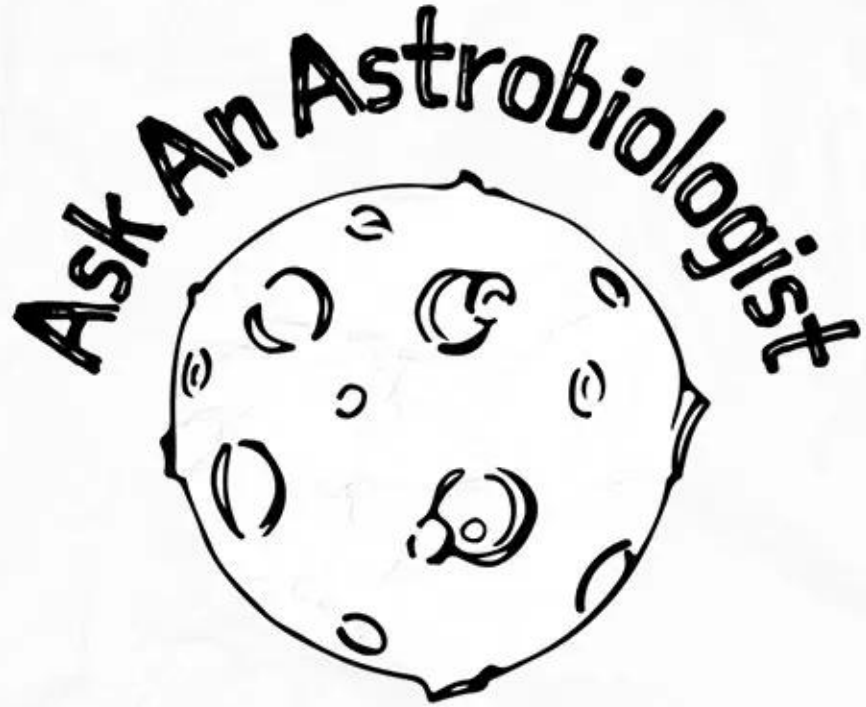

Episode 15: September 25th, 2018

Dr. Amanda Stockton

NASA Astrobiology Program

1
00:00:00,500 --> 00:00:29,230
[Music]

2
00:00:34,520 --> 00:00:31,339
greetings my fellow earthlings and

3
00:00:36,459 --> 00:00:34,530
welcome to ask an astrobiologist the

4
00:00:39,290 --> 00:00:36,469
show for those who are curious about

5
00:00:42,410 --> 00:00:39,300
astrobiologists and what we do in our

6
00:00:44,180 --> 00:00:42,420
science my name is Graham Lau and some

7
00:00:46,130 --> 00:00:44,190
of you who are returning in our audience

8
00:00:48,290 --> 00:00:46,140
might notice that you haven't seen my

9
00:00:50,990 --> 00:00:48,300
face before that's because this is my

10
00:00:52,790 --> 00:00:51,000
first time hosting the show from here on

11
00:00:55,610 --> 00:00:52,800
out I'll be sharing in the hosting

12
00:00:57,979 --> 00:00:55,620
duties with Sanjoy song our show is

13
00:01:01,040 --> 00:00:57,989

sponsored by the NASA Astrobiology

14
00:01:05,390 --> 00:01:01,050
program and the nonprofit Blue Marble

15
00:01:07,850 --> 00:01:05,400
space you can ask us questions on the

16
00:01:10,280 --> 00:01:07,860
show using the hashtag ask Astro bio on

17
00:01:13,310 --> 00:01:10,290
Twitter by joining us in the chat room

18
00:01:15,410 --> 00:01:13,320
on Sagan net org or in the comments

19
00:01:17,749 --> 00:01:15,420
section on our NASA Astrobiology

20
00:01:20,929 --> 00:01:17,759
Facebook live page where you can also

21
00:01:22,550 --> 00:01:20,939
watch the show before we get today

22
00:01:24,530 --> 00:01:22,560
today's main show we have to talk a

23
00:01:26,600 --> 00:01:24,540
little bit about our photo contest

24
00:01:28,940 --> 00:01:26,610
you might notice behind me this really

25
00:01:31,640 --> 00:01:28,950
awesome picture of a cool location

26
00:01:33,980 --> 00:01:31,650
somewhere here on the planet that is

27
00:01:36,140 --> 00:01:33,990
asked your biologically relevant well

28
00:01:37,730 --> 00:01:36,150
every month we show one of these last

29
00:01:40,039 --> 00:01:37,740
month's picture was a really cool

30
00:01:42,679 --> 00:01:40,049
looking image from somewhere special on

31
00:01:44,420 --> 00:01:42,689
the earth now yesterday we opened up the

32
00:01:47,690 --> 00:01:44,430
contest to see who could tell us what

33
00:01:50,240 --> 00:01:47,700
this location actually was well we had

34
00:01:52,039 --> 00:01:50,250
several very good answers we picked

35
00:01:54,950 --> 00:01:52,049
three of the best ones for who answered

36
00:01:57,709 --> 00:01:54,960
correctly this is the Danakil depression

37
00:02:00,859 --> 00:01:57,719
the dow law hot springs in northern

38
00:02:04,459 --> 00:02:00,869

ethiopia these hot springs are rich in

39
00:02:06,350 --> 00:02:04,469
chlorine and sulfur they deposit a lot

40
00:02:09,680 --> 00:02:06,360
of minerals around this geothermally

41
00:02:12,380 --> 00:02:09,690
heated fluid and now astrobiologists are

42
00:02:13,580 --> 00:02:12,390
studying the organisms that thrive in

43
00:02:16,190 --> 00:02:13,590
the spring

44
00:02:18,199 --> 00:02:16,200
to try to better understand how life can

45
00:02:20,869 --> 00:02:18,209
exist in street extreme environments on

46
00:02:22,970 --> 00:02:20,879
earth how life might have originated on

47
00:02:25,910 --> 00:02:22,980
earth and whether or not we can find

48
00:02:28,009 --> 00:02:25,920
life on other worlds so of all of our

49
00:02:31,190 --> 00:02:28,019
corrupt answers we chose three as our

50
00:02:34,400 --> 00:02:31,200
top winners they are mahmoud al saeed

51
00:02:37,130 --> 00:02:34,410
who won first place grin shams on

52
00:02:40,009 --> 00:02:37,140
twitter who won second place and johnny

53
00:02:42,199 --> 00:02:40,019
offe Arnon who won third place our third

54
00:02:44,300 --> 00:02:42,209
place winner will get some NASA stickers

55
00:02:46,539 --> 00:02:44,310
our second-place winner gets some NASA

56
00:02:49,069 --> 00:02:46,549
stickers and some graphic histories of

57
00:02:51,470 --> 00:02:49,079
astrobiology and then our first place

58
00:02:53,420 --> 00:02:51,480
winner mock mood you get some stickers

59
00:02:56,240 --> 00:02:53,430
from NASA some graphic histories of

60
00:02:59,210 --> 00:02:56,250
astrobiology and a very cool Sagan net

61
00:03:01,610 --> 00:02:59,220
drinking glass with the logo for Sagan

62
00:03:04,130 --> 00:03:01,620
net itself so congratulations to all

63
00:03:05,990 --> 00:03:04,140

three of you and for anyone watching now

64
00:03:08,780 --> 00:03:06,000
tune in next month within a day before

65
00:03:11,330 --> 00:03:08,790
our episode will announce the location

66
00:03:14,780 --> 00:03:11,340
competition to tell us what this site is

67
00:03:16,569 --> 00:03:14,790
right behind me right now now before we

68
00:03:18,860 --> 00:03:16,579
get to speaking with today's guest

69
00:03:21,129 --> 00:03:18,870
should mention that those data that

70
00:03:24,080 --> 00:03:21,139
Danakil depression in northern ethiopia

71
00:03:24,830 --> 00:03:24,090
exists in a really interesting place on

72
00:03:26,990 --> 00:03:24,840
our planet

73
00:03:30,349 --> 00:03:27,000
it exists in what's called the afar

74
00:03:32,530 --> 00:03:30,359
triangle a region where the East African

75
00:03:35,599 --> 00:03:32,540
Rift zone is meeting with two other

76
00:03:38,360 --> 00:03:35,609
mid-ocean spreading centers from the

77
00:03:39,949 --> 00:03:38,370
Gulf of Aden and the Red Sea and there's

78
00:03:42,259 --> 00:03:39,959
three year coming together and kind of

79
00:03:43,940 --> 00:03:42,269
spreading the continent apart and the

80
00:03:46,699 --> 00:03:43,950
land is dropping and that's why it's

81
00:03:49,220 --> 00:03:46,709
called a depression this is also one of

82
00:03:52,789 --> 00:03:49,230
only two places on the entire planet

83
00:03:54,680 --> 00:03:52,799
where mid-ocean ridges spread right at

84
00:03:57,770 --> 00:03:54,690
the surface and can be expressed for us

85
00:04:00,020 --> 00:03:57,780
as geologists which I am to look at at

86
00:04:02,330 --> 00:04:00,030
the surface of our planet the other

87
00:04:05,210 --> 00:04:02,340
place that happens is in Iceland the

88
00:04:07,039 --> 00:04:05,220

land of Ice and Fire and today's guest

89
00:04:09,050 --> 00:04:07,049
happens to have been there several times

90
00:04:10,550 --> 00:04:09,060
for some cool astrobiological research

91
00:04:12,680 --> 00:04:10,560
but I think we'll probably end up

92
00:04:14,150 --> 00:04:12,690
talking about a bit here today so

93
00:04:17,270 --> 00:04:14,160
without further ado let me welcome

94
00:04:19,370 --> 00:04:17,280
today's guest dr. Amanda Stockton an

95
00:04:21,649 --> 00:04:19,380
assistant professor in chemistry and

96
00:04:23,510 --> 00:04:21,659
biochemistry at Georgia Tech dr.

97
00:04:26,180 --> 00:04:23,520
Stockton hi and thanks for joining us in

98
00:04:26,780 --> 00:04:26,190
the show hi thanks and thank you for

99
00:04:28,820 --> 00:04:26,790
inviting

100
00:04:31,160 --> 00:04:28,830
be here I'm really excited to

101
00:04:32,510 --> 00:04:31,170
participate in this if you know that's

102
00:04:33,830 --> 00:04:32,520
really great to have you here I'm really

103
00:04:35,840 --> 00:04:33,840
excited for it again my first time

104
00:04:37,250 --> 00:04:35,850
hosting so it's kind of cool I've always

105
00:04:38,840 --> 00:04:37,260
nerd out in the side and watch these

106
00:04:40,850 --> 00:04:38,850
episodes and thought how cool it is to

107
00:04:44,240 --> 00:04:40,860
hear about all the awesome research

108
00:04:46,340 --> 00:04:44,250
going on those who do know me know that

109
00:04:48,680 --> 00:04:46,350
I'm also involved in saggin net I often

110
00:04:50,660 --> 00:04:48,690
answer questions for those who are high

111
00:04:51,820 --> 00:04:50,670
school students and college students who

112
00:04:54,290 --> 00:04:51,830
are interested in becoming

113
00:04:55,850 --> 00:04:54,300

astrobiologists themselves and so I

114
00:04:57,800 --> 00:04:55,860
thought before maybe getting into your

115
00:04:59,630 --> 00:04:57,810
current research it'd be really awesome

116
00:05:02,870 --> 00:04:59,640
if you could just tell our listeners

117
00:05:06,220 --> 00:05:02,880
about your process your journey into

118
00:05:08,810 --> 00:05:06,230
becoming the scientist you are today

119
00:05:11,630 --> 00:05:08,820
thanks that's that's a good question I

120
00:05:16,310 --> 00:05:11,640
was always interested in space and I

121
00:05:18,830 --> 00:05:16,320
always wanted to go into space and look

122
00:05:22,100 --> 00:05:18,840
for signs of life I grew up on Star Trek

123
00:05:25,240 --> 00:05:22,110
and Star Wars and just the whole idea of

124
00:05:28,280 --> 00:05:25,250
being able to find life beyond Earth was

125
00:05:30,440 --> 00:05:28,290
incredibly exciting to me now of course

126
00:05:34,130 --> 00:05:30,450
I grew up on a cattle ranch in Oklahoma

127
00:05:36,260 --> 00:05:34,140
and my dad had gotten an associates

128
00:05:40,460 --> 00:05:36,270
degree but neither of my parents really

129
00:05:42,200 --> 00:05:40,470
had much in the way towards education in

130
00:05:45,850 --> 00:05:42,210
this sciences and so we really didn't

131
00:05:50,110 --> 00:05:45,860
have a good idea how to go from you know

132
00:05:55,250 --> 00:05:50,120
elementary school kid it likes to play

133
00:05:59,120 --> 00:05:55,260
space cowboys and Aliens versus a future

134
00:06:02,330 --> 00:05:59,130
where I could actually do that so with

135
00:06:05,240 --> 00:06:02,340
Tommy and that evolved and in seventh

136
00:06:06,800 --> 00:06:05,250
grade I had a English teacher who gave

137
00:06:10,190 --> 00:06:06,810
us this fun assignment where we had to

138
00:06:12,170 --> 00:06:10,200

plan out our life and for the next 10

139
00:06:15,830 --> 00:06:12,180
years and so I really took that as a

140
00:06:17,840 --> 00:06:15,840
challenge it was it was a report that we

141
00:06:21,280 --> 00:06:17,850
were supposed to write but it was it

142
00:06:23,890 --> 00:06:21,290
wasn't done in such a fun way and so I

143
00:06:26,660 --> 00:06:23,900
looked in the National Geographic and

144
00:06:28,450 --> 00:06:26,670
Scientific American and I found this

145
00:06:32,330 --> 00:06:28,460
article about Jennifer Harris

146
00:06:34,250 --> 00:06:32,340
she has since moved on her name is now

147
00:06:37,040 --> 00:06:34,260
Jennifer Roessler but she still works at

148
00:06:40,129 --> 00:06:37,050
JPL and how she got there in this little

149
00:06:42,649 --> 00:06:40,139
bio is went to MIT major

150
00:06:44,839 --> 00:06:42,659
aerospace engineering works at JPL send

151
00:06:48,890 --> 00:06:44,849
stuff to Mars she was the lead systems

152
00:06:53,390 --> 00:06:48,900
integration engineer for the Pathfinder

153
00:06:55,969 --> 00:06:53,400
mission which was just way too cool so

154
00:07:00,499 --> 00:06:55,979
that's what I wrote in my report I was

155
00:07:03,019 --> 00:07:00,509
going to go to MIT major in aerospace

156
00:07:08,480 --> 00:07:03,029
engineering work at JPL ascend stuff to

157
00:07:10,640 --> 00:07:08,490
Mars for the most part that's the Tod

158
00:07:12,679 --> 00:07:10,650
happened I had a really great chemistry

159
00:07:15,170 --> 00:07:12,689
teacher in high school and so when I got

160
00:07:18,110 --> 00:07:15,180
to MIT I round up double majoring and

161
00:07:20,029 --> 00:07:18,120
chemistry and engineering and honestly

162
00:07:22,279 --> 00:07:20,039
that was probably the best thing I could

163
00:07:27,140 --> 00:07:22,289

have done for what I actually wanted to

164
00:07:30,890 --> 00:07:27,150
do without background and both I

165
00:07:33,709 --> 00:07:30,900
wouldn't be as well suited to the types

166
00:07:34,100 --> 00:07:33,719
of work that I get to do now that's

167
00:07:36,350 --> 00:07:34,110
awesome

168
00:07:38,540 --> 00:07:36,360
it sounds very hard to chemistry and

169
00:07:45,230 --> 00:07:38,550
aerospace it sounds like a lot of

170
00:07:48,010 --> 00:07:45,240
classwork I'm sure it was things the

171
00:07:50,119 --> 00:07:48,020
work oh it's wonderful

172
00:07:51,409 --> 00:07:50,129
that's very cool it's quit school aware

173
00:07:53,510 --> 00:07:51,419
that you're inspired such a young age

174
00:07:56,389 --> 00:07:53,520
too to kind of follow that kind of

175
00:07:58,189 --> 00:07:56,399
pathway of you know pursuing aerospace

176
00:08:01,969 --> 00:07:58,199
and the sciences engineering and science

177
00:08:03,559 --> 00:08:01,979
together in your own career well at the

178
00:08:06,409 --> 00:08:03,569
early age I didn't know what I was doing

179
00:08:07,999 --> 00:08:06,419
I wanted to be an engineer but later

180
00:08:09,740 --> 00:08:08,009
when I got to MIT it was just the

181
00:08:13,070 --> 00:08:09,750
chemistry classes were fun the aerospace

182
00:08:15,379 --> 00:08:13,080
engineering classes for fun and you know

183
00:08:18,260 --> 00:08:15,389
many undergrads do that like a major of

184
00:08:19,670 --> 00:08:18,270
the month a rotation their freshman

185
00:08:22,760 --> 00:08:19,680
Karen and I kind of did a little bit of

186
00:08:25,820 --> 00:08:22,770
that also occurred and just wound up

187
00:08:27,800 --> 00:08:25,830
with enough credits to get both awesome

188
00:08:29,360 --> 00:08:27,810

that's very cool so that so then what

189
00:08:31,429 --> 00:08:29,370
was your your pathway then into the

190
00:08:33,319 --> 00:08:31,439
research that you've done I understand

191
00:08:34,969 --> 00:08:33,329
you have a master's degree and a PhD and

192
00:08:39,050 --> 00:08:34,979
then you did some time as a postdoc at

193
00:08:43,339 --> 00:08:39,060
JPL correct right so I didn't master's

194
00:08:45,019 --> 00:08:43,349
at Brown I graduated relatively soon

195
00:08:48,259 --> 00:08:45,029
after 9/11 and so there weren't very

196
00:08:49,490 --> 00:08:48,269
many aerospace jobs relative to the

197
00:08:50,900 --> 00:08:49,500
number of aerospace engineering

198
00:08:53,470 --> 00:08:50,910
graduates that were coming out and so

199
00:08:56,050 --> 00:08:53,480
the market was really saturated over

200
00:08:59,290 --> 00:08:56,060
so I applied to a whole bunch of

201
00:09:01,060 --> 00:08:59,300
different positions jobs from the

202
00:09:02,170 --> 00:09:01,070
aerospace side and I also applied to a

203
00:09:06,100 --> 00:09:02,180
whole bunch of different chemistry grad

204
00:09:08,680 --> 00:09:06,110
schools because either-or would have

205
00:09:16,360 --> 00:09:08,690
been perfectly fine with me the program

206
00:09:17,430 --> 00:09:16,370
I got into at Brown it was more actual

207
00:09:25,540 --> 00:09:17,440
chemistry

208
00:09:28,420 --> 00:09:25,550
a method using these small peptide

209
00:09:31,840 --> 00:09:28,430
chains that were be found to determine

210
00:09:34,360 --> 00:09:31,850
chirality of different species the whole

211
00:09:36,670 --> 00:09:34,370
idea was that it would be a faster

212
00:09:39,970 --> 00:09:36,680
cheaper way to determine enantiomeric

213
00:09:43,900 --> 00:09:39,980

purity of drugs because it turns out

214
00:09:44,980 --> 00:09:43,910
that with with many drugs they are

215
00:09:47,920 --> 00:09:44,990
chiral that means they're

216
00:09:50,410 --> 00:09:47,930
non-superimposable mirror images just

217
00:09:51,940 --> 00:09:50,420
like your hands and so just like when

218
00:09:54,010 --> 00:09:51,950
you go to shake hands with someone if

219
00:09:56,050 --> 00:09:54,020
they offer their right hand and you

220
00:09:57,850 --> 00:09:56,060
offer your right hand it lines up and

221
00:09:59,110 --> 00:09:57,860
you shake well but if you offer your

222
00:10:02,490 --> 00:09:59,120
right hand and they offer their left

223
00:10:05,920 --> 00:10:02,500
hand it doesn't quite work out right and

224
00:10:07,840 --> 00:10:05,930
when it comes to handedness all the way

225
00:10:09,220 --> 00:10:07,850
down on the biomolecule side if you

226
00:10:11,019 --> 00:10:09,230
shake hands you have an effective

227
00:10:15,579 --> 00:10:11,029
treatment if you don't shake hands you

228
00:10:19,360 --> 00:10:15,589
have a poison so that was kind of Canada

229
00:10:21,569 --> 00:10:19,370
thinking there it turns out that I was

230
00:10:24,519 --> 00:10:21,579
not horribly enthused about

231
00:10:26,290 --> 00:10:24,529
pharmaceutical chemistry research I find

232
00:10:28,930 --> 00:10:26,300
it to be incredibly valuable and I'm

233
00:10:30,639 --> 00:10:28,940
really many people want to do it but it

234
00:10:35,620 --> 00:10:30,649
was not my passion and it was really

235
00:10:38,470 --> 00:10:35,630
challenging for me to really want to do

236
00:10:40,480 --> 00:10:38,480
it and it turns out with many people if

237
00:10:41,949 --> 00:10:40,490
you don't really want to do it then

238
00:10:46,000 --> 00:10:41,959

you're not going to do as good of a job

239
00:10:48,220 --> 00:10:46,010
on it and maybe you could so after a

240
00:10:51,160 --> 00:10:48,230
couple of years of that and doing some

241
00:10:54,100 --> 00:10:51,170
real soul-searching I applied again to

242
00:10:57,370 --> 00:10:54,110
other graduate programs where I could do

243
00:10:59,650 --> 00:10:57,380
more astrobiology type work staying

244
00:11:01,569 --> 00:10:59,660
inside of chemistry but pulling back in

245
00:11:04,560 --> 00:11:01,579
some of my engineering background and

246
00:11:06,540 --> 00:11:04,570
that was how I found professor rich man

247
00:11:08,850 --> 00:11:06,550
at the University of california-berkeley

248
00:11:09,360 --> 00:11:08,860
and that's where I did my PhD working on

249
00:11:12,060 --> 00:11:09,370
new Mars

250
00:11:14,040 --> 00:11:12,070
organic analyzer system which at the

251
00:11:19,590 --> 00:11:14,050
time was supposed to go on the ExoMars

252
00:11:21,150 --> 00:11:19,600
Rover it got the scoped in 2009 which

253
00:11:24,780 --> 00:11:21,160
led to all of the funding being cut

254
00:11:27,090 --> 00:11:24,790
which led to be graduating in 2010 good

255
00:11:28,920 --> 00:11:27,100
giving a NASA postdoctoral program

256
00:11:31,350 --> 00:11:28,930
fellowship so that I could continued

257
00:11:32,970 --> 00:11:31,360
some of that work down at JPL okay

258
00:11:35,280 --> 00:11:32,980
awesome I mean it's it's unfortunate

259
00:11:37,740 --> 00:11:35,290
that that gets got scrapped from the

260
00:11:39,420 --> 00:11:37,750
ExoMars mission I'm sure it was still

261
00:11:40,560 --> 00:11:39,430
valuable for you to learn that process

262
00:11:43,020 --> 00:11:40,570
of what it takes to develop an

263
00:11:44,580 --> 00:11:43,030

instrument and then use it on a rover on

264
00:11:47,280 --> 00:11:44,590
another planet I'm sure that process

265
00:11:50,310 --> 00:11:47,290
takes a lot of work it's absolutely

266
00:11:55,680 --> 00:11:50,320
fabulous the instrument development

267
00:11:57,320 --> 00:11:55,690
process is very fascinating and it's one

268
00:11:59,880 --> 00:11:57,330
of the things that I absolutely love

269
00:12:01,770 --> 00:11:59,890
awesome that's wonderful yeah and then

270
00:12:04,710 --> 00:12:01,780
JPL for those who don't know is the Jet

271
00:12:07,260 --> 00:12:04,720
Propulsion Laboratory out in California

272
00:12:10,110 --> 00:12:07,270
it's become kind of a mecca for space

273
00:12:11,670 --> 00:12:10,120
exploration a lot of us space nerds love

274
00:12:13,140 --> 00:12:11,680
visiting and it's really cool that you

275
00:12:17,940 --> 00:12:13,150
had a chance to work there I'm so

276
00:12:20,220 --> 00:12:17,950
jealous what was that like it's one

277
00:12:21,870 --> 00:12:20,230
thing to get to do work that you're

278
00:12:23,310 --> 00:12:21,880
interested in it's another thing to get

279
00:12:25,440 --> 00:12:23,320
to do work that you're interested in and

280
00:12:27,780 --> 00:12:25,450
then on your way to lunch just happen to

281
00:12:29,340 --> 00:12:27,790
walk past the engineering mock-up for

282
00:12:30,660 --> 00:12:29,350
the Curiosity rover that they're taking

283
00:12:35,030 --> 00:12:30,670
up to the Mars yard to test the

284
00:12:38,430 --> 00:12:35,040
maneuvers just all of the history and

285
00:12:40,050 --> 00:12:38,440
really cool facilities and the the work

286
00:12:42,480 --> 00:12:40,060
that's actually happening there it's

287
00:12:44,130 --> 00:12:42,490
very exciting that's awesome

288
00:12:47,790 --> 00:12:44,140

that's very young people are pretty

289
00:12:49,680 --> 00:12:47,800
great too yes so I've heard a lot of my

290
00:12:51,810 --> 00:12:49,690
friends work at JPL and quite jealous of

291
00:12:53,880 --> 00:12:51,820
all of them it's very cool so I

292
00:12:55,440 --> 00:12:53,890
understand that a lot of your time then

293
00:12:58,530 --> 00:12:55,450
since your PhD has been focused on

294
00:13:00,240 --> 00:12:58,540
developing instrumentation for surface

295
00:13:02,430 --> 00:13:00,250
experiments but also for understanding

296
00:13:04,260 --> 00:13:02,440
how we can kind of mix those surface

297
00:13:06,330 --> 00:13:04,270
experiments with remote sensing as well

298
00:13:07,950 --> 00:13:06,340
to better understand what we're looking

299
00:13:09,450 --> 00:13:07,960
for on these planetary bodies can you

300
00:13:11,910 --> 00:13:09,460
speak to that for a little bit about

301
00:13:13,680 --> 00:13:11,920
this process of developing instruments

302
00:13:15,840 --> 00:13:13,690
for various worlds and trying to look

303
00:13:18,540 --> 00:13:15,850
for life or signs of life on these

304
00:13:19,980 --> 00:13:18,550
worlds yeah so

305
00:13:23,820 --> 00:13:19,990
there's something called technology

306
00:13:25,500 --> 00:13:23,830
readiness levels and that's TRL that go

307
00:13:28,140 --> 00:13:25,510
from one you can write it on a napkin

308
00:13:30,450 --> 00:13:28,150
all the way up to 10 weeks fluent in

309
00:13:32,580 --> 00:13:30,460
multiple times already my group is

310
00:13:35,370 --> 00:13:32,590
really interested in that 1 2 3 where

311
00:13:37,590 --> 00:13:35,380
the exciting new developments happen

312
00:13:41,300 --> 00:13:37,600
that gives us access to a lot more

313
00:13:43,590 --> 00:13:41,310

different types of technology at JPL

314
00:13:48,240 --> 00:13:43,600
they're very good at getting you from 6

315
00:13:50,670 --> 00:13:48,250
to flight so once you have already done

316
00:13:51,570 --> 00:13:50,680
your crazy ideas stop going from here

317
00:13:53,400 --> 00:13:51,580
and rest of the way up but there's a

318
00:13:55,500 --> 00:13:53,410
little bit of a gap there and that's

319
00:13:58,800 --> 00:13:55,510
where Berkeley Space Science Lab comes

320
00:14:00,840 --> 00:13:58,810
in and so they're they're working on the

321
00:14:03,120 --> 00:14:00,850
Enceladus organic analyzer that was

322
00:14:04,620 --> 00:14:03,130
based off of the Mars organic analyzer

323
00:14:07,860 --> 00:14:04,630
that I worked on when I was a PhD

324
00:14:09,510 --> 00:14:07,870
student and getting it from three to six

325
00:14:10,830 --> 00:14:09,520
over the next few years and I've got a

326
00:14:15,330 --> 00:14:10,840
grad student that's helping with that

327
00:14:18,000 --> 00:14:15,340
project down here and the 1-2-3 range is

328
00:14:22,230 --> 00:14:18,010
where I'm taking that basic sort of

329
00:14:24,270 --> 00:14:22,240
technology and modifying it and making

330
00:14:28,440 --> 00:14:24,280
it more robust such that it could

331
00:14:30,870 --> 00:14:28,450
survive a fifty thousand G impact with

332
00:14:33,210 --> 00:14:30,880
an icy moon the acceleration that you

333
00:14:36,000 --> 00:14:33,220
get when you go to a dead stop from five

334
00:14:38,670 --> 00:14:36,010
kilometers per second within about 20

335
00:14:40,800 --> 00:14:38,680
milliseconds of hitting it an icy moon

336
00:14:42,030 --> 00:14:40,810
and so it turns out that that's the

337
00:14:45,630 --> 00:14:42,040
accelerations that you would experience

338
00:14:47,520 --> 00:14:45,640

if you didn't slow down at all after a

339
00:14:49,290 --> 00:14:47,530
standard Holmen transfer which is the

340
00:14:51,540 --> 00:14:49,300
the most efficient way to get from the

341
00:14:52,320 --> 00:14:51,550
earth to an icy moon you do a burn

342
00:14:53,790 --> 00:14:52,330
around the earth

343
00:14:55,920 --> 00:14:53,800
you another burn to go into an

344
00:14:57,270 --> 00:14:55,930
elliptical orbit around the Sun and then

345
00:15:00,720 --> 00:14:57,280
do another burden to slow down and go

346
00:15:03,950 --> 00:15:00,730
into orbit around Earth like Saturn or

347
00:15:06,090 --> 00:15:03,960
Jupiter five kilometres per second

348
00:15:08,190 --> 00:15:06,100
slowing down from that is really card

349
00:15:09,810 --> 00:15:08,200
you de robo Lando is going to be a very

350
00:15:12,510 --> 00:15:09,820
big mission it's going to get to land in

351
00:15:14,460 --> 00:15:12,520
one place but for the cost of one big

352
00:15:16,530 --> 00:15:14,470
mission we could fly several little guys

353
00:15:17,910 --> 00:15:16,540
they can all hit the surface in a bunch

354
00:15:20,040 --> 00:15:17,920
of different places and get it's a lot

355
00:15:22,410 --> 00:15:20,050
of different measurements obviously this

356
00:15:26,040 --> 00:15:22,420
is not ready to fly on the Europa Lander

357
00:15:27,750 --> 00:15:26,050
I have a platform yet that's why we're

358
00:15:30,210 --> 00:15:27,760
down here in the TRL one-two-three

359
00:15:32,249 --> 00:15:30,220
regime it's how can we make these

360
00:15:35,249 --> 00:15:32,259
seemingly crazy mission

361
00:15:37,710 --> 00:15:35,259
concepts actually happen definitely wow

362
00:15:39,090 --> 00:15:37,720
that's really cool I remember right when

363
00:15:41,340 --> 00:15:39,100

I first heard about Europa clipper they

364
00:15:44,309 --> 00:15:41,350
had discussed the idea of putting some

365
00:15:45,689 --> 00:15:44,319
smaller like nano SATs on the spacecraft

366
00:15:47,429 --> 00:15:45,699
and kind of launching those off the

367
00:15:48,689 --> 00:15:47,439
spacecraft to Europa I know that idea is

368
00:15:51,239 --> 00:15:48,699
kind of you know been pushed to the side

369
00:15:54,210 --> 00:15:51,249
now but it is a very cool idea for the

370
00:15:56,519 --> 00:15:54,220
future I love that so much

371
00:15:58,259 --> 00:15:56,529
one of the problems we've had with doing

372
00:16:00,239 --> 00:15:58,269
these as Landers is that we haven't had

373
00:16:03,419 --> 00:16:00,249
instruments robust enough to survive the

374
00:16:07,279 --> 00:16:03,429
impact and so that's uh that's what's in

375
00:16:10,139 --> 00:16:07,289
here is one of them but we're also

376
00:16:12,779 --> 00:16:10,149
interested in trying to figure out if we

377
00:16:16,609 --> 00:16:12,789
did have one of these fake landings what

378
00:16:19,829 --> 00:16:16,619
would be the minimum instrument suite

379
00:16:23,369 --> 00:16:19,839
the correct combination of measurements

380
00:16:25,049 --> 00:16:23,379
to accurately predict habitability of a

381
00:16:27,269 --> 00:16:25,059
sample to figure out how many samples

382
00:16:30,929 --> 00:16:27,279
you must collect in order to actually

383
00:16:32,939 --> 00:16:30,939
represent a region and kind of things

384
00:16:36,389 --> 00:16:32,949
like that and for that we've been in

385
00:16:38,759 --> 00:16:36,399
Iceland where we do our feldspar project

386
00:16:41,429 --> 00:16:38,769
that's probably my largest funded

387
00:16:44,869 --> 00:16:41,439
project it's a P Star planetary science

388
00:16:50,340 --> 00:16:44,879

and technology for analog research

389
00:16:52,349 --> 00:16:50,350
feldspar is field exploration and life

390
00:16:53,809 --> 00:16:52,359
detection sampling for planetary analog

391
00:16:56,369 --> 00:16:53,819
research

392
00:16:58,889 --> 00:16:56,379
fortunately the acronym actually makes

393
00:17:00,509 --> 00:16:58,899
sense and it is the main mineral and our

394
00:17:04,199 --> 00:17:00,519
basalt samples that we collect in

395
00:17:06,000 --> 00:17:04,209
Iceland I'm very cool yeah and so we go

396
00:17:08,779 --> 00:17:06,010
to a bunch of very barren regions and

397
00:17:11,879 --> 00:17:08,789
Iceland we've got two volcanoes one

398
00:17:14,939 --> 00:17:11,889
little house area it was associated with

399
00:17:17,460 --> 00:17:14,949
the afk local corruption that famously

400
00:17:20,819 --> 00:17:17,470
shut down European air traffic back in

401
00:17:24,149 --> 00:17:20,829
like 2010 2011 we've been going to that

402
00:17:28,169 --> 00:17:24,159
site for ever since it cooled off enough

403
00:17:34,190 --> 00:17:28,179
to let people hike up there so I think

404
00:17:39,269 --> 00:17:34,200
we went in 2013 2015 and 2017 although

405
00:17:41,549 --> 00:17:39,279
the group that came before me for the

406
00:17:43,830 --> 00:17:41,559
summer school that started this whole

407
00:17:45,900 --> 00:17:43,840
thing I think they went in 2011 or 2012

408
00:17:48,279 --> 00:17:45,910
I can't remember exactly

409
00:17:50,770 --> 00:17:48,289
that's one of them and the other one

410
00:17:52,390 --> 00:17:50,780
Kollek rune just cooled off enough to

411
00:17:58,330 --> 00:17:52,400
allow us to traipse all over that

412
00:18:01,060 --> 00:17:58,340
volcano in 2016 and we've been going

413
00:18:03,250 --> 00:18:01,070

there every year since then and that's

414
00:18:04,960 --> 00:18:03,260
that's a very remote area you have to

415
00:18:07,120 --> 00:18:04,970
drive for a really long time bring a

416
00:18:09,070 --> 00:18:07,130
second gas tank sleep in these little

417
00:18:10,450 --> 00:18:09,080
cabins that they technically have

418
00:18:14,970 --> 00:18:10,460
running water because there's a stream

419
00:18:19,270 --> 00:18:17,140
yeah remote fuel or get field work it's

420
00:18:21,159 --> 00:18:19,280
pretty cool it's it's really nice being

421
00:18:23,080 --> 00:18:21,169
travel somewhere so far away from people

422
00:18:25,990 --> 00:18:23,090
and find these really exciting spots on

423
00:18:27,279 --> 00:18:26,000
our planet to kind of explore can you

424
00:18:29,140 --> 00:18:27,289
talk a little bit more about your team

425
00:18:31,299 --> 00:18:29,150
about the process I know you mentioned

426
00:18:33,510 --> 00:18:31,309
the summer school can you explain how

427
00:18:37,330 --> 00:18:33,520
this kind of grew out of a summer school

428
00:18:39,850 --> 00:18:37,340
yeah so there's an occasional biology

429
00:18:42,760 --> 00:18:39,860
summer school that was held in Iceland

430
00:18:44,169 --> 00:18:42,770
every other year I believe and then

431
00:18:46,419 --> 00:18:44,179
there was a winter school in the off

432
00:18:49,260 --> 00:18:46,429
years that was held in Hawaii and it was

433
00:18:51,250 --> 00:18:49,270
a collaboration between NASA

434
00:18:55,000 --> 00:18:51,260
Astrobiology and the European Space

435
00:18:59,470 --> 00:18:55,010
Agency wolf Gabbert was the organizer

436
00:19:01,570 --> 00:18:59,480
for the winter school in Iceland and he

437
00:19:04,720 --> 00:19:01,580
had invited David Cohen who was the

438
00:19:07,029 --> 00:19:04,730

deputy deputy API for the light marker

439
00:19:09,820 --> 00:19:07,039
chip which just happened to also be on

440
00:19:13,510 --> 00:19:09,830
the ExoMars Rover and was also D Scott

441
00:19:15,549 --> 00:19:13,520
during that programmatic change and what

442
00:19:17,529 --> 00:19:15,559
was going on with the ExoMars Rover so

443
00:19:20,409 --> 00:19:17,539
we we can commiserate on a couple of

444
00:19:23,470 --> 00:19:20,419
things so dave was running the science

445
00:19:26,110 --> 00:19:23,480
lab wolf was running the school itself

446
00:19:29,520 --> 00:19:26,120
and a bunch of people

447
00:19:34,390 --> 00:19:29,530
Diana Gentry Morgan cable Adam Stevens

448
00:19:37,930 --> 00:19:34,400
gayatri Mary case on Eddie Shui Durman

449
00:19:40,870 --> 00:19:37,940
elena Amador I know that I'm forgetting

450
00:19:43,890 --> 00:19:40,880
some people here we're all part of that

451
00:19:46,149 --> 00:19:43,900
school and after the school ended um

452
00:19:48,340 --> 00:19:46,159
they had fallen in love with the volcano

453
00:19:51,760 --> 00:19:48,350
they fell in love with Iceland and the

454
00:19:55,570 --> 00:19:51,770
idea that we could do actual quality

455
00:19:58,760 --> 00:19:55,580
Mars analog research just as students

456
00:20:05,090 --> 00:20:00,860
Morden came back she shared an office

457
00:20:06,410 --> 00:20:05,100
with me and a lab and said oh we're

458
00:20:08,270 --> 00:20:06,420
gonna do this do you want to come and

459
00:20:11,150 --> 00:20:08,280
part of it may have been that I had

460
00:20:13,430 --> 00:20:11,160
still MPP funds and could rent the car

461
00:20:19,190 --> 00:20:13,440
for the group that may not have been

462
00:20:21,350 --> 00:20:19,200
tough really altruistic but we did we

463
00:20:23,030 --> 00:20:21,360

put together bootstrap funds from a

464
00:20:25,820 --> 00:20:23,040
bunch of different sources and we went

465
00:20:30,020 --> 00:20:25,830
back out into the field and that 2013

466
00:20:32,570 --> 00:20:30,030
field season by the 2015 field season I

467
00:20:36,740 --> 00:20:32,580
had just started my professor at Georgia

468
00:20:39,200 --> 00:20:36,750
Tech and part of the startup funds I

469
00:20:42,260 --> 00:20:39,210
negotiated for was enough money to

470
00:20:45,169 --> 00:20:42,270
support one more field campaign to go to

471
00:20:50,000 --> 00:20:45,179
Iceland with all of my closest friends

472
00:20:52,340 --> 00:20:50,010
and collaborators that turned out to be

473
00:20:57,230 --> 00:20:52,350
very fruitful and so when we submitted

474
00:21:00,049 --> 00:20:57,240
to NASA after that it became this large

475
00:21:02,890 --> 00:21:00,059
multi-year international effort we've

476
00:21:05,150 --> 00:21:02,900
got a lot more new people involved now

477
00:21:08,060 --> 00:21:05,160
like Erica Rader who's now a professor

478
00:21:12,340 --> 00:21:08,070
at the University of Idaho and a whole

479
00:21:15,140 --> 00:21:12,350
number of different students that have

480
00:21:17,150 --> 00:21:15,150
started picking up early career side of

481
00:21:18,740 --> 00:21:17,160
this that's awesome

482
00:21:20,000 --> 00:21:18,750
could you mine describing some of the

483
00:21:21,080 --> 00:21:20,010
research that you guys are doing there

484
00:21:22,460 --> 00:21:21,090
what kinds of instruments you're using

485
00:21:23,830 --> 00:21:22,470
in the field what kinds of things you're

486
00:21:27,380 --> 00:21:23,840
looking for while you're actually there

487
00:21:28,600 --> 00:21:27,390
yeah so it is it is a peacetime project

488
00:21:31,610 --> 00:21:28,610

which means we're trying to have

489
00:21:33,890 --> 00:21:31,620
fidelity to a Mars mission particularly

490
00:21:35,930 --> 00:21:33,900
looking at Mars sample return in three

491
00:21:37,549 --> 00:21:35,940
key areas and one of those is that is

492
00:21:38,960 --> 00:21:37,559
the science which I've already mentioned

493
00:21:40,760 --> 00:21:38,970
a little bit of how we're trying to

494
00:21:42,500 --> 00:21:40,770
figure out where to pick a sample

495
00:21:44,480 --> 00:21:42,510
doesn't matter if I pick it from here

496
00:21:47,030 --> 00:21:44,490
instead of here what if it's you know

497
00:21:50,180 --> 00:21:47,040
100 meters that way or a kilometer over

498
00:21:52,130 --> 00:21:50,190
there what matters in those respects

499
00:21:56,690 --> 00:21:52,140
we're also very interested in just this

500
00:21:59,900 --> 00:21:56,700
primary secession type of an event where

501
00:22:01,400 --> 00:21:59,910
after a whole life has been wiped out by

502
00:22:03,770 --> 00:22:01,410
a catastrophic to the electrical event

503
00:22:06,350 --> 00:22:03,780
like we're servicing by a lava flow how

504
00:22:08,660 --> 00:22:06,360
does life recover what does that look

505
00:22:11,010 --> 00:22:08,670
like and how do the communities and

506
00:22:12,900 --> 00:22:11,020
begin to depend upon other

507
00:22:15,780 --> 00:22:12,910
members of the community rather than

508
00:22:18,900 --> 00:22:15,790
those little microclimate variables like

509
00:22:23,610 --> 00:22:18,910
the mineral composition in moisture

510
00:22:24,930 --> 00:22:23,620
content etc so part of it is the science

511
00:22:26,400 --> 00:22:24,940
another thing is the technology and

512
00:22:28,110 --> 00:22:26,410
you'd asked about the instruments that

513
00:22:30,210 --> 00:22:28,120

we bring out and so with the technology

514
00:22:34,620 --> 00:22:30,220
we do have analogs to things that could

515
00:22:38,160 --> 00:22:34,630
be on Mars mission so we do XRD which is

516
00:22:43,890 --> 00:22:38,170
similar to what chemin does on Mars

517
00:22:47,040 --> 00:22:43,900
we've got a ASD reflectance spectrometer

518
00:22:50,340 --> 00:22:47,050
which is similar to what like prism is

519
00:22:52,200 --> 00:22:50,350
able to image from orbit around Mars and

520
00:22:55,320 --> 00:22:52,210
basically these are portable handheld

521
00:22:57,600 --> 00:22:55,330
bug wars looking laser guns that you

522
00:22:58,530 --> 00:22:57,610
literally zap the rock with a laser to

523
00:23:03,180 --> 00:22:58,540
find out what it's made of

524
00:23:08,310 --> 00:23:05,580
after that we pick up the samples and we

525
00:23:13,770 --> 00:23:08,320
drag them back to our field lab at the

526
00:23:16,470 --> 00:23:13,780
University of Aachen Annie where we take

527
00:23:19,230 --> 00:23:16,480
the samples apart and try to figure out

528
00:23:22,169 --> 00:23:19,240
how much ATP is in them that's identies

529
00:23:24,870 --> 00:23:22,179
a triphosphate and that is the molecule

530
00:23:29,430 --> 00:23:24,880
that all terrestrial lights uses in

531
00:23:32,510 --> 00:23:29,440
energy there's some thoughts that this

532
00:23:35,190 --> 00:23:32,520
is kind of an energy currency of

533
00:23:38,669 --> 00:23:35,200
terrestrial life and therefore can serve

534
00:23:42,120 --> 00:23:38,679
as a proxy for metabolic activity of the

535
00:23:45,299 --> 00:23:42,130
organisms in the sample so we we have to

536
00:23:46,590 --> 00:23:45,309
do that immediately because as you take

537
00:23:48,540 --> 00:23:46,600
the sample out of its native environment

538
00:23:49,980 --> 00:23:48,550

you know some things are now going to

539
00:23:51,540 --> 00:23:49,990
freak out and die other things are going

540
00:23:56,220 --> 00:23:51,550
to go oh wow this is beautiful if I got

541
00:23:58,560 --> 00:23:56,230
a bloom and so doing that analysis as

542
00:24:01,500 --> 00:23:58,570
close to collection as is possible is

543
00:24:03,840 --> 00:24:01,510
really key and actually getting a good

544
00:24:05,820 --> 00:24:03,850
measurement there after that we drag

545
00:24:07,290 --> 00:24:05,830
everything back to the home lab where we

546
00:24:09,750 --> 00:24:07,300
do a bunch of other things we do

547
00:24:12,270 --> 00:24:09,760
quantitative PCR for different primers

548
00:24:14,790 --> 00:24:12,280
that are conserved for different classes

549
00:24:17,940 --> 00:24:14,800
of microorganisms we do community

550
00:24:23,790 --> 00:24:17,950
sequencing moisture content at grain

551
00:24:24,760 --> 00:24:23,800
size more XRF over at the University of

552
00:24:26,780 --> 00:24:24,770
Idaho

553
00:24:28,190 --> 00:24:26,790
just a bunch of different things trying

554
00:24:31,310 --> 00:24:28,200
to kind of build this data set so that

555
00:24:34,700 --> 00:24:31,320
we can see what are those and variables

556
00:24:37,040 --> 00:24:34,710
that correlate to each other because ATP

557
00:24:41,690 --> 00:24:37,050
may not be the conservative biomarker on

558
00:24:43,340 --> 00:24:41,700
Mars or Europa but the mineralogy should

559
00:24:45,200 --> 00:24:43,350
be the same and so if we can kind of

560
00:24:50,570 --> 00:24:45,210
constrain what manner apologies help us

561
00:24:53,030 --> 00:24:50,580
get better habitability then then we may

562
00:24:55,970 --> 00:24:53,040
have a better shot moving forward in

563
00:24:57,860 --> 00:24:55,980

selecting examples oh very cool yeah I

564
00:24:59,510 --> 00:24:57,870
mean with Mars you know we first see

565
00:25:02,660 --> 00:24:59,520
Mars from orbit right we do remote

566
00:25:05,240 --> 00:25:02,670
sensing looking down and we can send our

567
00:25:07,040 --> 00:25:05,250
Landers our Rovers to pick up samples

568
00:25:09,170 --> 00:25:07,050
and hopefully one day do a sample return

569
00:25:11,210 --> 00:25:09,180
and send them back home and then I

570
00:25:14,060 --> 00:25:11,220
imagine what we would do here in a lab

571
00:25:15,710 --> 00:25:14,070
either in orbit of Earth or in a safe

572
00:25:17,270 --> 00:25:15,720
lab somewhere here on the earth is to

573
00:25:18,290 --> 00:25:17,280
then analyze those samples in the same

574
00:25:21,140 --> 00:25:18,300
way that you're kind of doing right now

575
00:25:23,360 --> 00:25:21,150
right yeah that would be the goal and we

576
00:25:26,210 --> 00:25:23,370
were really trying to have this fidelity

577
00:25:27,620 --> 00:25:26,220
to a Mars mission on multiple scales

578
00:25:30,620 --> 00:25:27,630
like what you're talking about we wanted

579
00:25:33,220 --> 00:25:30,630
to have those analogs for orbit we've

580
00:25:36,230 --> 00:25:33,230
got a quadcopter so that we can do

581
00:25:37,820 --> 00:25:36,240
digital mapping of an area and there's

582
00:25:39,860 --> 00:25:37,830
been some talk of maybe putting a

583
00:25:42,110 --> 00:25:39,870
helicopter in Lenexa Mars Lander we'll

584
00:25:47,330 --> 00:25:42,120
see I think it would be a hexacopter

585
00:25:50,270 --> 00:25:47,340
actually and then down to those remote

586
00:25:52,250 --> 00:25:50,280
sensing type of instruments that could

587
00:25:54,680 --> 00:25:52,260
go in a Mars rover so I didn't mention

588
00:25:59,030 --> 00:25:54,690

ROM on that will that has been selected

589
00:26:00,770 --> 00:25:59,040
for the Mars 2020 sample return mission

590
00:26:02,690 --> 00:26:00,780
but we're also interested in those other

591
00:26:04,550 --> 00:26:02,700
instruments that are on the Curiosity

592
00:26:08,210 --> 00:26:04,560
rover and kind of having analogs for

593
00:26:10,010 --> 00:26:08,220
those and then of course back to the

594
00:26:13,000 --> 00:26:10,020
home lab and all of the detailed

595
00:26:15,680 --> 00:26:13,010
chemical analyses that we can do here

596
00:26:17,630 --> 00:26:15,690
definitely that's so cool yeah I'm the

597
00:26:19,160 --> 00:26:17,640
director for logistics for a robotics

598
00:26:21,320 --> 00:26:19,170
competition that happens every year in

599
00:26:23,540 --> 00:26:21,330
the desert called the University Rover

600
00:26:25,390 --> 00:26:23,550
challenge and in that competition we've

601
00:26:28,370 --> 00:26:25,400
actually had some students now build

602
00:26:30,260 --> 00:26:28,380
quad copters hexacopters to take off of

603
00:26:32,450 --> 00:26:30,270
the rover and fly out and do

604
00:26:34,040 --> 00:26:32,460
reconnaissance for them and and I can

605
00:26:36,710 --> 00:26:34,050
definitely see that becoming part of our

606
00:26:38,390 --> 00:26:36,720
future Mars missions as well if that if

607
00:26:40,280 --> 00:26:38,400
that hexacopter quad

608
00:26:43,460 --> 00:26:40,290
they're from JPL does take off of Mars

609
00:26:45,260 --> 00:26:43,470
2020 it'd be very cool but let's step

610
00:26:47,420 --> 00:26:45,270
back for her for one minute I do want to

611
00:26:49,340 --> 00:26:47,430
let our audience know if you'd like to

612
00:26:52,100 --> 00:26:49,350
ask some questions of dr. Stockton you

613
00:26:54,740 --> 00:26:52,110

can use the hashtag ask Astro bio on

614
00:26:56,390 --> 00:26:54,750
Twitter to ask a question you can use

615
00:26:58,640 --> 00:26:56,400
the comments section in the Facebook

616
00:27:01,100 --> 00:26:58,650
live page or you can ask your questions

617
00:27:03,710 --> 00:27:01,110
directly on Sagan net org where we're

618
00:27:04,910 --> 00:27:03,720
also live streaming right now and so

619
00:27:07,100 --> 00:27:04,920
stepping back a little bit we have

620
00:27:09,799 --> 00:27:07,110
actually one question already from our

621
00:27:12,500 --> 00:27:09,809
other host of the show Sanjoy Somme

622
00:27:15,020 --> 00:27:12,510
Sanjoy wants to know why iceland is such

623
00:27:16,940 --> 00:27:15,030
a good analog for doing this planetary

624
00:27:19,549 --> 00:27:16,950
style of research disaster biological

625
00:27:24,290 --> 00:27:19,559
research okay that's a really good

626
00:27:26,540 --> 00:27:24,300
question so Mars is quite barren you

627
00:27:29,480 --> 00:27:26,550
don't see much green things growing

628
00:27:32,150 --> 00:27:29,490
there and so in order for us to mimic

629
00:27:34,090 --> 00:27:32,160
that in any way we need to go to

630
00:27:39,980 --> 00:27:34,100
someplace that is also quite barren

631
00:27:41,930 --> 00:27:39,990
another thing is Mars doesn't have a lot

632
00:27:43,730 --> 00:27:41,940
of people traipsing around and humans

633
00:27:47,060 --> 00:27:43,740
are kind of living breathing bags of

634
00:27:51,650 --> 00:27:47,070
bacteria just spreading our our nasty

635
00:27:54,620 --> 00:27:51,660
it's all over a place and so if you will

636
00:27:58,010 --> 00:27:54,630
see any pictures of us in the field

637
00:27:59,750 --> 00:27:58,020
we're usually face masks gloves and arm

638
00:28:05,060 --> 00:27:59,760

covers and things like that to try to

639
00:28:07,730 --> 00:28:05,070
keep our human biota from contaminating

640
00:28:10,460 --> 00:28:07,740
our samples and so one of the problems

641
00:28:12,320 --> 00:28:10,470
that we have with some of the different

642
00:28:15,200 --> 00:28:12,330
volcanoes around Hawaii and stuff like

643
00:28:19,640 --> 00:28:15,210
that it's even though it's new lava it's

644
00:28:21,830 --> 00:28:19,650
also often right in the middle of this

645
00:28:24,260 --> 00:28:21,840
tropical paradise with lots of tourists

646
00:28:27,740 --> 00:28:24,270
and trees and birds and everything else

647
00:28:30,770 --> 00:28:27,750
and there aren't too many trees or birds

648
00:28:33,290 --> 00:28:30,780
or humans to be shedding and there

649
00:28:35,330 --> 00:28:33,300
bacteria over the volcanoes that we that

650
00:28:38,810 --> 00:28:35,340
we study in Iceland particularly not go

651
00:28:43,220 --> 00:28:38,820
through that model house is a little

652
00:28:44,810 --> 00:28:43,230
traffic mountain pass now and it is it's

653
00:28:47,720 --> 00:28:44,820
getting to be a little inhabited and not

654
00:28:50,900 --> 00:28:47,730
only that but we saw like multicellular

655
00:28:52,040 --> 00:28:50,910
life last time lichen so our volcano has

656
00:28:54,080 --> 00:28:52,050
grown up and

657
00:28:56,990 --> 00:28:54,090
now it's microbiota is determined more

658
00:29:00,220 --> 00:28:57,000
by the structures of the the macro fauna

659
00:29:02,090 --> 00:29:00,230
that's providing nutrients to the soil

660
00:29:04,430 --> 00:29:02,100
definitely it seems like everywhere we

661
00:29:06,020 --> 00:29:04,440
go on the planet there's life earth is

662
00:29:08,030 --> 00:29:06,030
surrounded by it right even in the most

663
00:29:10,040 --> 00:29:08,040

inhospitable environments we still find

664
00:29:11,420 --> 00:29:10,050
living things on our planet so it's

665
00:29:14,660 --> 00:29:11,430
definitely hard to find places without

666
00:29:17,540 --> 00:29:14,670
it right yes there's even microbes that

667
00:29:20,870 --> 00:29:17,550
live in the the nuclear wastes the

668
00:29:22,490 --> 00:29:20,880
nuclear water cooling system absolutely

669
00:29:25,100 --> 00:29:22,500
yeah one of my favorites Dino Cox's

670
00:29:29,090 --> 00:29:25,110
radio Durin's yeah it's name means

671
00:29:31,310 --> 00:29:29,100
terrible little berry let's move to some

672
00:29:33,140 --> 00:29:31,320
questions now from our our our audience

673
00:29:35,300 --> 00:29:33,150
starting in is a question from Elizabeth

674
00:29:38,380 --> 00:29:35,310
Hutton on Twitter

675
00:29:40,310 --> 00:29:38,390
she says hi dr. Stockton your area of

676
00:29:42,320 --> 00:29:40,320
astrobiology is pretty much what I want

677
00:29:44,750 --> 00:29:42,330
to be doing with my biochemistry major

678
00:29:47,420 --> 00:29:44,760
I've also been considering minoring in

679
00:29:52,520 --> 00:29:47,430
geology or oceanography what are your

680
00:29:56,210 --> 00:29:52,530
recommendations okay I did not take in

681
00:29:58,670 --> 00:29:56,220
geology until I was I finished my

682
00:30:00,770 --> 00:29:58,680
postdoc and I took the class at a

683
00:30:04,790 --> 00:30:00,780
community college I had to pick up an

684
00:30:07,970 --> 00:30:04,800
awful lot of geology along the way

685
00:30:11,120 --> 00:30:07,980
and I would highly recommend just just

686
00:30:15,470 --> 00:30:11,130
one class if you can in geology because

687
00:30:18,050 --> 00:30:15,480
it's another language and it's not

688
00:30:19,010 --> 00:30:18,060

exactly the easiest thing to pick up

689
00:30:20,390 --> 00:30:19,020
you're already doing chemistry

690
00:30:23,240 --> 00:30:20,400
chemistry's also one of those it's

691
00:30:25,360 --> 00:30:23,250
another language things and this thing

692
00:30:27,130 --> 00:30:25,370
about astrobiology is it is so

693
00:30:29,870 --> 00:30:27,140
interdisciplinary and multidisciplinary

694
00:30:33,590 --> 00:30:29,880
but just being able to to speak the

695
00:30:37,460 --> 00:30:33,600
language can really help you out you

696
00:30:38,810 --> 00:30:37,470
don't have to minor in it necessarily

697
00:30:41,780 --> 00:30:38,820
unless that's something you're really

698
00:30:43,220 --> 00:30:41,790
interested in but just getting the

699
00:30:46,700 --> 00:30:43,230
backgrounds on there it is quite useful

700
00:30:48,680 --> 00:30:46,710
I don't know what type of astrobiology

701
00:30:50,720 --> 00:30:48,690
you really want to be doing you say it's

702
00:30:53,180 --> 00:30:50,730
the type that I'm doing sounds like the

703
00:30:55,520 --> 00:30:53,190
cool part and which case I would say

704
00:30:57,530 --> 00:30:55,530
getting some engineering background can

705
00:30:58,970 --> 00:30:57,540
be really helpful because engineering is

706
00:31:03,260 --> 00:30:58,980
another one of those that's a different

707
00:31:05,440 --> 00:31:03,270
language and being able to speak science

708
00:31:07,990 --> 00:31:05,450
true scientists engineer

709
00:31:12,009 --> 00:31:08,000
to scientists and science to engineers

710
00:31:13,779 --> 00:31:12,019
it's a really good skill to have

711
00:31:18,850 --> 00:31:13,789
particularly if you want to do

712
00:31:21,789 --> 00:31:18,860
instrument development I hope that helps

713
00:31:22,870 --> 00:31:21,799

her out I imagine some I'm glad you

714
00:31:24,879 --> 00:31:22,880
mentioned you know like these different

715
00:31:26,529 --> 00:31:24,889
languages we use I mean we're still

716
00:31:28,060 --> 00:31:26,539
speaking the same language but we have

717
00:31:30,009 --> 00:31:28,070
different jargon and different ways of

718
00:31:31,740 --> 00:31:30,019
expressing our ideas in these different

719
00:31:33,940 --> 00:31:31,750
Sciences from biology and chemistry

720
00:31:36,129 --> 00:31:33,950
oceanography geology aerospace

721
00:31:37,570 --> 00:31:36,139
engineering and and across the board so

722
00:31:38,560 --> 00:31:37,580
I'm very glad you mentioned that that's

723
00:31:41,529 --> 00:31:38,570
really important I think for our

724
00:31:44,919 --> 00:31:41,539
audience to hear our next questions

725
00:31:47,139 --> 00:31:44,929
comes from Tom Caruso Tom says dr.

726
00:31:48,789 --> 00:31:47,149
Stockton thanks for your time can you

727
00:31:50,860 --> 00:31:48,799
take a minute to explain the possible

728
00:31:53,860 --> 00:31:50,870
seawater chemistry for a subsurface

729
00:31:56,500 --> 00:31:53,870
ocean like what may be under the ice of

730
00:31:58,450 --> 00:31:56,510
Enceladus possible description of how a

731
00:32:01,720 --> 00:31:58,460
hydrothermal plume might behave in the

732
00:32:06,480 --> 00:32:01,730
low gravity of a moon like Enceladus all

733
00:32:10,180 --> 00:32:06,490
right so it's getting a little bit into

734
00:32:12,100 --> 00:32:10,190
more planetary physics I again remember

735
00:32:14,620 --> 00:32:12,110
I only took one geology class after I

736
00:32:16,539 --> 00:32:14,630
finished my postdoc I can do the best

737
00:32:17,649 --> 00:32:16,549
that I can here and I would strongly

738
00:32:20,259 --> 00:32:17,659

refer you to

739
00:32:23,889 --> 00:32:20,269
there was an insulative special issue of

740
00:32:26,919 --> 00:32:23,899
astrobiology recently where the the

741
00:32:29,230 --> 00:32:26,929
chemistry that was determined by a

742
00:32:32,110 --> 00:32:29,240
Cassini flying through that clue was

743
00:32:36,610 --> 00:32:32,120
laid out in quite some detail here's

744
00:32:39,070 --> 00:32:36,620
what we kind of know at this point we're

745
00:32:41,169 --> 00:32:39,080
relatively certain that that subsurface

746
00:32:44,560 --> 00:32:41,179
liquid water ocean is in direct contact

747
00:32:45,480 --> 00:32:44,570
with a rocky core everywhere that we

748
00:32:50,710 --> 00:32:45,490
know of

749
00:32:53,049 --> 00:32:50,720
ie earth where we have water interacting

750
00:32:55,840 --> 00:32:53,059
with rock on a planetary scale you get

751
00:33:01,120 --> 00:32:55,850
subduction of the water down under the

752
00:33:04,029 --> 00:33:01,130
crust that leads to oxidizing reactions

753
00:33:06,430 --> 00:33:04,039
of the rock which reduces the chemistry

754
00:33:08,049 --> 00:33:06,440
and the fluid those reactions are

755
00:33:10,629 --> 00:33:08,059
exothermic which means they release a

756
00:33:12,460 --> 00:33:10,639
lot of heat and so that heat then heats

757
00:33:15,220 --> 00:33:12,470
up your fluid and forces it back out and

758
00:33:17,139 --> 00:33:15,230
you get what are now known as alkaline

759
00:33:19,270 --> 00:33:17,149
packing their whole vent systems from

760
00:33:22,690 --> 00:33:19,280
these sorts of environments

761
00:33:24,250 --> 00:33:22,700
those are high temperature but they're

762
00:33:25,570 --> 00:33:24,260
they're actually pretty low temperature

763
00:33:28,900 --> 00:33:25,580

compared to like a black smoke or

764
00:33:30,520 --> 00:33:28,910
volcanic system so black smokers are

765
00:33:32,830 --> 00:33:30,530
magnetically heated and they get up to

766
00:33:38,370 --> 00:33:32,840
like 450 degrees and they can have lots

767
00:33:41,980 --> 00:33:38,380
of acid and etc etc a alkaline event is

768
00:33:44,530 --> 00:33:41,990
you know only in the hundred ish range

769
00:33:46,420 --> 00:33:44,540
is Celsius which we know of organisms

770
00:33:48,580 --> 00:33:46,430
that can survive above 100 degrees

771
00:33:50,980 --> 00:33:48,590
Celsius thanks to the black smokers and

772
00:33:52,510 --> 00:33:50,990
these are off access systems so they're

773
00:33:56,410 --> 00:33:52,520
not magnetically heated so you don't

774
00:33:58,530 --> 00:33:56,420
have to have active magnetic process

775
00:34:01,800 --> 00:33:58,540
needs completely driven by

776
00:34:04,510 --> 00:34:01,810
serpentinization type reactions

777
00:34:08,350 --> 00:34:04,520
everything that we've seen in the plume

778
00:34:10,720 --> 00:34:08,360
of Enceladus is consistent with their

779
00:34:13,000 --> 00:34:10,730
being active ongoing alkaline

780
00:34:15,730 --> 00:34:13,010
hydrothermal vent activity that would be

781
00:34:18,580 --> 00:34:15,740
really cool there have also been organic

782
00:34:20,290 --> 00:34:18,590
molecules detected in the plume and with

783
00:34:22,389 --> 00:34:20,300
some suggestions that perhaps we're

784
00:34:25,119 --> 00:34:22,399
seeing fragmentation patterns of larger

785
00:34:27,070 --> 00:34:25,129
organic molecules than the Cassini I am

786
00:34:28,419 --> 00:34:27,080
neutral mass spectrometer was ever

787
00:34:30,430 --> 00:34:28,429
designed to accept because it was

788
00:34:34,770 --> 00:34:30,440

supposed to fly around in space and

789
00:34:37,750 --> 00:34:34,780
detect small things it was never even

790
00:34:39,730 --> 00:34:37,760
you know really hoped that there would

791
00:34:41,619 --> 00:34:39,740
be this massive plume shooting free

792
00:34:47,619 --> 00:34:41,629
samples out into space from this

793
00:34:49,450 --> 00:34:47,629
interior ocean now how those systems

794
00:34:50,889 --> 00:34:49,460
might work under reduced gravity like

795
00:34:53,530 --> 00:34:50,899
you asked if that would be a question

796
00:34:56,370 --> 00:34:53,540
for a planetary physicist because I

797
00:34:57,520 --> 00:34:56,380
don't have a good handle on that myself

798
00:34:59,500 --> 00:34:57,530
awesome

799
00:35:02,380 --> 00:34:59,510
I recall some years back I attended a

800
00:35:04,600 --> 00:35:02,390
meeting at NASA Ames we were considering

801
00:35:06,190 --> 00:35:04,610
whether or not Europa has plumes as you

802
00:35:07,960 --> 00:35:06,200
might have heard there have been Hubble

803
00:35:10,000 --> 00:35:07,970
Space Telescope observations that

804
00:35:12,600 --> 00:35:10,010
suggest there could be intermittent

805
00:35:14,800 --> 00:35:12,610
blooming of water out of Europa as well

806
00:35:17,050 --> 00:35:14,810
and at that meeting we were really

807
00:35:18,910 --> 00:35:17,060
talking about what instrument could be

808
00:35:21,340 --> 00:35:18,920
put on the Europa clipper for instance

809
00:35:22,960 --> 00:35:21,350
that just in case there is a plume and

810
00:35:24,370 --> 00:35:22,970
we can fly through it it will help us

811
00:35:26,350 --> 00:35:24,380
out and figuring out what's going on

812
00:35:28,600 --> 00:35:26,360
because like you mentioned with Cassini

813
00:35:31,120 --> 00:35:28,610

we didn't know until we got there to

814
00:35:32,350 --> 00:35:31,130
expect the plumes in the first place so

815
00:35:33,010 --> 00:35:32,360
I'm wondering if we ever have another

816
00:35:35,920 --> 00:35:33,020
mission go

817
00:35:37,810 --> 00:35:35,930
back to Enceladus and you were given the

818
00:35:39,430 --> 00:35:37,820
chance to develop an instrument for

819
00:35:41,290 --> 00:35:39,440
flying through the plumes and doing some

820
00:35:42,970 --> 00:35:41,300
kind of detection what kind of

821
00:35:46,720 --> 00:35:42,980
instrument would you propose to send

822
00:35:48,760 --> 00:35:46,730
along on that mission okay thank you for

823
00:35:50,440 --> 00:35:48,770
the opportunity to shamelessly pitch an

824
00:35:53,680 --> 00:35:50,450
instrument technology that I think has

825
00:35:56,080 --> 00:35:53,690
the most highest six chance of success

826
00:35:56,650 --> 00:35:56,090
sorry my language just totally went out

827
00:35:58,859 --> 00:35:56,660
the window

828
00:36:01,000 --> 00:35:58,869
you got me excited about instruments

829
00:36:02,740 --> 00:36:01,010
there's something called the Enceladus

830
00:36:05,109 --> 00:36:02,750
organic analyzer it's being developed

831
00:36:07,090 --> 00:36:05,119
out of the University of California at

832
00:36:10,359 --> 00:36:07,100
Berkeley and the Berkeley space science

833
00:36:12,010 --> 00:36:10,369
labs it's based on microchip capillary

834
00:36:15,060 --> 00:36:12,020
electrophoresis I'm gonna see if I can

835
00:36:18,000 --> 00:36:15,070
show you this here do you see these long

836
00:36:21,900 --> 00:36:18,010
channels here

837
00:36:24,690 --> 00:36:21,910
those long channels are microfabricated

838
00:36:27,910 --> 00:36:24,700

capillaries fabricated via standard

839
00:36:32,790 --> 00:36:27,920
micro electronic type processes the same

840
00:36:37,840 --> 00:36:35,770
electrophoresis just means separating

841
00:36:41,890 --> 00:36:37,850
molecules by applying a high voltage and

842
00:36:43,660 --> 00:36:41,900
so if we apply 15,000 volts across the

843
00:36:46,180 --> 00:36:43,670
length of that channel we can start to

844
00:36:52,150 --> 00:36:46,190
separate molecules based on their charge

845
00:36:54,220 --> 00:36:52,160
to size ratio and if we add in a chiral

846
00:36:56,710 --> 00:36:54,230
additive we can start to separate the

847
00:36:58,930 --> 00:36:56,720
two hands and from what we can tell

848
00:37:00,130 --> 00:36:58,940
biology almost always has to do that

849
00:37:02,520 --> 00:37:00,140
one-handed that's just like I was

850
00:37:04,840 --> 00:37:02,530
talking about with the the

851
00:37:07,510 --> 00:37:04,850
pharmaceuticals where one one hand

852
00:37:09,910 --> 00:37:07,520
shakes hands correctly you get a drug

853
00:37:12,160 --> 00:37:09,920
the other hand doesn't you get a poison

854
00:37:15,340 --> 00:37:12,170
that seems to be ubiquitous across

855
00:37:16,960 --> 00:37:15,350
biology brno it seems to be something

856
00:37:19,990 --> 00:37:16,970
that is an evolved characteristic no

857
00:37:23,349 --> 00:37:20,000
matter which hand is selected for at the

858
00:37:25,960 --> 00:37:23,359
beginning okay so this separates

859
00:37:28,240 --> 00:37:25,970
molecules then we have a laser induced

860
00:37:30,849 --> 00:37:28,250
fluorescence detection system basically

861
00:37:32,770 --> 00:37:30,859
we use at the channel with a laser and

862
00:37:34,960 --> 00:37:32,780
we look for the fluorescence of the

863
00:37:37,840 --> 00:37:34,970

organic molecules to help in this we

864
00:37:41,890 --> 00:37:37,850
have a compound specific fluorescent

865
00:37:45,130 --> 00:37:41,900
molecules so that we can tag different

866
00:37:46,040 --> 00:37:45,140
molecules with these fluorescent probes

867
00:37:48,320 --> 00:37:46,050
so we're not relying

868
00:37:50,930 --> 00:37:48,330
on native fluorescents instead we've

869
00:37:53,630 --> 00:37:50,940
added in our own and laser induced

870
00:37:56,180 --> 00:37:53,640
fluorescence detection is quite simply

871
00:37:57,860 --> 00:37:56,190
the most sensitive technique you could

872
00:38:01,460 --> 00:37:57,870
possibly send its concentration

873
00:38:03,770 --> 00:38:01,470
sensitive so an emission profile that

874
00:38:05,630 --> 00:38:03,780
would support the enceladus organic

875
00:38:07,940 --> 00:38:05,640
analyzer we would have a capture plate

876
00:38:08,240 --> 00:38:07,950
we have it slide in a plume we close it

877
00:38:11,000 --> 00:38:08,250
up

878
00:38:15,530 --> 00:38:11,010
we dissolve molecules cut them over into

879
00:38:17,900 --> 00:38:15,540
our microfabricated system where they're

880
00:38:19,730 --> 00:38:17,910
separated the different enantiomers are

881
00:38:22,130 --> 00:38:19,740
resolved from each other and been

882
00:38:25,190 --> 00:38:22,140
detected all the way down to some parts

883
00:38:27,710 --> 00:38:25,200
per trillion lower limits of detection

884
00:38:30,560 --> 00:38:27,720
with the fluorescent system that's the

885
00:38:34,730 --> 00:38:30,570
one I think has the best chance we

886
00:38:38,120 --> 00:38:34,740
should be TRL six by the end of our the

887
00:38:39,680 --> 00:38:38,130
next three years of the grant and you

888
00:38:41,840 --> 00:38:39,690

know if anyone out there is listening

889
00:38:44,510 --> 00:38:41,850
please put us on your mission that would

890
00:38:46,400 --> 00:38:44,520
be awesome I hope so that sounds

891
00:38:47,690 --> 00:38:46,410
incredible I really hope if we have an

892
00:38:49,910 --> 00:38:47,700
inside of this mission in the near

893
00:38:51,680 --> 00:38:49,920
future that will see that organic

894
00:38:53,840 --> 00:38:51,690
analyzer on that mission that'd be so

895
00:38:55,490 --> 00:38:53,850
cool yeah it'd be really cool to see

896
00:38:56,930 --> 00:38:55,500
some of the images that the data coming

897
00:38:57,890 --> 00:38:56,940
back as well showing us if we're

898
00:39:00,490 --> 00:38:57,900
actually making those fluorescent

899
00:39:03,080 --> 00:39:00,500
detections yeah I would love to see

900
00:39:04,880 --> 00:39:03,090
before it before we go on the ion that

901
00:39:07,220 --> 00:39:04,890
one is Richard Mathies but out of the

902
00:39:09,680 --> 00:39:07,230
space science lab I have to make sure

903
00:39:11,480 --> 00:39:09,690
that I'm clear about that and not not

904
00:39:16,070 --> 00:39:11,490
inadvertently taking credit for all that

905
00:39:19,010 --> 00:39:16,080
work our next question comes from second

906
00:39:21,440 --> 00:39:19,020
net from siddharth penned a siddharth

907
00:39:23,960 --> 00:39:21,450
says or asks what are some of the

908
00:39:26,510 --> 00:39:23,970
pressing engineering challenges faced

909
00:39:28,370 --> 00:39:26,520
during feldspar that would potentially

910
00:39:33,530 --> 00:39:28,380
be a concern during off earth

911
00:39:35,900 --> 00:39:33,540
exploration oh that's a good question

912
00:39:40,640 --> 00:39:35,910
most of the technology challenges that

913
00:39:43,370 --> 00:39:40,650

we experience are either I would

914
00:39:45,260 --> 00:39:43,380
categorize them into being kind of like

915
00:39:47,540 --> 00:39:45,270
a logistics problem and the other being

916
00:39:49,190 --> 00:39:47,550
kind of like a stupid problem a stupid

917
00:39:50,510 --> 00:39:49,200
problem is you have everything with you

918
00:39:54,530 --> 00:39:50,520
that you need but you forgot to pack the

919
00:39:56,210 --> 00:39:54,540
batteries that is a on an actual space

920
00:39:57,410 --> 00:39:56,220
mission you would have a list of

921
00:39:59,270 --> 00:39:57,420
requirements and then you would have

922
00:40:00,890 --> 00:39:59,280
your validation and verification

923
00:40:03,260 --> 00:40:00,900
near come in and check that all of these

924
00:40:04,610 --> 00:40:03,270
these requirements have been met and so

925
00:40:05,630 --> 00:40:04,620
that's a big team effort where

926
00:40:07,690 --> 00:40:05,640
everyone's going through and checking

927
00:40:10,040 --> 00:40:07,700
like yes we brought the batteries

928
00:40:14,600 --> 00:40:10,050
everything is charged everything's gonna

929
00:40:16,610 --> 00:40:14,610
work so the the the stupid problems we

930
00:40:18,650 --> 00:40:16,620
have mechanisms in place to avoid those

931
00:40:22,460 --> 00:40:18,660
in an actual mission and we should have

932
00:40:23,720 --> 00:40:22,470
better ones for our own work we do have

933
00:40:25,070 --> 00:40:23,730
checklists and we are getting better

934
00:40:27,350 --> 00:40:25,080
about this there's always just that

935
00:40:28,550 --> 00:40:27,360
point like late in the campaign when

936
00:40:29,690 --> 00:40:28,560
everyone's like aw we've done this a

937
00:40:31,550 --> 00:40:29,700
million times I'm gonna have to go down

938
00:40:33,590 --> 00:40:31,560

the checklist yes yes you still have to

939
00:40:36,410 --> 00:40:33,600
come down and check and then over here

940
00:40:40,580 --> 00:40:36,420
are more logistical problems where for

941
00:40:42,950 --> 00:40:40,590
example giving a target of opportunity

942
00:40:45,050 --> 00:40:42,960
and wanting to go collect a bunch of

943
00:40:47,450 --> 00:40:45,060
samples from that spot but since we did

944
00:40:49,160 --> 00:40:47,460
not plan ahead for it all of a sudden we

945
00:40:52,220 --> 00:40:49,170
don't have enough consumables in place

946
00:40:56,450 --> 00:40:52,230
to do the sample collection and analysis

947
00:40:58,340 --> 00:40:56,460
without kind of calling in support and

948
00:41:01,130 --> 00:40:58,350
you can't call in support on on a

949
00:41:03,500 --> 00:41:01,140
mission but the problem is even more

950
00:41:06,890 --> 00:41:03,510
intense on a mission because consumables

951
00:41:08,540 --> 00:41:06,900
are if for me it's an extra checked bag

952
00:41:15,880 --> 00:41:08,550
you can't just check an extra bag with a

953
00:41:19,250 --> 00:41:15,890
Mars Lander so those types of concerns

954
00:41:25,310 --> 00:41:19,260
those become a really big challenge for

955
00:41:26,990 --> 00:41:25,320
a mission team to figure out whether

956
00:41:28,400 --> 00:41:27,000
that cool target of opportunity is

957
00:41:29,810 --> 00:41:28,410
actually worth going to pursue because

958
00:41:31,760 --> 00:41:29,820
it might mean that we're it's limiting

959
00:41:33,710 --> 00:41:31,770
our future science over in this other

960
00:41:35,570 --> 00:41:33,720
area that we wanted to do but those are

961
00:41:39,590 --> 00:41:35,580
big discussions held by met lots of

962
00:41:42,520 --> 00:41:39,600
people on large teams so it's not one

963
00:41:44,360 --> 00:41:42,530

person trying to figure out engine

964
00:41:45,740 --> 00:41:44,370
absolutely yeah it's interesting how

965
00:41:47,360 --> 00:41:45,750
collaborative the science gets with

966
00:41:49,190 --> 00:41:47,370
there's very large scale missions like

967
00:41:51,500 --> 00:41:49,200
that then where there is a lot of input

968
00:41:53,210 --> 00:41:51,510
from a lot of people yeah so thank you

969
00:41:55,720 --> 00:41:53,220
for that answer the next question is

970
00:41:58,340 --> 00:41:55,730
from Richard Goran asking on Sagan net

971
00:42:01,220 --> 00:41:58,350
Richard asks starting from a barren

972
00:42:04,310 --> 00:42:01,230
volcano in what order of succession do

973
00:42:06,980 --> 00:42:04,320
you see bacteria archaea and single-cell

974
00:42:10,380 --> 00:42:06,990
eukaryotes oh that's a really good

975
00:42:13,080 --> 00:42:10,390
question so we're trying to understand

976
00:42:15,150 --> 00:42:13,090
so far our tools and techniques are

977
00:42:19,320 --> 00:42:15,160
somewhat biased so we see a lot more

978
00:42:21,660 --> 00:42:19,330
bacteria than we see archaea and we see

979
00:42:23,610 --> 00:42:21,670
more eukaryotes than we see archaea but

980
00:42:26,040 --> 00:42:23,620
bacteria dominate that doesn't

981
00:42:28,140 --> 00:42:26,050
necessarily mean that bacteria to

982
00:42:31,020 --> 00:42:28,150
dominate as we're learning as we go

983
00:42:33,620 --> 00:42:31,030
through the lab process and optimizer

984
00:42:35,940 --> 00:42:33,630
protocols we're finding out that our

985
00:42:39,030 --> 00:42:35,950
bacterial assays are just a lot more

986
00:42:41,460 --> 00:42:39,040
efficient than our archaeal assays and

987
00:42:44,400 --> 00:42:41,470
part of that might be that bacteria has

988
00:42:47,370 --> 00:42:44,410

been studied more by geo microbiologists

989
00:42:48,980 --> 00:42:47,380
than archaea historically and only

990
00:42:52,230 --> 00:42:48,990
recently have archaea really came into

991
00:42:57,060 --> 00:42:52,240
this this new hotness of wanting to know

992
00:43:00,360 --> 00:42:57,070
more about them and our eukaryote assays

993
00:43:02,310 --> 00:43:00,370
are also just a little less efficient it

994
00:43:03,870 --> 00:43:02,320
seems we're not sure we're still trying

995
00:43:05,790 --> 00:43:03,880
to nail that down actually I think that

996
00:43:10,170 --> 00:43:05,800
it's got setting this out they're

997
00:43:13,410 --> 00:43:10,180
working on that today right now so it's

998
00:43:14,820 --> 00:43:13,420
a good question we want to know do we

999
00:43:18,480 --> 00:43:14,830
actually have a good handle on the

1000
00:43:21,540 --> 00:43:18,490
answer not entirely but we should really

1001
00:43:22,440 --> 00:43:21,550
soon know it's wonderful and I look

1002
00:43:23,940 --> 00:43:22,450
forward to hearing more about the

1003
00:43:26,040 --> 00:43:23,950
results from feldspar then for the fair

1004
00:43:27,420 --> 00:43:26,050
we're gonna learn from that our next

1005
00:43:31,980 --> 00:43:27,430
question comes to us from the Twitter

1006
00:43:34,110 --> 00:43:31,990
from user avi at vid o nine eight Ivy

1007
00:43:36,810 --> 00:43:34,120
asks what suggestion would you give to a

1008
00:43:39,230 --> 00:43:36,820
graduate student in geology who wishes

1009
00:43:42,290 --> 00:43:39,240
to be an astrobiologist and pursue a PhD

1010
00:43:48,180 --> 00:43:42,300
what would be the right courses to take

1011
00:43:52,800 --> 00:43:48,190
um so you're a geology person in grad

1012
00:43:55,890 --> 00:43:52,810
school already good courses Mike should

1013
00:44:01,580 --> 00:43:55,900

I keep going or should I pause let's get

1014
00:44:05,910 --> 00:44:01,590
going man little things okay so in

1015
00:44:09,120 --> 00:44:05,920
geology you probably have not gotten

1016
00:44:12,030 --> 00:44:09,130
very many biology type classes but you

1017
00:44:13,980 --> 00:44:12,040
probably had some chemistry classes so

1018
00:44:17,010 --> 00:44:13,990
you probably can speak chemistry okay

1019
00:44:18,630 --> 00:44:17,020
but biology is going to be a bit of a

1020
00:44:21,570 --> 00:44:18,640
stretch for you and lets you make the

1021
00:44:23,940 --> 00:44:21,580
effort to jump out there and get those

1022
00:44:28,660 --> 00:44:26,410
other ones that are available to you

1023
00:44:30,310 --> 00:44:28,670
probably inside of your own program

1024
00:44:34,120 --> 00:44:30,320
would be the planetary science type

1025
00:44:38,500 --> 00:44:34,130
classes and obviously taking those would

1026
00:44:39,820 --> 00:44:38,510
be fun and useful but given what you've

1027
00:44:44,110 --> 00:44:39,830
said about your background I would

1028
00:44:46,480 --> 00:44:44,120
suggest biology biochemistry as some

1029
00:44:50,200 --> 00:44:46,490
areas that you're probably not getting

1030
00:44:53,410 --> 00:44:50,210
the kind of language background inside

1031
00:44:54,880 --> 00:44:53,420
of your current major awesome yeah thank

1032
00:44:57,100 --> 00:44:54,890
you for that and I hope that helps ah be

1033
00:44:59,500 --> 00:44:57,110
our next question comes to us from

1034
00:45:01,390 --> 00:44:59,510
Stephanie : Santos

1035
00:45:04,360 --> 00:45:01,400
Stephanie asks could the mineral

1036
00:45:06,970 --> 00:45:04,370
evolution theory as proposed by as

1037
00:45:10,270 --> 00:45:06,980
proposed by Bob Hazen be a starting

1038
00:45:13,180 --> 00:45:10,280

point for a generic biomarker so not

1039
00:45:15,190 --> 00:45:13,190
necessarily atp-dependent or is the

1040
00:45:17,080 --> 00:45:15,200
ambiguity of the planets evolution a

1041
00:45:19,000 --> 00:45:17,090
major bottleneck for detecting life as

1042
00:45:21,460 --> 00:45:19,010
we know it okay

1043
00:45:23,920 --> 00:45:21,470
so first off I want you to address the

1044
00:45:26,500 --> 00:45:23,930
ATP as a biomarker I am NOT suggesting

1045
00:45:28,390 --> 00:45:26,510
in any way shape or form that we go to

1046
00:45:31,060 --> 00:45:28,400
and some of us and we look for ATP I'm

1047
00:45:33,070 --> 00:45:31,070
simply saying that given that feldspar

1048
00:45:34,600 --> 00:45:33,080
is constrained to earth and we are

1049
00:45:36,940 --> 00:45:34,610
looking for earth life that this is a

1050
00:45:40,120 --> 00:45:36,950
very easy biomarker for us to use here

1051
00:45:42,100 --> 00:45:40,130
to ascertain habitability here on earth

1052
00:45:46,030 --> 00:45:42,110
once we start talking about going to

1053
00:45:48,040 --> 00:45:46,040
another location that's when these types

1054
00:45:50,980 --> 00:45:48,050
of molecular evolution theories come in

1055
00:45:55,330 --> 00:45:50,990
quite handy where we can realize that

1056
00:45:58,270 --> 00:45:55,340
the set of molecules that life uses has

1057
00:46:01,290 --> 00:45:58,280
been evolutionarily selected for given

1058
00:46:04,300 --> 00:46:01,300
the unique chemical and thermodynamic

1059
00:46:07,600 --> 00:46:04,310
parameters of the environment in which

1060
00:46:10,300 --> 00:46:07,610
that life evolved now on earth that gave

1061
00:46:12,940 --> 00:46:10,310
rise to four nucleobases a set of 20

1062
00:46:15,400 --> 00:46:12,950
amino acids that we use and our proteins

1063
00:46:19,300 --> 00:46:15,410

and it's all homework I roll one of

1064
00:46:21,070 --> 00:46:19,310
those hands we can make some assumptions

1065
00:46:25,210 --> 00:46:21,080
that if we were to go to another

1066
00:46:27,640 --> 00:46:25,220
location if life had evolved there it

1067
00:46:29,740 --> 00:46:27,650
would similarly have narrowed down the

1068
00:46:32,010 --> 00:46:29,750
fast suite of organic molecules that you

1069
00:46:35,410 --> 00:46:32,020
would find like Titan's atmosphere or

1070
00:46:36,850 --> 00:46:35,420
meteorites where there's just hundreds

1071
00:46:39,280 --> 00:46:36,860
of amino acid

1072
00:46:40,350 --> 00:46:39,290
racemic for the most part lots of

1073
00:46:43,840 --> 00:46:40,360
different nucleobases

1074
00:46:45,430 --> 00:46:43,850
and so that like broad mix of different

1075
00:46:47,020 --> 00:46:45,440
organic molecules that doesn't look like

1076
00:46:51,160 --> 00:46:47,030
life either what we want to do is we

1077
00:46:52,810 --> 00:46:51,170
want to go and we want to see where the

1078
00:46:55,510 --> 00:46:52,820
number of different molecules has been

1079
00:46:56,950 --> 00:46:55,520
limited to just a few and there's kind

1080
00:46:59,140 --> 00:46:56,960
of a paradigm that I'm looking at and I

1081
00:47:01,060 --> 00:46:59,150
think that that's falling in line quite

1082
00:47:04,690 --> 00:47:01,070
nicely with what you're recommending as

1083
00:47:05,950 --> 00:47:04,700
well which is not stick to a single

1084
00:47:07,090 --> 00:47:05,960
biomarker we're not going to look for

1085
00:47:09,100 --> 00:47:07,100
ATP we're not going to look for

1086
00:47:11,530 --> 00:47:09,110
cytochrome C oxidase those are the

1087
00:47:15,250 --> 00:47:11,540
evolutionary end products and what if

1088
00:47:17,410 --> 00:47:15,260

that life selected a different track for

1089
00:47:18,910 --> 00:47:17,420
evolution and never got to ATP you got a

1090
00:47:23,260 --> 00:47:18,920
completely different energy currency

1091
00:47:26,460 --> 00:47:23,270
molecule yeah so that's my that's my

1092
00:47:29,640 --> 00:47:26,470
soapbox on that one day I really can't

1093
00:47:31,540 --> 00:47:29,650
get behind looking for a single

1094
00:47:32,860 --> 00:47:31,550
biomarker or a single class of

1095
00:47:36,040 --> 00:47:32,870
biomarkers I really think we have to

1096
00:47:39,060 --> 00:47:36,050
have a broad search where we can survey

1097
00:47:41,710 --> 00:47:39,070
the entire chemical environment

1098
00:47:43,060 --> 00:47:41,720
absolutely it's very cool I think a lot

1099
00:47:44,500 --> 00:47:43,070
of us in the astrobiology realm have

1100
00:47:46,990 --> 00:47:44,510
kind of started opening out that way -

1101
00:47:48,520 --> 00:47:47,000
ever since you know at the 70s we sent

1102
00:47:50,890 --> 00:47:48,530
the Viking landers to Mars we were

1103
00:47:52,960 --> 00:47:50,900
looking for a very specific kind of

1104
00:47:54,790 --> 00:47:52,970
earth life and there's a lot of other

1105
00:47:56,320 --> 00:47:54,800
potential out there so I like your

1106
00:47:58,390 --> 00:47:56,330
suggestion a lot of computing our minds

1107
00:48:00,280 --> 00:47:58,400
more open to the possibilities because

1108
00:48:03,820 --> 00:48:00,290
life might not have evolved the way we

1109
00:48:07,030 --> 00:48:03,830
did I love that a lot our next question

1110
00:48:08,560 --> 00:48:07,040
comes to us from Sanjoy Somme he wants

1111
00:48:11,770 --> 00:48:08,570
to know if you can speak a little bit

1112
00:48:13,600 --> 00:48:11,780
about the mentoring process if there's

1113
00:48:15,130 --> 00:48:13,610

anything that you know now now that

1114
00:48:17,860 --> 00:48:15,140
you're a professor and you're mentoring

1115
00:48:19,900 --> 00:48:17,870
students of your own if you can speak to

1116
00:48:25,390 --> 00:48:19,910
the process of being a mentor and also a

1117
00:48:27,280 --> 00:48:25,400
finding good mentors okay I don't

1118
00:48:29,110 --> 00:48:27,290
necessarily know that I know how to be a

1119
00:48:31,930 --> 00:48:29,120
good mentor yet I'm still working on

1120
00:48:35,200 --> 00:48:31,940
that I'm sure my students can point to a

1121
00:48:39,070 --> 00:48:35,210
number of mistakes that I've made in

1122
00:48:41,770 --> 00:48:39,080
terms of finding a good mentor I saw

1123
00:48:46,840 --> 00:48:41,780
this TED talk the other day where the

1124
00:48:49,870 --> 00:48:46,850
message was basically to to teach

1125
00:48:53,829 --> 00:48:49,880
bravery and that

1126
00:48:59,589 --> 00:48:53,839
Eddie has traditionally rewarded bravery

1127
00:49:04,509 --> 00:48:59,599
and boys and perfection performance and

1128
00:49:08,709 --> 00:49:04,519
girls and so that leads to at these

1129
00:49:14,319 --> 00:49:08,719
higher levels of education now we've got

1130
00:49:15,999 --> 00:49:14,329
the group selected that have been very

1131
00:49:17,709 --> 00:49:16,009
high performers they've been rewarded

1132
00:49:20,009 --> 00:49:17,719
for being high performing but they

1133
00:49:24,400 --> 00:49:20,019
haven't always been rewarded for taking

1134
00:49:28,359 --> 00:49:24,410
risks for going out in the lead and so I

1135
00:49:31,569 --> 00:49:28,369
think when you are going to find a

1136
00:49:33,009 --> 00:49:31,579
mentor it can be very scary and it can

1137
00:49:34,209 --> 00:49:33,019
seem like you're really extending

1138
00:49:39,849 --> 00:49:34,219

yourself and you're putting yourself out

1139
00:49:43,589 --> 00:49:39,859
there and those people who have been

1140
00:49:46,359 --> 00:49:43,599
conditioned to just perform well and not

1141
00:49:48,459 --> 00:49:46,369
extend themselves out are going to have

1142
00:49:51,249 --> 00:49:48,469
a lot of trouble doing that but the best

1143
00:49:54,819 --> 00:49:51,259
thing you can do is walk up to that

1144
00:49:57,189 --> 00:49:54,829
person call that person say hey you have

1145
00:50:01,120 --> 00:49:57,199
the job that I want to do can we talk

1146
00:50:07,059 --> 00:50:01,130
like I'm looking for a mentor you will

1147
00:50:09,130 --> 00:50:07,069
never find a person who is genuinely

1148
00:50:12,339 --> 00:50:09,140
interested in their job who is not going

1149
00:50:17,680 --> 00:50:12,349
to be like oh yes let's talk let me tell

1150
00:50:19,509 --> 00:50:17,690
you all about me and Michael work so if

1151
00:50:21,819 --> 00:50:19,519
you don't get that sort of a response

1152
00:50:24,579 --> 00:50:21,829
maybe the person was busy maybe you

1153
00:50:25,900 --> 00:50:24,589
should try again or maybe the person is

1154
00:50:29,109 --> 00:50:25,910
not the sort of person you want as your

1155
00:50:33,640 --> 00:50:29,119
mentor anyway and you should go try the

1156
00:50:35,380 --> 00:50:33,650
next person so that being brave and

1157
00:50:39,099 --> 00:50:35,390
being willing to jump out there and take

1158
00:50:42,309 --> 00:50:39,109
a risk and build your mentorship team to

1159
00:50:46,539 --> 00:50:42,319
meet your needs

1160
00:50:49,150 --> 00:50:46,549
rather than help provide that positive

1161
00:50:51,059 --> 00:50:49,160
reinforcement of being a high performer

1162
00:50:55,059 --> 00:50:51,069
I think that's that's a very important

1163
00:50:57,640 --> 00:50:55,069

message that many students need to get

1164
00:51:00,570 --> 00:50:57,650
and I've seen I've seen several students

1165
00:51:04,390 --> 00:51:00,580
kind of limited by their

1166
00:51:05,950 --> 00:51:04,400
their desire to always come across as as

1167
00:51:07,030 --> 00:51:05,960
the perfect student rather than being

1168
00:51:11,080 --> 00:51:07,040
willing to be like hey I don't know

1169
00:51:12,160 --> 00:51:11,090
what's going on can you please help yeah

1170
00:51:13,870 --> 00:51:12,170
I definitely would have made it through

1171
00:51:15,190 --> 00:51:13,880
grad school if I if I didn't have the

1172
00:51:16,630 --> 00:51:15,200
moments where I could just ask a

1173
00:51:18,940 --> 00:51:16,640
question and be like I have no idea how

1174
00:51:20,620 --> 00:51:18,950
to do this can you help me I also love

1175
00:51:23,290 --> 00:51:20,630
that idea of finding your bravery

1176
00:51:24,640 --> 00:51:23,300
I'm a Toastmaster and I often tell

1177
00:51:27,160 --> 00:51:24,650
people when learning how to do public

1178
00:51:29,350 --> 00:51:27,170
speaking is to find comfort and being

1179
00:51:30,640 --> 00:51:29,360
uncomfortable and so it kind of goes

1180
00:51:33,730 --> 00:51:30,650
along the same lines of finding your

1181
00:51:34,900 --> 00:51:33,740
bravery I love that message a lot let's

1182
00:51:38,620 --> 00:51:34,910
see we have some time for a few more

1183
00:51:41,590 --> 00:51:38,630
questions yet on según net penny Boston

1184
00:51:44,110 --> 00:51:41,600
asks if you had your choice and money

1185
00:51:46,840 --> 00:51:44,120
being no object would you rather have a

1186
00:51:49,450 --> 00:51:46,850
single rover with major instrumentation

1187
00:51:52,330 --> 00:51:49,460
on it so like another big curiosity or a

1188
00:51:54,280 --> 00:51:52,340

suite of mini Landers slash Rovers but

1189
00:51:59,020 --> 00:51:54,290
with each having much simpler instrument

1190
00:52:03,820 --> 00:51:59,030
capabilities all right penny can I have

1191
00:52:07,540 --> 00:52:03,830
both and thank you

1192
00:52:09,040 --> 00:52:07,550
I suppose it goes both ways it depends

1193
00:52:14,170 --> 00:52:09,050
on the instruments that you can put on

1194
00:52:18,310 --> 00:52:14,180
either of them in my personal experience

1195
00:52:20,530 --> 00:52:18,320
with fieldwork you get exceptionally

1196
00:52:22,600 --> 00:52:20,540
different environments in different

1197
00:52:23,680 --> 00:52:22,610
locations and it's hard to access all of

1198
00:52:25,780 --> 00:52:23,690
those different environments with a

1199
00:52:27,430 --> 00:52:25,790
single large Rover and so it would be so

1200
00:52:28,870 --> 00:52:27,440
valuable to be able to get access to

1201
00:52:31,240 --> 00:52:28,880
those multiple other environments

1202
00:52:34,270 --> 00:52:31,250
however without the right technology on

1203
00:52:36,460 --> 00:52:34,280
those little Rovers the information

1204
00:52:38,200 --> 00:52:36,470
you're going to get back it's possibly

1205
00:52:41,350 --> 00:52:38,210
not worth the sacrificing your big

1206
00:52:47,200 --> 00:52:41,360
rubber so I won't both and that's why

1207
00:52:49,240 --> 00:52:47,210
we're doing the little easy to fly easy

1208
00:52:51,190 --> 00:52:49,250
access to services type instrumentation

1209
00:52:53,500 --> 00:52:51,200
because we really need to boost the

1210
00:52:56,110 --> 00:52:53,510
capabilities of these non flagship class

1211
00:52:59,020 --> 00:52:56,120
type instrument technologies so that we

1212
00:53:01,800 --> 00:52:59,030
can have several little Rovers that are

1213
00:53:04,150 --> 00:53:01,810

basically the equivalent of one big one

1214
00:53:05,800 --> 00:53:04,160
absolutely yeah I would love to see the

1215
00:53:07,180 --> 00:53:05,810
big ones and the small ones and do it

1216
00:53:08,110 --> 00:53:07,190
well let's just do it all give us all

1217
00:53:11,230 --> 00:53:08,120
the money and we'll just do everything

1218
00:53:12,990 --> 00:53:11,240
and that'd be awesome I have a few more

1219
00:53:15,780 --> 00:53:13,000
questions from the audience but I

1220
00:53:17,580 --> 00:53:15,790
to Preetha to Brian Collins I apologize

1221
00:53:20,760 --> 00:53:17,590
I'm going to ask the last question

1222
00:53:23,130 --> 00:53:20,770
myself actually I noticed on your

1223
00:53:25,800 --> 00:53:23,140
website you have a quote from Elon Musk

1224
00:53:28,290 --> 00:53:25,810
that says I believe it is possible for

1225
00:53:31,050 --> 00:53:28,300
ordinary people to choose to be

1226
00:53:32,940 --> 00:53:31,060
extraordinary can I ask you why you put

1227
00:53:35,849 --> 00:53:32,950
that quote on your website and what that

1228
00:53:37,920 --> 00:53:35,859
means to you so I think I just found

1229
00:53:40,830 --> 00:53:37,930
that kind of randomly I was looking for

1230
00:53:44,730 --> 00:53:40,840
a good quote to put but it kind of meets

1231
00:53:47,820 --> 00:53:44,740
this whole idea that you get to build

1232
00:53:50,490 --> 00:53:47,830
the life that you want to have you get

1233
00:53:52,440 --> 00:53:50,500
to go out as a geologist and find your

1234
00:53:55,700 --> 00:53:52,450
biology classes as a biologist and find

1235
00:53:58,830 --> 00:53:55,710
your geologist classes and you get to

1236
00:54:00,180 --> 00:53:58,840
pick your mentors and pick the people

1237
00:54:04,109 --> 00:54:00,190
that you will mentor you get to develop

1238
00:54:09,390 --> 00:54:04,119

your own community and just this idea

1239
00:54:10,950 --> 00:54:09,400
that a group of otherwise ordinary early

1240
00:54:14,460 --> 00:54:10,960
career people could get together and

1241
00:54:20,390 --> 00:54:14,470
start this feldspar projects this male

1242
00:54:22,920 --> 00:54:20,400
multi national field work initiative

1243
00:54:24,720 --> 00:54:22,930
that just kind of fits in in line with

1244
00:54:26,099 --> 00:54:24,730
the whole thing I think it's important

1245
00:54:27,990 --> 00:54:26,109
for people to remember you can feel so

1246
00:54:29,880 --> 00:54:28,000
small and ordinary but you can do

1247
00:54:32,849 --> 00:54:29,890
extraordinary things when you want to

1248
00:54:35,210 --> 00:54:32,859
you just have to you have to want it you

1249
00:54:37,490 --> 00:54:35,220
have to make it you have to build it

1250
00:54:40,170 --> 00:54:37,500
absolutely get out there and do it right

1251
00:54:41,609 --> 00:54:40,180
dr. Stockton thank you so much for your

1252
00:54:43,320 --> 00:54:41,619
time today we really appreciate having

1253
00:54:46,290 --> 00:54:43,330
you on the show you've been a wonderful

1254
00:54:47,339 --> 00:54:46,300
guest I apologize again to our audience

1255
00:54:49,500 --> 00:54:47,349
the questions we didn't get to today

1256
00:54:51,329 --> 00:54:49,510
we'll try to answer those sometime

1257
00:54:54,240 --> 00:54:51,339
throughout the coming weeks on Twitter

1258
00:54:57,420 --> 00:54:54,250
and Facebook again dr. Stockton thank

1259
00:54:57,870 --> 00:54:57,430
you to everyone out there ciao and stay

1260
00:54:59,550 --> 00:54:57,880
curious