



Ask An Astrobiologist



EPISODE 32: MAY 20<sup>TH</sup>, 2020

**DR. KEVIN HAND**



Astrobiology Program

1  
00:00:00,690 --> 00:00:29,750

[Music]

2  
00:00:34,920 --> 00:00:32,880

greetings friends and fellow terrestrial

3  
00:00:37,260 --> 00:00:34,930

beings and welcome to ask an

4  
00:00:40,470 --> 00:00:37,270

astrobiologists the show that celebrates

5  
00:00:43,619 --> 00:00:40,480

the science and the scientists involved

6  
00:00:46,229 --> 00:00:43,629

in our quest to understand the nature of

7  
00:00:47,580 --> 00:00:46,239

life in the cosmos we are brought to you

8  
00:00:50,280 --> 00:00:47,590

by Sagan net org

9  
00:00:53,310 --> 00:00:50,290

and the NASA Astrobiology program and I

10  
00:00:56,729 --> 00:00:53,320

am your host Graham the Cosmo biologist

11  
00:00:58,770 --> 00:00:56,739

loud hi everyone we have a really

12  
00:01:00,119 --> 00:00:58,780

incredible guest for you this month and

13  
00:01:01,740 --> 00:01:00,129

I have to say like I've kind of been

14

00:01:03,840 --> 00:01:01,750

like geeking out in the background here

15

00:01:05,789 --> 00:01:03,850

thinking about having him on I've been

16

00:01:07,530 --> 00:01:05,799

following his work for a very long time

17

00:01:10,219 --> 00:01:07,540

and we have a lot of cool stuff to talk

18

00:01:12,870 --> 00:01:10,229

about about Europa and working at JPL

19

00:01:14,940 --> 00:01:12,880

just so much cool science and a really

20

00:01:16,500 --> 00:01:14,950

awesome book that just came out but

21

00:01:18,510 --> 00:01:16,510

before we get to that and I introduce

22

00:01:20,219 --> 00:01:18,520

our guests we have some of our usual

23

00:01:22,620 --> 00:01:20,229

awesome things that we do with our show

24

00:01:24,539 --> 00:01:22,630

like for instance our field site

25

00:01:26,550 --> 00:01:24,549

challenge as many of our audience

26

00:01:29,250 --> 00:01:26,560

members know each month before the

27

00:01:31,830 --> 00:01:29,260

episode airs the day before we launched

28

00:01:33,930 --> 00:01:31,840

on Twitter a challenge for you to figure

29

00:01:37,650 --> 00:01:33,940

out some ester biologically relevant

30

00:01:39,150 --> 00:01:37,660

field site here on our earth and this is

31

00:01:41,760 --> 00:01:39,160

the picture from this month we're

32

00:01:44,490 --> 00:01:41,770

putting up right now for you to see this

33

00:01:46,950 --> 00:01:44,500

is an image of the Sully hydrothermal

34

00:01:50,520 --> 00:01:46,960

vent in the main endeavour event field

35

00:01:54,360 --> 00:01:50,530

off the Juan de Fuca Ridge this bet is

36

00:01:56,940 --> 00:01:54,370

some 2,200 meters underwater a region

37

00:01:59,190 --> 00:01:56,950

where fluids circulating into the crust

38

00:02:02,190 --> 00:01:59,200

come back out at hundreds of degrees

39

00:02:04,170 --> 00:02:02,200

Celsius bringing out this black material

40

00:02:06,870 --> 00:02:04,180

in this hydrothermal vent this black

41

00:02:08,999 --> 00:02:06,880

smoker chimney around the chimney is an

42

00:02:11,610 --> 00:02:09,009

oasis of life including those long two

43

00:02:13,170 --> 00:02:11,620

burns the rift II at the Kip Tala these

44

00:02:15,240 --> 00:02:13,180

sites are so important for us as

45

00:02:17,670 --> 00:02:15,250

astrobiologists after that they're

46

00:02:20,130 --> 00:02:17,680

discovered the 1970s we realized that

47

00:02:22,920 --> 00:02:20,140

these hydrothermal vents could be sites

48

00:02:24,449 --> 00:02:22,930

not just for life to thrive in Oasis and

49

00:02:26,850 --> 00:02:24,459

ocean floors on earth and beyond the

50

00:02:29,460 --> 00:02:26,860

potential sites for the origins of life

51  
00:02:30,869 --> 00:02:29,470  
as well and so they've been crucial now

52  
00:02:33,479 --> 00:02:30,879  
to our understanding of how life

53  
00:02:35,460 --> 00:02:33,489  
functions and so our winner this month

54  
00:02:37,500 --> 00:02:35,470  
of all the wonderful correct answers we

55  
00:02:38,800 --> 00:02:37,510  
got on Twitter about the location of

56  
00:02:41,170 --> 00:02:38,810  
this site is

57  
00:02:43,089 --> 00:02:41,180  
in Cairo I actually know Tristan Tristan

58  
00:02:45,490 --> 00:02:43,099  
is a graduate student at the University

59  
00:02:47,080 --> 00:02:45,500  
of Colorado he's also a member of the

60  
00:02:49,780 --> 00:02:47,090  
research coordination network called

61  
00:02:52,180 --> 00:02:49,790  
n-fold or the network for life detection

62  
00:02:54,370 --> 00:02:52,190  
so congratulations Tristan on winning

63  
00:02:56,110 --> 00:02:54,380

and thank you to all of you who competed

64

00:02:59,020 --> 00:02:56,120

this month in every single month in our

65

00:03:01,839 --> 00:02:59,030

field site challenge we also do a

66

00:03:04,509 --> 00:03:01,849

monthly ambassador of the month trying

67

00:03:06,520 --> 00:03:04,519

to celebrate those of you who go out of

68

00:03:08,320 --> 00:03:06,530

your way to give us some love in the

69

00:03:10,540 --> 00:03:08,330

digital realm through social media on

70

00:03:12,280 --> 00:03:10,550

Twitter and Facebook LinkedIn reddit

71

00:03:14,140 --> 00:03:12,290

Instagram and all the other awesome

72

00:03:17,080 --> 00:03:14,150

places you can share ask an

73

00:03:19,240 --> 00:03:17,090

astrobiologist we actually had so many

74

00:03:21,190 --> 00:03:19,250

people this month sharing us that we

75

00:03:22,650 --> 00:03:21,200

wanted to name four of you specifically

76

00:03:26,229 --> 00:03:22,660

and say thank you for your hard work

77

00:03:29,110 --> 00:03:26,239

those for our Emily Felder at sub-atomic

78

00:03:33,280 --> 00:03:29,120

Emily on Twitter Anna root mohanty at

79

00:03:35,699 --> 00:03:33,290

stray ologist steena at steena - five

80

00:03:36,820 --> 00:03:35,709

zero six two three five three and

81

00:03:40,089 --> 00:03:36,830

Dallara

82

00:03:42,400 --> 00:03:40,099

coke Arslan at Dobie delle on twitter

83

00:03:43,930 --> 00:03:42,410

thanks thank you to the four of you we

84

00:03:47,530 --> 00:03:43,940

really appreciate all that you do for

85

00:03:50,740 --> 00:03:47,540

our show now without any further ado I

86

00:03:52,240 --> 00:03:50,750

get to introduce this month's guest dr.

87

00:03:54,610 --> 00:03:52,250

Kevin hand of a NASA Jet Propulsion

88

00:03:57,009 --> 00:03:54,620

Laboratory dr. Kevin Han thank you so

89

00:03:59,110 --> 00:03:57,019

much for joining us hey thanks Graham

90

00:04:01,059 --> 00:03:59,120

thanks Mike I'm so excited to have you

91

00:04:03,699 --> 00:04:01,069

on the show like I said I've been

92

00:04:06,370 --> 00:04:03,709

following your work for a long time and

93

00:04:08,170 --> 00:04:06,380

I know a lot about since my own graduate

94

00:04:10,300 --> 00:04:08,180

research was in the realm of

95

00:04:13,210 --> 00:04:10,310

understanding analogues for Europa and

96

00:04:14,710 --> 00:04:13,220

Enceladus and other worlds but for our

97

00:04:17,050 --> 00:04:14,720

audience you know I'd really like to get

98

00:04:19,270 --> 00:04:17,060

to you know who you are as a scientist

99

00:04:21,909 --> 00:04:19,280

what you do you work at NASA's Jet

100

00:04:24,070 --> 00:04:21,919

Propulsion Laboratory you're involved in

101  
00:04:26,379 --> 00:04:24,080  
upcoming research on developing a lander

102  
00:04:28,330 --> 00:04:26,389  
for Europa but can you give us just a

103  
00:04:29,680 --> 00:04:28,340  
little background about your career in

104  
00:04:42,430 --> 00:04:29,690  
science and what led you to where you

105  
00:04:46,029 --> 00:04:42,440  
are right now so I was born and raised

106  
00:04:50,470 --> 00:04:46,039  
in a pretty small town in southwestern

107  
00:04:53,290 --> 00:04:50,480  
Vermont's town called Manchester Vermont

108  
00:04:56,770 --> 00:04:53,300  
and I attribute my fascination my

109  
00:04:59,470 --> 00:04:56,780  
obsession my curiosity with the search

110  
00:05:02,940 --> 00:04:59,480  
for life beyond Earth to the the clear

111  
00:05:05,440 --> 00:05:02,950  
night skies of Vermont and having

112  
00:05:09,370 --> 00:05:05,450  
parents and then living in a community

113  
00:05:12,910 --> 00:05:09,380

where all of us kids were just kind of

114

00:05:18,880 --> 00:05:12,920

kicked out at sunrise and we had to come

115

00:05:22,180 --> 00:05:18,890

back in time for dinner and so my friend

116

00:05:24,910 --> 00:05:22,190

my siblings that I and my friends and I

117

00:05:28,180 --> 00:05:24,920

we all just kind of lived in the woods

118

00:05:30,970 --> 00:05:28,190

and played in mud puddles it was the

119

00:05:36,210 --> 00:05:30,980

best analogy for my childhood is is

120

00:05:44,710 --> 00:05:40,810

beyond a nurturing community of friends

121

00:05:47,740 --> 00:05:44,720

and family who just kind of let us all

122

00:05:49,720 --> 00:05:47,750

room I had a wonderful teacher in

123

00:05:52,840 --> 00:05:49,730

seventh and eighth grade a science

124

00:05:55,660 --> 00:05:52,850

teacher was adamant about just getting

125

00:05:59,970 --> 00:05:55,670

us out and having us explore and build

126

00:06:02,890 --> 00:05:59,980

things his name was Mike sefirot and he

127

00:06:05,950 --> 00:06:02,900

he got us out to these old cow pastures

128

00:06:09,700 --> 00:06:05,960

in Vermont and these old rivers where

129

00:06:13,030 --> 00:06:09,710

there had been water wheels and sawmills

130

00:06:16,420 --> 00:06:13,040

that were powered by simple machines and

131

00:06:19,030 --> 00:06:16,430

that really get a sense for what early

132

00:06:22,210 --> 00:06:19,040

technology in colonial America was was

133

00:06:28,800 --> 00:06:22,220

like and so that kind of captivated my

134

00:06:33,070 --> 00:06:28,810

imagination with the basic physics of

135

00:06:36,760 --> 00:06:33,080

the world around me and then combine

136

00:06:40,840 --> 00:06:36,770

that with the night sky above and a

137

00:06:45,040 --> 00:06:40,850

dance and Carl Sagan books and building

138

00:06:47,320 --> 00:06:45,050

a lot of rockets yeah it's a I just feel

139

00:06:55,050 --> 00:06:47,330

very fortunate that I grew up in a in an

140

00:06:59,710 --> 00:06:58,150

well there's an interesting kind of

141

00:07:01,870 --> 00:06:59,720

compare and contrast some people have a

142

00:07:03,770 --> 00:07:01,880

childhood where they have academic

143

00:07:06,170 --> 00:07:03,780

parents and they get like streamline

144

00:07:10,550 --> 00:07:06,180

on this thing that thing I didn't have

145

00:07:12,830 --> 00:07:10,560

that and obviously having parents who

146

00:07:17,360 --> 00:07:12,840

know what a PhD is or who are into

147

00:07:19,300 --> 00:07:17,370

academia can get you on that path very

148

00:07:24,790 --> 00:07:19,310

quickly but I've worried that sometimes

149

00:07:32,240 --> 00:07:24,800

those folks are not necessarily choosing

150

00:07:34,550 --> 00:07:32,250

their their path and so I feel very

151  
00:07:38,300 --> 00:07:34,560  
fortunate that I kind of organically

152  
00:07:40,580 --> 00:07:38,310  
came to love the universe around me and

153  
00:07:43,160 --> 00:07:40,590  
and that did result in some challenges

154  
00:07:45,770 --> 00:07:43,170  
in terms of how the heck do I make a

155  
00:07:48,380 --> 00:07:45,780  
career out of this and we can get into

156  
00:07:51,620 --> 00:07:48,390  
some of that but but the seeds were

157  
00:07:53,990 --> 00:07:51,630  
planted by just the the sort of fertile

158  
00:07:54,530 --> 00:07:54,000  
soil of Vermont so to speak that's

159  
00:07:56,330 --> 00:07:54,540  
awesome

160  
00:07:57,590 --> 00:07:56,340  
and to say you know as a parent myself

161  
00:07:59,720 --> 00:07:57,600  
with a young child you know I've been

162  
00:08:01,220 --> 00:07:59,730  
thinking a lot about ways to to be

163  
00:08:03,440 --> 00:08:01,230

supportive but also not to like you know

164

00:08:05,000 --> 00:08:03,450

to shoehorn him into like some path that

165

00:08:06,830 --> 00:08:05,010

I want for him and you know to give him

166

00:08:07,820 --> 00:08:06,840

that chance so it's it's kind of cool to

167

00:08:09,530 --> 00:08:07,830

hear about that you know you have an

168

00:08:10,790 --> 00:08:09,540

environment that nurtures and challenges

169

00:08:14,810 --> 00:08:10,800

you but doesn't you know direct you

170

00:08:16,370 --> 00:08:14,820

necessarily where to go so so tell us

171

00:08:17,870 --> 00:08:16,380

that about about your career kind of

172

00:08:19,550 --> 00:08:17,880

your adventure going into into college

173

00:08:20,810 --> 00:08:19,560

and and what you studied and how it kind

174

00:08:24,620 --> 00:08:20,820

of brought you to be the scientist that

175

00:08:30,860 --> 00:08:24,630

you are well old is your child he's 10

176

00:08:33,500 --> 00:08:30,870

months old right now I was gonna

177

00:08:38,719 --> 00:08:33,510

recommend mud puddles and cardboard

178

00:08:40,219 --> 00:08:38,729

boxes so yeah I definitely made a lot of

179

00:08:43,570 --> 00:08:40,229

sports and spaceships out of

180

00:08:47,920 --> 00:08:43,580

refrigerator boxes and anything that

181

00:08:52,340 --> 00:08:47,930

then my siblings and I could crawl into

182

00:08:54,470 --> 00:08:52,350

yeah so the with regard to how I got

183

00:08:56,810 --> 00:08:54,480

from from there to to where I am now

184

00:08:58,370 --> 00:08:56,820

there's many many steps that probably

185

00:09:02,270 --> 00:08:58,380

take a lot a lot longer than we have

186

00:09:06,550 --> 00:09:02,280

today but originally I wanted to go to

187

00:09:10,190 --> 00:09:06,560

Cornell and study under a Carl Sagan and

188

00:09:12,680 --> 00:09:10,200

that's I got into Cornell and and I

189

00:09:16,070 --> 00:09:12,690

really didn't have much guidance as far

190

00:09:18,470 --> 00:09:16,080

as how to become a scientist a lot of

191

00:09:20,750 --> 00:09:18,480

in public schools in Vermont or just

192

00:09:24,020 --> 00:09:20,760

kind of well go to UVM which is a great

193

00:09:25,880 --> 00:09:24,030

school but there wasn't too much

194

00:09:32,950 --> 00:09:25,890

guidance about I want to become a

195

00:09:39,320 --> 00:09:35,570

was sort of morally opposed to the cost

196

00:09:42,350 --> 00:09:39,330

of college back then which this is this

197

00:09:45,190 --> 00:09:42,360

is the early 90s and obviously this has

198

00:09:53,080 --> 00:09:45,200

become a huge issue in the modern era

199

00:09:55,040 --> 00:09:53,090

but during junior high and high school I

200

00:09:57,170 --> 00:09:55,050

will actually goes back even further

201

00:10:01,580 --> 00:09:57,180

than that but as a young child I got

202

00:10:05,150 --> 00:10:01,590

captivated also by magic and and some of

203

00:10:09,650 --> 00:10:05,160

the the juggling and riding unicycles

204

00:10:14,900 --> 00:10:09,660

and all that stuff and I think magic and

205

00:10:19,400 --> 00:10:14,910

magic tricks can definitely get your

206

00:10:20,660 --> 00:10:19,410

your sort of childhood OCD going on if

207

00:10:22,250 --> 00:10:20,670

you've got a curious mind that's

208

00:10:23,930 --> 00:10:22,260

obsessed with puzzles and figuring

209

00:10:25,700 --> 00:10:23,940

things out and then you see a magic

210

00:10:28,730 --> 00:10:25,710

trick that just does not make sense with

211

00:10:32,060 --> 00:10:28,740

the universe around you you can obsess

212

00:10:34,430 --> 00:10:32,070

over those things so I definitely got

213

00:10:38,840 --> 00:10:34,440

hooked on magic as a young kid and then

214

00:10:40,880 --> 00:10:38,850

I ended up starting a a small business

215

00:10:44,990 --> 00:10:40,890

where I went around with a buddy of mine

216

00:10:50,750 --> 00:10:45,000

and we did birthday parties and senior

217

00:10:53,870 --> 00:10:50,760

living homes and VFW holiday parties and

218

00:10:56,540 --> 00:10:53,880

things like that I bought my first car

219

00:10:58,730 --> 00:10:56,550

with money I made from the magic shows

220

00:11:04,570 --> 00:10:58,740

and everything so there was actually a

221

00:11:08,450 --> 00:11:04,580

time period where I looked at going to a

222

00:11:12,200 --> 00:11:08,460

circus college and I had actually gone

223

00:11:15,110 --> 00:11:12,210

to magic camp and so there was a there's

224

00:11:19,040 --> 00:11:15,120

a whole kind of alternate universe where

225

00:11:22,130 --> 00:11:19,050

I where I pursued all of that but then I

226

00:11:23,810 --> 00:11:22,140

got into Cornell and I ended up having

227

00:11:29,510 --> 00:11:23,820

some some scholarships and some

228

00:11:31,160 --> 00:11:29,520

financial aid that made college possible

229

00:11:35,000 --> 00:11:31,170

and when I went out to Cornell and

230

00:11:38,000 --> 00:11:35,010

visited I talked with a physics

231

00:11:39,650 --> 00:11:38,010

professor there and he said there's no

232

00:11:41,330 --> 00:11:39,660

way you're ever gonna meet Carl there's

233

00:11:44,660 --> 00:11:41,340

no way you're ever going to get a chance

234

00:11:49,370 --> 00:11:44,670

to work with him and so I kind of I left

235

00:11:51,110 --> 00:11:49,380

Cornell and then was a bit sad and my

236

00:11:53,750 --> 00:11:51,120

English teacher had advised that I look

237

00:11:55,640 --> 00:11:53,760

at Dartmouth College and I went to

238

00:11:57,530 --> 00:11:55,650

Dartmouth I didn't like it on my first

239

00:12:00,530 --> 00:11:57,540

trip because I did the sort of standard

240

00:12:03,650 --> 00:12:00,540

tour and I didn't like a bunch of the

241

00:12:05,630 --> 00:12:03,660

sort of Greek life aspect of all that

242

00:12:10,880 --> 00:12:05,640

but then I went back up there on my own

243

00:12:12,800 --> 00:12:10,890

and met a bunch of the mountaineering

244

00:12:14,120 --> 00:12:12,810

club and Outing Club folks and I had a

245

00:12:19,970 --> 00:12:14,130

great talk with a physics professor

246

00:12:23,360 --> 00:12:19,980

there who was not at all condescending

247

00:12:25,610 --> 00:12:23,370

he entertained all my naive questions

248

00:12:27,650 --> 00:12:25,620

about general relativity and quantum

249

00:12:29,480 --> 00:12:27,660

mechanics and all that so I ended up

250

00:12:32,350 --> 00:12:29,490

going to Dartmouth and studied physics

251  
00:12:35,120 --> 00:12:32,360  
and psychology and astronomy there and

252  
00:12:37,370 --> 00:12:35,130  
then from there there were a number of

253  
00:12:38,540 --> 00:12:37,380  
internships and then the hiccups here

254  
00:12:40,880 --> 00:12:38,550  
and there that we can get into if you

255  
00:12:43,790 --> 00:12:40,890  
like but that's sort of how I went from

256  
00:12:45,740 --> 00:12:43,800  
a child to then being actually engaged

257  
00:12:49,060 --> 00:12:45,750  
in a formal academic system that that

258  
00:12:51,590 --> 00:12:49,070  
would eventually lead to me being at JPL

259  
00:12:53,540 --> 00:12:51,600  
that's awesome and it's hard to imagine

260  
00:12:54,770 --> 00:12:53,550  
that you know this universe where Kevin

261  
00:12:58,340 --> 00:12:54,780  
Ham is you know the master of

262  
00:13:00,170 --> 00:12:58,350  
legerdemain and a magician it's kind of

263  
00:13:01,550 --> 00:13:00,180

cool though I like hearing that that

264

00:13:03,590 --> 00:13:01,560

story in your background you know that

265

00:13:05,440 --> 00:13:03,600

there is that this interest in magic and

266

00:13:07,640 --> 00:13:05,450

in developing that kind of as a career

267

00:13:09,110 --> 00:13:07,650

and also the enchantment that comes with

268

00:13:11,000 --> 00:13:09,120

that and kind of the all in wonder of

269

00:13:12,290 --> 00:13:11,010

this world of magic that you know kind

270

00:13:14,270 --> 00:13:12,300

of draws a lot of people to it we also

271

00:13:18,740 --> 00:13:14,280

have that a lot in astrobiology and the

272

00:13:20,810 --> 00:13:18,750

sciences well so you know you work

273

00:13:23,750 --> 00:13:20,820

currently at JPL which is like the mecca

274

00:13:25,010 --> 00:13:23,760

of space exploration can you just give

275

00:13:26,270 --> 00:13:25,020

our audience like an idea of you know

276

00:13:28,340 --> 00:13:26,280

what a general day I mean we're in

277

00:13:30,050 --> 00:13:28,350

pandemic right now obviously but but

278

00:13:33,260 --> 00:13:30,060

what is the love life of a JPL

279

00:13:37,460 --> 00:13:33,270

scientists like well obviously I can

280

00:13:42,780 --> 00:13:37,470

really only for myself buddy in general

281

00:13:49,490 --> 00:13:42,790

the scientists at JPL we have to publish

282

00:13:53,250 --> 00:13:49,500

and we kind of partition our our

283

00:13:54,990 --> 00:13:53,260

workload into fundamental research and

284

00:13:56,910 --> 00:13:55,000

writing proposals to support that

285

00:14:04,400 --> 00:13:56,920

fundamental research and then doing

286

00:14:10,620 --> 00:14:07,170

formulate or implement missions in other

287

00:14:12,420 --> 00:14:10,630

words help get missions approved or help

288

00:14:16,830 --> 00:14:12,430

get missions built or some combination

289

00:14:19,800 --> 00:14:16,840

therein in my case I run the ocean

290

00:14:21,450 --> 00:14:19,810

worlds lab at JPL and we've got a great

291

00:14:23,310 --> 00:14:21,460

team in that lab and we do these

292

00:14:25,830 --> 00:14:23,320

experiments that simulate Europa's

293

00:14:27,720 --> 00:14:25,840

surface and subsurface Enceladus is

294

00:14:32,610 --> 00:14:27,730

surface and subsurface and a little bit

295

00:14:36,900 --> 00:14:32,620

of Titan work in there earth ice and

296

00:14:39,840 --> 00:14:36,910

ocean work in our lab and so part of my

297

00:14:44,310 --> 00:14:39,850

time is spent on land and writing up

298

00:14:46,140 --> 00:14:44,320

those results part of my time it's spent

299

00:14:49,860 --> 00:14:46,150

right now on Mars 2020

300

00:14:53,700 --> 00:14:49,870

I'm helping as a member of the the

301  
00:14:57,600 --> 00:14:53,710  
Sherlock instrument team and then the

302  
00:15:00,030 --> 00:14:57,610  
other major component of my time is

303  
00:15:04,020 --> 00:15:00,040  
trying to get the Europa Lander mission

304  
00:15:06,840 --> 00:15:04,030  
concept moving forward we passed our

305  
00:15:10,980 --> 00:15:06,850  
Delta MCR our mission concept review

306  
00:15:13,680 --> 00:15:10,990  
which is a key to go to phase a the the

307  
00:15:17,040 --> 00:15:13,690  
kind of official greenlight permission

308  
00:15:19,020 --> 00:15:17,050  
to move forward but do a number of

309  
00:15:22,470 --> 00:15:19,030  
different factors were kind of in a

310  
00:15:25,770 --> 00:15:22,480  
parking orbit if you will and that

311  
00:15:28,410 --> 00:15:25,780  
mission will not move forward I'm

312  
00:15:31,490 --> 00:15:28,420  
certain it won't move into phase a

313  
00:15:34,740 --> 00:15:31,500

before the next Ocado survey is

314

00:15:36,540 --> 00:15:34,750

completed and distributed and so to that

315

00:15:38,550 --> 00:15:36,550

and we need the astrobiology community

316

00:15:41,730 --> 00:15:38,560

out there to get involved with the de

317

00:15:45,480 --> 00:15:41,740

kado survey and to help be a strong

318

00:15:48,000 --> 00:15:45,490

voice for our priorities in the next

319

00:15:49,440 --> 00:15:48,010

decade of exploration and hopefully

320

00:15:52,290 --> 00:15:49,450

getting things like a lander to the

321

00:15:54,660 --> 00:15:52,300

surface of Europa admission out to study

322

00:15:55,920 --> 00:15:54,670

the plumes of Enceladus and all those

323

00:16:00,990 --> 00:15:55,930

things so it's been

324

00:16:05,820 --> 00:16:01,000

a lot of time on that kind of mission

325

00:16:07,889 --> 00:16:05,830

development work and the the formulation

326

00:16:09,870 --> 00:16:07,899

and strategy side and then I'm a Kauai

327

00:16:12,120 --> 00:16:09,880

on Europa clipper and a Kauai on the

328

00:16:14,730 --> 00:16:12,130

Dragonfly mission and I do a fair amount

329

00:16:19,829 --> 00:16:14,740

of field work so it's uh it's a lot to

330

00:16:21,480 --> 00:16:19,839

juggle but try and keep all the balls in

331

00:16:23,400 --> 00:16:21,490

the air yeah so it sounds like a very

332

00:16:25,410 --> 00:16:23,410

busy life but also really exciting to be

333

00:16:26,519 --> 00:16:25,420

involved and all of these incredible

334

00:16:27,510 --> 00:16:26,529

missions and all these are the cool

335

00:16:29,760 --> 00:16:27,520

things that could be happening in the

336

00:16:31,889 --> 00:16:29,770

near future for our audience who aren't

337

00:16:33,480 --> 00:16:31,899

aware the decatur survey which has

338

00:16:34,590 --> 00:16:33,490

always been about planetary science now

339

00:16:37,350 --> 00:16:34,600

it's the de cable survey of planetary

340

00:16:39,870 --> 00:16:37,360

science and astrobiology which is pretty

341

00:16:40,949 --> 00:16:39,880

incredible this is a way for the

342

00:16:43,949 --> 00:16:40,959

community to come together as

343

00:16:46,829 --> 00:16:43,959

researchers and basically say within one

344

00:16:48,510 --> 00:16:46,839

large document kind of you know this is

345

00:16:51,000 --> 00:16:48,520

the vision for the next ten years of our

346

00:16:52,949 --> 00:16:51,010

exploration in this realm so it'd be

347

00:16:54,690 --> 00:16:52,959

very cool if we can get you know the rep

348

00:16:56,180 --> 00:16:54,700

a lander concept in there and you know

349

00:16:58,199 --> 00:16:56,190

they're getting a mission to Enceladus

350

00:16:59,370 --> 00:16:58,209

before we talk more about all these

351  
00:17:01,769 --> 00:16:59,380  
missions specifically I do want to

352  
00:17:02,699 --> 00:17:01,779  
mention your book which I had seen you

353  
00:17:03,930 --> 00:17:02,709  
know you mentioned on Twitter it was

354  
00:17:05,220 --> 00:17:03,940  
being released and that's why I wanted

355  
00:17:07,710 --> 00:17:05,230  
to bring you on the show what it was to

356  
00:17:09,929 --> 00:17:07,720  
talk about this that is alien oceans for

357  
00:17:12,059 --> 00:17:09,939  
our audience you can pick this book up

358  
00:17:13,380 --> 00:17:12,069  
now unfortunately it's hard to pandemic

359  
00:17:15,480 --> 00:17:13,390  
to go to bookstores and find it but it

360  
00:17:18,510 --> 00:17:15,490  
is available online

361  
00:17:23,130 --> 00:17:18,520  
I've really enjoyed thus far and one

362  
00:17:25,949 --> 00:17:23,140  
place during grad to join a trip as

363  
00:17:27,990 --> 00:17:25,959

Cameron to go down into a submersible in

364

00:17:30,180 --> 00:17:28,000

the ocean not just once but I think nine

365

00:17:33,630 --> 00:17:30,190

times you mentioned you had a chance to

366

00:17:35,669 --> 00:17:33,640

go down what was that like for you that

367

00:17:37,950 --> 00:17:35,679

experience of becoming one of the very

368

00:17:42,419 --> 00:17:37,960

few humans who's ever gone down to the

369

00:17:45,870 --> 00:17:42,429

bottom of the ocean in a submersible it

370

00:17:49,370 --> 00:17:45,880

was remarkable and then and

371

00:17:51,390 --> 00:17:49,380

mind-altering and and and all of those

372

00:17:53,940 --> 00:17:51,400

aspects I'll get into the actual

373

00:17:55,590 --> 00:17:53,950

experience in in a second but as I as I

374

00:17:58,560 --> 00:17:55,600

described in the book it was not an

375

00:18:01,020 --> 00:17:58,570

obvious choice for me at the time I was

376

00:18:05,339 --> 00:18:01,030

out at the geobiology summer school on

377

00:18:10,209 --> 00:18:08,649

this was a TV thing a Hollywood thing or

378

00:18:12,669 --> 00:18:10,219

whatever and I had done a little bit of

379

00:18:14,259 --> 00:18:12,679

work here and there with that and for

380

00:18:20,799 --> 00:18:14,269

the most part kind of saw that as a

381

00:18:23,440 --> 00:18:20,809

distraction but my close friend George

382

00:18:26,649 --> 00:18:23,450

Whitesides was at some other it was a

383

00:18:30,579 --> 00:18:26,659

calm space company at the time he called

384

00:18:33,159 --> 00:18:30,589

me up and said James Cameron is looking

385

00:18:35,919 --> 00:18:33,169

at me of connecting hydrothermal vents

386

00:18:39,449 --> 00:18:35,929

to Europa and he's looking for young

387

00:18:42,200 --> 00:18:39,459

scientists to talk about that connection

388

00:18:46,580 --> 00:18:42,210

well

389

00:18:47,900 --> 00:18:46,590

interesting then I went and they kind of

390

00:18:51,230 --> 00:18:47,910

interviewed me and stuff and there we

391

00:18:53,720 --> 00:18:51,240

went well and I was you know because I

392

00:18:57,800 --> 00:18:53,730

had this great thing at the geobiology

393

00:19:03,460 --> 00:18:57,810

summer school and I asked Ken Neelson

394

00:19:06,200 --> 00:19:03,470

who many of you know of Ken Ken's at USC

395

00:19:08,150 --> 00:19:06,210

and he's just an incredible store in the

396

00:19:09,860 --> 00:19:08,160

bobbin can't you tonight should I do

397

00:19:13,970 --> 00:19:09,870

this thing is this a distraction is it

398

00:19:17,540 --> 00:19:13,980

was a you know I'm in the PhD this is

399

00:19:20,570 --> 00:19:17,550

gonna be some time off and yeah what his

400

00:19:22,010 --> 00:19:20,580

hand on my hand just said Kevin if

401  
00:19:23,920 --> 00:19:22,020  
there's any chance in hell you get to go

402  
00:19:27,620 --> 00:19:23,930  
to the bottom the ocean damnit take it

403  
00:19:32,480 --> 00:19:27,630  
and that was really really good advice

404  
00:19:34,460 --> 00:19:32,490  
and so we I got to go to the bottom nine

405  
00:19:38,780 --> 00:19:34,470  
times and see hydrothermal vents up

406  
00:19:41,150 --> 00:19:38,790  
close to see those bizarre and beautiful

407  
00:19:47,570 --> 00:19:41,160  
ecosystems and all right in front of my

408  
00:19:49,460 --> 00:19:47,580  
eyes and it's uh it was just absolutely

409  
00:19:53,270 --> 00:19:49,470  
stunning and and it's it's sort of

410  
00:19:55,820 --> 00:19:53,280  
holding a philosophy of robots versus

411  
00:19:57,620 --> 00:19:55,830  
human exploration and having grown up in

412  
00:19:59,270 --> 00:19:57,630  
the mountains and and done a lot of

413  
00:20:02,690 --> 00:19:59,280

climbing and mountaineering and and

414

00:20:05,450 --> 00:20:02,700

getting on to the mountains there were

415

00:20:08,210 --> 00:20:05,460

interesting parallels with being down at

416

00:20:11,150 --> 00:20:08,220

the bottom of the ocean and that sense

417

00:20:12,740 --> 00:20:11,160

of all I know obviously kind of leaves

418

00:20:15,230 --> 00:20:12,750

me speechless but I described it in the

419

00:20:16,700 --> 00:20:15,240

book and I wouldn't trade that

420

00:20:18,890 --> 00:20:16,710

experience for anything in the world

421

00:20:20,620 --> 00:20:18,900

that's there for kind of reminds me of

422

00:20:22,360 --> 00:20:20,630

you know that

423

00:20:24,790 --> 00:20:22,370

in our Frank white point his term in

424

00:20:27,070 --> 00:20:24,800

1987 that you know less than six hundred

425

00:20:28,420 --> 00:20:27,080

humans so far gone into space and you

426

00:20:30,400 --> 00:20:28,430

passed the Karman line in the orbit and

427

00:20:32,530 --> 00:20:30,410

and looked down at our earth from above

428

00:20:34,360 --> 00:20:32,540

but in some ways you had a very similar

429

00:20:36,280 --> 00:20:34,370

experience by going down to the bottom

430

00:20:38,080 --> 00:20:36,290

of the ocean in a submersible which you

431

00:20:39,610 --> 00:20:38,090

know also very few humans have done and

432

00:20:41,710 --> 00:20:39,620

you know it's it's a very you know a

433

00:20:43,060 --> 00:20:41,720

place we humans don't you know we didn't

434

00:20:45,010 --> 00:20:43,070

evolve to live in such kind of

435

00:20:46,330 --> 00:20:45,020

environments and so and it's kind of

436

00:20:48,400 --> 00:20:46,340

staggering to think about you know the

437

00:20:49,360 --> 00:20:48,410

fact that we can send people to those

438

00:20:51,940 --> 00:20:49,370

places to explore

439

00:20:53,800 --> 00:20:51,950

yeah and in the same way that the

440

00:20:56,500 --> 00:20:53,810

overview effect which is up on my

441

00:20:59,380 --> 00:20:56,510

bookshelf here somewhere it's a an old

442

00:21:03,460 --> 00:20:59,390

classic in the same way that's the

443

00:21:06,100 --> 00:21:03,470

overview effect is conceived of as a way

444

00:21:08,500 --> 00:21:06,110

to potentially transform our

445

00:21:11,680 --> 00:21:08,510

understanding of our place on planet

446

00:21:13,360 --> 00:21:11,690

Earth and in the in the cosmos in a way

447

00:21:18,190 --> 00:21:13,370

to maybe catalyze some altruistic

448

00:21:23,380 --> 00:21:18,200

behavior to to get us to be to see a

449

00:21:27,550 --> 00:21:23,390

world without borders that kind of

450

00:21:30,040 --> 00:21:27,560

immersive experience I think connects

451  
00:21:31,180 --> 00:21:30,050  
back to the deep ocean exploration and

452  
00:21:32,770 --> 00:21:31,190  
it seems like right now you know with

453  
00:21:34,690 --> 00:21:32,780  
the pandemic as well it's a good time

454  
00:21:36,280 --> 00:21:34,700  
for us to to have people who've had

455  
00:21:38,050 --> 00:21:36,290  
those experiences sharing that you know

456  
00:21:39,430 --> 00:21:38,060  
and so with you sharing it through your

457  
00:21:40,960 --> 00:21:39,440  
book you know other people have had

458  
00:21:43,330 --> 00:21:40,970  
these awesome experiences sharing it now

459  
00:21:44,800 --> 00:21:43,340  
with others around the globe now they're

460  
00:21:46,210 --> 00:21:44,810  
all connecting more online and it's a

461  
00:21:48,010 --> 00:21:46,220  
chance for all of us to get into this

462  
00:21:49,360 --> 00:21:48,020  
conversation about our responsibilities

463  
00:21:53,050 --> 00:21:49,370

towards our planet

464

00:21:54,880 --> 00:21:53,060

yes it's very cool so I mean I I love

465

00:21:57,070 --> 00:21:54,890

Europa it's it's my favorite of the icy

466

00:21:58,570 --> 00:21:57,080

worlds of our solar system you do a

467

00:22:02,080 --> 00:21:58,580

really good job in the book kind of

468

00:22:04,360 --> 00:22:02,090

explaining this slow methodical process

469

00:22:07,300 --> 00:22:04,370

that we went through to discover that

470

00:22:10,180 --> 00:22:07,310

Europa has an ocean down below a very

471

00:22:12,730 --> 00:22:10,190

deep ocean down below and then could

472

00:22:13,750 --> 00:22:12,740

even have some life inside of it I don't

473

00:22:15,010 --> 00:22:13,760

want to give away too much from inside

474

00:22:16,240 --> 00:22:15,020

the book but I do love that there's a

475

00:22:17,980 --> 00:22:16,250

chapter in the book where you kind of

476

00:22:20,740 --> 00:22:17,990

start talking about some of the

477

00:22:24,130 --> 00:22:20,750

potential biology that could occur in

478

00:22:26,050 --> 00:22:24,140

Europa's ocean I recall Carol Cleland

479

00:22:27,730 --> 00:22:26,060

the philosopher she loves always joke

480

00:22:28,630 --> 00:22:27,740

that there might be whales inside of

481

00:22:30,340 --> 00:22:28,640

Europa

482

00:22:34,060 --> 00:22:30,350

and so I wonder if you could like give

483

00:22:35,680 --> 00:22:34,070

us a vision of your own if you could if

484

00:22:37,200 --> 00:22:35,690

there is a biosphere in your rope but

485

00:22:41,410 --> 00:22:37,210

what does that look like to you

486

00:22:45,310 --> 00:22:41,420

yeah well as you know I love this this

487

00:22:47,440 --> 00:22:45,320

check am i one of the most fun chapters

488

00:22:53,530 --> 00:22:47,450

for me to write was this chapter called

489

00:22:58,440 --> 00:22:53,540

the octopus in the hammer and it down

490

00:23:04,320 --> 00:22:58,450

boy hey so I wrote this book in part for

491

00:23:09,220 --> 00:23:04,330

the 15 to 25 year old version of me that

492

00:23:11,380 --> 00:23:09,230

wanted some detail wanted some equations

493

00:23:15,790 --> 00:23:11,390

wanted some you know we wanted to be

494

00:23:18,060 --> 00:23:15,800

challenged with really hard science but

495

00:23:22,510 --> 00:23:18,070

I also wanted the book to have some

496

00:23:24,340 --> 00:23:22,520

speculative fun and that's where that

497

00:23:27,340 --> 00:23:24,350

chapter really comes into play and this

498

00:23:31,690 --> 00:23:27,350

actually links back to a question that

499

00:23:33,540 --> 00:23:31,700

that's one way as somebody in your

500

00:23:37,930 --> 00:23:33,550

audience asked I'm forgetting his name

501  
00:23:40,120 --> 00:23:37,940  
about why I studied psychology and I

502  
00:23:42,460 --> 00:23:40,130  
studied psychology in college in part

503  
00:23:48,669 --> 00:23:42,470  
because I was fascinated with with human

504  
00:23:54,490 --> 00:23:48,679  
consciousness and how we even understand

505  
00:23:58,330 --> 00:23:54,500  
our place in the universe and also with

506  
00:24:00,520 --> 00:23:58,340  
what it would mean for organisms on

507  
00:24:03,480 --> 00:24:00,530  
distant planets or distant moons to

508  
00:24:05,680 --> 00:24:03,490  
evolve their sensory modalities

509  
00:24:08,440 --> 00:24:05,690  
everything that we know and love and

510  
00:24:12,520 --> 00:24:08,450  
understand about our universe comes

511  
00:24:19,960 --> 00:24:12,530  
through our five senses yet of course

512  
00:24:23,460 --> 00:24:19,970  
whales dolphins bees a various kinds of

513  
00:24:26,320 --> 00:24:23,470

fish have senses that we don't have and

514

00:24:29,560 --> 00:24:26,330

if they were to evolve the consciousness

515

00:24:31,450 --> 00:24:29,570

how would those different sensory

516

00:24:33,730 --> 00:24:31,460

modalities affect their perception of

517

00:24:39,200 --> 00:24:33,740

the universe or on them so I go into

518

00:24:44,120 --> 00:24:39,210

some detail on that in that chapter and

519

00:24:46,820 --> 00:24:44,130

within Europa sorry I'm jumping around

520

00:24:48,889 --> 00:24:46,830

here a little bit died within Europa

521

00:24:54,320 --> 00:24:48,899

there is the potential that we could

522

00:24:57,409 --> 00:24:54,330

have larger organisms and so the the

523

00:25:00,769 --> 00:24:57,419

radiation bombardment of Europa surface

524

00:25:03,950 --> 00:25:00,779

generates oxygen when we know that solid

525

00:25:07,220 --> 00:25:03,960

phase oxygen exists in Europa's ice and

526  
00:25:11,360 --> 00:25:07,230  
if that oxygen is cycled into the ocean

527  
00:25:14,180 --> 00:25:11,370  
below and there is the possibility that

528  
00:25:17,260 --> 00:25:14,190  
we could know that your robos ocean

529  
00:25:19,610 --> 00:25:17,270  
could support multicellular life

530  
00:25:20,600 --> 00:25:19,620  
obviously for the most part when we talk

531  
00:25:22,220 --> 00:25:20,610  
about the search for life elsewhere

532  
00:25:26,000 --> 00:25:22,230  
we're talking about the search for even

533  
00:25:27,799 --> 00:25:26,010  
the tiniest of microbe but Europa's got

534  
00:25:30,950 --> 00:25:27,809  
this pretty unique situation where the

535  
00:25:36,529 --> 00:25:30,960  
radiation chemistry on the surface could

536  
00:25:40,480 --> 00:25:36,539  
play a role in you very yeah an ocean

537  
00:25:48,860 --> 00:25:44,779  
amount of that could then motivates a

538  
00:25:50,630 --> 00:25:48,870

sort of Cambrian explosion or Europa's

539

00:25:53,570 --> 00:25:50,640

version of a Cambrian explosion which

540

00:25:57,139 --> 00:25:53,580

could potentially lead to organisms like

541

00:25:58,880 --> 00:25:57,149

octopi or its equator cuttlefish as much

542

00:26:00,409 --> 00:25:58,890

as I love whales keep in mind of course

543

00:26:03,980 --> 00:26:00,419

that whales have to come on land and

544

00:26:07,820 --> 00:26:03,990

back same with dolphins so listen thank

545

00:26:10,519 --> 00:26:07,830

you octopi or some your open version of

546

00:26:14,600 --> 00:26:10,529

occupy within Europa or for that matter

547

00:26:17,480 --> 00:26:14,610

some distant version of Europa that's

548

00:26:19,730 --> 00:26:17,490

orbiting some other star you know the

549

00:26:22,779 --> 00:26:19,740

the the nice thing about Europa's is

550

00:26:26,120 --> 00:26:22,789

that they it might be ubiquitous in our

551  
00:26:28,730 --> 00:26:26,130  
galaxy and our universe so somewhere

552  
00:26:33,799 --> 00:26:28,740  
there probably well I shouldn't say

553  
00:26:36,909 --> 00:26:33,809  
probably but I would predict that there

554  
00:26:40,610 --> 00:26:36,919  
is multicellular life within some

555  
00:26:45,169 --> 00:26:40,620  
ice-covered ocean world out there in our

556  
00:26:49,350 --> 00:26:45,179  
galaxy then you can ask would it develop

557  
00:26:53,190 --> 00:26:49,360  
the tool using capability that that

558  
00:26:55,860 --> 00:26:53,200  
early hominids did would it develop a

559  
00:27:00,480 --> 00:26:55,870  
consciousness and a philosophy or

560  
00:27:04,410 --> 00:27:00,490  
religion akin to what our own pathway

561  
00:27:09,450 --> 00:27:04,420  
from Australopithecus as yoga and then

562  
00:27:15,120 --> 00:27:09,460  
one of my favorite thoughts is much of

563  
00:27:17,130 --> 00:27:15,130

our philosophy has been driven by our

564

00:27:21,110 --> 00:27:17,140

capacity to look up and see the night

565

00:27:24,720 --> 00:27:21,120

sky the the moon and the stars the Sun

566

00:27:27,720 --> 00:27:24,730

to explore we've been able to look over

567

00:27:30,390 --> 00:27:27,730

the horizon watch the Sun dip over the

568

00:27:32,310 --> 00:27:30,400

horizon watch it rise again same with

569

00:27:36,030 --> 00:27:32,320

the moon we've been able to see the

570

00:27:38,250 --> 00:27:36,040

Stars circle around us and then realize

571

00:27:41,850 --> 00:27:38,260

we are our circle around circling around

572

00:27:44,430 --> 00:27:41,860

a star if you're an intelligent octopus

573

00:27:46,350 --> 00:27:44,440

beneath an ice shell on Europa

574

00:27:51,240 --> 00:27:46,360

you're not looking up and seeing the

575

00:27:54,090 --> 00:27:51,250

Stars you are hearing the creaks and

576

00:27:56,520 --> 00:27:54,100

cracks of that ice shell echoing

577

00:27:59,280 --> 00:27:56,530

throughout your ocean those creaks and

578

00:28:01,919 --> 00:27:59,290

cracks are connected to the tides that

579

00:28:03,990 --> 00:28:01,929

results from this moon orbiting a giant

580

00:28:07,580 --> 00:28:04,000

world like like Jupiter in the case of

581

00:28:11,310 --> 00:28:07,590

Europa and so I want to just think about

582

00:28:13,560 --> 00:28:11,320

how consciousness and philosophy and

583

00:28:17,610 --> 00:28:13,570

potentially religion and a sense of

584

00:28:19,289 --> 00:28:17,620

place would develop in a an intelligent

585

00:28:22,680 --> 00:28:19,299

creature within an ice-covered ocean

586

00:28:24,360 --> 00:28:22,690

that has no access to the stars above so

587

00:28:27,240 --> 00:28:24,370

that's part of what I get into in that

588

00:28:28,710 --> 00:28:27,250

chapter and again that's that was a fun

589

00:28:30,990 --> 00:28:28,720

chapter for me to write because I got to

590

00:28:35,640 --> 00:28:31,000

kind of speculate I don't know a lot of

591

00:28:37,500 --> 00:28:35,650

these fun but deep ideas well I'll tell

592

00:28:39,870 --> 00:28:37,510

you for for a reader it's also very fun

593

00:28:41,730 --> 00:28:39,880

as well my mind was just envisioning you

594

00:28:43,950 --> 00:28:41,740

know this crackling of an ice shell and

595

00:28:45,360 --> 00:28:43,960

what that would do for for this you know

596

00:28:46,740 --> 00:28:45,370

these beings if they were creating their

597

00:28:48,480 --> 00:28:46,750

own mythology's their own culture their

598

00:28:50,460 --> 00:28:48,490

own understanding them that themselves

599

00:28:52,409 --> 00:28:50,470

in a cosmos they can't you know they

600

00:28:54,840 --> 00:28:52,419

can't perceive because it's you know

601  
00:28:56,760 --> 00:28:54,850  
through ten kilometers or more of ice

602  
00:28:58,680 --> 00:28:56,770  
so that was really cool for me one thing

603  
00:29:00,030 --> 00:28:58,690  
for our audience we are going to open up

604  
00:29:02,220 --> 00:29:00,040  
the audience questions here really soon

605  
00:29:03,930 --> 00:29:02,230  
for those watching second net on

606  
00:29:05,190 --> 00:29:03,940  
Facebook you can just drop your

607  
00:29:06,870 --> 00:29:05,200  
questions into the chat and we'll pick

608  
00:29:09,600 --> 00:29:06,880  
them up now you can also ask questions

609  
00:29:11,940 --> 00:29:09,610  
using hashtag ask Astro bio on Twitter

610  
00:29:14,250 --> 00:29:11,950  
as usual and we'll open it up here very

611  
00:29:16,080 --> 00:29:14,260  
soon I have one more question of my own

612  
00:29:19,470 --> 00:29:16,090  
and we'll start asking audience

613  
00:29:21,360 --> 00:29:19,480

questions so Kevin for one thing I

614

00:29:23,370 --> 00:29:21,370

really don't like myself right now in

615

00:29:27,150 --> 00:29:23,380

the realm of astrobiology is this use of

616

00:29:29,010 --> 00:29:27,160

the term habitable zone because it seems

617

00:29:30,630 --> 00:29:29,020

presumptive you know that it seems like

618

00:29:32,570 --> 00:29:30,640

we're telling you know the people around

619

00:29:35,190 --> 00:29:32,580

the world that we're only going to find

620

00:29:38,250 --> 00:29:35,200

habitation by alien life inside of this

621

00:29:39,870 --> 00:29:38,260

zone around a star but you you know you

622

00:29:42,300 --> 00:29:39,880

present very compelling arguments in

623

00:29:43,560 --> 00:29:42,310

your book for potential for life in icy

624

00:29:46,470 --> 00:29:43,570

worlds and ocean worlds in our solar

625

00:29:49,200 --> 00:29:46,480

system and it seems likely that there's

626

00:29:50,340 --> 00:29:49,210

probably more ocean worlds with icy

627

00:29:53,400 --> 00:29:50,350

surfaces than there are terrestrial

628

00:29:56,610 --> 00:29:53,410

worlds in our galaxy some more potential

629

00:29:57,720 --> 00:29:56,620

in those oceans so so how do you think

630

00:30:00,030 --> 00:29:57,730

what do you think about this term

631

00:30:01,110 --> 00:30:00,040

habitable zone how does it apply to your

632

00:30:02,970 --> 00:30:01,120

own thinking when you're thinking about

633

00:30:05,010 --> 00:30:02,980

potential for life in these worlds that

634

00:30:07,830 --> 00:30:05,020

aren't anywhere close to that habitable

635

00:30:09,810 --> 00:30:07,840

zone right yeah so they the traditional

636

00:30:13,560 --> 00:30:09,820

habitable zone as you're alluding to is

637

00:30:15,270 --> 00:30:13,570

that one where the energy for

638

00:30:18,540 --> 00:30:15,280

maintaining liquid water oceans comes

639

00:30:20,850 --> 00:30:18,550

from your parent star if you're too

640

00:30:22,740 --> 00:30:20,860

close like Venus or too hot if you're

641

00:30:24,330 --> 00:30:22,750

too far away like Mars you're too cold

642

00:30:26,400 --> 00:30:24,340

if you're at the Earth's Sun distance

643

00:30:28,410 --> 00:30:26,410

then you're you're in just the right

644

00:30:30,480 --> 00:30:28,420

region you're in the habitable zone now

645

00:30:34,800 --> 00:30:30,490

obviously the story is much more complex

646

00:30:37,320 --> 00:30:34,810

than that but but nevertheless this kind

647

00:30:39,540 --> 00:30:37,330

of old Goldilocks scenario the

648

00:30:42,090 --> 00:30:39,550

traditional habitable zone is pretty

649

00:30:45,540 --> 00:30:42,100

limiting when we think about the vast

650

00:30:48,630 --> 00:30:45,550

volume of real estate that exists within

651  
00:30:49,610 --> 00:30:48,640  
our own solar system within the realms

652  
00:30:51,660 --> 00:30:49,620  
of these ice-covered

653  
00:30:57,630 --> 00:30:51,670  
alien oceans of the outer solar system

654  
00:30:59,520 --> 00:30:57,640  
and so it may be that when you add up

655  
00:31:02,160 --> 00:30:59,530  
the amount of liquid water within

656  
00:31:05,520 --> 00:31:02,170  
Europa's ocean this is ocean titans

657  
00:31:06,510 --> 00:31:05,530  
ocean Ganymede Callisto possibly titania

658  
00:31:10,620 --> 00:31:06,520  
I'm Miranda

659  
00:31:14,010 --> 00:31:10,630  
maybe even - and Pluto there maybe

660  
00:31:16,320 --> 00:31:14,020  
upwards of 50 times the volume of liquid

661  
00:31:20,850 --> 00:31:16,330  
water within these oceans of the outer

662  
00:31:22,970 --> 00:31:20,860  
soul there is found here on earth now of

663  
00:31:27,540 --> 00:31:22,980

course the liquid water is not

664

00:31:29,910 --> 00:31:27,550

sufficient to to provide for life as we

665

00:31:33,020 --> 00:31:29,920

know it but it is a necessary condition

666

00:31:37,380 --> 00:31:33,030

for life as we know it and so that much

667

00:31:40,800 --> 00:31:37,390

liquid water is certainly changing the

668

00:31:42,660 --> 00:31:40,810

way we think about what it means for a

669

00:31:45,320 --> 00:31:42,670

world to be habitable and how much

670

00:31:48,990 --> 00:31:45,330

habitable real estate might be out there

671

00:31:50,310 --> 00:31:49,000

beyond our solar system exactly so yeah

672

00:31:52,500 --> 00:31:50,320

it's an interesting thing you know I

673

00:31:53,910 --> 00:31:52,510

think our thinking is changing more and

674

00:31:56,540 --> 00:31:53,920

more the more we realize these worlds

675

00:31:58,980 --> 00:31:56,550

could be potentially inhabited with life

676  
00:32:01,440 --> 00:31:58,990  
as we know it or maybe life as we don't

677  
00:32:04,680 --> 00:32:01,450  
know it for some places like Titan but

678  
00:32:06,870 --> 00:32:04,690  
before we good well just another

679  
00:32:10,140 --> 00:32:06,880  
critical aspect there that that is part

680  
00:32:12,150 --> 00:32:10,150  
of kind of the framework of any ocean

681  
00:32:17,970 --> 00:32:12,160  
worlds program and part of what our what

682  
00:32:21,750 --> 00:32:17,980  
our some of the key motivation has been

683  
00:32:24,870 --> 00:32:21,760  
is that the ocean worlds of the outer

684  
00:32:29,210 --> 00:32:24,880  
solar system present an opportunity to

685  
00:32:33,090 --> 00:32:29,220  
search for and possibly find extant life

686  
00:32:38,100 --> 00:32:33,100  
life that is alive today why is that

687  
00:32:42,750 --> 00:32:38,110  
important I love Mars I do some work on

688  
00:32:45,360 --> 00:32:42,760

Mars Mars as a as a beautiful place what

689

00:32:47,610 --> 00:32:45,370

our search for life on Mars at least in

690

00:32:51,900 --> 00:32:47,620

its current inception is a search for

691

00:32:55,440 --> 00:32:51,910

past life and the Curiosity rover could

692

00:32:58,620 --> 00:32:55,450

turn a corner and on mouth sharp

693

00:33:01,730 --> 00:32:58,630

tomorrow and find stromatolites and that

694

00:33:04,110 --> 00:33:01,740

would that would be revolutionary

695

00:33:06,450 --> 00:33:04,120

everybody would jump up and down it

696

00:33:08,540 --> 00:33:06,460

would be amazing but as we know from

697

00:33:12,330 --> 00:33:08,550

stromatolites here on the earth these

698

00:33:15,919 --> 00:33:12,340

bed forms of possible indications of

699

00:33:18,500 --> 00:33:15,929

past microbial activity on earth

700

00:33:21,500 --> 00:33:18,510

the large biomolecules of life do not

701

00:33:23,960 --> 00:33:21,510

last long in the rock record so you can

702

00:33:29,870 --> 00:33:23,970

cannot easily go to a stromatolite and

703

00:33:32,180 --> 00:33:29,880

find a fragment of DNA and so on Mars we

704

00:33:34,510 --> 00:33:32,190

might find fossil evidence of past life

705

00:33:37,070 --> 00:33:34,520

but then we would have a very limited

706

00:33:40,039 --> 00:33:37,080

capability to understand its

707

00:33:42,110 --> 00:33:40,049

biochemistry these ocean worlds of the

708

00:33:44,899 --> 00:33:42,120

outer solar system are places where

709

00:33:48,970 --> 00:33:44,909

liquid water exists today and where we

710

00:33:51,590 --> 00:33:48,980

could eventually find living life and

711

00:33:55,399 --> 00:33:51,600

study its biochemistry to see whether or

712

00:33:57,740 --> 00:33:55,409

not it runs on DNA RNA proteins ATP or

713

00:34:00,049 --> 00:33:57,750

if there's some other game in town and

714

00:34:02,510 --> 00:34:00,059

so that's part of what I find so

715

00:34:04,490 --> 00:34:02,520

compelling about these these ocean

716

00:34:06,740 --> 00:34:04,500

worlds the prospect of finding extant

717

00:34:09,260 --> 00:34:06,750

life where we can truly understand its

718

00:34:11,540 --> 00:34:09,270

biochemistry yeah absolutely comparative

719

00:34:13,280 --> 00:34:11,550

biology would be a game-changer right

720

00:34:14,810 --> 00:34:13,290

not just for for looking at different

721

00:34:16,040 --> 00:34:14,820

biomolecules and things like that but

722

00:34:19,879 --> 00:34:16,050

understanding this is this ID like what

723

00:34:21,290 --> 00:34:19,889

is life define life maybe if we had

724

00:34:23,629 --> 00:34:21,300

another example we actually would have

725

00:34:25,730 --> 00:34:23,639

something to work against you know it's

726

00:34:27,290 --> 00:34:25,740

rather incredible I do want to open up

727

00:34:28,339 --> 00:34:27,300

now to the audience questions I'm seeing

728

00:34:30,169 --> 00:34:28,349

that we actually have a lot of them

729

00:34:31,579 --> 00:34:30,179

already so again for those of you

730

00:34:35,000 --> 00:34:31,589

watching please ask your questions in a

731

00:34:37,940 --> 00:34:35,010

second net on the Facebook page or on

732

00:34:39,200 --> 00:34:37,950

Twitter using hashtag ask s or bio let's

733

00:34:41,960 --> 00:34:39,210

start off here with a question from

734

00:34:45,440 --> 00:34:41,970

tardy grata at just brought up on

735

00:34:47,089 --> 00:34:45,450

Twitter she says I was wondering how you

736

00:34:49,700 --> 00:34:47,099

decided to become an astrobiologist

737

00:34:51,740 --> 00:34:49,710

which we discussed a little bit and then

738

00:34:54,500 --> 00:34:51,750

also do you have any advice for young

739

00:34:57,470 --> 00:34:54,510

students who want to pursue a career in

740

00:34:59,480 --> 00:34:57,480

this very vast field yeah this is a

741

00:35:01,670 --> 00:34:59,490

great question I might spend a fair

742

00:35:05,990 --> 00:35:01,680

amount of time on this one because it's

743

00:35:08,210 --> 00:35:06,000

a really important one I've got loads

744

00:35:13,910 --> 00:35:08,220

and loads of stories of the trials and

745

00:35:16,070 --> 00:35:13,920

tribulations of my own path and but I do

746

00:35:18,560 --> 00:35:16,080

want to mention I mean this is my own

747

00:35:21,829 --> 00:35:18,570

path listen let's state the obvious I'm

748

00:35:24,920 --> 00:35:21,839

a white male and and I was becoming an

749

00:35:28,520 --> 00:35:24,930

astrobiologist in the in the mid to late

750

00:35:29,100 --> 00:35:28,530

90s and so you know I can't even imagine

751  
00:35:34,260 --> 00:35:29,110  
what

752  
00:35:36,210 --> 00:35:34,270  
like for anyone coming without that kind

753  
00:35:39,510 --> 00:35:36,220  
of advantage of being a white male

754  
00:35:40,860 --> 00:35:39,520  
especially back back in those days but

755  
00:35:42,660 --> 00:35:40,870  
nevertheless the the trials and

756  
00:35:45,450 --> 00:35:42,670  
tribulations that I experienced which is

757  
00:35:50,360 --> 00:35:45,460  
kind of the tip of the iceberg for these

758  
00:35:52,740 --> 00:35:50,370  
challenges so having said that

759  
00:36:00,740 --> 00:35:52,750  
astrobiology was not a field when I was

760  
00:36:04,440 --> 00:36:00,750  
an undergrad I the kind of canonical

761  
00:36:09,540 --> 00:36:04,450  
astrobiology is now a thing goes back to

762  
00:36:15,060 --> 00:36:09,550  
the alh84001 timeframe in roughly 1997

763  
00:36:19,260 --> 00:36:15,070

or so and actually there was a thing

764

00:36:22,800 --> 00:36:19,270

this is 1999 so this is a key article on

765

00:36:24,960 --> 00:36:22,810

astrobiology from Jerry soften and Jerry

766

00:36:30,470 --> 00:36:24,970

soften was the project scientist for the

767

00:36:34,530 --> 00:36:30,480

Viking missions and Jerry was just a

768

00:36:39,420 --> 00:36:34,540

real Mensch and he formed the NASA

769

00:36:43,440 --> 00:36:39,430

Astrobiology Academy and in 1997 they

770

00:36:47,250 --> 00:36:43,450

started an astrobiology branch of the

771

00:36:50,190 --> 00:36:47,260

NASA Academy at NASA Ames and I applied

772

00:36:51,750 --> 00:36:50,200

to that as an undergrad when I first saw

773

00:36:53,810 --> 00:36:51,760

that and this is back in the days when

774

00:36:56,520 --> 00:36:53,820

the internet was not that that prevalent

775

00:37:00,150 --> 00:36:56,530

and so there was a website for it and

776

00:37:04,320 --> 00:37:00,160

they had a little Europa melt probe but

777

00:37:08,760 --> 00:37:04,330

I applied to that program and was so

778

00:37:10,860 --> 00:37:08,770

excited about it and I just so happened

779

00:37:13,070 --> 00:37:10,870

the day before the application was due I

780

00:37:15,600 --> 00:37:13,080

had long since sent off my application I

781

00:37:18,960 --> 00:37:15,610

called to check to make sure that my

782

00:37:20,370 --> 00:37:18,970

application had been received and the

783

00:37:23,490 --> 00:37:20,380

person on the other end who answered

784

00:37:25,380 --> 00:37:23,500

Doug o Hanley who ran that program well

785

00:37:28,470 --> 00:37:25,390

I don't have any application with that

786

00:37:34,200 --> 00:37:28,480

name on it no sorry I don't know what to

787

00:37:35,820 --> 00:37:34,210

tell you so I I was devastated but I

788

00:37:36,930 --> 00:37:35,830

ended up calling around and trying to

789

00:37:38,340 --> 00:37:36,940

figure out what happened to my

790

00:37:40,800 --> 00:37:38,350

application and it turned out that it

791

00:37:42,120 --> 00:37:40,810

was sitting on the desk of somebody at

792

00:37:44,759 --> 00:37:42,130

the local

793

00:37:46,349 --> 00:37:44,769

New Hampshire Space Grant and that

794

00:37:47,819 --> 00:37:46,359

person had been on vacation or something

795

00:37:50,789 --> 00:37:47,829

and they were supposed to turn it into

796

00:37:51,380 --> 00:37:50,799

NASA more broadly and and but that never

797

00:37:53,849 --> 00:37:51,390

happened

798

00:37:57,630 --> 00:37:53,859

thankfully the person at the New

799

00:38:01,229 --> 00:37:57,640

Hampshire Space Grant then faxed it on

800

00:38:03,329 --> 00:38:01,239

to to the folks at Ames and so my

801  
00:38:06,779 --> 00:38:03,339  
application made it in time to be

802  
00:38:09,329 --> 00:38:06,789  
considered I'd like to use that that

803  
00:38:12,960 --> 00:38:09,339  
story just to emphasize the need for

804  
00:38:14,430 --> 00:38:12,970  
persistence and I never followed up and

805  
00:38:16,529 --> 00:38:14,440  
just sort of checked out you know just a

806  
00:38:18,299 --> 00:38:16,539  
stupid thing just check on my

807  
00:38:20,400 --> 00:38:18,309  
application make sure it was received at

808  
00:38:22,920 --> 00:38:20,410  
the other end and I never checked on

809  
00:38:24,509 --> 00:38:22,930  
that I never would have heard from the

810  
00:38:25,729 --> 00:38:24,519  
program I would have thought that I was

811  
00:38:30,120 --> 00:38:25,739  
just rejected outright

812  
00:38:31,979 --> 00:38:30,130  
and I would have been really sad since

813  
00:38:36,329 --> 00:38:31,989

it seemed like that astrobiology program

814

00:38:39,900 --> 00:38:36,339

was it was exactly what I what I wanted

815

00:38:42,660 --> 00:38:39,910

to do so now that was the first

816

00:38:45,779 --> 00:38:42,670

internship that I did the astrobiology

817

00:38:49,140 --> 00:38:45,789

Academy back in 1997 and that helps

818

00:38:56,370 --> 00:38:49,150

build some other bridges towards

819

00:38:59,009 --> 00:38:56,380

eventually working at JPL and if we have

820

00:39:01,789 --> 00:38:59,019

time there's a nice story with I met

821

00:39:08,670 --> 00:39:01,799

Jill tarter during that internship and

822

00:39:12,450 --> 00:39:08,680

he gave me some good advice and but onto

823

00:39:14,370 --> 00:39:12,460

some logistics for for students and this

824

00:39:17,849 --> 00:39:14,380

kind of falls into a bit of my

825

00:39:19,859 --> 00:39:17,859

experience with with Jill I'll go

826  
00:39:22,170 --> 00:39:19,869  
through just a couple of things and then

827  
00:39:25,739 --> 00:39:22,180  
these points are ones that I've

828  
00:39:27,870 --> 00:39:25,749  
developed over years of talking with

829  
00:39:30,509 --> 00:39:27,880  
students and and trying to distill out

830  
00:39:34,789 --> 00:39:30,519  
some some good advice first and foremost

831  
00:39:37,769 --> 00:39:34,799  
is to find your question astrobiology is

832  
00:39:40,829 --> 00:39:37,779  
biased nature broad and can be somewhat

833  
00:39:46,450 --> 00:39:40,839  
vague and I often get students say you

834  
00:39:48,250 --> 00:39:46,460  
know I want to develop spectra

835  
00:39:50,380 --> 00:39:48,260  
the bio signatures I want to do this

836  
00:39:53,020 --> 00:39:50,390  
thing or that thing that's that's not

837  
00:39:56,740 --> 00:39:53,030  
really a question figure out your

838  
00:39:59,589 --> 00:39:56,750

question and then it's some of these

839

00:40:05,040 --> 00:39:59,599

other aspects kind of come out of really

840

00:40:08,140 --> 00:40:05,050

developing your question and so that and

841

00:40:10,690 --> 00:40:08,150

if you're gonna pursue a PhD you need to

842

00:40:13,839 --> 00:40:10,700

be very specific and make sure that your

843

00:40:17,220 --> 00:40:13,849

question is framed as an hypothesis

844

00:40:20,410 --> 00:40:17,230

because really doing a PhD is about

845

00:40:21,700 --> 00:40:20,420

adding new knowledge to the Canon of

846

00:40:26,920 --> 00:40:21,710

knowledge that is out there on a

847

00:40:30,549 --> 00:40:26,930

specific topic and a PhD really is kind

848

00:40:33,160 --> 00:40:30,559

of a test of your ability to advance

849

00:40:35,440 --> 00:40:33,170

human knowledge even by just a tiny

850

00:40:37,450 --> 00:40:35,450

increment and so you really have to

851

00:40:40,829 --> 00:40:37,460

dedicate yourself to it

852

00:40:43,930 --> 00:40:40,839

you have to make a concrete scientific

853

00:40:45,670 --> 00:40:43,940

contribution before broadening out and

854

00:40:47,910 --> 00:40:45,680

and all too often I see that happening

855

00:40:52,359 --> 00:40:47,920

in astrobiology where where people

856

00:40:54,370 --> 00:40:52,369

broaden out too soon and you really they

857

00:40:56,230 --> 00:40:54,380

admissions stay specific at least

858

00:41:00,190 --> 00:40:56,240

through your PhD maybe use your postdoc

859

00:41:01,750 --> 00:41:00,200

as an opportunity to Braun now that said

860

00:41:05,170 --> 00:41:01,760

if you're having a hard time finding

861

00:41:06,970 --> 00:41:05,180

your question and my recommendation is

862

00:41:10,900 --> 00:41:06,980

to become a microbiologist or an

863

00:41:13,720 --> 00:41:10,910

oceanographer and I say that because I

864

00:41:16,000 --> 00:41:13,730

in part where I wish that I had gone on

865

00:41:18,309 --> 00:41:16,010

that path I studied physics and

866

00:41:20,890 --> 00:41:18,319

astronomy and I have no regrets on that

867

00:41:22,839 --> 00:41:20,900

but my goodness microbiology and

868

00:41:26,730 --> 00:41:22,849

oceanography there's so much great work

869

00:41:29,140 --> 00:41:26,740

to be done that is really valuable for

870

00:41:31,900 --> 00:41:29,150

understanding Earth's biosphere and

871

00:41:34,120 --> 00:41:31,910

earth as a planet and you can then

872

00:41:37,660 --> 00:41:34,130

bridge to astrobiology quite quite

873

00:41:40,000 --> 00:41:37,670

easily and so I advise students to go

874

00:41:42,400 --> 00:41:40,010

into those fields if they are still kind

875

00:41:44,589 --> 00:41:42,410

of in in search mode but there's a lot

876

00:41:47,230 --> 00:41:44,599

of low-hanging scientific fruit they're

877

00:41:49,420 --> 00:41:47,240

exciting fields you can get out into the

878

00:41:52,420 --> 00:41:49,430

field on a cruise you can get data

879

00:41:54,430 --> 00:41:52,430

easily and that's important at least

880

00:41:56,589 --> 00:41:54,440

compared to planetary science you can

881

00:41:59,770 --> 00:41:56,599

get data easily if you go into

882

00:42:03,890 --> 00:41:59,780

microbiology or ocean

883

00:42:07,250 --> 00:42:03,900

and as I mentioned don't become an

884

00:42:09,140 --> 00:42:07,260

astrobiologist too early specialize and

885

00:42:13,670 --> 00:42:09,150

make a concrete scientific contribution

886

00:42:17,570 --> 00:42:13,680

before broadening and to that end

887

00:42:21,140 --> 00:42:17,580

I took time off in between undergrad and

888

00:42:26,120 --> 00:42:21,150

grad school I worked at NASA Ames I went

889

00:42:29,360 --> 00:42:26,130

I hitchhiked around the u.s. and around

890

00:42:31,130 --> 00:42:29,370

Europe and Russia and Africa juggled to

891

00:42:33,680 --> 00:42:31,140

make money on the sides of streets when

892

00:42:39,950 --> 00:42:33,690

I needed a little little cash for food

893

00:42:41,920 --> 00:42:39,960

and things life is short and so if you

894

00:42:44,000 --> 00:42:41,930

have any doubts take some time off

895

00:42:46,490 --> 00:42:44,010

really the only time that you're going

896

00:42:49,040 --> 00:42:46,500

to be able to to take off is between

897

00:42:50,300 --> 00:42:49,050

undergrad and graduate school and as

898

00:42:51,680 --> 00:42:50,310

long as you make sure that you do

899

00:42:56,030 --> 00:42:51,690

something somewhat productive in that

900

00:42:58,460 --> 00:42:56,040

timeframe you'll you'll be able to apply

901  
00:43:01,330 --> 00:42:58,470  
to grad school without that time off

902  
00:43:15,170 --> 00:43:01,340  
being a negative on your application I

903  
00:43:17,840 --> 00:43:15,180  
work for a year in a lab work is a ship

904  
00:43:20,300 --> 00:43:17,850  
and on on a research vessel or something

905  
00:43:21,440 --> 00:43:20,310  
like that to kind of explore what

906  
00:43:26,510 --> 00:43:21,450  
interests you and what kind of

907  
00:43:29,660 --> 00:43:26,520  
opportunities exist and let's see just

908  
00:43:42,590 --> 00:43:29,670  
lastly well looking so many things grant

909  
00:43:45,650 --> 00:43:42,600  
I would say mentor above all and seek

910  
00:43:49,550 --> 00:43:45,660  
out somebody who inspires you again life

911  
00:43:55,310 --> 00:43:49,560  
is too short life is too short to work

912  
00:43:57,620 --> 00:43:55,320  
with a jerk simply put and I think my

913  
00:44:01,580 --> 00:43:57,630

friend John Speer has said something

914

00:44:04,040 --> 00:44:01,590

along the lines of of that and work with

915

00:44:07,610 --> 00:44:04,050

somebody who inspires you who also you

916

00:44:10,560 --> 00:44:07,620

know will help cultivate your interest

917

00:44:12,720 --> 00:44:10,570

in in science and

918

00:44:15,360 --> 00:44:12,730

take some time to to kind of search

919

00:44:17,310 --> 00:44:15,370

around and and find somebody who's

920

00:44:19,830 --> 00:44:17,320

pursuing questions that interest you and

921

00:44:22,440 --> 00:44:19,840

somebody who's a human being with whom

922

00:44:24,180 --> 00:44:22,450

you want to work and I spent quite a bit

923

00:44:29,640 --> 00:44:24,190

of time searching around and I had a

924

00:44:30,840 --> 00:44:29,650

couple of different options and so that

925

00:44:35,460 --> 00:44:30,850

sort of connects back to Jill tarter

926

00:44:37,770 --> 00:44:35,470

when I was an intern at NASA Ames Jill

927

00:44:40,050 --> 00:44:37,780

came and gave a talk to our astrobiology

928

00:44:41,640 --> 00:44:40,060

Academy and at the end she kind of made

929

00:44:43,890 --> 00:44:41,650

this offhand comment if you ever want to

930

00:44:44,760 --> 00:44:43,900

come to the SETI Institute and see how

931

00:44:48,960 --> 00:44:44,770

we search for extraterrestrial

932

00:44:50,850 --> 00:44:48,970

intelligence feel free to come by and

933

00:44:53,810 --> 00:44:50,860

truth be told I think she kind of said

934

00:44:57,000 --> 00:44:53,820

it not thinking anybody would follow up

935

00:44:58,890 --> 00:44:57,010

but I had grown up obsessed with SETI I

936

00:45:00,540 --> 00:44:58,900

had got in there a little newsletter is

937

00:45:06,060 --> 00:45:00,550

that they would occasionally send out in

938

00:45:08,460 --> 00:45:06,070

the mail and so I walked and took a bus

939

00:45:11,220 --> 00:45:08,470

and eventually found my way to landings

940

00:45:14,190 --> 00:45:11,230

drive which is where the original SETI

941

00:45:16,190 --> 00:45:14,200

Institute was and went up to the the

942

00:45:19,170 --> 00:45:16,200

counter there and I think Edna Devore

943

00:45:22,560 --> 00:45:19,180

was at the at the counter they I said

944

00:45:24,690 --> 00:45:22,570

she'll tire mentioned that you know I

945

00:45:26,160 --> 00:45:24,700

can maybe see some of the computers

946

00:45:28,590 --> 00:45:26,170

where you're generating the waterfall

947

00:45:31,260 --> 00:45:28,600

plots and everything and so and I went

948

00:45:32,460 --> 00:45:31,270

to check on Jill the Jill came out and

949

00:45:34,920 --> 00:45:32,470

she was a little bit frazzled at the

950

00:45:38,280 --> 00:45:34,930

time and but graciously brought me in to

951  
00:45:42,390 --> 00:45:38,290  
just sit here and watch and it turns out

952  
00:45:44,760 --> 00:45:42,400  
that I had happened to stop by in 1997

953  
00:45:47,130 --> 00:45:44,770  
during there was some sort of anomaly

954  
00:45:50,820 --> 00:45:47,140  
with the Soho satellite that was a that

955  
00:45:54,180 --> 00:45:50,830  
was a big possible signal they didn't

956  
00:45:57,060 --> 00:45:54,190  
know it was so hot at the time and so

957  
00:45:58,980 --> 00:45:57,070  
Jill was very patient with me and just

958  
00:46:00,570 --> 00:45:58,990  
kind of occasionally saying this is what

959  
00:46:03,540 --> 00:46:00,580  
you're seeing this is exciting just stay

960  
00:46:04,500 --> 00:46:03,550  
quiet and we've got champagne in the in

961  
00:46:11,970 --> 00:46:04,510  
the fridge over there just in case

962  
00:46:15,150 --> 00:46:11,980  
everything goes yeah yeah Jill had kind

963  
00:46:18,270 --> 00:46:15,160

of taken pity on me and then connected

964

00:46:20,630 --> 00:46:18,280

me up with a couple of other folks and

965

00:46:23,070 --> 00:46:20,640

eventually that led to me meeting

966

00:46:24,500 --> 00:46:23,080

Christopher Chava who then later became

967

00:46:27,290 --> 00:46:24,510

my PhD advisor

968

00:46:30,200 --> 00:46:27,300

so that's the abbreviated version thanks

969

00:46:32,360 --> 00:46:30,210

al we actually had Joel on the show just

970

00:46:34,880 --> 00:46:32,370

last year and it's cool that was during

971

00:46:37,760 --> 00:46:34,890

the NASA Academy for for me I was in the

972

00:46:40,340 --> 00:46:37,770

NASA Academy at Ames in 2007 and it was

973

00:46:42,890 --> 00:46:40,350

meeting Peter Diamandis of the XPrize

974

00:46:44,900 --> 00:46:42,900

foundation zero-g corporation he kind of

975

00:46:46,640 --> 00:46:44,910

inspired me to then continue my career

976

00:46:48,170 --> 00:46:46,650

in a different way I had degrees in

977

00:46:50,390 --> 00:46:48,180

biology and chemistry and he kind of

978

00:46:51,920 --> 00:46:50,400

inspired me to then pursue astrophysics

979

00:46:53,840 --> 00:46:51,930

and geology in graduate school which I

980

00:46:56,150 --> 00:46:53,850

ended up doing that's pretty cool

981

00:46:58,090 --> 00:46:56,160

actually I have Doug Hanley signature on

982

00:47:00,410 --> 00:46:58,100

a guitar sitting right here beside me

983

00:47:03,200 --> 00:47:00,420

audience who are unaware Doug passed

984

00:47:04,300 --> 00:47:03,210

away some years ago unfortunately we

985

00:47:06,560 --> 00:47:04,310

lost him

986

00:47:07,940 --> 00:47:06,570

well yeah it's a wonderful answer for

987

00:47:10,010 --> 00:47:07,950

everyone everyone watching

988

00:47:12,110 --> 00:47:10,020

unfortunately IC Academy has changed a

989

00:47:13,610 --> 00:47:12,120

lot these past several years so there's

990

00:47:14,720 --> 00:47:13,620

not what the astrobiology Academy like

991

00:47:16,870 --> 00:47:14,730

there used to be but there still are

992

00:47:19,190 --> 00:47:16,880

lots of opportunities for undergraduates

993

00:47:20,330 --> 00:47:19,200

here in the US we also have the NSF

994

00:47:23,360 --> 00:47:20,340

research experiences for undergraduates

995

00:47:24,860 --> 00:47:23,370

programmer ru program if you're

996

00:47:26,240 --> 00:47:24,870

interested in microbiology and that kind

997

00:47:28,460 --> 00:47:26,250

of stuff you can apply for those as well

998

00:47:29,630 --> 00:47:28,470

but we do have a lot of questions and so

999

00:47:32,120 --> 00:47:29,640

I'm gonna try to jump into a few more of

1000

00:47:34,640 --> 00:47:32,130

those if we can hear Kevin mode Nasser

1001  
00:47:36,380 --> 00:47:34,650  
from Sagan net asks so being at the

1002  
00:47:38,450 --> 00:47:36,390  
bottom of the ocean in that in their

1003  
00:47:40,220 --> 00:47:38,460  
submarines how did that feel on a

1004  
00:47:42,710 --> 00:47:40,230  
personal level and did it change any of

1005  
00:47:49,900 --> 00:47:42,720  
your ideas or morals about you know your

1006  
00:47:58,520 --> 00:47:55,490  
but I don't think it necessarily changed

1007  
00:48:04,670 --> 00:47:58,530  
anything more than really codified

1008  
00:48:06,890 --> 00:48:04,680  
things in a in a much different realm as

1009  
00:48:11,480 --> 00:48:06,900  
I mentioned in the book I grew up in the

1010  
00:48:13,190 --> 00:48:11,490  
mountains and and had that kind of I'm

1011  
00:48:16,970 --> 00:48:13,200  
not a religious person but I'm spiritual

1012  
00:48:20,600 --> 00:48:16,980  
I'm the kind of love the connection with

1013  
00:48:22,340 --> 00:48:20,610

nature and I've always been able to read

1014

00:48:27,290 --> 00:48:22,350

the trees and the clouds and the

1015

00:48:30,590 --> 00:48:27,300

mountains but out at sea I didn't know

1016

00:48:32,930 --> 00:48:30,600

how to do that it was it was unsettling

1017

00:48:34,700 --> 00:48:32,940

initially and this is just being on a

1018

00:48:36,560 --> 00:48:34,710

ship where I were where I could not

1019

00:48:38,330 --> 00:48:36,570

we're surrounded by

1020

00:48:42,890 --> 00:48:38,340

by ocean this isn't even getting into

1021

00:48:47,120 --> 00:48:42,900

the depths of the ocean and so that

1022

00:48:49,100 --> 00:48:47,130

experience of learning how to read the

1023

00:48:51,440 --> 00:48:49,110

ocean learning on what the clouds were

1024

00:48:54,140 --> 00:48:51,450

telling me out at sea learning what the

1025

00:48:57,560 --> 00:48:54,150

waves were saying and then getting down

1026

00:48:59,990 --> 00:48:57,570

into the the depths of the ocean really

1027

00:49:03,560 --> 00:49:00,000

was a different dimension of the same

1028

00:49:08,570 --> 00:49:03,570

kind of connection to the natural world

1029

00:49:10,400 --> 00:49:08,580

that I experienced just hiking through

1030

00:49:13,190 --> 00:49:10,410

mud puddles back home in Vermont so it

1031

00:49:17,330 --> 00:49:13,200

was it was more of like a extending the

1032

00:49:19,940 --> 00:49:17,340

axes as opposed to something entirely

1033

00:49:23,210 --> 00:49:19,950

new thanks s so for our viewers get out

1034

00:49:25,670 --> 00:49:23,220

there and explore the nature another

1035

00:49:28,250 --> 00:49:25,680

question so Anna root mohanty that's

1036

00:49:30,380 --> 00:49:28,260

Trey ologist on Twitter asks and this is

1037

00:49:33,110 --> 00:49:30,390

a clicker question what are the biggest

1038

00:49:41,720 --> 00:49:33,120

challenges we face during the Europe a

1039

00:49:44,240 --> 00:49:41,730

clipper mission so the the main answer

1040

00:49:47,470 --> 00:49:44,250

that is given to that question is the

1041

00:49:53,030 --> 00:49:47,480

radiation environment of Jupiter and the

1042

00:49:58,040 --> 00:49:53,040

the environment around Europa and so

1043

00:50:00,890 --> 00:49:58,050

that's that's challenging but I'll tell

1044

00:50:03,620 --> 00:50:00,900

you as a scientist I find a tremendous

1045

00:50:06,170 --> 00:50:03,630

amount of inspiration from the engineers

1046

00:50:10,750 --> 00:50:06,180

with whom I work I don't know how many

1047

00:50:16,880 --> 00:50:14,540

blossoming engineers but please go in

1048

00:50:18,080 --> 00:50:16,890

the engineering and there's a tremendous

1049

00:50:23,560 --> 00:50:18,090

amount of great engineering that

1050

00:50:28,640 --> 00:50:23,570

astrobiology needs we scientists are the

1051  
00:50:33,010 --> 00:50:28,650  
are the the crazy fools with the big

1052  
00:50:39,230 --> 00:50:33,020  
questions and we count on the engineers

1053  
00:50:40,700 --> 00:50:39,240  
to solve the problems the pragmatic

1054  
00:50:43,640 --> 00:50:40,710  
problems of what it actually takes to

1055  
00:50:45,410 --> 00:50:43,650  
get out there to these worlds and answer

1056  
00:50:47,570 --> 00:50:45,420  
these questions so on the clipper

1057  
00:50:48,700 --> 00:50:47,580  
mission it has just been tremendous to

1058  
00:50:53,380 --> 00:50:48,710  
see

1059  
00:50:57,520 --> 00:50:53,390  
the engineers tackle and solve the

1060  
00:50:58,569 --> 00:50:57,530  
radiation problem as well as ways in

1061  
00:51:01,000 --> 00:50:58,579  
which to have all the different

1062  
00:51:03,520 --> 00:51:01,010  
instruments code more sighted so they

1063  
00:51:05,460 --> 00:51:03,530

can all collect data that couples

1064

00:51:09,099 --> 00:51:05,470

together quite well like a Russian doll

1065

00:51:12,849 --> 00:51:09,109

and so it really is a remarkable mission

1066

00:51:16,780 --> 00:51:12,859

the trajectory team has just given this

1067

00:51:19,870 --> 00:51:16,790

this wonderful tour that will do these

1068

00:51:23,200 --> 00:51:19,880

flybys with close approaches that will

1069

00:51:25,450 --> 00:51:23,210

kind of almost like a hoop going around

1070

00:51:27,910 --> 00:51:25,460

different parts of your belly you'll get

1071

00:51:31,120 --> 00:51:27,920

a close approach on different regions of

1072

00:51:32,589 --> 00:51:31,130

Europa and so it's it's an incredibly

1073

00:51:34,690 --> 00:51:32,599

exciting mission I just hope we can get

1074

00:51:37,809 --> 00:51:34,700

it to launchpad sooner as opposed to

1075

00:51:39,280 --> 00:51:37,819

later yeah absolutely I'm really excited

1076

00:51:40,660 --> 00:51:39,290

for clicker there's a lot of science to

1077

00:51:41,589 --> 00:51:40,670

get out of that but you're right though

1078

00:51:42,640 --> 00:51:41,599

I mean that the engineering is

1079

00:51:44,620 --> 00:51:42,650

incredible some of these things that

1080

00:51:46,150 --> 00:51:44,630

we've been doing on Mars and you know

1081

00:51:47,470 --> 00:51:46,160

something probes out to other worlds and

1082

00:51:50,410 --> 00:51:47,480

outside of our solar system it's just

1083

00:51:56,710 --> 00:51:50,420

incredible to think of and I should

1084

00:51:59,079 --> 00:51:56,720

mention grandma just really please do

1085

00:52:00,970 --> 00:51:59,089

consider if you're interested in

1086

00:52:04,059 --> 00:52:00,980

astrobiology consider the fields of

1087

00:52:08,740 --> 00:52:04,069

engineering in many ways my engineering

1088

00:52:15,039 --> 00:52:08,750

friends at JPL kind of have a a more fun

1089

00:52:16,660 --> 00:52:15,049

life they've got a hard life but even

1090

00:52:18,970 --> 00:52:16,670

though all that stuff that I described

1091

00:52:21,490 --> 00:52:18,980

earlier running a lab helping can be a

1092

00:52:23,620 --> 00:52:21,500

part of missions although that even

1093

00:52:25,690 --> 00:52:23,630

though that sounds exciting it's really

1094

00:52:28,089 --> 00:52:25,700

important especially for young students

1095

00:52:30,099 --> 00:52:28,099

to appreciate that a lot of being a

1096

00:52:33,549 --> 00:52:30,109

scientist is not fun

1097

00:52:37,030 --> 00:52:33,559

it's writing proposals getting

1098

00:52:40,539 --> 00:52:37,040

rejections I like to say failure has to

1099

00:52:44,260 --> 00:52:40,549

be an option I have failed so many times

1100

00:52:46,930 --> 00:52:44,270

I have submitted countless proposals to

1101  
00:52:49,690 --> 00:52:46,940  
the roses program failure failure

1102  
00:52:52,839 --> 00:52:49,700  
failure of submitted countless proposals

1103  
00:52:55,720 --> 00:52:52,849  
to instruments to be on missions I've

1104  
00:52:58,750 --> 00:52:55,730  
been on a lot of mission proposals that

1105  
00:53:00,730 --> 00:52:58,760  
have not been selected failure has to be

1106  
00:53:01,900 --> 00:53:00,740  
an option you have to learn not to take

1107  
00:53:03,910 --> 00:53:01,910  
these things personally

1108  
00:53:06,000 --> 00:53:03,920  
you have to learn just to pick yourself

1109  
00:53:08,640 --> 00:53:06,010  
up off the floor

1110  
00:53:11,170 --> 00:53:08,650  
count on certain friends who can help

1111  
00:53:15,549 --> 00:53:11,180  
pull the little marionette strings to

1112  
00:53:17,200 --> 00:53:15,559  
help get you up off the floor and so

1113  
00:53:19,900 --> 00:53:17,210

being a scientist whether it's in

1114

00:53:24,099 --> 00:53:19,910

astrobiology or in any other field is a

1115

00:53:28,900 --> 00:53:24,109

difficult life do not choose that path

1116

00:53:31,599 --> 00:53:28,910

lightly I love it but trust me it's it's

1117

00:53:33,640 --> 00:53:31,609

miserable for a decent fraction of the

1118

00:53:35,470 --> 00:53:33,650

time you really have to be obsessed with

1119

00:53:37,299 --> 00:53:35,480

this stuff and be willing to make the

1120

00:53:38,770 --> 00:53:37,309

sacrifices that come along with all the

1121

00:53:49,660 --> 00:53:38,780

failure and rejection and stuff that

1122

00:53:53,260 --> 00:53:49,670

you'll face meanwhile not that engineers

1123

00:53:56,319 --> 00:53:53,270

have it easy but the life of an engineer

1124

00:53:58,930 --> 00:53:56,329

at JPL is one where they work in very

1125

00:54:01,510 --> 00:53:58,940

close-knit teams the structure is such

1126  
00:54:04,630 --> 00:54:01,520  
that they they get assigned to a mission

1127  
00:54:06,400 --> 00:54:04,640  
they have less autonomy they don't they

1128  
00:54:09,250 --> 00:54:06,410  
don't necessarily get to decide their

1129  
00:54:11,890 --> 00:54:09,260  
own fate well I mean come on at JPL

1130  
00:54:14,349 --> 00:54:11,900  
you're working on Mars 2020 or Europa

1131  
00:54:18,730 --> 00:54:14,359  
clipper or hopefully someday a Europa

1132  
00:54:21,240 --> 00:54:18,740  
Lander and they don't have to write

1133  
00:54:23,829 --> 00:54:21,250  
proposals they don't have to publish

1134  
00:54:26,319 --> 00:54:23,839  
they don't face all that rejection that

1135  
00:54:28,750 --> 00:54:26,329  
we scientists face and yet they get to

1136  
00:54:30,039 --> 00:54:28,760  
solve some of the really hard problems

1137  
00:54:32,740 --> 00:54:30,049  
or they get to tackle some of those

1138  
00:54:34,990 --> 00:54:32,750

really hard problems and so I just want

1139

00:54:38,079 --> 00:54:35,000

folks to to not think of just the

1140

00:54:39,609 --> 00:54:38,089

sciences but also of the engineering

1141

00:54:41,380 --> 00:54:39,619

aspects of what it takes for NASA

1142

00:54:44,740 --> 00:54:41,390

missions to get done and in particular

1143

00:54:45,819 --> 00:54:44,750

astrobiology missions definitely yeah

1144

00:54:47,289 --> 00:54:45,829

they're there's so much that we can do

1145

00:54:48,370 --> 00:54:47,299

together when engineering and scientists

1146

00:54:50,349 --> 00:54:48,380

cannot come together and make these

1147

00:54:51,640 --> 00:54:50,359

things happen we only have a few minutes

1148

00:54:53,380 --> 00:54:51,650

left and so you want to pop in a few

1149

00:54:56,049 --> 00:54:53,390

more questions here

1150

00:54:59,380 --> 00:54:56,059

this one's from Rohan Shyam Chowdhury on

1151  
00:55:01,660 --> 00:54:59,390  
Twitter at Rohan s Chowdhury and they

1152  
00:55:03,789 --> 00:55:01,670  
asked suppose we find life in one of

1153  
00:55:08,650 --> 00:55:03,799  
these alien oceans what's what's the

1154  
00:55:10,120 --> 00:55:08,660  
next step yeah I like to say that yeah

1155  
00:55:11,950 --> 00:55:10,130  
it's not gonna change the way you make

1156  
00:55:14,630 --> 00:55:11,960  
your coffee in the morning it's not

1157  
00:55:17,610 --> 00:55:14,640  
gonna shorten your commute

1158  
00:55:20,100 --> 00:55:17,620  
but I spent a chapter in the book on

1159  
00:55:23,870 --> 00:55:20,110  
this this concept that I like to frame

1160  
00:55:27,470 --> 00:55:23,880  
as a periodic table for life

1161  
00:55:32,970 --> 00:55:27,480  
think about what it was like for the

1162  
00:55:37,560 --> 00:55:32,980  
early chemists Lavoisier Mendeleev etc

1163  
00:55:45,380 --> 00:55:37,570

we're studying the elements and what it

1164

00:55:53,490 --> 00:55:50,370

oxygen didn't quite make sense and our

1165

00:55:56,820 --> 00:55:53,500

atomic theory for matter didn't quite

1166

00:55:59,400 --> 00:55:56,830

fully click into place until we had a

1167

00:56:02,850 --> 00:55:59,410

periodic table of the elements and we

1168

00:56:05,190 --> 00:56:02,860

could see how they were were related and

1169

00:56:08,580 --> 00:56:05,200

how they they could connect with each

1170

00:56:11,640 --> 00:56:08,590

other I love to think about a similar

1171

00:56:13,560 --> 00:56:11,650

framework perhaps existing out there in

1172

00:56:16,020 --> 00:56:13,570

our universe somewhere where there is a

1173

00:56:20,730 --> 00:56:16,030

periodic table for life some great tree

1174

00:56:22,740 --> 00:56:20,740

of life that gives us a pattern for the

1175

00:56:24,750 --> 00:56:22,750

different biochemistry and the different

1176

00:56:28,170 --> 00:56:24,760

ways in which life works and this

1177

00:56:30,990 --> 00:56:28,180

connects back to the defining an element

1178

00:56:33,090 --> 00:56:31,000

in part took the periodic table so

1179

00:56:35,930 --> 00:56:33,100

perhaps defining life and understanding

1180

00:56:38,340 --> 00:56:35,940

what life truly is will require

1181

00:56:40,500 --> 00:56:38,350

discovering life elsewhere if it exists

1182

00:56:42,900 --> 00:56:40,510

and putting into a framework of the

1183

00:56:45,180 --> 00:56:42,910

periodic table and so I'd love to think

1184

00:56:49,230 --> 00:56:45,190

also that perhaps is elsewhere in the

1185

00:56:51,660 --> 00:56:49,240

galaxy there is a classroom where those

1186

00:56:53,280 --> 00:56:51,670

students are in a civilization that has

1187

00:56:56,040 --> 00:56:53,290

already discovered life beyond their

1188

00:56:58,920 --> 00:56:56,050

home planet and on the side of that

1189

00:57:01,920 --> 00:56:58,930

classroom is not just a periodic table

1190

00:57:05,520 --> 00:57:01,930

of the elements but also a periodic

1191

00:57:08,250 --> 00:57:05,530

table of life and they are just looking

1192

00:57:09,860 --> 00:57:08,260

at other examples out there maybe they

1193

00:57:13,140 --> 00:57:09,870

already know of life here on earth

1194

00:57:15,470 --> 00:57:13,150

maybe they don't and maybe someday we

1195

00:57:19,940 --> 00:57:15,480

will be notched into a little section of

1196

00:57:21,690 --> 00:57:19,950

that chart that they have on their wall

1197

00:57:23,100 --> 00:57:21,700

it's just it's not like a Glass

1198

00:57:25,290 --> 00:57:23,110

Menagerie where they have like a human

1199

00:57:28,620 --> 00:57:25,300

inside

1200

00:57:31,440 --> 00:57:28,630

I love that idea yeah again comparative

1201  
00:57:33,420 --> 00:57:31,450  
biology would be so huge for us we are

1202  
00:57:36,330 --> 00:57:33,430  
at the top of the hour if you have time

1203  
00:57:38,940 --> 00:57:36,340  
we ask one more question sure yeah okay

1204  
00:57:42,000 --> 00:57:38,950  
so and this question is from a long time

1205  
00:57:43,740 --> 00:57:42,010  
audience member Tom Caruso and it takes

1206  
00:57:45,390 --> 00:57:43,750  
my mind down to our oceans and makes me

1207  
00:57:47,640 --> 00:57:45,400  
think about some of these weird you know

1208  
00:57:49,440 --> 00:57:47,650  
mid-ocean rivers and you know we're

1209  
00:57:51,900 --> 00:57:49,450  
weird basins in the on the ocean floor

1210  
00:57:54,990 --> 00:57:51,910  
of different kind of Brian levels of

1211  
00:57:57,600 --> 00:57:55,000  
fluids so Tom wants to know that if it's

1212  
00:57:59,940 --> 00:57:57,610  
possible that ice brine channels in the

1213  
00:58:02,430 --> 00:57:59,950

bottom of an alien ocean are the alien

1214

00:58:04,530 --> 00:58:02,440

host and ocean ice shells if they could

1215

00:58:04,890 --> 00:58:04,540

satisfy the criteria for the origin of

1216

00:58:07,800 --> 00:58:04,900

life

1217

00:58:10,080 --> 00:58:07,810

so gradients amongst minerals salts pH

1218

00:58:12,330 --> 00:58:10,090

there's kind of things what your view of

1219

00:58:13,830 --> 00:58:12,340

that would be yeah and my short answer

1220

00:58:16,560 --> 00:58:13,840

is yes I think there's a lot of

1221

00:58:20,580 --> 00:58:16,570

interesting potential there micro Sol

1222

00:58:23,100 --> 00:58:20,590

Alison Marie and I wrote a paper in

1223

00:58:24,600 --> 00:58:23,110

astrobiology about this and it's

1224

00:58:27,210 --> 00:58:24,610

something that we're looking at here on

1225

00:58:30,720 --> 00:58:27,220

earth these these practicals and and how

1226

00:58:33,660 --> 00:58:30,730

those chemical gradients may provide

1227

00:58:37,790 --> 00:58:33,670

some interesting catalytic surfaces and

1228

00:58:41,100 --> 00:58:37,800

chemistry then it could help with the

1229

00:58:43,890 --> 00:58:41,110

the pathway to the origin of life so I

1230

00:58:48,990 --> 00:58:43,900

think there's a lot of low-hanging fruit

1231

00:58:50,370 --> 00:58:49,000

in the realm of cold origins nasan well

1232

00:58:51,690 --> 00:58:50,380

I think we're gonna sum up there we

1233

00:58:54,210 --> 00:58:51,700

actually have a lot more questions so

1234

00:58:55,200 --> 00:58:54,220

for all of our viewers to reach out to

1235

00:59:00,660 --> 00:58:55,210

you where's the best way for them to

1236

00:59:03,420 --> 00:59:00,670

find you online alien oceans is my

1237

00:59:06,120 --> 00:59:03,430

twitter handle I'm not very good on

1238

00:59:10,740 --> 00:59:06,130

Twitter my thumb's are too big or

1239

00:59:13,710 --> 00:59:10,750

something but the I try and be somewhat

1240

00:59:15,870 --> 00:59:13,720

responsive on there I just also have a

1241

00:59:18,020 --> 00:59:15,880

hard time with the character limit and

1242

00:59:19,950 --> 00:59:18,030

all that stuff but I'll do my best

1243

00:59:21,090 --> 00:59:19,960

awesome yeah so for all of you watching

1244

00:59:23,370 --> 00:59:21,100

thank you so much for all your questions

1245

00:59:25,910 --> 00:59:23,380

miss RB didn't get to that many of them

1246

00:59:28,280 --> 00:59:25,920

please reach out to dr. Kevin hand on

1247

00:59:31,430 --> 00:59:28,290

please read his book alien oceans it's a

1248

00:59:32,420 --> 00:59:31,440

fantastic read and thank you all for

1249

00:59:34,250 --> 00:59:32,430

joining us

1250

00:59:37,250 --> 00:59:34,260

and when you're going forward this month

1251  
00:59:40,430 --> 00:59:37,260  
and thinking about astrobiology what

1252  
00:59:41,990 --> 00:59:40,440  
what are the major challenges in the

1253  
00:59:44,480 --> 00:59:42,000  
engineering for us to do the

1254  
00:59:46,430 --> 00:59:44,490  
astrobiology what we want to do for our

1255  
00:59:49,610 --> 00:59:46,440  
audience members why not reach out to us

1256  
00:59:51,110 --> 00:59:49,620  
at Sagan net org at second order on

1257  
00:59:52,580 --> 00:59:51,120  
Twitter let us know what your thoughts

1258  
00:59:54,650 --> 00:59:52,590  
are what are the big challenges for us

1259  
00:59:56,060 --> 00:59:54,660  
to do to bring science and engineering

1260  
00:59:56,870 --> 00:59:56,070  
together to solve these problems in the

1261  
00:59:58,400 --> 00:59:56,880  
future

1262  
00:59:59,840 --> 00:59:58,410  
Kevin thank you so much for joining us

1263  
01:00:01,760 --> 00:59:59,850

for ask an astrobiologist it's been a

1264

01:00:04,700 --> 01:00:01,770

pleasure having you on the show thanks

1265

01:00:06,320 --> 01:00:04,710

Graham any time happy to come back and

1266

01:00:08,300 --> 01:00:06,330

answer more questions now that'd be

1267

01:00:10,070 --> 01:00:08,310

great Thank You Evan for joining us and

1268

01:00:51,970 --> 01:00:10,080

numbers stay curious