00:02:01,710
twitter keep a good sight of this

37
00:02:05,990 --> 00:02:03,540
background behind me and we will talk

38
00:02:08,419 --> 00:02:06,000

about it next months when we chat with

39
00:02:10,790 --> 00:02:08,429
our new guest so this month we welcome

40
00:02:13,760 --> 00:02:10,800
dr. Eric Boyd from Montana State hello

41
00:02:16,250 --> 00:02:13,770
Eric how are you today

42
00:02:17,660 --> 00:02:16,260
enjoy thanks for inviting me along we're

43
00:02:19,130 --> 00:02:17,670
very lucky to have you thank you for

44
00:02:20,960 --> 00:02:19,140
being here we know you're busy guy and

45
00:02:22,460 --> 00:02:20,970
often you're in the field doing cool

46
00:02:24,650 --> 00:02:22,470
stuff and we'll talk about that but

47
00:02:26,270 --> 00:02:24,660
first like we like to do in the show is

48
00:02:29,090 --> 00:02:26,280
turn back the wheels of time a little

49
00:02:31,310 --> 00:02:29,100
bit and could you perhaps describe to us

50
00:02:32,930 --> 00:02:31,320
a little bit how you got started in

51
00:02:36,290 --> 00:02:32,940
science in the first place for some of

52
00:02:37,280 --> 00:02:36,300
our younger viewers I think that's a

53
00:02:39,380 --> 00:02:37,290
really good question

54
00:02:41,180 --> 00:02:39,390
Sanjoy one that I think is really

55
00:02:44,750 --> 00:02:41,190
important for for a lot of younger

56
00:02:47,810 --> 00:02:44,760
viewers to hear sometimes our paths are

57
00:02:51,920 --> 00:02:47,820
are kind of fortuitous aren't they and I

58
00:02:54,920 --> 00:02:51,930
I grew up and in Des Moines Iowa and I

59
00:02:57,800 --> 00:02:54,930
think I got started interested in

60
00:03:00,110 --> 00:02:57,810
science at a very young age my my mom

61
00:03:02,660 --> 00:03:00,120
and dad made sure that we explored the

62
00:03:05,900 --> 00:03:02,670
outdoors any chance that we could get

63
00:03:08,060 --> 00:03:05,910

but it was really a class in Earth

64
00:03:12,200 --> 00:03:08,070
Sciences and seventh grade that got me

65
00:03:14,000 --> 00:03:12,210
really excited about geology and didn't

66
00:03:16,390 --> 00:03:14,010
get interested in microbiology until

67
00:03:19,070 --> 00:03:16,400
much later but that class in geology

68
00:03:22,870 --> 00:03:19,080
studying concepts like plate tectonics

69
00:03:25,750 --> 00:03:22,880
and unconformity right how is the earth

70
00:03:28,840 --> 00:03:25,760
working how can we date rocks in a very

71
00:03:31,400 --> 00:03:28,850
basic way and so on and so forth that

72
00:03:34,430 --> 00:03:31,410
really got me excited about science and

73
00:03:37,190 --> 00:03:34,440
from there I was fortunate enough to go

74
00:03:39,620 --> 00:03:37,200
to Iowa State University and study

75
00:03:41,750 --> 00:03:39,630
obtain a degree in biology but it was

76
00:03:44,270 --> 00:03:41,760
not the degree in biology that got me

77
00:03:48,350 --> 00:03:44,280
really excited it was working in the

78
00:03:50,570 --> 00:03:48,360
labs of several microbiologists in

79
00:03:53,510 --> 00:03:50,580
particular and gentleman named Alan

80
00:03:56,630 --> 00:03:53,520
DiSpirito who's a professor of microbial

81
00:04:00,110 --> 00:03:56,640
physiology at Montana R at Iowa State

82
00:04:01,910 --> 00:04:00,120
University and and working in his lab he

83
00:04:05,449 --> 00:04:01,920
really opened up a lot of doors for me

84
00:04:07,160 --> 00:04:05,459
let me do explore microbiology in a way

85
00:04:10,280 --> 00:04:07,170
that you know I haven't been able to do

86
00:04:13,640 --> 00:04:10,290
until I got my own lab and from there

87
00:04:16,099 --> 00:04:13,650
you know there was a an individual from

88
00:04:18,890 --> 00:04:16,109

Montana State that came out and gave a

89
00:04:21,229 --> 00:04:18,900
seminar at Iowa State Guide by the

90
00:04:22,850 --> 00:04:21,239
gentleman by the name of Bill Koster

91
00:04:25,640 --> 00:04:22,860
Tinh who is the director of the Center

92
00:04:27,180 --> 00:04:25,650
for biofilm engineering here at Montana

93
00:04:29,879 --> 00:04:27,190
State and

94
00:04:32,710 --> 00:04:29,889
he showed me all of these images of

95
00:04:36,430 --> 00:04:32,720
microbial mats living in Hot Springs and

96
00:04:38,260 --> 00:04:36,440
ever since that point I was I was bent

97
00:04:39,999 --> 00:04:38,270
on coming to Montana State and studying

98
00:04:44,110 --> 00:04:40,009
hot springs in life that lives in those

99
00:04:46,749 --> 00:04:44,120
hot springs very cool I want to chat a

100
00:04:48,640 --> 00:04:46,759
little bit about your your professor at

101
00:04:50,980 --> 00:04:48,650
Iowa State's that you mentioned you work

102
00:04:53,260 --> 00:04:50,990
in his lab how did you reach out to him

103
00:04:55,950 --> 00:04:53,270
how did you find him how did he what was

104
00:04:58,990 --> 00:04:55,960
the process of starting to work in a lab

105
00:05:00,700 --> 00:04:59,000
well I worked in several labs as an

106
00:05:03,430 --> 00:05:00,710
undergraduate I worked in a structural

107
00:05:05,439 --> 00:05:03,440
biology lab so as my first lab

108
00:05:08,529 --> 00:05:05,449
experience was as freshmen my first

109
00:05:10,770 --> 00:05:08,539
semester I was in the honors program at

110
00:05:13,480 --> 00:05:10,780
Iowa State University and they they

111
00:05:15,430 --> 00:05:13,490
really promoted working obtaining

112
00:05:18,999 --> 00:05:15,440
undergraduate research experience and

113
00:05:21,040 --> 00:05:19,009

I'm very grateful for that worked in the

114
00:05:23,950 --> 00:05:21,050
lab of Amy andreotti and we studied this

115
00:05:25,749 --> 00:05:23,960
protein that that not to get down into

116
00:05:27,850 --> 00:05:25,759
the weeds and details but just how it

117
00:05:30,760 --> 00:05:27,860
functioned what powdered structure

118
00:05:33,640 --> 00:05:30,770
equate to function at a protein at an

119
00:05:37,029 --> 00:05:33,650
enzymatic level was excited about that

120
00:05:40,510 --> 00:05:37,039
research the summer after my sophomore

121
00:05:42,939 --> 00:05:40,520
year in college I decided to go to the

122
00:05:46,779 --> 00:05:42,949
Rocky Mountain Biological lab out

123
00:05:49,240 --> 00:05:46,789
Crested Butte Colorado and just for a

124
00:05:52,180 --> 00:05:49,250
different experience and started

125
00:05:53,649 --> 00:05:52,190
studying wetlands ecology and Glaciology

126
00:05:55,390 --> 00:05:53,659
were the two classes I took out there

127
00:05:58,170 --> 00:05:55,400
and really started getting more excited

128
00:06:01,809 --> 00:05:58,180
about the environmental side of of

129
00:06:04,240 --> 00:06:01,819
biology and came back to Iowa State in

130
00:06:08,020 --> 00:06:04,250
the way I got into Allan DiSpirito slab

131
00:06:09,820 --> 00:06:08,030
is interesting my older brother Jeff is

132
00:06:13,240 --> 00:06:09,830
a professor out at Rutgers University

133
00:06:16,450 --> 00:06:13,250
was actually working in his lab and so

134
00:06:19,330 --> 00:06:16,460
my in the way that I got in at an Al's

135
00:06:20,800 --> 00:06:19,340
lab completely grateful for it was

136
00:06:23,459 --> 00:06:20,810
through my through my older brothers

137
00:06:25,480 --> 00:06:23,469
experience and I started in studying

138
00:06:28,629 --> 00:06:25,490

microorganisms that oxidized methane

139
00:06:31,240 --> 00:06:28,639
methane gas and just follow them up with

140
00:06:35,800 --> 00:06:31,250
with that process and of course

141
00:06:39,180 --> 00:06:35,810
microbial diversity from there on so

142
00:06:40,690 --> 00:06:39,190
you're a micro biologist studying

143
00:06:43,390 --> 00:06:40,700
microbes in

144
00:06:47,110 --> 00:06:43,400
environments and diverse set of settings

145
00:06:48,850 --> 00:06:47,120
and a diverse set of bacteria how does

146
00:06:54,400 --> 00:06:48,860
that fit in into your interest in

147
00:06:56,980 --> 00:06:54,410
astrobiology yeah another great question

148
00:06:59,380 --> 00:06:56,990
you know what is astrobiology you know

149
00:07:03,370 --> 00:06:59,390
it's it's studying how life originated

150
00:07:05,560 --> 00:07:03,380
on earth what life is today on Earth and

151
00:07:07,420 --> 00:07:05,570
searching for life on other planets in a

152
00:07:10,450 --> 00:07:07,430
nutshell I think you could you could

153
00:07:13,300 --> 00:07:10,460
call that astrobiology and so if you're

154
00:07:15,520 --> 00:07:13,310
going to understand how life originated

155
00:07:18,250 --> 00:07:15,530
you better have a good perspective on

156
00:07:20,380 --> 00:07:18,260
what life looks like now you're going to

157
00:07:21,730 --> 00:07:20,390
identify what life might look like at

158
00:07:23,710 --> 00:07:21,740
another planet

159
00:07:25,210 --> 00:07:23,720
you better have a good perspective on

160
00:07:28,420 --> 00:07:25,220
what life looks like in diverse

161
00:07:30,850 --> 00:07:28,430
environmental settings here on earth and

162
00:07:32,800 --> 00:07:30,860
then of course you can you can use this

163
00:07:34,270 --> 00:07:32,810

information we there's a lot of

164
00:07:36,870 --> 00:07:34,280
scientists that believe that life

165
00:07:39,930 --> 00:07:36,880
originated in a hot environment

166
00:07:43,020 --> 00:07:39,940
something like 3.8 billion years ago

167
00:07:45,640 --> 00:07:43,030
it's not a hard it's not a stretch to

168
00:07:47,500 --> 00:07:45,650
suggest that hot springs represent

169
00:07:50,980 --> 00:07:47,510
modern analogs of what an early Earth

170
00:07:52,870 --> 00:07:50,990
hot environment might look like and it

171
00:07:55,930 --> 00:07:52,880
turns out when we look at life and these

172
00:07:59,080 --> 00:07:55,940
hot spring environments we see very

173
00:08:01,870 --> 00:07:59,090
ancient lineages of microorganisms so

174
00:08:04,750 --> 00:08:01,880
microorganisms that that when we look at

175
00:08:07,420 --> 00:08:04,760
their evolutionary history branch very

176
00:08:09,690 --> 00:08:07,430
early right we look at humans and all

177
00:08:12,640 --> 00:08:09,700
the animals and plants that we see today

178
00:08:14,380 --> 00:08:12,650
with our naked eyes are those branch

179
00:08:16,120 --> 00:08:14,390
very recently those are recent

180
00:08:18,450 --> 00:08:16,130
evolutionary adaptations what we're

181
00:08:22,360 --> 00:08:18,460
talking about our microbial lineage is

182
00:08:25,450 --> 00:08:22,370
that that diverged you know somewhere on

183
00:08:26,710 --> 00:08:25,460
a 3.5 3.8 billion years ago and so we

184
00:08:29,700 --> 00:08:26,720
think we're on pretty solid footing

185
00:08:33,120 --> 00:08:29,710
looking at life's origins in modern

186
00:08:35,589 --> 00:08:33,130
extreme environments like hot springs

187
00:08:37,270 --> 00:08:35,599
cool for speaking of hot springs you do

188
00:08:39,370 --> 00:08:37,280

quite a bit of work at Yellowstone

189
00:08:41,380 --> 00:08:39,380
National Park another hot spring area

190
00:08:43,420 --> 00:08:41,390
for those of us who don't have who have

191
00:08:45,070 --> 00:08:43,430
not traveled to such sites or I don't

192
00:08:46,360 --> 00:08:45,080
have much experience with them could you

193
00:08:48,850 --> 00:08:46,370
tell us a little bit what it's like to

194
00:08:51,700 --> 00:08:48,860
work next what is really incredibly

195
00:08:53,440 --> 00:08:51,710
beautiful yet dangerous Springs or you

196
00:08:54,460 --> 00:08:53,450
what you feel like what does it smell

197
00:08:58,390 --> 00:08:54,470
like what does it look like

198
00:09:06,400 --> 00:08:58,400
and what do you actually do well uh it's

199
00:09:08,860 --> 00:09:06,410
it's an absolute amazing experience just

200
00:09:11,380 --> 00:09:08,870
to say just say it you know broadly

201
00:09:12,910 --> 00:09:11,390
speaking it's it's if you haven't been

202
00:09:16,320 --> 00:09:12,920
to Yellowstone if you haven't seen a hot

203
00:09:21,280 --> 00:09:16,330
spring you need to go

204
00:09:24,550 --> 00:09:21,290
tremendous colors different minerals

205
00:09:26,680 --> 00:09:24,560
different microbial pigments it's it's a

206
00:09:29,500 --> 00:09:26,690
it's a tremendous place but it's a very

207
00:09:31,810 --> 00:09:29,510
dangerous place these Hot Springs are

208
00:09:33,190 --> 00:09:31,820
scalding right boiling water hold up I

209
00:09:40,570 --> 00:09:33,200
just need to get a drink of water hold

210
00:09:43,030 --> 00:09:40,580
on an absolutely tremendous place but

211
00:09:45,280 --> 00:09:43,040
again you got to be very careful and so

212
00:09:48,790 --> 00:09:45,290
when a visitor comes to Yellowstone Park

213
00:09:50,500 --> 00:09:48,800

and wants to see hot springs the park is

214
00:09:52,230 --> 00:09:50,510
built boardwalks to keep them safe to

215
00:09:54,430 --> 00:09:52,240
keep them from falling into hot springs

216
00:09:56,320 --> 00:09:54,440
we're not allowed to sample off the

217
00:09:57,820 --> 00:09:56,330
boardwalks we're not allowed to sample a

218
00:09:59,410 --> 00:09:57,830
public view which means that we're going

219
00:10:02,260 --> 00:09:59,420
off boardwalk we're going into the

220
00:10:05,170 --> 00:10:02,270
backcountry of Yellowstone to get our

221
00:10:07,060 --> 00:10:05,180
samples so we have to be very cautious

222
00:10:08,830 --> 00:10:07,070
about what we're doing where we're

223
00:10:12,490 --> 00:10:08,840
walking what kind of trails were walking

224
00:10:17,590 --> 00:10:12,500
on what is it what is it actually like

225
00:10:19,390 --> 00:10:17,600
to take a sample well it's it's amazing

226
00:10:21,640 --> 00:10:19,400
because you're taking this you know

227
00:10:24,220 --> 00:10:21,650
typically it's we're interested in

228
00:10:26,830 --> 00:10:24,230
organisms that cycle sulfur iron and so

229
00:10:29,920 --> 00:10:26,840
we're taking literally mineral sulfur or

230
00:10:31,690 --> 00:10:29,930
mineral iron as our sample and looking

231
00:10:34,390 --> 00:10:31,700
at the microbes that are associated with

232
00:10:37,180 --> 00:10:34,400
those with those minerals but because of

233
00:10:41,260 --> 00:10:37,190
that and the springs that we're actually

234
00:10:44,590 --> 00:10:41,270
working in tend to be acidic we come

235
00:10:48,280 --> 00:10:44,600
home from the field smelling like rotten

236
00:10:49,720 --> 00:10:48,290
eggs hydrogen sulfide gas that's being

237
00:10:53,950 --> 00:10:49,730
emitted from these hot springs every

238
00:10:55,720 --> 00:10:53,960

time I come home my wife my dogs are you

239
00:10:58,050 --> 00:10:55,730
know what is that smell well it's me

240
00:11:00,400 --> 00:10:58,060
it's is permeated your clothes it's it's

241
00:11:01,960 --> 00:11:00,410
it's a pretty impressive place but you

242
00:11:06,150 --> 00:11:01,970
need to get people need to go and check

243
00:11:09,939 --> 00:11:06,160
this place Yellowstone tremendous

244
00:11:12,040 --> 00:11:09,949
so the ancient earth was emanating a lot

245
00:11:13,629 --> 00:11:12,050
more heat than it is today and so

246
00:11:15,819 --> 00:11:13,639
perhaps a lot of the ancient earth

247
00:11:18,280 --> 00:11:15,829
surface was a lot more covered with

248
00:11:21,550 --> 00:11:18,290
these springs you ever have a sense that

249
00:11:23,379 --> 00:11:21,560
you're walking back in time or walking

250
00:11:28,389 --> 00:11:23,389
on another planet when you go to these

251
00:11:30,579 --> 00:11:28,399
hot spring parks yeah well you for

252
00:11:32,769 --> 00:11:30,589
reasons that I mentioned previously we

253
00:11:34,689 --> 00:11:32,779
know we're dealing with with modern

254
00:11:37,059 --> 00:11:34,699
representatives of very earth early

255
00:11:39,850 --> 00:11:37,069
evolving life-forms no no question about

256
00:11:43,269 --> 00:11:39,860
that that's that's really special right

257
00:11:46,290 --> 00:11:43,279
studying primitive life-forms some of

258
00:11:49,720 --> 00:11:46,300
the places that we go sample look like

259
00:11:51,460 --> 00:11:49,730
more or less Martian landscapes there's

260
00:11:54,040 --> 00:11:51,470
just not there's nothing there's no

261
00:11:55,689 --> 00:11:54,050
nothing grain living right they're so

262
00:11:58,619 --> 00:11:55,699
acidic they're so high temperature that

263
00:12:01,420 --> 00:11:58,629

that the plants can't grow in the soils

264
00:12:04,059 --> 00:12:01,430
and so you do get that kind of

265
00:12:06,040 --> 00:12:04,069
otherworldly experience or that you know

266
00:12:08,350 --> 00:12:06,050
imagining what the early Earth used to

267
00:12:11,110 --> 00:12:08,360
look like prior to plants coming around

268
00:12:15,220 --> 00:12:11,120
and animals coming around very barren

269
00:12:18,910 --> 00:12:15,230
landscapes minerals stains all over the

270
00:12:20,740 --> 00:12:18,920
rocks and so on and so forth it's so to

271
00:12:22,780 --> 00:12:20,750
answer your question absolutely it's

272
00:12:24,280 --> 00:12:22,790
it's it's an incredible experience if

273
00:12:26,590 --> 00:12:24,290
you do feel like you're walking back in

274
00:12:29,710 --> 00:12:26,600
time or even off the planet walking in

275
00:12:31,240 --> 00:12:29,720
outer space in a sense that's one of my

276
00:12:33,009 --> 00:12:31,250
favorite things I might ask for biology

277
00:12:34,840 --> 00:12:33,019
not only is it grounded in rigorous

278
00:12:38,170 --> 00:12:34,850
science but it also also very

279
00:12:39,819 --> 00:12:38,180
philosophical and artistic discipline we

280
00:12:43,480 --> 00:12:39,829
try to paint in a picture in your mind

281
00:12:46,299 --> 00:12:43,490
of what life could be a elsewhere so

282
00:12:48,100 --> 00:12:46,309
yeah I've been privileged to be to go to

283
00:12:50,049 --> 00:12:48,110
Yellowstone and I echo a lot of your

284
00:12:52,990 --> 00:12:50,059
sentiments that it's really a magical

285
00:12:54,669 --> 00:12:53,000
place so when you are close to the

286
00:12:56,860 --> 00:12:54,679
spring you approach the spring safely

287
00:13:00,249 --> 00:12:56,870
you get water samples and then you

288
00:13:02,049 --> 00:13:00,259

filter that water through filters - to

289
00:13:04,840 --> 00:13:02,059
capture some of those bacteria those

290
00:13:07,179 --> 00:13:04,850
cells those extremophiles and what kind

291
00:13:08,889 --> 00:13:07,189
of extreme doing do we see in those

292
00:13:14,590 --> 00:13:08,899
Springs and then you bring all these to

293
00:13:17,740 --> 00:13:14,600
the lab and then what yeah so so our lab

294
00:13:19,610 --> 00:13:17,750
really does does three things when we go

295
00:13:24,320 --> 00:13:19,620
to the spring okay we

296
00:13:28,010 --> 00:13:24,330
most always sample those waters to bring

297
00:13:30,470 --> 00:13:28,020
back to the lab we don't do anything to

298
00:13:34,160 --> 00:13:30,480
them we put them in little sealed vials

299
00:13:35,720 --> 00:13:34,170
and put them in thermos mugs to bring

300
00:13:36,940 --> 00:13:35,730
them back to the lab keeping them at

301
00:13:40,430 --> 00:13:36,950
high temperature and we'll actually

302
00:13:42,650 --> 00:13:40,440
design growth media to grow those

303
00:13:44,120 --> 00:13:42,660
organisms so that's one thing that we do

304
00:13:45,740 --> 00:13:44,130
and so we grow a lot of thermo files

305
00:13:50,030 --> 00:13:45,750
we've got bugs in the lab drilling right

306
00:13:51,980 --> 00:13:50,040
now in the upper 80s degrees centigrade

307
00:13:54,290 --> 00:13:51,990
so that's that's almost boiling boiling

308
00:13:59,329 --> 00:13:54,300
here in Bozeman Montana is 93 degrees

309
00:14:01,900 --> 00:13:59,339
centigrade what we'll also do is we'll

310
00:14:05,150 --> 00:14:01,910
collect samples for molecular analyses

311
00:14:08,090 --> 00:14:05,160
and so by that I made will take water

312
00:14:12,290 --> 00:14:08,100
and we'll filter that water through tiny

313
00:14:15,140 --> 00:14:12,300

mesh screens these mesh screens are 220

314
00:14:17,870 --> 00:14:15,150
nanometer pore size diameters this is

315
00:14:20,750 --> 00:14:17,880
way smaller than the width of a human

316
00:14:22,670 --> 00:14:20,760
hair way smaller than that and that's

317
00:14:24,829 --> 00:14:22,680
the size of these bacteria and archaea

318
00:14:26,870 --> 00:14:24,839
that we're working with well trap those

319
00:14:29,120 --> 00:14:26,880
organisms on these filters on these mesh

320
00:14:32,390 --> 00:14:29,130
filters and we'll bring them back to the

321
00:14:34,490 --> 00:14:32,400
lab or we'll do DNA based analyses on

322
00:14:35,630 --> 00:14:34,500
those organisms and we could use that to

323
00:14:40,000 --> 00:14:35,640
then reconstruct the evolutionary

324
00:14:45,290 --> 00:14:42,530
the third thing that we'll do is we'll

325
00:14:46,550 --> 00:14:45,300
actually characterize the environment so

326
00:14:48,590 --> 00:14:46,560
we'll take measurements of the

327
00:14:51,949 --> 00:14:48,600
temperature of that spring of the pH of

328
00:14:54,110 --> 00:14:51,959
that spring will look at some chemical

329
00:14:56,329 --> 00:14:54,120
species how much hydrogen sulfide is in

330
00:14:57,829 --> 00:14:56,339
that that rotten egg smell how much of

331
00:15:01,610 --> 00:14:57,839
that is actually dissolved in that water

332
00:15:03,500 --> 00:15:01,620
how much iron is in the water can we do

333
00:15:05,090 --> 00:15:03,510
this because those are the nutrients

334
00:15:07,430 --> 00:15:05,100
that actually sustain this life these

335
00:15:09,890 --> 00:15:07,440
are a lot not life forms but are

336
00:15:12,740 --> 00:15:09,900
dependent on light energy all of the

337
00:15:15,050 --> 00:15:12,750
life forms that you and I see saw on our

338
00:15:17,180 --> 00:15:15,060

way to work this morning those are all

339
00:15:20,300 --> 00:15:17,190
life forms that are dependent on the Sun

340
00:15:24,560 --> 00:15:20,310
as a source of energy what we're talking

341
00:15:26,030 --> 00:15:24,570
about is life that's not using Sun they

342
00:15:28,640 --> 00:15:26,040
don't want Sun they don't care about

343
00:15:31,310 --> 00:15:28,650
sunlight they're using mineral chemical

344
00:15:32,470 --> 00:15:31,320
sources of energy to sustain themselves

345
00:15:35,199 --> 00:15:32,480
and there he goes

346
00:15:37,000 --> 00:15:35,209
systems which is a yet another reason

347
00:15:40,509 --> 00:15:37,010
that we study these organisms because we

348
00:15:42,850 --> 00:15:40,519
know that photosynthesis didn't evolve

349
00:15:44,980 --> 00:15:42,860
on earth and tell about Oh somewhere

350
00:15:48,100 --> 00:15:44,990
around 2.8 billion years ago so prior

351
00:15:50,019 --> 00:15:48,110
that prior to 2.8 billion years ago all

352
00:15:52,360 --> 00:15:50,029
of those life-forms were dependent on a

353
00:15:54,160 --> 00:15:52,370
mineral sources of energy so what yet

354
00:15:57,400 --> 00:15:54,170
another reason why we study hot springs

355
00:16:00,460 --> 00:15:57,410
high temperature hot springs for

356
00:16:02,590 --> 00:16:00,470
astrobiology studies so it's been

357
00:16:05,530 --> 00:16:02,600
incredible these are living life-forms

358
00:16:08,410 --> 00:16:05,540
that use only rock and hot water as

359
00:16:10,629 --> 00:16:08,420
their source of food and energy and of

360
00:16:13,090 --> 00:16:10,639
course rocks and hot water are not

361
00:16:16,329 --> 00:16:13,100
limited to earth right there's relict

362
00:16:19,210 --> 00:16:16,339
hot springs on mars and there are moons

363
00:16:22,180 --> 00:16:19,220

around our gas giants Jupiter and Saturn

364
00:16:25,930 --> 00:16:22,190
which have geysers coming out of their

365
00:16:28,870 --> 00:16:25,940
icy surface which implies water and rock

366
00:16:31,240 --> 00:16:28,880
reactions in their subsurface do you

367
00:16:33,939 --> 00:16:31,250
think we will find life in those in

368
00:16:36,340 --> 00:16:33,949
those Springs once we go explore Europa

369
00:16:39,340 --> 00:16:36,350
so the moon of Jupiter and Enceladus

370
00:16:41,079 --> 00:16:39,350
which is the moon of Saturn those are

371
00:16:43,389 --> 00:16:41,089
those were really great points to enjoy

372
00:16:46,300 --> 00:16:43,399
and I I want to back up just a second

373
00:16:47,980 --> 00:16:46,310
here and say that hot springs are one of

374
00:16:51,150 --> 00:16:47,990
the few places on the surface of the

375
00:16:53,230 --> 00:16:51,160
earth because the high-temperature

376
00:16:54,879 --> 00:16:53,240
photosynthetic life has never figured

377
00:16:58,240 --> 00:16:54,889
out how to grow at a temperature higher

378
00:17:00,910 --> 00:16:58,250
than 70 degrees centigrade so any hot

379
00:17:02,680 --> 00:17:00,920
spring that we sample above that

380
00:17:04,539 --> 00:17:02,690
temperature it's all dependent on on

381
00:17:07,090 --> 00:17:04,549
mineral sources of energy that's what

382
00:17:09,760 --> 00:17:07,100
these rocks that you were just way to go

383
00:17:13,179 --> 00:17:09,770
I also like to point out that the

384
00:17:15,970 --> 00:17:13,189
largest biosphere on earth is is in the

385
00:17:18,510 --> 00:17:15,980
subsurface right so the rocks that are

386
00:17:23,429 --> 00:17:18,520
underneath our feet host microbial

387
00:17:26,890 --> 00:17:23,439
ecosystems that dwarf incise what we see

388
00:17:31,289 --> 00:17:26,900

on the surface of the earth okay so if

389
00:17:34,810 --> 00:17:31,299
we know all of that and we didn't go to

390
00:17:38,530 --> 00:17:34,820
let's let's take a walk to Mars we're

391
00:17:40,419 --> 00:17:38,540
walking on Mars and we know at the very

392
00:17:43,120 --> 00:17:40,429
least there's glacial ice on Mars so

393
00:17:45,610 --> 00:17:43,130
there's water we go drill down into the

394
00:17:46,240 --> 00:17:45,620
surface of Mars not even very far we're

395
00:17:48,340 --> 00:17:46,250
going to find

396
00:17:51,720 --> 00:17:48,350
good water there's certainly plenty of

397
00:17:54,100 --> 00:17:51,730
rock there right it's a rocky planet

398
00:17:56,730 --> 00:17:54,110
plenty of iron oxide on the surface

399
00:17:59,440 --> 00:17:56,740
which is what makes it red so presumably

400
00:18:01,240 --> 00:17:59,450
deeper within the crust you've got more

401
00:18:03,640 --> 00:18:01,250
reduced forms of these minerals that

402
00:18:06,850 --> 00:18:03,650
could support life you've really got all

403
00:18:09,910 --> 00:18:06,860
the ingredients don't you if we go to

404
00:18:11,890 --> 00:18:09,920
the place like Europa where we know or

405
00:18:16,120 --> 00:18:11,900
Enceladus where we know we've got this

406
00:18:17,710 --> 00:18:16,130
this thin layer of ice these icy worlds

407
00:18:21,490 --> 00:18:17,720
and we've got a liquid ocean underneath

408
00:18:23,380 --> 00:18:21,500
them Enceladus we now think that we've

409
00:18:25,810 --> 00:18:23,390
got actually geysers and hydrothermal

410
00:18:27,040 --> 00:18:25,820
activity on on Enceladus right you've

411
00:18:27,700 --> 00:18:27,050
got the ingredients there you've got

412
00:18:31,690 --> 00:18:27,710
water

413
00:18:33,960 --> 00:18:31,700

you've got minerals spewing out

414
00:18:37,420 --> 00:18:33,970
nutrients that can support life and so I

415
00:18:40,540 --> 00:18:37,430
think as soon as we can get sampling

416
00:18:43,330 --> 00:18:40,550
gear that might include being a sending

417
00:18:45,630 --> 00:18:43,340
a scientist up there to one of these

418
00:18:49,240 --> 00:18:45,640
rocky planets that we're going to find

419
00:18:51,700 --> 00:18:49,250
my prediction is that yes we'll find

420
00:18:55,510 --> 00:18:51,710
evidence for life I'd be surprised if we

421
00:18:57,820 --> 00:18:55,520
did actually and so if there is life on

422
00:19:00,460 --> 00:18:57,830
our neighbouring moons in our solar

423
00:19:02,680 --> 00:19:00,470
system that would presumably mean means

424
00:19:04,330 --> 00:19:02,690
that life is a by-product of planet

425
00:19:06,370 --> 00:19:04,340
revolution if the conditions are right

426
00:19:09,880 --> 00:19:06,380
and so it should be plastered all over

427
00:19:11,830 --> 00:19:09,890
the galaxy I think I think it is a

428
00:19:14,590 --> 00:19:11,840
planet I think life is a planetary

429
00:19:16,540 --> 00:19:14,600
process just like a planet

430
00:19:19,180 --> 00:19:16,550
differentiating at the earth

431
00:19:21,130 --> 00:19:19,190
differentiating we now have a crust and

432
00:19:25,920 --> 00:19:21,140
we have a mantle and we have a core as

433
00:19:29,640 --> 00:19:25,930
part of a planetary process that core is

434
00:19:34,840 --> 00:19:29,650
releasing a ton of heat as it undergoes

435
00:19:37,990 --> 00:19:34,850
fusion reactions that is a planetary

436
00:19:39,820 --> 00:19:38,000
process dissipating energy and I had a

437
00:19:43,060 --> 00:19:39,830
good friend of mine a colleague down at

438
00:19:45,700 --> 00:19:43,070

Arizona State you know he's really

439
00:19:48,550 --> 00:19:45,710
pushed this idea a lot the idea that

440
00:19:52,240 --> 00:19:48,560
life is a planetary process ever it

441
00:19:55,330 --> 00:19:52,250
shocked to suggest that when chemical

442
00:19:57,580 --> 00:19:55,340
reactions take place they're taking

443
00:19:59,130 --> 00:19:57,590
place without life's involvement all

444
00:20:01,530 --> 00:19:59,140
around us all of the time

445
00:20:03,960 --> 00:20:01,540
okay but when those chemical reactions

446
00:20:04,620 --> 00:20:03,970
slow down to a point that they're so

447
00:20:06,630 --> 00:20:04,630
slow

448
00:20:09,930 --> 00:20:06,640
that's what that's that's where biology

449
00:20:12,810 --> 00:20:09,940
gets its stronghold biology creeps in

450
00:20:14,550 --> 00:20:12,820
and catalyzes that process as part of

451
00:20:18,480 --> 00:20:14,560
the planetary process of energy

452
00:20:23,040 --> 00:20:18,490
dissipation turning chemical energy into

453
00:20:25,230 --> 00:20:23,050
heat and so I I completely agree with

454
00:20:27,390 --> 00:20:25,240
your statement that you know any place

455
00:20:30,240 --> 00:20:27,400
that we have climate conditions so

456
00:20:32,670 --> 00:20:30,250
enough stability for biomolecules to

457
00:20:36,240 --> 00:20:32,680
form and be maintained and be replicated

458
00:20:38,880 --> 00:20:36,250
we have liquid water we have sources of

459
00:20:42,180 --> 00:20:38,890
chemical disequilibrium so I mean a

460
00:20:45,150 --> 00:20:42,190
source of energy chemical disequilibrium

461
00:20:47,490 --> 00:20:45,160
what I mean by that not to up to again

462
00:20:48,930 --> 00:20:47,500
get into the details but if you're going

463
00:20:50,640 --> 00:20:48,940

to eat a cheeseburger for lunch today

464
00:20:52,890 --> 00:20:50,650
that cheeseburgers and chemical

465
00:20:54,900 --> 00:20:52,900
disequilibrium with the oxygen that

466
00:20:57,720 --> 00:20:54,910
you're going to be breathing in to

467
00:21:00,570 --> 00:20:57,730
oxidize that cheeseburger to generate

468
00:21:02,520 --> 00:21:00,580
the energy that fuels yourself okay

469
00:21:04,470 --> 00:21:02,530
that's what I'm talking about with

470
00:21:06,540 --> 00:21:04,480
chemical disequilibrium so in a planet

471
00:21:10,770 --> 00:21:06,550
that has chemical disequilibrium water

472
00:21:11,910 --> 00:21:10,780
climate conditions I see no reason to

473
00:21:14,280 --> 00:21:11,920
think that there wouldn't be life

474
00:21:17,960 --> 00:21:14,290
present there and have originated there

475
00:21:21,330 --> 00:21:17,970
just like it on earth this has of course

476
00:21:23,400 --> 00:21:21,340
important social implications that we'll

477
00:21:26,730 --> 00:21:23,410
get to in a little bit giving you some

478
00:21:28,470 --> 00:21:26,740
time to think about it but I want to get

479
00:21:31,260 --> 00:21:28,480
back to Enceladus because just a few

480
00:21:34,020 --> 00:21:31,270
weeks ago NASA made this discovery made

481
00:21:36,540 --> 00:21:34,030
his announcement that hydrogen was

482
00:21:37,800 --> 00:21:36,550
discovered spewing out of the geysers in

483
00:21:39,600 --> 00:21:37,810
on Enceladus

484
00:21:42,330 --> 00:21:39,610
what's so what's so valuable about

485
00:21:45,720 --> 00:21:42,340
hydrogen as a source for biology or

486
00:21:49,680 --> 00:21:45,730
energy for biology whether I could I can

487
00:21:52,290 --> 00:21:49,690
tell you that as a lab we were extremely

488
00:21:55,140 --> 00:21:52,300

excited about that discovery so most

489
00:21:57,740 --> 00:21:55,150
everybody in our lab studies hydrogen I

490
00:22:01,260 --> 00:21:57,750
would say that our lab is a hydrogen lab

491
00:22:03,510 --> 00:22:01,270
hydrogen is a is a gas the minor

492
00:22:05,250 --> 00:22:03,520
component of our atmosphere but it's a

493
00:22:07,830 --> 00:22:05,260
major component of the gases and hot

494
00:22:10,560 --> 00:22:07,840
springs the major component of gases

495
00:22:12,560 --> 00:22:10,570
dissolved gases that we find in the

496
00:22:15,200 --> 00:22:12,570
subsurface subsurface fracture

497
00:22:18,230 --> 00:22:15,210
fluids and unearth and the reason for

498
00:22:22,399 --> 00:22:18,240
that is that minerals that are rich in

499
00:22:24,889 --> 00:22:22,409
iron when they interact with water they

500
00:22:28,759 --> 00:22:24,899
reduce that water and make hydrogen gas

501
00:22:30,740 --> 00:22:28,769
so a completely abiotic process makes

502
00:22:32,509 --> 00:22:30,750
hydrogen Cassim and we know that at

503
00:22:34,460 --> 00:22:32,519
higher temperatures this processes

504
00:22:37,730 --> 00:22:34,470
happen faster which is why we see so

505
00:22:39,379 --> 00:22:37,740
much hydrogen and hot springs but we see

506
00:22:41,360 --> 00:22:39,389
a lot of microorganisms and those hot

507
00:22:43,850 --> 00:22:41,370
springs that are dependent on that

508
00:22:46,369 --> 00:22:43,860
hydrogen as their their food source and

509
00:22:48,769 --> 00:22:46,379
so our lab studies the role of hydrogen

510
00:22:51,789 --> 00:22:48,779
and sustaining these mineral dependent

511
00:22:54,409 --> 00:22:51,799
forms of life so we are really excited

512
00:22:57,769 --> 00:22:54,419
by the discovery by the announcement of

513
00:23:00,080 --> 00:22:57,779

NASA that at these plumes being ejected

514
00:23:01,639 --> 00:23:00,090
from Enceladus contained hydrogen

515
00:23:04,879 --> 00:23:01,649
because we have pretty good evidence

516
00:23:07,480 --> 00:23:04,889
that underneath this this icy layer an

517
00:23:11,269 --> 00:23:07,490
ocean of Enceladus there should be

518
00:23:15,110 --> 00:23:11,279
plenty of rock to generate that hydrogen

519
00:23:17,419 --> 00:23:15,120
gas if you've got hydrogen gas again and

520
00:23:19,490 --> 00:23:17,429
disequilibrium with with with another

521
00:23:21,379 --> 00:23:19,500
chemical species there's a source of

522
00:23:23,720 --> 00:23:21,389
energy there a large source of energy

523
00:23:25,460 --> 00:23:23,730
there's a lot of energy and hydrogen

524
00:23:30,259 --> 00:23:25,470
when you oxidize it with other other

525
00:23:33,350 --> 00:23:30,269
chemical species so the simple reaction

526
00:23:35,659 --> 00:23:33,360
of water reacting with a rock that's not

527
00:23:40,669 --> 00:23:35,669
unique to earth can produce this

528
00:23:43,519 --> 00:23:40,679
fundamental food source for biology yeah

529
00:23:47,299 --> 00:23:43,529
there's there's no question that these

530
00:23:49,970 --> 00:23:47,309
rocks are not unique to earth okay we

531
00:23:52,240 --> 00:23:49,980
find similar minerals on Mars we haven't

532
00:23:55,610 --> 00:23:52,250
we don't know much about the mineralogy

533
00:23:58,210 --> 00:23:55,620
or I should I don't think we know very

534
00:24:03,529 --> 00:23:58,220
much about the mineralogy of Enceladus

535
00:24:05,180 --> 00:24:03,539
in Europa's course right harder to get

536
00:24:06,680 --> 00:24:05,190
to but we find this the same minerals

537
00:24:08,869 --> 00:24:06,690
that we find on Mars we find on earth

538
00:24:11,419 --> 00:24:08,879

okay there's nothing unique about these

539
00:24:14,149 --> 00:24:11,429
minerals on earth that we know when they

540
00:24:18,499 --> 00:24:14,159
interact with water generate hydrogen

541
00:24:22,129 --> 00:24:18,509
gas okay and so again there's a ton of

542
00:24:26,150 --> 00:24:22,139
energy in hydrogen the reason you know

543
00:24:29,990 --> 00:24:26,160
we everybody's probably heard about

544
00:24:31,940 --> 00:24:30,000
the Zeppelin it was a blimp that they

545
00:24:34,190 --> 00:24:31,950
filled with hydrogen gas okay and

546
00:24:36,290 --> 00:24:34,200
hydrogen is lighter than nitrogen so it

547
00:24:41,470 --> 00:24:36,300
caused the blimp to float this is great

548
00:24:46,040 --> 00:24:43,730
there was a problem with the Zeppelin

549
00:24:48,620 --> 00:24:46,050
that's because it was filled with

550
00:24:52,580 --> 00:24:48,630
hydrogen in an atmosphere that was 21%

551
00:24:55,280 --> 00:24:52,590
oxygen and somebody lit a flame that

552
00:24:57,050 --> 00:24:55,290
blew up hydrogen is explosive there's a

553
00:24:59,030 --> 00:24:57,060
ton of energy to be had there when you

554
00:25:01,190 --> 00:24:59,040
oxidize it with something like oxygen so

555
00:25:03,080 --> 00:25:01,200
we were extremely excited now I think

556
00:25:07,550 --> 00:25:03,090
the next question at least with respect

557
00:25:09,020 --> 00:25:07,560
to Enceladus is what other sources of

558
00:25:10,820 --> 00:25:09,030
nutrients might be there that allow

559
00:25:15,320 --> 00:25:10,830
these microorganisms to get after that

560
00:25:16,520 --> 00:25:15,330
hydrogen gas fascinating those of you

561
00:25:18,910 --> 00:25:16,530
who are watching don't forget you can

562
00:25:21,560 --> 00:25:18,920
ask your questions using hashtag ask

563
00:25:23,150 --> 00:25:21,570

astrobiology I'm on the Signet chat and

564
00:25:25,400 --> 00:25:23,160
we'll talk about your questions where's

565
00:25:27,050 --> 00:25:25,410
Erik in a little bit but you mentioned

566
00:25:29,390 --> 00:25:27,060
Mars I'm interested in about Mars as

567
00:25:31,040 --> 00:25:29,400
well because on Mars you have the rocks

568
00:25:33,110 --> 00:25:31,050
volcanic rocks that are similar to the

569
00:25:34,790 --> 00:25:33,120
volcanic sub rocks on earth there is

570
00:25:37,840 --> 00:25:34,800
evidence for past's liquid water

571
00:25:40,220 --> 00:25:37,850
activity on the planet and the dominant

572
00:25:42,830 --> 00:25:40,230
composition of the Martian atmosphere is

573
00:25:45,530 --> 00:25:42,840
co2 now there are some bacteria that

574
00:25:48,800 --> 00:25:45,540
used this rock generated hydrogen with

575
00:25:51,560 --> 00:25:48,810
co2 to form this gas methane that you

576
00:25:53,540 --> 00:25:51,570
mentioned earlier and methane has been

577
00:25:55,640 --> 00:25:53,550
controversially discovered in the

578
00:26:00,770 --> 00:25:55,650
atmospheres of Mars what are your

579
00:26:02,900 --> 00:26:00,780
thoughts on this so we we have pretty

580
00:26:06,350 --> 00:26:02,910
solid evidence that actually came out of

581
00:26:08,860 --> 00:26:06,360
our lab back in 2014 that the earliest

582
00:26:11,110 --> 00:26:08,870
forms of life on Earth

583
00:26:13,370 --> 00:26:11,120
certainly the earliest forms of hydrogen

584
00:26:17,000 --> 00:26:13,380
dependant life-forms on earth are these

585
00:26:19,400 --> 00:26:17,010
organisms called methanogens okay and so

586
00:26:21,890 --> 00:26:19,410
we study methanogens we study hydrogen

587
00:26:24,770 --> 00:26:21,900
these organisms are taking hydrogen gas

588
00:26:27,260 --> 00:26:24,780

the same way that we're eating a

589
00:26:28,610 --> 00:26:27,270
cheeseburger they're eating hydrogen on

590
00:26:32,500 --> 00:26:28,620
the same way that we're breathing oxygen

591
00:26:36,590 --> 00:26:32,510
they're breathing co2 and they're

592
00:26:39,020 --> 00:26:36,600
exhaling methane and so what you were

593
00:26:39,789 --> 00:26:39,030
referring to earlier was this paper from

594
00:26:43,220 --> 00:26:39,799
I believe

595
00:26:46,690 --> 00:26:43,230
2009 plus or minus a year they're out of

596
00:26:50,860 --> 00:26:46,700
NASA Goddard's lab Mike Mumma they're

597
00:26:53,509 --> 00:26:50,870
where they discovered temporal so

598
00:26:56,210 --> 00:26:53,519
variable concentrations of methane in

599
00:26:58,970 --> 00:26:56,220
the atmosphere of Mars that was really

600
00:27:00,460 --> 00:26:58,980
exciting that was at a time I was

601
00:27:03,769 --> 00:27:00,470
actually doing my NASA postdoctoral

602
00:27:06,110 --> 00:27:03,779
fellowship research at that time where

603
00:27:07,879 --> 00:27:06,120
we focused our work on on those

604
00:27:09,320 --> 00:27:07,889
organisms as methanogens that live

605
00:27:13,340 --> 00:27:09,330
underneath ice sheets underneath

606
00:27:15,860 --> 00:27:13,350
glaciers and we did so because we know

607
00:27:19,399 --> 00:27:15,870
that at least a predominant source of

608
00:27:22,580 --> 00:27:19,409
water on Mars is in the form of ice so

609
00:27:24,499 --> 00:27:22,590
can we understand the role of glaciated

610
00:27:26,899 --> 00:27:24,509
systems in the formation of methane

611
00:27:29,869 --> 00:27:26,909
through microbial activity here on earth

612
00:27:31,899 --> 00:27:29,879
and he's that to guide our search and

613
00:27:36,139 --> 00:27:31,909

our exploration on Mars

614
00:27:38,110 --> 00:27:36,149
absolutely good question very cool

615
00:27:41,240 --> 00:27:38,120
that's it's fascinating that such a

616
00:27:42,409 --> 00:27:41,250
fundamental process water and rock it's

617
00:27:45,320 --> 00:27:42,419
nothing complicated really

618
00:27:48,350 --> 00:27:45,330
can one generate heat generate food for

619
00:27:50,180 --> 00:27:48,360
biology and is kind of abundant in our

620
00:27:52,639 --> 00:27:50,190
solar system and elsewhere so it's it I

621
00:27:54,970 --> 00:27:52,649
think causes pause to think about it you

622
00:27:57,499 --> 00:27:54,980
know when you look at stars at night and

623
00:28:00,619 --> 00:27:57,509
I think it's important to break down the

624
00:28:02,899 --> 00:28:00,629
problem like like what you just did you

625
00:28:06,379 --> 00:28:02,909
know so it's not that difficult to

626
00:28:10,340 --> 00:28:06,389
envision we know you can you know you

627
00:28:12,139 --> 00:28:10,350
can take rocks grind them up rocks from

628
00:28:15,259 --> 00:28:12,149
your backyard grind them up put them in

629
00:28:18,019 --> 00:28:15,269
water they'll make hydrogen gas we know

630
00:28:19,669 --> 00:28:18,029
that so that's not that difficult of a

631
00:28:22,820 --> 00:28:19,679
process to get around when we're talking

632
00:28:25,460 --> 00:28:22,830
about what does it take to support life

633
00:28:27,499 --> 00:28:25,470
on a rocky planet and you start looking

634
00:28:30,619 --> 00:28:27,509
at some of the microorganisms that use

635
00:28:32,889 --> 00:28:30,629
that hydrogen gas for example and they

636
00:28:35,960 --> 00:28:32,899
start looking at their biochemistry and

637
00:28:38,600 --> 00:28:35,970
you start realizing that that even their

638
00:28:41,389 --> 00:28:38,610

biochemistry is pretty streamlined it's

639
00:28:44,779 --> 00:28:41,399
pretty basic when we compare it to the

640
00:28:46,850 --> 00:28:44,789
biochemistry of more evolved beings like

641
00:28:48,289 --> 00:28:46,860
ourselves and so you've got to break

642
00:28:51,379 --> 00:28:48,299
these problems down these complex

643
00:28:53,120 --> 00:28:51,389
problems allow yourself to think a

644
00:28:56,029 --> 00:28:53,130
little bit side outside of the box

645
00:28:58,580 --> 00:28:56,039
absolutely I think astrobiology helps

646
00:29:00,620 --> 00:28:58,590
you take your very specific field

647
00:29:01,940 --> 00:29:00,630
location and detailed analyses of your

648
00:29:04,580 --> 00:29:01,950
bacteria and putting this broader

649
00:29:07,029 --> 00:29:04,590
concept might be quite fun to chat about

650
00:29:11,270 --> 00:29:07,039
over beers or other beverages of course

651
00:29:12,950 --> 00:29:11,280
absolutely so I could chat with you

652
00:29:14,060 --> 00:29:12,960
about this for a very long time but

653
00:29:15,710 --> 00:29:14,070
we've been chatting for half an hour so

654
00:29:17,900 --> 00:29:15,720
I think it's about time to open it up

655
00:29:20,150 --> 00:29:17,910
for questions so don't forget you can

656
00:29:23,480 --> 00:29:20,160
ask your questions using hashtag ask ask

657
00:29:26,690 --> 00:29:23,490
for bio as well as using the Signet org

658
00:29:29,210 --> 00:29:26,700
chat where our community is at so the

659
00:29:32,630 --> 00:29:29,220
first question comes from dr. Jim Paz

660
00:29:35,950 --> 00:29:32,640
and he asks what do you think are the

661
00:29:43,340 --> 00:29:35,960
socio-cultural implications of

662
00:29:46,190 --> 00:29:43,350
astrobiology research I yeah there are

663
00:29:48,799 --> 00:29:46,200

probably quite a few I think that there

664
00:29:52,760 --> 00:29:48,809
are people that that don't want to think

665
00:29:55,909 --> 00:29:52,770
that their that life originated on earth

666
00:30:00,140 --> 00:29:55,919
3.8 million years ago that would prefer

667
00:30:01,580 --> 00:30:00,150
to not think about life existing on

668
00:30:04,600 --> 00:30:01,590
another plants because that would

669
00:30:09,110 --> 00:30:04,610
challenge their way of thinking about

670
00:30:11,480 --> 00:30:09,120
this you know what's going on in their

671
00:30:13,970 --> 00:30:11,490
daily lives and I I would counter with

672
00:30:16,760 --> 00:30:13,980
that I'd say you know it's it's this is

673
00:30:18,380 --> 00:30:16,770
a scientific discipline and it's not

674
00:30:21,470 --> 00:30:18,390
something it's not something that's

675
00:30:22,669 --> 00:30:21,480
meant to challenge your traditional ways

676
00:30:25,310 --> 00:30:22,679
of thinking about things

677
00:30:28,190 --> 00:30:25,320
it doesn't need to what are the

678
00:30:30,770 --> 00:30:28,200
implications of this word from a broader

679
00:30:33,980 --> 00:30:30,780
context you know if we were to find

680
00:30:37,279 --> 00:30:33,990
evidence for life on another planet my

681
00:30:40,100 --> 00:30:37,289
hope would be that humanity would take a

682
00:30:43,340 --> 00:30:40,110
step back and realize that that we're

683
00:30:45,830 --> 00:30:43,350
part of this planetary process - and

684
00:30:48,320 --> 00:30:45,840
just like any other beings on any other

685
00:30:51,620 --> 00:30:48,330
planets might be and that we perhaps

686
00:30:53,840 --> 00:30:51,630
take a different approach towards being

687
00:30:56,149 --> 00:30:53,850
stewards of this planet but that's my

688
00:30:59,060 --> 00:30:56,159

own personal perspective on that that

689
00:31:00,980 --> 00:30:59,070
interesting question I agree with you I

690
00:31:03,560 --> 00:31:00,990
think you've more of us because just end

691
00:31:05,180 --> 00:31:03,570
of time just staring at the pale blue

692
00:31:06,799 --> 00:31:05,190
dot images that I've been coming back

693
00:31:09,799 --> 00:31:06,809
from different spacecraft boy

694
00:31:11,629 --> 00:31:09,809
Pioneer and Cassini and others and just

695
00:31:13,430 --> 00:31:11,639
look at this little blue pixel and think

696
00:31:15,440 --> 00:31:13,440
that that's that's all we've got you

697
00:31:21,080 --> 00:31:15,450
know it's it's it's a humbling thing to

698
00:31:23,119 --> 00:31:21,090
do I saw I saw a bumper sticker

699
00:31:25,730 --> 00:31:23,129
the other day that made me do a

700
00:31:31,610 --> 00:31:25,740
double-take and for an interesting

701
00:31:34,610 --> 00:31:31,620
reason it was there is no planet be okay

702
00:31:37,129 --> 00:31:34,620
and so it was obviously somebody from an

703
00:31:38,629 --> 00:31:37,139
environmental perspective that was

704
00:31:40,850 --> 00:31:38,639
saying we need to be better stewards of

705
00:31:42,680 --> 00:31:40,860
our planet but it really got me to

706
00:31:44,239 --> 00:31:42,690
double take because I started to ask

707
00:31:48,499 --> 00:31:44,249
myself well is that true

708
00:31:50,090 --> 00:31:48,509
is there no planet B and I I don't think

709
00:31:54,499 --> 00:31:50,100
we know that the answer to that question

710
00:31:55,759 --> 00:31:54,509
and but you know from based on what

711
00:31:58,609 --> 00:31:55,769
we've been talking about I think that

712
00:32:00,739 --> 00:31:58,619
there probably is another earth-like

713
00:32:03,080 --> 00:32:00,749

planet out there and probably not too

714
00:32:07,340 --> 00:32:03,090
far too terribly far away in this this

715
00:32:09,019 --> 00:32:07,350
galaxy it's it's undoubted it's there's

716
00:32:10,789 --> 00:32:09,029
a little doubt in my mind that humans

717
00:32:13,549 --> 00:32:10,799
will venture out of Planet Earth and

718
00:32:15,560 --> 00:32:13,559
then on to other worlds but for the time

719
00:32:19,759 --> 00:32:15,570
being though it is the only planet we

720
00:32:22,519 --> 00:32:19,769
have there's no doubt there our next

721
00:32:24,830 --> 00:32:22,529
question comes from Graham who asks

722
00:32:26,629 --> 00:32:24,840
what's one astrobiological relevant

723
00:32:30,970 --> 00:32:26,639
research site on earth that you haven't

724
00:32:37,789 --> 00:32:35,840
yeah it turns out that we do a lot of

725
00:32:41,450 --> 00:32:37,799
really cool work a lot of really cool

726
00:32:43,879 --> 00:32:41,460
places probably one of the things I've

727
00:32:45,350 --> 00:32:43,889
been thinking about so that includes

728
00:32:47,149 --> 00:32:45,360
Iceland we study

729
00:32:50,600 --> 00:32:47,159
microbes that live other glaciers in

730
00:32:54,320 --> 00:32:50,610
Iceland and Greece and Greenland work on

731
00:32:56,659 --> 00:32:54,330
the Great Salt Lake Yellowstone Hot

732
00:32:58,399 --> 00:32:56,669
Springs obviously hot springs in China

733
00:33:01,220 --> 00:32:58,409
so we got to go to a lot of neat places

734
00:33:03,830 --> 00:33:01,230
that image of Quatro Cienega syv been at

735
00:33:06,980 --> 00:33:03,840
Quattro ski probably the one

736
00:33:11,139 --> 00:33:06,990
place that I'd like to go more than any

737
00:33:15,080 --> 00:33:11,149
right now is Shark Bay in Australia and

738
00:33:18,169 --> 00:33:15,090

this stems from some work that a

739
00:33:19,850 --> 00:33:18,179
graduate student in my lab maladie

740
00:33:20,570 --> 00:33:19,860
Lindsay's been working on as a side

741
00:33:23,509 --> 00:33:20,580
project

742
00:33:26,870 --> 00:33:23,519
looking at this traumatic that we find

743
00:33:29,269 --> 00:33:26,880
in the Great Salt Lake and their amazing

744
00:33:31,970 --> 00:33:29,279
structures are amazing these carbonate

745
00:33:33,440 --> 00:33:31,980
structures through these microbes are

746
00:33:35,750 --> 00:33:33,450
literally the architects of the

747
00:33:38,110 --> 00:33:35,760
formation of these carbonate minerals

748
00:33:41,000 --> 00:33:38,120
these big coral reef like structures

749
00:33:45,200 --> 00:33:41,010
that cover somewhere between 20 and 30%

750
00:33:50,600 --> 00:33:45,210
of the bed of Great Salt Lake Shark Bay

751
00:33:53,210 --> 00:33:50,610
is is kind of you know the epitome of

752
00:33:55,129 --> 00:33:53,220
stromatolite field locations and these

753
00:33:56,690 --> 00:33:55,139
you know if you know if you know the

754
00:33:58,519 --> 00:33:56,700
word stromatolite chances are pretty

755
00:34:00,110 --> 00:33:58,529
good that you know that you associate

756
00:34:03,500 --> 00:34:00,120
that with the stromatolite from Shark

757
00:34:05,509 --> 00:34:03,510
Bay I'd really like to go and see that

758
00:34:06,649 --> 00:34:05,519
play it's a World Heritage Site so just

759
00:34:10,280 --> 00:34:06,659
like Yellowstone as a World Heritage

760
00:34:13,430 --> 00:34:10,290
Site I'd really like to go to Shark Bay

761
00:34:17,419 --> 00:34:13,440
yeah let's motor lights at some of the

762
00:34:20,149 --> 00:34:17,429
oldest known fossils of life on Earth I

763
00:34:21,770 --> 00:34:20,159

mean the oldest unequivocal ones are 3.4

764
00:34:23,720 --> 00:34:21,780
billion years old and there are some

765
00:34:25,879 --> 00:34:23,730
controversial ones that are even older

766
00:34:27,829 --> 00:34:25,889
roughly 3.8 that were discovered in

767
00:34:29,659 --> 00:34:27,839
Iceland I think a year or two ago I'm

768
00:34:32,780 --> 00:34:29,669
not in Iceland Greenland sorry a year or

769
00:34:34,760 --> 00:34:32,790
two a year or two ago so yeah it's crazy

770
00:34:38,480 --> 00:34:34,770
that those traumatic i'ts these

771
00:34:41,180 --> 00:34:38,490
microbial mats have lasted up to today

772
00:34:42,589 --> 00:34:41,190
you know we find them known in Shark Bay

773
00:34:44,180 --> 00:34:42,599
is probably the most famous sites but

774
00:34:45,530 --> 00:34:44,190
it's not limited to Shark Bay which is

775
00:34:49,940 --> 00:34:45,540
just extraordinary

776
00:34:51,109 --> 00:34:49,950
oh yeah the next question oh I was just

777
00:34:53,389 --> 00:34:51,119
going to mention there's actually

778
00:34:55,520 --> 00:34:53,399
stromatolites in those pools and

779
00:34:57,290 --> 00:34:55,530
cointreau Cienega s-- that's right right

780
00:34:59,930 --> 00:34:57,300
so those microbial mats that are growing

781
00:35:02,359 --> 00:34:59,940
on top of each other over time actually

782
00:35:04,400 --> 00:35:02,369
are causing those mats to lithified to

783
00:35:05,780 --> 00:35:04,410
form minerals that get preserved in the

784
00:35:08,359 --> 00:35:05,790
rock record and so when we start

785
00:35:10,790 --> 00:35:08,369
thinking about we're going to go to some

786
00:35:13,160 --> 00:35:10,800
other planet look for either current

787
00:35:15,380 --> 00:35:13,170
life or extant lot extinct life what

788
00:35:18,170 --> 00:35:15,390

would you be looking for well iree

789
00:35:18,620 --> 00:35:18,180
stromatolite sir are a good place to

790
00:35:21,200 --> 00:35:18,630
start

791
00:35:24,740 --> 00:35:21,210
as far as our search for biomass and

792
00:35:27,380 --> 00:35:24,750
biomarkers of extinct light yeah I agree

793
00:35:30,620 --> 00:35:27,390
with you so our next question is from

794
00:35:34,040 --> 00:35:30,630
Jacob hack misra and he asks if hydrogen

795
00:35:35,720 --> 00:35:34,050
is energy could an inhabited

796
00:35:37,910 --> 00:35:35,730
I think that's a key word there planet

797
00:35:41,150 --> 00:35:37,920
maintain a thick hydrogen atmosphere I

798
00:35:47,080 --> 00:35:41,160
would get a woody or would that hydrogen

799
00:35:50,900 --> 00:35:47,090
atmosphere get eaten up I think that

800
00:35:55,100 --> 00:35:50,910
well let's let's take an analogy here so

801
00:35:57,410 --> 00:35:55,110
Earth's atmosphere is 21% oxygen and we

802
00:35:59,060 --> 00:35:57,420
know that pretty much all of the life

803
00:36:00,980 --> 00:35:59,070
that we could see at least the animal

804
00:36:04,970 --> 00:36:00,990
life that we can see is dependent on on

805
00:36:06,200 --> 00:36:04,980
oxygen we need to breathe the reason we

806
00:36:09,920 --> 00:36:06,210
need to breathe is degree than that

807
00:36:13,130 --> 00:36:09,930
oxygen and so so even with that we have

808
00:36:16,310 --> 00:36:13,140
we maintain a 21% oxygen atmosphere now

809
00:36:18,470 --> 00:36:16,320
I think it's really unlikely that you're

810
00:36:21,500 --> 00:36:18,480
going to find an atmosphere on some

811
00:36:24,470 --> 00:36:21,510
planet inhabited or not that's that's

812
00:36:25,340 --> 00:36:24,480
dominantly hydrogen gas that's because

813
00:36:27,500 --> 00:36:25,350

it's pretty easy

814
00:36:29,900 --> 00:36:27,510
hydrogen is a really small molecule with

815
00:36:32,570 --> 00:36:29,910
a really small and a small molecular

816
00:36:35,570 --> 00:36:32,580
weight it's easy for it to escape from

817
00:36:37,280 --> 00:36:35,580
the atmosphere okay and so whether or

818
00:36:39,440 --> 00:36:37,290
not there's life there consuming it or

819
00:36:42,680 --> 00:36:39,450
not I don't think that you're going to

820
00:36:45,890 --> 00:36:42,690
find an atmosphere that's predominantly

821
00:36:48,830 --> 00:36:45,900
hydrogen but that being said I'm not a

822
00:36:51,170 --> 00:36:48,840
planetary atmospheric scientist and so I

823
00:36:53,740 --> 00:36:51,180
would I would direct that question with

824
00:36:56,380 --> 00:36:53,750
more detail to somebody like that

825
00:36:58,820 --> 00:36:56,390
hopefully that answers it's a question

826
00:37:02,270 --> 00:36:58,830
yeah I guess it's a matter of sources on

827
00:37:05,120 --> 00:37:02,280
sinks right so there's a question that's

828
00:37:08,390 --> 00:37:05,130
coming in but I can ask one in the

829
00:37:10,280 --> 00:37:08,400
meantime so you've done field work in in

830
00:37:12,050 --> 00:37:10,290
very exciting places you have any

831
00:37:13,400 --> 00:37:12,060
anecdotes of some some funny things that

832
00:37:15,110 --> 00:37:13,410
happen has your field work at

833
00:37:17,900 --> 00:37:15,120
Yellowstone for example been interrupted

834
00:37:22,670 --> 00:37:17,910
by oh I don't know a bison North thing

835
00:37:24,590 --> 00:37:22,680
like that oh yeah absolutely I've got a

836
00:37:28,580 --> 00:37:24,600
lot of funny stories about fieldwork

837
00:37:34,310 --> 00:37:28,590
there's no shortage of those one of my

838
00:37:35,720 --> 00:37:34,320

students her she's Hawaii went to school

839
00:37:37,940 --> 00:37:35,730
here in the States but really hadn't

840
00:37:40,640 --> 00:37:37,950
spent much time in the West let alone

841
00:37:43,550 --> 00:37:40,650
and in the Mountain West let alone at

842
00:37:46,370 --> 00:37:43,560
Yellowstone where there are bears and

843
00:37:47,450 --> 00:37:46,380
bison and elk and wolves and whatnot and

844
00:37:52,940 --> 00:37:47,460
on her

845
00:37:55,900 --> 00:37:52,950
day first field hike into a hot spring

846
00:37:59,600 --> 00:37:55,910
basin we got trailed out of the woods

847
00:38:01,850 --> 00:37:59,610
granted there is about 10 or 15 of us so

848
00:38:03,830 --> 00:38:01,860
it wasn't we weren't that terribly

849
00:38:08,180 --> 00:38:03,840
worried about the situation but we got

850
00:38:10,130 --> 00:38:08,190
followed out of the woods into this hot

851
00:38:14,600 --> 00:38:10,140
spring basin by two juvenile a grizzly

852
00:38:20,060 --> 00:38:14,610
bears and that that was an interest that

853
00:38:22,460 --> 00:38:20,070
was interesting a lot of the people in

854
00:38:24,620 --> 00:38:22,470
the field with us that day we're pretty

855
00:38:26,930 --> 00:38:24,630
well frightened and so that cutter day

856
00:38:30,910 --> 00:38:26,940
short we had to leave we found another

857
00:38:35,000 --> 00:38:30,920
exit point to avoid those grizzly bears

858
00:38:37,700 --> 00:38:35,010
just this last April I went to Iceland

859
00:38:39,590 --> 00:38:37,710
to collect samples from some of the ice

860
00:38:42,650 --> 00:38:39,600
caps there that are these glaciers

861
00:38:43,700 --> 00:38:42,660
overriding the salt lock so this basalts

862
00:38:46,370 --> 00:38:43,710
really iron-rich

863
00:38:48,350 --> 00:38:46,380

and it has a strong potential to make a

864
00:38:52,010 --> 00:38:48,360
lot of hydrogen gas which is what our

865
00:38:54,650 --> 00:38:52,020
lab really studies we hired this what

866
00:38:58,430 --> 00:38:54,660
you would call a super cheap this is a

867
00:39:00,340 --> 00:38:58,440
this was a jeep that and you can google

868
00:39:02,660 --> 00:39:00,350
this and look at pictures of these

869
00:39:06,380 --> 00:39:02,670
monstrous they look like monster trucks

870
00:39:07,940 --> 00:39:06,390
their tires are about four feet tall and

871
00:39:09,890 --> 00:39:07,950
you have to climb into these things and

872
00:39:12,770 --> 00:39:09,900
we got this because we're driving up a

873
00:39:14,540 --> 00:39:12,780
glacial outwash plain really soft and we

874
00:39:19,070 --> 00:39:14,550
needed something that could get through

875
00:39:24,110 --> 00:39:19,080
it and this person that we this guide

876
00:39:27,470 --> 00:39:24,120
that we had contracted out or to take us

877
00:39:28,880 --> 00:39:27,480
up there with his super Jeep I asked him

878
00:39:31,610 --> 00:39:28,890
point-blank on the way up have you ever

879
00:39:36,640 --> 00:39:31,620
gotten this thing stuck because oh no no

880
00:39:39,470 --> 00:39:36,650
no not not a worry well we buried it

881
00:39:43,940 --> 00:39:39,480
buried this thing and in the sander

882
00:39:45,770 --> 00:39:43,950
coming out of the glacier which wasn't

883
00:39:49,550 --> 00:39:45,780
that big of a deal except for the fact

884
00:39:54,860 --> 00:39:49,560
that it was raining were ten miles away

885
00:39:57,860 --> 00:39:54,870
from you know anybody but fortunately

886
00:40:00,590 --> 00:39:57,870
this guy was able to get us out of this

887
00:40:01,309 --> 00:40:00,600
thing but I mean imagine I imagine your

888
00:40:03,709 --> 00:40:01,319

car

889
00:40:06,949 --> 00:40:03,719
stuck and four feet of more or less

890
00:40:08,569 --> 00:40:06,959
quicksand that's what we were but he was

891
00:40:09,289 --> 00:40:08,579
able to get us out using his winch and

892
00:40:12,739 --> 00:40:09,299
whatnot

893
00:40:15,799 --> 00:40:12,749
pretty incredible experiences that a lot

894
00:40:19,069 --> 00:40:15,809
of our field work is as put us has

895
00:40:22,459 --> 00:40:19,079
allowed for for sure I look forward to

896
00:40:26,839 --> 00:40:22,469
your memoirs when you retire it means

897
00:40:28,640 --> 00:40:26,849
cable news station yeah the next

898
00:40:31,249 --> 00:40:28,650
question is from Graham again and he

899
00:40:34,430 --> 00:40:31,259
asks so if funding weren't an issue

900
00:40:40,880 --> 00:40:34,440
what kind of astrobiology mission would

901
00:40:44,239 --> 00:40:40,890
you ask NASA to descend oh that's a good

902
00:40:47,150 --> 00:40:44,249
question um I I would I'm still I am

903
00:40:48,829 --> 00:40:47,160
still a major fan of going arse Mars

904
00:40:53,779 --> 00:40:48,839
research I know that there's a lot of

905
00:40:57,140 --> 00:40:53,789
interest in icy planets Europa or icy

906
00:41:01,640 --> 00:40:57,150
moons I should say Europa Enceladus and

907
00:41:03,469 --> 00:41:01,650
whatnot I'm still I'm not done with Mars

908
00:41:05,749 --> 00:41:03,479
research I'd really like to go to Mars

909
00:41:08,779 --> 00:41:05,759
and I'd like to drill money wasn't an

910
00:41:13,370 --> 00:41:08,789
issue let's launch a drill rig up there

911
00:41:15,199 --> 00:41:13,380
and let's find unaltered minerals that

912
00:41:17,420 --> 00:41:15,209
haven't that haven't been fully oxidized

913
00:41:20,209 --> 00:41:17,430

like the surface has let's see what we

914
00:41:23,630 --> 00:41:20,219
can see there and the first thing I

915
00:41:24,589 --> 00:41:23,640
would do with those samples is I look at

916
00:41:28,489 --> 00:41:24,599
him under a microscope

917
00:41:30,529 --> 00:41:28,499
a simple microbiology that you know this

918
00:41:33,439 --> 00:41:30,539
is where microbiology got its roots back

919
00:41:36,049 --> 00:41:33,449
in the 1700s with microscopes that's

920
00:41:40,989 --> 00:41:36,059
what I would still use today to look for

921
00:41:45,170 --> 00:41:40,999
evidence for life cool there's a

922
00:41:47,229 --> 00:41:45,180
question from Preeti who is a talking to

923
00:41:50,059 --> 00:41:47,239
us from the Signet chat hello pretty and

924
00:41:52,670 --> 00:41:50,069
she asks as a layperson I would like to

925
00:41:55,640 --> 00:41:52,680
ask could I find stromatolites on any

926
00:41:58,069 --> 00:41:55,650
beach or is there a typical biochemical

927
00:42:03,829 --> 00:41:58,079
environment where such stromatolites can

928
00:42:08,329 --> 00:42:03,839
be formed yeah but that's a very good

929
00:42:10,099 --> 00:42:08,339
question you know typically so typically

930
00:42:12,049 --> 00:42:10,109
you don't find stromatolites everywhere

931
00:42:15,050 --> 00:42:12,059
that's the the quickest answer and the

932
00:42:17,360 --> 00:42:15,060
reason for that is that you need some G

933
00:42:22,130 --> 00:42:17,370
chemical condition that precludes

934
00:42:24,620 --> 00:42:22,140
higher-order life by that I mean you

935
00:42:27,080 --> 00:42:24,630
know precludes predators so microbial

936
00:42:29,360 --> 00:42:27,090
mats are tasty they form the base

937
00:42:31,880 --> 00:42:29,370
microbes from the base of all ecosystems

938
00:42:33,470 --> 00:42:31,890

that we're familiar with hey the

939
00:42:35,240 --> 00:42:33,480
microbes are the soils are what break

940
00:42:38,180 --> 00:42:35,250
those soils down to allow the plants to

941
00:42:41,270 --> 00:42:38,190
live that feed you know the herbivores

942
00:42:43,640 --> 00:42:41,280
and so on and so forth it's no different

943
00:42:46,280 --> 00:42:43,650
in these environments that that form

944
00:42:47,960 --> 00:42:46,290
stromatolite s-- but the big difference

945
00:42:50,780 --> 00:42:47,970
is that say the Great Salt Lake for

946
00:42:53,540 --> 00:42:50,790
example is it's so salty that it limits

947
00:42:55,100 --> 00:42:53,550
the amount of predation that that can

948
00:42:58,490 --> 00:42:55,110
happen on those microbial mats that

949
00:43:01,280 --> 00:42:58,500
allow them to them form and then lift

950
00:43:02,060 --> 00:43:01,290
the Phi and then build on top of each

951
00:43:05,150 --> 00:43:02,070
other

952
00:43:07,880 --> 00:43:05,160
em Quatro Cienega s-- they think that

953
00:43:09,110 --> 00:43:07,890
the reason for the stromatolites that

954
00:43:11,480 --> 00:43:09,120
you find there is the extreme

955
00:43:13,660 --> 00:43:11,490
phosphorous limitation okay

956
00:43:19,250 --> 00:43:13,670
not enough phosphorous in those waters

957
00:43:23,470 --> 00:43:19,260
to support higher order organisms that

958
00:43:25,730 --> 00:43:23,480
predate on that microbial prey chart Bay

959
00:43:30,290 --> 00:43:25,740
salinity is a problem and it's in an

960
00:43:33,470 --> 00:43:30,300
intertidal area so you water comes in

961
00:43:35,000 --> 00:43:33,480
and floods it with the saline ocean

962
00:43:38,870 --> 00:43:35,010
water three and a half percent but then

963
00:43:40,610 --> 00:43:38,880

it pulls back and that dries up microbes

964
00:43:41,980 --> 00:43:40,620
can handle desiccation pretty well

965
00:43:46,310 --> 00:43:41,990
they're pretty well adapted to

966
00:43:49,040 --> 00:43:46,320
desiccation higher order organisms don't

967
00:43:51,140 --> 00:43:49,050
handle desiccation right we I don't know

968
00:43:52,670 --> 00:43:51,150
how you feel when you are out for a walk

969
00:43:54,770 --> 00:43:52,680
and you don't have a bottle of water but

970
00:43:56,300 --> 00:43:54,780
you know you're looking for water as

971
00:43:58,550 --> 00:43:56,310
soon as you can find it well microbes

972
00:44:00,290 --> 00:43:58,560
they can handle they've got adaptive

973
00:44:01,820 --> 00:44:00,300
mechanisms that allow them to handle

974
00:44:04,040 --> 00:44:01,830
that desiccation and that's why they can

975
00:44:05,120 --> 00:44:04,050
thrive in those environments so not

976
00:44:08,390 --> 00:44:05,130
every beach is going to have

977
00:44:09,770 --> 00:44:08,400
stromatolites and and there's a reason

978
00:44:11,210 --> 00:44:09,780
for them so that's one of the reasons

979
00:44:13,160 --> 00:44:11,220
that we go to a lot of these special or

980
00:44:17,060 --> 00:44:13,170
extreme environments to do these kind of

981
00:44:18,500 --> 00:44:17,070
studies it's almost as if humans were

982
00:44:20,090 --> 00:44:18,510
the extremophiles right because we were

983
00:44:22,190 --> 00:44:20,100
only comfortable and it's such a narrow

984
00:44:25,580 --> 00:44:22,200
range of environment conditions whereas

985
00:44:27,500 --> 00:44:25,590
microbes can be fine at a very broad set

986
00:44:30,220 --> 00:44:27,510
of environmental conditions conditions

987
00:44:32,630 --> 00:44:30,230
that would kill us instantly

988
00:44:35,090 --> 00:44:32,640

right I think that you know it's it's

989
00:44:38,000 --> 00:44:35,100
it's difficult to imagine an environment

990
00:44:39,530 --> 00:44:38,010
on earth where a surface and near

991
00:44:42,470 --> 00:44:39,540
surface environment on earth where you

992
00:44:45,050 --> 00:44:42,480
won't find life there are some don't get

993
00:44:47,510 --> 00:44:45,060
me wrong but you've got to get really

994
00:44:49,700 --> 00:44:47,520
high temperature you can't there's not

995
00:44:51,800 --> 00:44:49,710
you can't get salty enough microbes have

996
00:44:54,080 --> 00:44:51,810
figured out saturating concentrations of

997
00:44:55,880 --> 00:44:54,090
a table salt for example you can

998
00:44:57,440 --> 00:44:55,890
dissolve as much table salt in water as

999
00:45:00,260 --> 00:44:57,450
you want microbes will still live in

1000
00:45:01,700 --> 00:45:00,270
that water and so your analogy is right

1001
00:45:05,210 --> 00:45:01,710
right

1002
00:45:08,330 --> 00:45:05,220
humans need we need so many things to be

1003
00:45:11,420 --> 00:45:08,340
right in this narrow slice of perfection

1004
00:45:13,840 --> 00:45:11,430
or we just can't hack it right humans

1005
00:45:17,060 --> 00:45:13,850
weren't made to live in Antarctica

1006
00:45:19,070 --> 00:45:17,070
or the north the North Pole right that's

1007
00:45:22,850 --> 00:45:19,080
not our our niche that's not within our

1008
00:45:26,540 --> 00:45:22,860
habitable zone yep thankfully for

1009
00:45:28,070 --> 00:45:26,550
technology next question is from Graham

1010
00:45:30,320 --> 00:45:28,080
again great questions Graham thank you

1011
00:45:32,900 --> 00:45:30,330
very much so he talks about the shadow

1012
00:45:35,240 --> 00:45:32,910
biosphere and possibility that is a dark

1013
00:45:37,100 --> 00:45:35,250

biosphere outside of our current

1014
00:45:39,050 --> 00:45:37,110
understanding of what life is but on

1015
00:45:42,380 --> 00:45:39,060
earth do you think there's a type of

1016
00:45:44,510 --> 00:45:42,390
life that's not like life or comfortable

1017
00:45:46,660 --> 00:45:44,520
with on earth or know about that exists

1018
00:45:49,730 --> 00:45:46,670
on our planet that we haven't detected

1019
00:45:52,040 --> 00:45:49,740
um it's something I've thought about

1020
00:45:54,800 --> 00:45:52,050
quite a bit is there a shadow biosphere

1021
00:46:00,230 --> 00:45:54,810
or a biosphere that's not detectable

1022
00:46:03,050 --> 00:46:00,240
using our current technology it would be

1023
00:46:05,270 --> 00:46:03,060
surprising to me if that I won't say

1024
00:46:07,640 --> 00:46:05,280
that there's not because you know I

1025
00:46:09,740 --> 00:46:07,650
simply don't know

1026
00:46:12,410 --> 00:46:09,750
but it would be surprising to me if if

1027
00:46:15,680 --> 00:46:12,420
that were true that we wouldn't see

1028
00:46:18,020 --> 00:46:15,690
evidence of that and that we can't turn

1029
00:46:20,780 --> 00:46:18,030
our current understanding of life on the

1030
00:46:26,420 --> 00:46:20,790
planet today is inadequate to explain

1031
00:46:28,370 --> 00:46:26,430
some set of observations that we see you

1032
00:46:30,230 --> 00:46:28,380
know I it's it's hard for me to imagine

1033
00:46:32,240 --> 00:46:30,240
that we wouldn't see some evidence for

1034
00:46:38,080 --> 00:46:32,250
whether it's you know some geo chemical

1035
00:46:40,520 --> 00:46:38,090
signature some isotopic signature I

1036
00:46:42,300 --> 00:46:40,530
think we would see it and I just hey I

1037
00:46:47,250 --> 00:46:42,310
haven't seen any evidence for that

1038
00:46:50,580 --> 00:46:47,260

but jury's still out right and precisely

1039
00:46:52,380 --> 00:46:50,590
I would argue sigh sodam yeah they'd

1040
00:46:54,510 --> 00:46:52,390
leave some sort of mark but I would I

1041
00:46:57,860 --> 00:46:54,520
would I'd follow that with saying that

1042
00:47:01,830 --> 00:46:57,870
you know we know so very little about

1043
00:47:04,680 --> 00:47:01,840
life and the sub surface of the earth as

1044
00:47:06,060 --> 00:47:04,690
a friend of mine likens it you know what

1045
00:47:08,640 --> 00:47:06,070
do we know about life in the subsurface

1046
00:47:10,050 --> 00:47:08,650
well we know what we know about life in

1047
00:47:13,800 --> 00:47:10,060
the subsurface because we've sampled

1048
00:47:15,990 --> 00:47:13,810
waters out of a few mines these mines in

1049
00:47:18,000 --> 00:47:16,000
South Africa that are you know four four

1050
00:47:21,450 --> 00:47:18,010
kilometers deep we've sampled those

1051
00:47:25,290 --> 00:47:21,460
waters we've sampled a couple of cores

1052
00:47:28,410 --> 00:47:25,300
that we've drilled from a few places all

1053
00:47:30,360 --> 00:47:28,420
around the globe we just don't have a

1054
00:47:33,210 --> 00:47:30,370
good glimpse of what's going on in the

1055
00:47:35,250 --> 00:47:33,220
subsurface from these you likens it to a

1056
00:47:37,040 --> 00:47:35,260
pin cushion we've just been sticking a

1057
00:47:39,000 --> 00:47:37,050
few pins in here and there and

1058
00:47:41,190 --> 00:47:39,010
extrapolating that to saying we

1059
00:47:43,440 --> 00:47:41,200
understand what's going on with our

1060
00:47:45,300 --> 00:47:43,450
system and we just simply don't and so I

1061
00:47:49,740 --> 00:47:45,310
graham to get back to your question

1062
00:47:51,840 --> 00:47:49,750
until we really explore this planet to a

1063
00:47:53,910 --> 00:47:51,850

level that we can feel confident that we

1064
00:47:57,270 --> 00:47:53,920
know what's going on I I don't think we

1065
00:47:58,860 --> 00:47:57,280
can really answer that question and this

1066
00:48:00,360 --> 00:47:58,870
question fin analogy is even the

1067
00:48:02,100 --> 00:48:00,370
quote-unquote worse for planetary

1068
00:48:03,840 --> 00:48:02,110
systems right we just put a few Landers

1069
00:48:06,630 --> 00:48:03,850
here and there and it's of course very

1070
00:48:08,340 --> 00:48:06,640
hard to make global conclusions based on

1071
00:48:11,040 --> 00:48:08,350
these few measurements

1072
00:48:13,500 --> 00:48:11,050
but in that theme of exploration of

1073
00:48:15,810 --> 00:48:13,510
outside the earth Adam Smith asks who's

1074
00:48:18,090 --> 00:48:15,820
on say Gannett hello Adam is there going

1075
00:48:21,480 --> 00:48:18,100
to take humans to find life elsewhere in

1076
00:48:26,730 --> 00:48:21,490
our solar system or our robots be able

1077
00:48:30,300 --> 00:48:26,740
to do that uh another very good question

1078
00:48:33,980 --> 00:48:30,310
I we've been trying the robot thing for

1079
00:48:36,150 --> 00:48:33,990
a while right curiosity has a bunch of

1080
00:48:39,330 --> 00:48:36,160
robots on it and a bunch of

1081
00:48:40,980 --> 00:48:39,340
instrumentation I think that that's

1082
00:48:44,090 --> 00:48:40,990
that's the approach we're going to be

1083
00:48:46,320 --> 00:48:44,100
using for for the near future there's no

1084
00:48:49,410 --> 00:48:46,330
work we just don't have the technology

1085
00:48:52,500 --> 00:48:49,420
to launch a human to Mars and then

1086
00:48:55,680 --> 00:48:52,510
return that person safely right now and

1087
00:48:58,950 --> 00:48:55,690
so with that yeah robots let's

1088
00:49:00,510 --> 00:48:58,960

let's go for it all the way but I do

1089
00:49:05,279 --> 00:49:00,520
think that there would be an added

1090
00:49:08,849 --> 00:49:05,289
benefit for a human to be on Mars making

1091
00:49:11,190 --> 00:49:08,859
decisions making observations firsthand

1092
00:49:14,520 --> 00:49:11,200
and acting on those observations may be

1093
00:49:17,900 --> 00:49:14,530
modifying sampling regimes and sampling

1094
00:49:20,220 --> 00:49:17,910
locations because of what they see and

1095
00:49:22,559 --> 00:49:20,230
so on and so forth things that we can't

1096
00:49:24,450 --> 00:49:22,569
do here on earth and we can't really

1097
00:49:27,990 --> 00:49:24,460
from Earth and we can't really train a

1098
00:49:30,599 --> 00:49:28,000
robot to think in those ways so I think

1099
00:49:32,339 --> 00:49:30,609
you know I think the future it's hard to

1100
00:49:34,890 --> 00:49:32,349
predict right what's NASA's funding

1101
00:49:38,670 --> 00:49:34,900
going to look like are we go develop the

1102
00:49:40,440 --> 00:49:38,680
technology to launch a human and return

1103
00:49:43,589 --> 00:49:40,450
a human from Mars or some other

1104
00:49:45,210 --> 00:49:43,599
planetary body difficult to say until

1105
00:49:48,260 --> 00:49:45,220
then we're certainly going to be using

1106
00:49:50,910 --> 00:49:48,270
robots to do a lot of our exploration

1107
00:49:52,319 --> 00:49:50,920
indeed it's I think will be great value

1108
00:49:56,640 --> 00:49:52,329
in combining human and robotic

1109
00:50:00,000 --> 00:49:56,650
exploration together so the next

1110
00:50:02,640 --> 00:50:00,010
question is from civilized barbarian on

1111
00:50:06,059 --> 00:50:02,650
Twitter hello civilized barbarian he

1112
00:50:08,519 --> 00:50:06,069
asks or she asks about photosynthetic

1113
00:50:10,260 --> 00:50:08,529

bacteria in hot springs presumably

1114
00:50:13,349 --> 00:50:10,270
whether their role in the whole ecology

1115
00:50:17,640 --> 00:50:13,359
and what about an ox ox hygienic

1116
00:50:21,180 --> 00:50:17,650
photosynthetic bacteria yeah absolutely

1117
00:50:23,940 --> 00:50:21,190
so an oxygen okoto synthetic bacteria

1118
00:50:26,609 --> 00:50:23,950
are certainly president hot springs just

1119
00:50:28,019 --> 00:50:26,619
like oxygenic photosynthesis so if

1120
00:50:30,930 --> 00:50:28,029
you've been to Yellowstone or you've

1121
00:50:33,299 --> 00:50:30,940
been to any hot spring system where

1122
00:50:35,819 --> 00:50:33,309
photosynthesis exists you'll find these

1123
00:50:37,589 --> 00:50:35,829
these thick gelatinous mats they're

1124
00:50:40,230 --> 00:50:37,599
typically bright green but they don't

1125
00:50:43,019 --> 00:50:40,240
have to be they can be other colors reds

1126
00:50:47,390 --> 00:50:43,029
and oranges and that's oftentimes

1127
00:50:51,269 --> 00:50:47,400
because of anoxygenic phototrophs now

1128
00:50:53,609 --> 00:50:51,279
what I believe the question might be

1129
00:50:56,069 --> 00:50:53,619
related to is an oxygenate phototrophs

1130
00:50:59,730 --> 00:50:56,079
we never find them above 70 degrees

1131
00:51:02,460 --> 00:50:59,740
centigrade either and so they're always

1132
00:51:04,200 --> 00:51:02,470
a minor component of photosynthetic mats

1133
00:51:04,960 --> 00:51:04,210
they're never the dominant component of

1134
00:51:09,520 --> 00:51:04,970
those mats

1135
00:51:11,230 --> 00:51:09,530
allô 70 degrees centigrade but above 70

1136
00:51:14,609 --> 00:51:11,240
degrees centigrade we're still in that

1137
00:51:21,640 --> 00:51:14,619
realm 70 to 93 degrees centigrade in

1138
00:51:23,500 --> 00:51:21,650

that realm of mineral supported life so

1139
00:51:25,510 --> 00:51:23,510
I think that maybe answers your question

1140
00:51:28,210 --> 00:51:25,520
if not please fire off another one and

1141
00:51:30,099 --> 00:51:28,220
I'll clarify so we're actually getting

1142
00:51:31,839 --> 00:51:30,109
close to time but I want to ask one more

1143
00:51:33,609 --> 00:51:31,849
question but I'm not going to ask it

1144
00:51:35,020 --> 00:51:33,619
because Margot Smith on second ed has

1145
00:51:36,880 --> 00:51:35,030
asked it for me

1146
00:51:38,950 --> 00:51:36,890
hello Margot and thank you for your

1147
00:51:41,079 --> 00:51:38,960
excellent question she asks I am

1148
00:51:43,510 --> 00:51:41,089
wondering how you overcame any career

1149
00:51:44,800 --> 00:51:43,520
challenges you may have faced and any

1150
00:51:51,400 --> 00:51:44,810
advice you have for early career

1151
00:51:53,740 --> 00:51:51,410
scientists in astrobiology yeah I I

1152
00:51:55,859 --> 00:51:53,750
definitely overcome challenges faced a

1153
00:51:57,910 --> 00:51:55,869
lot of challenges one of the child if

1154
00:51:59,890 --> 00:51:57,920
anybody that knows me out there I

1155
00:52:03,220 --> 00:51:59,900
actually did my graduate work here at

1156
00:52:04,660 --> 00:52:03,230
Montana State I did my postdoc work here

1157
00:52:07,540 --> 00:52:04,670
Montana State and now I'm a faculty

1158
00:52:12,099 --> 00:52:07,550
member here at Montana State and one of

1159
00:52:14,170 --> 00:52:12,109
the things that persistence is key okay

1160
00:52:17,170 --> 00:52:14,180
everybody told me I couldn't do what I

1161
00:52:19,480 --> 00:52:17,180
did everybody told me I couldn't do what

1162
00:52:21,670 --> 00:52:19,490
I did you can't stay in the same

1163
00:52:23,829 --> 00:52:21,680

University that you did your graduate

1164
00:52:27,579 --> 00:52:23,839
work and do a postdoc that's that's a

1165
00:52:29,980 --> 00:52:27,589
career killer you certainly can't get a

1166
00:52:32,740 --> 00:52:29,990
job as a faculty member at the same

1167
00:52:34,450 --> 00:52:32,750
University teacher postdoc and I'm here

1168
00:52:37,210 --> 00:52:34,460
to tell you that I was able to do that

1169
00:52:39,430 --> 00:52:37,220
and so when somebody tells you you can't

1170
00:52:41,200 --> 00:52:39,440
do something be honest with yourself

1171
00:52:44,550 --> 00:52:41,210
maybe there's a reason they're telling

1172
00:52:48,150 --> 00:52:44,560
you that and maybe there's a reason that

1173
00:52:50,589 --> 00:52:48,160
that you should listen to that advice

1174
00:52:52,599 --> 00:52:50,599
but if you don't feel compelled by that

1175
00:52:55,839 --> 00:52:52,609
advice don't let it stop you be

1176
00:52:58,120 --> 00:52:55,849
persistent and it brings me back to a

1177
00:53:02,410 --> 00:52:58,130
piece of advice that one of my mentors

1178
00:53:04,059 --> 00:53:02,420
Alan DiSpirito again told me once and

1179
00:53:07,180 --> 00:53:04,069
that is in science when somebody tells

1180
00:53:10,630 --> 00:53:07,190
you something's impossible that's when

1181
00:53:12,430 --> 00:53:10,640
you start looking right so life can

1182
00:53:15,160 --> 00:53:12,440
exist in this kind of environment well

1183
00:53:16,700 --> 00:53:15,170
okay I'm going to either prove that to

1184
00:53:19,010 --> 00:53:16,710
be right

1185
00:53:21,079 --> 00:53:19,020
or prove that to be wrong and so being

1186
00:53:23,059 --> 00:53:21,089
persistent and and kind of thinking

1187
00:53:28,460 --> 00:53:23,069
outside of the box right that's where

1188
00:53:31,490 --> 00:53:28,470

big discoveries are and that yeah there

1189
00:53:32,870 --> 00:53:31,500
you go oh that's great advice and Margot

1190
00:53:34,250 --> 00:53:32,880
you'd certainly not alone in asking

1191
00:53:35,780 --> 00:53:34,260
those questions and this is why we have

1192
00:53:38,000 --> 00:53:35,790
this community on Signet to kind of

1193
00:53:39,470 --> 00:53:38,010
share experiences and support each other

1194
00:53:40,760 --> 00:53:39,480
as we go through the scientific career

1195
00:53:44,000 --> 00:53:40,770
which is not an easy one but a very

1196
00:53:45,710 --> 00:53:44,010
rewarding one for sure Eric I just want

1197
00:53:47,359 --> 00:53:45,720
to say thank you I know you're extremely

1198
00:53:49,490 --> 00:53:47,369
busy scientist and you took the time to

1199
00:53:51,559 --> 00:53:49,500
chat with us for an entire hour thank

1200
00:53:53,780 --> 00:53:51,569
you very much good luck with your future

1201
00:53:55,329 --> 00:53:53,790
endeavors and I saw you join us on sega

1202
00:53:57,589 --> 00:53:55,339
nets are excited to have you there and

1203
00:54:00,680 --> 00:53:57,599
any final things you want to say and

1204
00:54:02,839 --> 00:54:00,690
we'll probably see you very soon well I

1205
00:54:04,750 --> 00:54:02,849
just say thanks thanks a lot for having

1206
00:54:07,490 --> 00:54:04,760
me I think it's really important

1207
00:54:08,690 --> 00:54:07,500
certainly people that are at that early

1208
00:54:10,579 --> 00:54:08,700
career stage whether or not you're

1209
00:54:12,890 --> 00:54:10,589
finishing up your doctoral degree you're

1210
00:54:16,400 --> 00:54:12,900
in a postdoc position you're looking for

1211
00:54:18,829 --> 00:54:16,410
a job reach out to people within our

1212
00:54:21,289 --> 00:54:18,839
community and ask for advice there's

1213
00:54:23,420 --> 00:54:21,299

we're all eager to help right we're all

1214
00:54:25,339 --> 00:54:23,430
eager to see people succeed in this in

1215
00:54:28,010 --> 00:54:25,349
this field we want to see it grow with

1216
00:54:30,079 --> 00:54:28,020
the brightest minds possible and so that

1217
00:54:32,450 --> 00:54:30,089
includes me if any of you feel like

1218
00:54:34,579 --> 00:54:32,460
reaching out to me and San Joey I'd

1219
00:54:37,039 --> 00:54:34,589
really like the opportunity to come back

1220
00:54:39,109 --> 00:54:37,049
and a year or two and share with you

1221
00:54:41,480 --> 00:54:39,119
what we've what we've discovered between

1222
00:54:42,920 --> 00:54:41,490
now and then okay I look very much

1223
00:54:45,349 --> 00:54:42,930
forward to that thank you Eric

1224
00:54:47,299 --> 00:54:45,359
those of you who are watching join us

1225
00:54:49,430 --> 00:54:47,309
next month for a new episode of ask an

1226
00:54:51,349 --> 00:54:49,440
astrobiologist we will have dr. Alexis

1227
00:54:53,390 --> 00:54:51,359
Templeton who's a professor at the

1228
00:54:55,700 --> 00:54:53,400
University of Colorado and until then