Ask An Astrobiologist

Episode 34: August 11th, 2020

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NASA Astrobiology Program

1
00:00:00,690 --> 00:00:28,830
[Music]

2
00:00:32,709 --> 00:00:30,550
so

3
00:00:33,750 --> 00:00:32,719
greetings friends and fellow users of

4
00:00:36,870 --> 00:00:33,760
technology

5
00:00:39,510 --> 00:00:36,880
and producers of techno signatures this

6
00:00:41,190 --> 00:00:39,520
is ask an astrobiologist the show that

7
00:00:43,350 --> 00:00:41,200
celebrates the science

8
00:00:44,470 --> 00:00:43,360
and celebrates the scientists involved

9
00:00:46,150 --> 00:00:44,480
in our quest

10
00:00:48,790 --> 00:00:46,160
to understand the nature of life in the

11
00:00:51,189 --> 00:00:48,800
cosmos i'm graeme lau

12
00:00:53,350 --> 00:00:51,199
also known as the cosmobiologist and

13
00:00:55,750 --> 00:00:53,360

we're brought to you by seganet.org and

14
00:00:57,830 --> 00:00:55,760
the nasa astrobiology program

15
00:00:59,189 --> 00:00:57,840
and i'll tell you folks the grooviness

16
00:01:00,470 --> 00:00:59,199
abounds for this episode

17
00:01:02,709 --> 00:01:00,480
we'll be talking about things like

18
00:01:05,509 --> 00:01:02,719
exoplanets and techno signatures

19
00:01:06,230 --> 00:01:05,519
and mars settlement and so much more but

20
00:01:08,789 --> 00:01:06,240
before i

21
00:01:09,429 --> 00:01:08,799
introduce this guest we have to do some

22
00:01:11,990 --> 00:01:09,439
of our

23
00:01:13,510 --> 00:01:12,000
our background things like our monthly

24
00:01:15,749 --> 00:01:13,520
field site challenge

25
00:01:17,990 --> 00:01:15,759
as you know before every episode the day

26
00:01:20,149 --> 00:01:18,000
before on twitter at saginorg

27
00:01:21,990 --> 00:01:20,159
we release a photo of a field site

28
00:01:24,550 --> 00:01:22,000
relevant to astrobiology

29
00:01:25,749 --> 00:01:24,560
and we ask you to tell us what is that

30
00:01:27,190 --> 00:01:25,759
image showing us

31
00:01:29,990 --> 00:01:27,200
and if you'd like you can tell us why

32
00:01:31,590 --> 00:01:30,000
it's relevant to astrobiology as well

33
00:01:34,550 --> 00:01:31,600
well the winner for this month's field

34
00:01:36,550 --> 00:01:34,560
site challenge is manavica kana

35
00:01:38,390 --> 00:01:36,560
manavica wrote a really cool description

36
00:01:40,230 --> 00:01:38,400
of what she saw on that image

37
00:01:42,630 --> 00:01:40,240
she said is it the presence of

38
00:01:45,429 --> 00:01:42,640

megastructures using electricity

39
00:01:47,030 --> 00:01:45,439
as a way to power a self-luminous city

40
00:01:47,830 --> 00:01:47,040
the location definitely seems to be

41
00:01:49,749 --> 00:01:47,840
italy

42
00:01:51,990 --> 00:01:49,759
well manavica yes you're right on both

43
00:01:53,030 --> 00:01:52,000
accounts the location is the italian

44
00:01:55,030 --> 00:01:53,040
peninsula

45
00:01:56,709 --> 00:01:55,040
and yes these are structures built by

46
00:01:57,749 --> 00:01:56,719
humans where we are producing

47
00:02:00,230 --> 00:01:57,759
electricity

48
00:02:01,830 --> 00:02:00,240
to power our cities at night so we can

49
00:02:03,990 --> 00:02:01,840
read from our kindles and watch

50
00:02:05,990 --> 00:02:04,000
netflix so we have lights over our

51
00:02:08,550 --> 00:02:06,000
streets and we can light our homes

52
00:02:09,990 --> 00:02:08,560
in the darkness of night but astronauts

53
00:02:11,110 --> 00:02:10,000
flying overhead on the international

54
00:02:13,430 --> 00:02:11,120
space station

55
00:02:15,589 --> 00:02:13,440
they can also see these lights they can

56
00:02:17,110 --> 00:02:15,599
see these as signs of our technology

57
00:02:19,990 --> 00:02:17,120
down on the earth below

58
00:02:21,350 --> 00:02:20,000
from that lofty perch above they see our

59
00:02:23,670 --> 00:02:21,360
techno signatures

60
00:02:25,190 --> 00:02:23,680
and maybe aliens far away can see our

61
00:02:26,470 --> 00:02:25,200
techno signatures as well

62
00:02:28,949 --> 00:02:26,480
and we're definitely looking for them

63
00:02:31,190 --> 00:02:28,959

ourselves so thank you so much manavika

64
00:02:32,710 --> 00:02:31,200
and all who gave us the right answer

65
00:02:34,470 --> 00:02:32,720
on this image for the field site

66
00:02:36,710 --> 00:02:34,480
challenge for this month

67
00:02:38,710 --> 00:02:36,720
and before we bring on our guests uh

68
00:02:40,390 --> 00:02:38,720
every episode we do want to mention

69
00:02:42,949 --> 00:02:40,400
those people who are out there working

70
00:02:44,390 --> 00:02:42,959
really hard are our most staunch fans

71
00:02:45,110 --> 00:02:44,400
who are celebrating the show who are

72
00:02:46,869 --> 00:02:45,120
sharing

73
00:02:48,390 --> 00:02:46,879
information about our upcoming episodes

74
00:02:50,470 --> 00:02:48,400
about our guests who are getting

75
00:02:53,270 --> 00:02:50,480
involved in the conversation who are the

76
00:02:55,270 --> 00:02:53,280
ambassadors for ask an astrobiologist

77
00:02:56,790 --> 00:02:55,280
this month we want to highlight azure

78
00:02:58,949 --> 00:02:56,800
pinochet barros

79
00:02:59,990 --> 00:02:58,959
de lara kelly charleston anna root

80
00:03:03,030 --> 00:03:00,000
mahanti

81
00:03:03,990 --> 00:03:03,040
and kashish gupta for helping us out and

82
00:03:05,830 --> 00:03:04,000
sharing the word about

83
00:03:09,030 --> 00:03:05,840
ask an astrobiologist and sharing our

84
00:03:10,869 --> 00:03:09,040
show thank you to all of you as always

85
00:03:12,149 --> 00:03:10,879
for being so involved in what we're

86
00:03:13,990 --> 00:03:12,159
doing here and trying to bring the

87
00:03:17,190 --> 00:03:14,000
voices of astrobiologists

88
00:03:19,030 --> 00:03:17,200

to the world with all that said now i

89
00:03:21,509 --> 00:03:19,040
get to introduce our guests

90
00:03:23,350 --> 00:03:21,519
uh jacob hochmisra earned his

91
00:03:24,550 --> 00:03:23,360
undergraduate degrees in astrophysics

92
00:03:26,949 --> 00:03:24,560
and computer science at the

93
00:03:28,789 --> 00:03:26,959
university of minnesota he also earned a

94
00:03:30,949 --> 00:03:28,799
master's degree in meteorology

95
00:03:33,509 --> 00:03:30,959
and his phd in meteorology and

96
00:03:35,910 --> 00:03:33,519
astrobiology at penn state university

97
00:03:37,670 --> 00:03:35,920
he's also a research scientist at blue

98
00:03:38,789 --> 00:03:37,680
marble space institute of science and a

99
00:03:42,070 --> 00:03:38,799
good friend of mine

100
00:03:43,430 --> 00:03:42,080
so welcome to the show dr jacob misra

101
00:03:45,270 --> 00:03:43,440
thanks so much graeme i'm happy to be

102
00:03:46,070 --> 00:03:45,280
here yeah it's really i mean we've

103
00:03:47,990 --> 00:03:46,080
talked for a long

104
00:03:49,750 --> 00:03:48,000
time now about getting you on the show

105
00:03:51,509 --> 00:03:49,760
you've been doing so much these past

106
00:03:52,309 --> 00:03:51,519
many years now and so many different

107
00:03:54,630 --> 00:03:52,319
areas

108
00:03:56,630 --> 00:03:54,640
of astrobiology and and beyond

109
00:03:57,509 --> 00:03:56,640
astrobiology as well and just last week

110
00:04:00,390 --> 00:03:57,519
you helped to run

111
00:04:01,830 --> 00:04:00,400
this workshop called technoclimbs uh so

112
00:04:03,350 --> 00:04:01,840
i definitely talk about all these cool

113
00:04:05,429 --> 00:04:03,360

things that you do

114
00:04:07,509 --> 00:04:05,439
but first let's get to know a bit about

115
00:04:08,470 --> 00:04:07,519
you uh for instance i kind of want to

116
00:04:11,030 --> 00:04:08,480
know what your science

117
00:04:12,710 --> 00:04:11,040
story is that brought you into becoming

118
00:04:14,710 --> 00:04:12,720
an astrobiologist

119
00:04:16,550 --> 00:04:14,720
what what took jacob hawk misro from a

120
00:04:18,550 --> 00:04:16,560
young boy to becoming who you are now as

121
00:04:20,870 --> 00:04:18,560
an astrobiologist

122
00:04:21,990 --> 00:04:20,880
absolutely that's a great question and

123
00:04:23,749 --> 00:04:22,000
you know i really

124
00:04:25,830 --> 00:04:23,759
don't even remember a time when i was

125
00:04:27,030 --> 00:04:25,840
not interested in space ever since i

126
00:04:29,430 --> 00:04:27,040
have memories

127
00:04:31,189 --> 00:04:29,440
i've i wanted to be a space scientist

128
00:04:33,830 --> 00:04:31,199
before i knew the word astronomer

129
00:04:35,350 --> 00:04:33,840
i even quickly pulled out i still have

130
00:04:37,670 --> 00:04:35,360
my first book about

131
00:04:38,870 --> 00:04:37,680
space right here i'm sure this is not in

132
00:04:40,710 --> 00:04:38,880
print anymore

133
00:04:41,990 --> 00:04:40,720
it has all kinds of great numbers like

134
00:04:43,670 --> 00:04:42,000
how long would it take to walk

135
00:04:45,030 --> 00:04:43,680
around the earth and how many earths fit

136
00:04:46,629 --> 00:04:45,040
inside the sun

137
00:04:48,870 --> 00:04:46,639
then the last page it says are there any

138
00:04:50,390 --> 00:04:48,880

space creatures it says no one knows yet

139
00:04:52,230 --> 00:04:50,400
maybe one day you will be a space

140
00:04:54,950 --> 00:04:52,240
explorer so that's

141
00:04:58,550 --> 00:04:54,960
the nutshell of my story is here i am

142
00:05:01,990 --> 00:04:58,560
fulfilling uh my first books call

143
00:05:03,430 --> 00:05:02,000
but um you know as i i i was always you

144
00:05:05,029 --> 00:05:03,440
know interested in in

145
00:05:06,550 --> 00:05:05,039
not just math and science but really

146
00:05:07,510 --> 00:05:06,560
everything you know and i think that's

147
00:05:10,469 --> 00:05:07,520
part of what

148
00:05:12,230 --> 00:05:10,479
makes astrobiology so fun is you know

149
00:05:12,870 --> 00:05:12,240
being interested in english and history

150
00:05:15,110 --> 00:05:12,880
is really

151
00:05:16,469 --> 00:05:15,120
just as relevant as studying math and

152
00:05:18,790 --> 00:05:16,479
science and everything else

153
00:05:20,790 --> 00:05:18,800
it's truly interdisciplinary so you know

154
00:05:23,350 --> 00:05:20,800
i i enjoyed school i got involved in a

155
00:05:25,350 --> 00:05:23,360
lot of programs

156
00:05:26,469 --> 00:05:25,360
science clubs and math clubs and music

157
00:05:28,390 --> 00:05:26,479
and things like that

158
00:05:30,150 --> 00:05:28,400
um you know the other side of that is

159
00:05:32,310 --> 00:05:30,160
you know i grew up um

160
00:05:34,070 --> 00:05:32,320
evangelical christian and so i've always

161
00:05:36,710 --> 00:05:34,080
been thinking about these big quest

162
00:05:38,070 --> 00:05:36,720
questions of meaning and purpose and and

163
00:05:40,629 --> 00:05:38,080

what's out there and

164
00:05:41,670 --> 00:05:40,639
and i'm an atheist now so i don't

165
00:05:43,270 --> 00:05:41,680
actually look for

166
00:05:44,870 --> 00:05:43,280
god anymore but i don't think it's

167
00:05:46,469 --> 00:05:44,880
coincidental that i'm interested

168
00:05:48,230 --> 00:05:46,479
in thinking about extraterrestrial

169
00:05:49,590 --> 00:05:48,240
intelligence and a lot of the other

170
00:05:51,990 --> 00:05:49,600
scientists i meet

171
00:05:53,510 --> 00:05:52,000
uh in in the city and search for

172
00:05:56,150 --> 00:05:53,520
extraterrestrial intelligence

173
00:05:56,629 --> 00:05:56,160
seti and uh techno signatures community

174
00:05:58,309 --> 00:05:56,639
um

175
00:05:59,670 --> 00:05:58,319
there is a presence of people who have

176
00:06:01,749 --> 00:05:59,680
similar backgrounds and

177
00:06:03,350 --> 00:06:01,759
you might have started out more strongly

178
00:06:04,710 --> 00:06:03,360
in a religious tradition but you don't

179
00:06:06,629 --> 00:06:04,720
lose that sense of

180
00:06:08,710 --> 00:06:06,639
these big philosophical questions why

181
00:06:09,749 --> 00:06:08,720
are we here where are we going what does

182
00:06:13,110 --> 00:06:09,759
it all mean

183
00:06:14,790 --> 00:06:13,120
and and so i really continued you know

184
00:06:16,390 --> 00:06:14,800
thinking through the science and those

185
00:06:17,830 --> 00:06:16,400
philosophical questions

186
00:06:19,510 --> 00:06:17,840
uh you know through high school into

187
00:06:22,550 --> 00:06:19,520
college you already

188
00:06:24,550 --> 00:06:22,560

read my degrees um you know but but um

189
00:06:25,830 --> 00:06:24,560
astrobiology really gave me this this

190
00:06:29,029 --> 00:06:25,840
interesting skill set

191
00:06:30,950 --> 00:06:29,039
to um to pursue those big questions

192
00:06:33,029 --> 00:06:30,960
so i guess the other thing i'll mention

193
00:06:35,430 --> 00:06:33,039
is is i was really interested in

194
00:06:38,550 --> 00:06:35,440
becoming a cosmologist initially

195
00:06:40,309 --> 00:06:38,560
um the part partly with the the

196
00:06:42,150 --> 00:06:40,319
the philosophical side of the christian

197
00:06:43,830 --> 00:06:42,160
tradition you know i like thinking about

198
00:06:45,830 --> 00:06:43,840
evolution and big bang and

199
00:06:47,990 --> 00:06:45,840
those are still part of astrobiology but

200
00:06:49,670 --> 00:06:48,000
i was i worked actually in a cosmology

201
00:06:51,670 --> 00:06:49,680
lab for a couple of years one one

202
00:06:53,670 --> 00:06:51,680
theoretical cosmology lab and then one

203
00:06:55,749 --> 00:06:53,680
experimental cosmology lab

204
00:06:57,510 --> 00:06:55,759
and that was really interesting it's

205
00:06:58,790 --> 00:06:57,520
relativity and quantum mechanics i'm

206
00:07:00,230 --> 00:06:58,800
sure it would have been a really fun

207
00:07:02,469 --> 00:07:00,240
career

208
00:07:04,309 --> 00:07:02,479
but in my junior year of college uh jill

209
00:07:05,270 --> 00:07:04,319
tarter came to our astrophysics

210
00:07:07,589 --> 00:07:05,280
department

211
00:07:09,430 --> 00:07:07,599
and she gave a lecture where she talked

212
00:07:11,670 --> 00:07:09,440
about seti but i actually heard the word

213
00:07:14,790 --> 00:07:11,680

astrobiology for the first time

214
00:07:16,870 --> 00:07:14,800
and i knew about seti this idea of

215
00:07:19,510 --> 00:07:16,880
listening for radio signals

216
00:07:20,469 --> 00:07:19,520
from other alien civilizations that

217
00:07:21,990 --> 00:07:20,479
might be out there

218
00:07:23,350 --> 00:07:22,000
i wasn't really sure what to think of it

219
00:07:25,270 --> 00:07:23,360
and i didn't really understand how it

220
00:07:27,350 --> 00:07:25,280
connected with the rest of science

221
00:07:29,830 --> 00:07:27,360
and joe gave this great talk about

222
00:07:31,110 --> 00:07:29,840
astrobiology and so i went home and i

223
00:07:33,670 --> 00:07:31,120
looked for summer programs in

224
00:07:36,150 --> 00:07:33,680
astrobiology i found one at penn state

225
00:07:38,390 --> 00:07:36,160
i worked that summer with jim casting

226
00:07:39,990 --> 00:07:38,400
who then became my graduate advisor

227
00:07:41,430 --> 00:07:40,000
and and you know that that's really how

228
00:07:43,670 --> 00:07:41,440
i ended up doing this

229
00:07:45,510 --> 00:07:43,680
specific kind of research studying what

230
00:07:46,390 --> 00:07:45,520
makes a planet habitable what kind of

231
00:07:48,869 --> 00:07:46,400
planets

232
00:07:50,950 --> 00:07:48,879
might support life how would we search

233
00:07:53,510 --> 00:07:50,960
them for signs of life and how would we

234
00:07:57,189 --> 00:07:53,520
search them for science of technology

235
00:07:57,510 --> 00:07:57,199
and uh yeah so so here i am i made it

236
00:08:01,990 --> 00:07:57,520
from

237
00:08:02,309 --> 00:08:02,000
to space scientists like everyone wanted

238
00:08:03,909 --> 00:08:02,319

to be

239
00:08:05,430 --> 00:08:03,919
though i love it so much i have to find

240
00:08:06,790 --> 00:08:05,440
a book like that for my son nolan for

241
00:08:09,029 --> 00:08:06,800
when he's ready to start

242
00:08:10,790 --> 00:08:09,039
reading books that might might lead him

243
00:08:12,629 --> 00:08:10,800
into his own career and lead him into a

244
00:08:13,830 --> 00:08:12,639
dream for the future uh jill is so

245
00:08:15,350 --> 00:08:13,840
wonderful we had her as a guest

246
00:08:16,710 --> 00:08:15,360
previously on the show

247
00:08:18,309 --> 00:08:16,720
so it's cool to hear that she kind of

248
00:08:19,749 --> 00:08:18,319
she gave you that impetus to kind of go

249
00:08:20,950 --> 00:08:19,759
even further from cosmology into

250
00:08:22,710 --> 00:08:20,960
astrobiology and

251
00:08:24,309 --> 00:08:22,720
it's really great to hear you know that

252
00:08:25,270 --> 00:08:24,319
you consider these larger questions too

253
00:08:27,029 --> 00:08:25,280
sometimes

254
00:08:28,710 --> 00:08:27,039
people think of astrobiology as just

255
00:08:29,430 --> 00:08:28,720
being about the science but there really

256
00:08:31,749 --> 00:08:29,440
is this

257
00:08:33,350 --> 00:08:31,759
in a larger realm of it and philosophy

258
00:08:34,230 --> 00:08:33,360
and how we really ask these larger

259
00:08:35,909 --> 00:08:34,240
questions

260
00:08:37,509 --> 00:08:35,919
about the nature of life in the cosmos

261
00:08:38,790 --> 00:08:37,519
i'm so glad to hear that

262
00:08:41,269 --> 00:08:38,800
uh and you brought up so much there at

263
00:08:43,190 --> 00:08:41,279

the end about your work in modeling

264
00:08:45,110 --> 00:08:43,200
exoplanets and trying to look for signs

265
00:08:46,710 --> 00:08:45,120
of life and look for techno signatures

266
00:08:48,870 --> 00:08:46,720
uh so let's talk about that for a little

267
00:08:49,990 --> 00:08:48,880
bit uh what kind of research are you

268
00:08:52,230 --> 00:08:50,000
currently doing

269
00:08:53,590 --> 00:08:52,240
uh in in this in this work of looking

270
00:08:55,829 --> 00:08:53,600
for signs of life for instance on

271
00:08:57,509 --> 00:08:55,839
exoplanets

272
00:08:59,590 --> 00:08:57,519
so one of the projects that i'm working

273
00:09:01,030 --> 00:08:59,600
on now it's it's coming to a close it's

274
00:09:02,230 --> 00:09:01,040
been a three year project with several

275
00:09:05,030 --> 00:09:02,240
of my colleagues

276
00:09:05,350 --> 00:09:05,040
in astrobiology and and we're looking at

277
00:09:09,030 --> 00:09:05,360
the

278
00:09:12,070 --> 00:09:09,040
habitable zones

279
00:09:12,870 --> 00:09:12,080
what what distance can a planet be from

280
00:09:14,949 --> 00:09:12,880
its star

281
00:09:16,470 --> 00:09:14,959
to support liquid water that doesn't

282
00:09:17,990 --> 00:09:16,480
mean that's the only type of planet that

283
00:09:18,949 --> 00:09:18,000
could support life but that's the way we

284
00:09:21,590 --> 00:09:18,959
can search

285
00:09:23,750 --> 00:09:21,600
that's a search constraint that works

286
00:09:27,190 --> 00:09:23,760
for telescopes so it's just a way

287
00:09:28,790 --> 00:09:27,200
to search um and and figure out which

288
00:09:31,030 --> 00:09:28,800

planets are more or less likely

289
00:09:32,630 --> 00:09:31,040
to have have water and then maybe maybe

290
00:09:34,829 --> 00:09:32,640
life um

291
00:09:36,070 --> 00:09:34,839
so a lot of people work on study this

292
00:09:38,550 --> 00:09:36,080
problem um

293
00:09:41,190 --> 00:09:38,560
specifically this project is about

294
00:09:42,230 --> 00:09:41,200
binary stars and the habitability of

295
00:09:45,910 --> 00:09:42,240
planets in

296
00:09:46,550 --> 00:09:45,920
binary star systems um binary stars are

297
00:09:48,389 --> 00:09:46,560
stars

298
00:09:50,070 --> 00:09:48,399
for which there are two of them they

299
00:09:52,470 --> 00:09:50,080
orbit each other uh

300
00:09:54,949 --> 00:09:52,480
when i was in college and you know not

301
00:09:56,310 --> 00:09:54,959
too long ago 2001 i mean i guess it's a

302
00:09:56,790 --> 00:09:56,320
long time for some of your viewers

303
00:10:00,070 --> 00:09:56,800
perhaps

304
00:10:02,389 --> 00:10:00,080
it doesn't feel that long for me um

305
00:10:04,389 --> 00:10:02,399
but when i was in college i learned

306
00:10:05,990 --> 00:10:04,399
correctly that about half of stars are

307
00:10:08,870 --> 00:10:06,000
in binary systems and we

308
00:10:10,710 --> 00:10:08,880
we we know that that's still true um i

309
00:10:13,030 --> 00:10:10,720
was also told that they probably

310
00:10:14,630 --> 00:10:13,040
can't support planets because the planet

311
00:10:16,630 --> 00:10:14,640
should be dynamically unstable

312
00:10:18,389 --> 00:10:16,640
well that's actually not correct because

313
00:10:19,990 --> 00:10:18,399

that we've found some planets some of my

314
00:10:23,190 --> 00:10:20,000
colleagues in this project have

315
00:10:25,590 --> 00:10:23,200
detected planets in binary star systems

316
00:10:27,829 --> 00:10:25,600
um we don't have the technology to find

317
00:10:30,069 --> 00:10:27,839
the earth-sized ones yet but we found

318
00:10:30,550 --> 00:10:30,079
these big jupiter neptune-sized ones and

319
00:10:33,590 --> 00:10:30,560
they are

320
00:10:34,389 --> 00:10:33,600
at the habitable zone distance so in

321
00:10:37,030 --> 00:10:34,399
principle

322
00:10:37,430 --> 00:10:37,040
we can't rule these out and so you know

323
00:10:45,829 --> 00:10:37,440
we

324
00:10:48,949 --> 00:10:45,839
adapt them to be able to consider

325
00:10:50,710 --> 00:10:48,959
weirder atmospheres like what if co2 was

326
00:10:52,230 --> 00:10:50,720
millions of times higher than today

327
00:10:53,910 --> 00:10:52,240
which wouldn't even happen for climate

328
00:10:55,750 --> 00:10:53,920
change or what if there was lots of

329
00:10:56,389 --> 00:10:55,760
methane or hydrogen or all sorts of

330
00:10:58,949 --> 00:10:56,399
things

331
00:10:59,590 --> 00:10:58,959
um but but you know the nutshell what

332
00:11:01,509 --> 00:10:59,600
we're finding

333
00:11:03,829 --> 00:11:01,519
is that there's really no reason that

334
00:11:06,069 --> 00:11:03,839
planets in these binary systems

335
00:11:08,069 --> 00:11:06,079
would not be habitable they might have

336
00:11:09,829 --> 00:11:08,079
like weird weather systems like

337
00:11:11,350 --> 00:11:09,839
different kinds of seasons because of

338
00:11:13,750 --> 00:11:11,360

having two stars

339
00:11:14,710 --> 00:11:13,760
but you know contrary to what i was told

340
00:11:17,829 --> 00:11:14,720
just you know

341
00:11:19,110 --> 00:11:17,839
15 20 years ago um not only are can they

342
00:11:20,710 --> 00:11:19,120
have planets but it's

343
00:11:22,389 --> 00:11:20,720
if you have a planet there's really no

344
00:11:24,150 --> 00:11:22,399
reason to think it would be any

345
00:11:26,389 --> 00:11:24,160
less habitable than earth maybe even

346
00:11:27,990 --> 00:11:26,399
more you know maybe having extra seasons

347
00:11:30,550 --> 00:11:28,000
helped accelerate the development

348
00:11:31,190 --> 00:11:30,560
of life or technology so you can kind of

349
00:11:34,310 --> 00:11:31,200
run

350
00:11:35,350 --> 00:11:34,320
but like you know i'm sure there's star

351
00:11:37,910 --> 00:11:35,360
wars fans these are

352
00:11:38,389 --> 00:11:37,920
like tatooine is the classic example and

353
00:11:43,829 --> 00:11:38,399
so

354
00:11:45,190 --> 00:11:43,839
habitability in the galaxy in the

355
00:11:47,269 --> 00:11:45,200
universe that at least

356
00:11:49,509 --> 00:11:47,279
based on what we're finding like we

357
00:11:50,470 --> 00:11:49,519
should search binary and single stars

358
00:11:52,389 --> 00:11:50,480
for for

359
00:11:53,590 --> 00:11:52,399
planets i love that so much and i love

360
00:11:55,110 --> 00:11:53,600
this idea of letting your imagination

361
00:11:56,629 --> 00:11:55,120
kind of run wild

362
00:11:58,069 --> 00:11:56,639
nick schneider is a professor at the

363
00:11:59,590 --> 00:11:58,079

university of colorado who i had for a

364
00:12:01,990 --> 00:11:59,600
graduate class in

365
00:12:03,750 --> 00:12:02,000
astrophysics and he was mentioning how

366
00:12:05,269 --> 00:12:03,760
with exoplanets almost everything we

367
00:12:07,030 --> 00:12:05,279
ever think we know about planets keeps

368
00:12:08,710 --> 00:12:07,040
getting smashed over and over again

369
00:12:10,069 --> 00:12:08,720
by new discoveries with new kinds of

370
00:12:11,509 --> 00:12:10,079
exoplanets and so

371
00:12:13,670 --> 00:12:11,519
maybe yeah maybe there's all kinds of

372
00:12:16,310 --> 00:12:13,680
weird things out there um

373
00:12:17,750 --> 00:12:16,320
so quick fun question say you're you're

374
00:12:19,430 --> 00:12:17,760
a smart alien uh

375
00:12:20,710 --> 00:12:19,440
civilization 100 light years away from

376
00:12:22,150 --> 00:12:20,720
where we are right now and you have the

377
00:12:24,550 --> 00:12:22,160
same astronomical

378
00:12:25,670 --> 00:12:24,560
technology that we do what what would

379
00:12:27,110 --> 00:12:25,680
you think looking

380
00:12:28,310 --> 00:12:27,120
at the earth and venus and mars what

381
00:12:31,430 --> 00:12:28,320
would you think looking at our solar

382
00:12:36,150 --> 00:12:34,389
well if i was an alien that far away i

383
00:12:38,389 --> 00:12:36,160
guess it would depend on what level of

384
00:12:40,870 --> 00:12:38,399
technology we were at um

385
00:12:43,910 --> 00:12:40,880
but but we tend to think that any

386
00:12:46,069 --> 00:12:43,920
extraterrestrials that we could observe

387
00:12:48,069 --> 00:12:46,079
are probably going to be around for a

388
00:12:49,110 --> 00:12:48,079

really long time they probably are not

389
00:12:50,790 --> 00:12:49,120
this transient

390
00:12:53,110 --> 00:12:50,800
phenomenon just because the likelihood

391
00:12:55,670 --> 00:12:53,120
that we catch a civilization

392
00:12:57,670 --> 00:12:55,680
in you know it's it's short brief

393
00:13:00,949 --> 00:12:57,680
lifetime before it goes extinct

394
00:13:02,550 --> 00:13:00,959
is just incredibly astronomically lucky

395
00:13:04,949 --> 00:13:02,560
but the ones we're more likely to see

396
00:13:06,790 --> 00:13:04,959
are any that have lasted for not just

397
00:13:08,310 --> 00:13:06,800
thousands but you know

398
00:13:10,230 --> 00:13:08,320
not even hundreds of thousands probably

399
00:13:11,829 --> 00:13:10,240
millions of years or longer

400
00:13:13,670 --> 00:13:11,839
because the time scales we talk about in

401
00:13:16,790 --> 00:13:13,680
astronomy are so

402
00:13:17,350 --> 00:13:16,800
big a star like the sun has another you

403
00:13:19,990 --> 00:13:17,360
know

404
00:13:20,790 --> 00:13:20,000
will last for five to ten billion years

405
00:13:27,350 --> 00:13:20,800
so

406
00:13:28,790 --> 00:13:27,360
civilizations a long-lived civilization

407
00:13:31,829 --> 00:13:28,800
and i looked at earth

408
00:13:33,990 --> 00:13:31,839
uh i mean we're we're in we're in a

409
00:13:35,910 --> 00:13:34,000
precarious phase we've we've

410
00:13:38,470 --> 00:13:35,920
developed a lot of technology we've

411
00:13:40,150 --> 00:13:38,480
developed the ability to send signals

412
00:13:42,069 --> 00:13:40,160
through interstellar space

413
00:13:43,750 --> 00:13:42,079

to start modifying our environment to

414
00:13:46,069 --> 00:13:43,760
modify our surface

415
00:13:47,590 --> 00:13:46,079
and and i think even from remote

416
00:13:49,829 --> 00:13:47,600
observations it would be

417
00:13:50,629 --> 00:13:49,839
unclear if earth could manage its

418
00:13:53,269 --> 00:13:50,639
trajectory

419
00:13:54,230 --> 00:13:53,279
for the long term right and you've been

420
00:13:55,829 --> 00:13:54,240
you've been really involved you've

421
00:13:57,990 --> 00:13:55,839
written articles about

422
00:14:00,150 --> 00:13:58,000
uh the future of our civilization and

423
00:14:01,670 --> 00:14:00,160
what comes next in our civilization

424
00:14:03,269 --> 00:14:01,680
um do you think that that

425
00:14:03,829 --> 00:14:03,279
technologically that we that we are

426
00:14:05,590 --> 00:14:03,839
doomed or

427
00:14:07,030 --> 00:14:05,600
that we're destined to to damage

428
00:14:08,310 --> 00:14:07,040
ourselves do you think there is a very

429
00:14:10,069 --> 00:14:08,320
good way forward

430
00:14:11,030 --> 00:14:10,079
um how do you envision the future

431
00:14:12,949 --> 00:14:11,040
looking forward right now for our

432
00:14:14,550 --> 00:14:12,959
civilization

433
00:14:17,189 --> 00:14:14,560
i'm an optimist i'll never say we're

434
00:14:20,629 --> 00:14:17,199
doomed that's that's there's always

435
00:14:21,829 --> 00:14:20,639
you always have to try um but we have

436
00:14:23,430 --> 00:14:21,839
some big challenges

437
00:14:25,590 --> 00:14:23,440
we definitely have big challenges

438
00:14:26,870 --> 00:14:25,600

there's i mean i mean climate change is

439
00:14:30,150 --> 00:14:26,880
almost a symptom

440
00:14:31,990 --> 00:14:30,160
of deeper problems there's there's uh

441
00:14:33,750 --> 00:14:32,000
really it's energy use there's there's

442
00:14:34,150 --> 00:14:33,760
aspects of the world that are dealing

443
00:14:40,710 --> 00:14:34,160
with

444
00:14:42,550 --> 00:14:40,720
and then the areas that are not are are

445
00:14:43,990 --> 00:14:42,560
dealing with an aging population and how

446
00:14:46,790 --> 00:14:44,000
to support the elderly so those

447
00:14:47,189 --> 00:14:46,800
are big social problems and coupled to

448
00:14:48,870 --> 00:14:47,199
those

449
00:14:50,310 --> 00:14:48,880
is a demand for increased energy

450
00:14:51,750 --> 00:14:50,320
everybody wants to have

451
00:14:53,110 --> 00:14:51,760
you know i have a very nice lifestyle

452
00:14:54,230 --> 00:14:53,120
here in the united states i'm very

453
00:14:55,910 --> 00:14:54,240
grateful for it

454
00:14:57,189 --> 00:14:55,920
there are and you know there's lots of

455
00:14:59,030 --> 00:14:57,199
other places in the world that have

456
00:15:00,230 --> 00:14:59,040
similar lifestyles but many places that

457
00:15:02,389 --> 00:15:00,240
do not at all have

458
00:15:03,750 --> 00:15:02,399
have a nice air-conditioned house to be

459
00:15:07,829 --> 00:15:03,760
in in the summer

460
00:15:10,310 --> 00:15:07,839
for example and i i think everybody

461
00:15:12,150 --> 00:15:10,320
has i would love for everybody to have

462
00:15:14,150 --> 00:15:12,160
that but the reality is probably more of

463
00:15:14,790 --> 00:15:14,160

us need to not have those luxuries in

464
00:15:17,350 --> 00:15:14,800
order

465
00:15:19,350 --> 00:15:17,360
to really have a sustainable future and

466
00:15:21,430 --> 00:15:19,360
so that's a really tricky balance

467
00:15:23,590 --> 00:15:21,440
and so there's we're continually

468
00:15:25,030 --> 00:15:23,600
demanding you know exponentially more

469
00:15:28,550 --> 00:15:25,040
energy each year

470
00:15:28,870 --> 00:15:28,560
um can we flatten out that curve to use

471
00:15:36,790 --> 00:15:28,880
the

472
00:15:39,110 --> 00:15:36,800
future

473
00:15:40,069 --> 00:15:39,120
we've slowed that growth and we found a

474
00:15:42,550 --> 00:15:40,079
way so that the energy

475
00:15:43,430 --> 00:15:42,560
we consume is is matching the energy we

476
00:15:46,310 --> 00:15:43,440
produce

477
00:15:47,749 --> 00:15:46,320
and and we're not outpacing our own

478
00:15:50,710 --> 00:15:47,759
growth and that's really the

479
00:15:50,949 --> 00:15:50,720
the risk well that's great um i mean

480
00:15:52,230 --> 00:15:50,959
it's

481
00:15:54,710 --> 00:15:52,240
important to think about right that this

482
00:15:56,550 --> 00:15:54,720
is where we are going um it also kind of

483
00:15:58,949 --> 00:15:56,560
leads me into this idea of the kardashev

484
00:16:01,350 --> 00:15:58,959
scale and how civilizations use energy

485
00:16:02,550 --> 00:16:01,360
uh and for a lot of us uh that was kind

486
00:16:04,069 --> 00:16:02,560
of our introduction to the idea of

487
00:16:05,269 --> 00:16:04,079
techno signatures was this idea of the

488
00:16:06,629 --> 00:16:05,279

kardashev scale but

489
00:16:09,430 --> 00:16:06,639
it's a really big scale that kind of

490
00:16:12,470 --> 00:16:09,440
goes out to like galactic civilizational

491
00:16:13,749 --> 00:16:12,480
technology use and you just organized

492
00:16:15,430 --> 00:16:13,759
this conference last week at this

493
00:16:16,310 --> 00:16:15,440
workshop last week called technoclimbs

494
00:16:17,590 --> 00:16:16,320
where

495
00:16:19,350 --> 00:16:17,600
you were discussing the science of

496
00:16:21,590 --> 00:16:19,360
techno signatures and what's coming

497
00:16:23,670 --> 00:16:21,600
in looking for technological signatures

498
00:16:25,030 --> 00:16:23,680
out there i wonder if you could just for

499
00:16:27,189 --> 00:16:25,040
our audience speak about

500
00:16:28,629 --> 00:16:27,199
what techno signatures really are and

501
00:16:30,150 --> 00:16:28,639
what this conference this this workshop

502
00:16:32,230 --> 00:16:30,160
was doing in trying to better understand

503
00:16:34,550 --> 00:16:32,240
that science

504
00:16:35,990 --> 00:16:34,560
absolutely and i'll even start with the

505
00:16:38,230 --> 00:16:36,000
connective scale since you mentioned

506
00:16:39,110 --> 00:16:38,240
it so so the idea with that kardashev

507
00:16:41,110 --> 00:16:39,120
was a russian

508
00:16:42,310 --> 00:16:41,120
scientist precursor to to a modern

509
00:16:44,790 --> 00:16:42,320
astrobiologist

510
00:16:45,829 --> 00:16:44,800
and and um the idea was what are the

511
00:16:48,150 --> 00:16:45,839
different scales

512
00:16:49,749 --> 00:16:48,160
of energy use are there for civilization

513
00:16:52,710 --> 00:16:49,759

so the type one would be

514
00:16:53,509 --> 00:16:52,720
using all the energy available to a

515
00:16:55,110 --> 00:16:53,519
planet from

516
00:16:57,350 --> 00:16:55,120
from the sunlight the starlight falling

517
00:16:59,670 --> 00:16:57,360
upon the planet

518
00:17:00,470 --> 00:16:59,680
and then a type 2 would be extending

519
00:17:02,870 --> 00:17:00,480
that sphere

520
00:17:03,990 --> 00:17:02,880
using all the sunlight available to to

521
00:17:06,230 --> 00:17:04,000
the entire

522
00:17:07,590 --> 00:17:06,240
solar system the planetary system and

523
00:17:09,510 --> 00:17:07,600
then the type three extends to the

524
00:17:10,470 --> 00:17:09,520
entire galaxy using all the energy

525
00:17:12,549 --> 00:17:10,480
output of all

526
00:17:14,069 --> 00:17:12,559
the stars now we did talk about some of

527
00:17:15,909 --> 00:17:14,079
that at this meeting

528
00:17:18,949 --> 00:17:15,919
uh which i'll get into we talked about

529
00:17:21,590 --> 00:17:18,959
galactic scale techno signatures

530
00:17:22,630 --> 00:17:21,600
and and but but um i think an

531
00:17:24,309 --> 00:17:22,640
interesting

532
00:17:26,069 --> 00:17:24,319
point that actually even motivated this

533
00:17:27,510 --> 00:17:26,079
meeting techno climbs being

534
00:17:29,350 --> 00:17:27,520
technological climates

535
00:17:31,350 --> 00:17:29,360
um one of my colleagues university of

536
00:17:33,510 --> 00:17:31,360
rochester professor adam frank

537
00:17:36,070 --> 00:17:33,520
he developed a scale that's kind of a

538
00:17:37,750 --> 00:17:36,080

complement to the kardashev scale

539
00:17:39,830 --> 00:17:37,760
where it's what are the scales of step

540
00:17:41,510 --> 00:17:39,840
steps in planetary evolution where

541
00:17:43,830 --> 00:17:41,520
there's like a class one planet which

542
00:17:45,990 --> 00:17:43,840
would be like mercury no atmosphere

543
00:17:47,909 --> 00:17:46,000
it's just heated by the star and it

544
00:17:50,070 --> 00:17:47,919
radiates out and that's it

545
00:17:52,230 --> 00:17:50,080
you might have a type 2 which would be

546
00:17:52,710 --> 00:17:52,240
like mars so there's no life but there

547
00:17:57,029 --> 00:17:52,720
is

548
00:17:58,549 --> 00:17:57,039
you're observing with a telescope

549
00:18:00,549 --> 00:17:58,559
you could differentiate between between

550
00:18:02,470 --> 00:18:00,559
those two and we found lots of examples

551
00:18:03,909 --> 00:18:02,480
of you know mercuries and and maybe some

552
00:18:07,190 --> 00:18:03,919
mars type planets

553
00:18:09,110 --> 00:18:07,200
um if if um

554
00:18:11,350 --> 00:18:09,120
type three and type four then are

555
00:18:13,590 --> 00:18:11,360
planets with life type three is a thin

556
00:18:15,909 --> 00:18:13,600
biosphere maybe like the early earth

557
00:18:16,390 --> 00:18:15,919
where you would see some signs of life

558
00:18:20,310 --> 00:18:16,400
but

559
00:18:23,430 --> 00:18:20,320
signature to pull out

560
00:18:25,430 --> 00:18:23,440
and and the influence of life is is not

561
00:18:26,870 --> 00:18:25,440
penetrated deep into the planet's

562
00:18:29,110 --> 00:18:26,880
geology yet

563
00:18:31,029 --> 00:18:29,120

type 4 you have a thick biosphere so

564
00:18:32,150 --> 00:18:31,039
everywhere you look on the planet life

565
00:18:34,950 --> 00:18:32,160
is present

566
00:18:35,669 --> 00:18:34,960
and that would be um that would be a

567
00:18:39,029 --> 00:18:35,679
very

568
00:18:40,470 --> 00:18:39,039
uh noticeable biosignature if uh

569
00:18:42,150 --> 00:18:40,480
if you were to observe that planet so

570
00:18:44,710 --> 00:18:42,160
then the one step further is a type

571
00:18:45,630 --> 00:18:44,720
five where you have a thick biosphere

572
00:18:48,310 --> 00:18:45,640
and a thick

573
00:18:50,070 --> 00:18:48,320
technosphere so what does that mean well

574
00:18:50,950 --> 00:18:50,080
it means that there's technology on the

575
00:18:53,750 --> 00:18:50,960
planet

576
00:18:55,350 --> 00:18:53,760
and it is like the biosphere in the

577
00:18:57,510 --> 00:18:55,360
sense that the life is permeating the

578
00:19:00,710 --> 00:18:57,520
whole planet you have technology

579
00:19:01,590 --> 00:19:00,720
that that has influence at all scales of

580
00:19:03,270 --> 00:19:01,600
the planet

581
00:19:05,350 --> 00:19:03,280
it's to the extent that it could be

582
00:19:07,909 --> 00:19:05,360
remotely detected if you're looking

583
00:19:08,789 --> 00:19:07,919
for that type of signature and so that's

584
00:19:11,190 --> 00:19:08,799
a techno

585
00:19:13,750 --> 00:19:11,200
signature it's some type of

586
00:19:15,510 --> 00:19:13,760
technological evidence on a planet or or

587
00:19:16,310 --> 00:19:15,520
elsewhere orbiting the planet or in the

588
00:19:19,270 --> 00:19:16,320

solar system

589
00:19:21,430 --> 00:19:19,280
but something that betrays evidence of

590
00:19:22,630 --> 00:19:21,440
technology just like a biosignature

591
00:19:23,990 --> 00:19:22,640
would be something you would look for

592
00:19:27,750 --> 00:19:24,000
that would betray evidence

593
00:19:29,669 --> 00:19:27,760
of life and so earth we're

594
00:19:31,110 --> 00:19:29,679
probably not a type one we're definitely

595
00:19:33,669 --> 00:19:31,120
not a type one kardashev

596
00:19:35,350 --> 00:19:33,679
yet we were i think about point seventy

597
00:19:37,430 --> 00:19:35,360
percent or eighty percent there

598
00:19:39,350 --> 00:19:37,440
roughly depending on how you calculate

599
00:19:43,029 --> 00:19:39,360
it and we're not at a type

600
00:19:44,070 --> 00:19:43,039
5 the class 5 planet yet we don't have

601
00:19:46,390 --> 00:19:44,080
this full

602
00:19:47,669 --> 00:19:46,400
thick technosphere we're what adam frank

603
00:19:49,750 --> 00:19:47,679
calls a hybrid planet

604
00:19:50,870 --> 00:19:49,760
we're between class 4 and 5 and the

605
00:19:53,110 --> 00:19:50,880
question is

606
00:19:54,950 --> 00:19:53,120
can we make it for the long term to be

607
00:19:57,669 --> 00:19:54,960
this this long-term

608
00:19:58,950 --> 00:19:57,679
sustainable planet with a thick techno

609
00:20:00,950 --> 00:19:58,960
sphere

610
00:20:02,549 --> 00:20:00,960
interesting does he also in this writing

611
00:20:04,870 --> 00:20:02,559
does he envision that technosphere

612
00:20:06,470 --> 00:20:04,880
growing out from the planet as well

613
00:20:08,710 --> 00:20:06,480

i mean we have things in orbit right now

614
00:20:09,990 --> 00:20:08,720
around our world a lot of us have loved

615
00:20:12,070 --> 00:20:10,000
like games like halo

616
00:20:13,750 --> 00:20:12,080
and and ring world from larry niven and

617
00:20:15,669 --> 00:20:13,760
science fiction some of these ideas

618
00:20:17,110 --> 00:20:15,679
um what is that for a techno signature

619
00:20:19,190 --> 00:20:17,120
then in this kind of scale

620
00:20:20,470 --> 00:20:19,200
when it goes beyond the world absolutely

621
00:20:22,230 --> 00:20:20,480
absolutely yeah that's where it's a

622
00:20:22,870 --> 00:20:22,240
compliment to the kardashians scale so

623
00:20:26,149 --> 00:20:22,880
the the

624
00:20:28,390 --> 00:20:26,159
atom scale really takes you up to

625
00:20:29,350 --> 00:20:28,400
class in type type one kardashev and

626
00:20:31,270 --> 00:20:29,360
then yeah of course

627
00:20:34,149 --> 00:20:31,280
so you know at this meeting techno

628
00:20:36,549 --> 00:20:34,159
climbs which was uh an online workshop

629
00:20:38,950 --> 00:20:36,559
we we did pitch it to nasa as an

630
00:20:40,390 --> 00:20:38,960
in-person workshop and then the pandemic

631
00:20:41,750 --> 00:20:40,400
happened and we said like well this is a

632
00:20:43,750 --> 00:20:41,760
great opportunity to

633
00:20:45,270 --> 00:20:43,760
at least still get together and talk

634
00:20:46,789 --> 00:20:45,280
about technic signatures and it was a

635
00:20:48,789 --> 00:20:46,799
really fun time and

636
00:20:50,390 --> 00:20:48,799
i'll tell you about the workshop in a

637
00:20:51,909 --> 00:20:50,400
bit um but

638
00:20:54,070 --> 00:20:51,919

we focused it really heavily on

639
00:20:55,350 --> 00:20:54,080
discussion which again can be more fun

640
00:20:56,149 --> 00:20:55,360
when you get to have dinner with people

641
00:20:58,630 --> 00:20:56,159
but you know what

642
00:20:59,190 --> 00:20:58,640
we had like you know over two hours of a

643
00:21:02,710 --> 00:20:59,200
really

644
00:21:05,350 --> 00:21:02,720
thought provoking

645
00:21:05,990 --> 00:21:05,360
we had a really wide range of career

646
00:21:07,510 --> 00:21:06,000
stages

647
00:21:09,350 --> 00:21:07,520
we had everyone from a high school

648
00:21:11,190 --> 00:21:09,360
student to to uh

649
00:21:12,470 --> 00:21:11,200
you know retirees in the field jill

650
00:21:15,510 --> 00:21:12,480
tarter was even there

651
00:21:17,029 --> 00:21:15,520
um we had we was and we even have

652
00:21:18,710 --> 00:21:17,039
three papers that are coming out of this

653
00:21:21,350 --> 00:21:18,720
that are being worked on now as to

654
00:21:24,549 --> 00:21:21,360
report to the community and what we did

655
00:21:26,950 --> 00:21:24,559
um so we certainly talked about techno

656
00:21:29,270 --> 00:21:26,960
signatures at all scales so

657
00:21:30,149 --> 00:21:29,280
some one example of a tech new signature

658
00:21:32,390 --> 00:21:30,159
might be

659
00:21:35,110 --> 00:21:32,400
things in the planet's atmosphere so

660
00:21:37,830 --> 00:21:35,120
with biosignatures you might look for

661
00:21:38,710 --> 00:21:37,840
wet methane and water vapor and oxygen

662
00:21:40,710 --> 00:21:38,720
and ozone

663
00:21:42,630 --> 00:21:40,720

so techno signatures might be something

664
00:21:44,470 --> 00:21:42,640
like chlorofluorocarbons

665
00:21:46,390 --> 00:21:44,480
which which as far as we know there's no

666
00:21:48,710 --> 00:21:46,400
biological process to make them these

667
00:21:50,950 --> 00:21:48,720
are industrial gases so there's

668
00:21:52,710 --> 00:21:50,960
you know things like that and there's a

669
00:21:54,230 --> 00:21:52,720
whole class of these these cfcs and

670
00:21:57,350 --> 00:21:54,240
related compounds

671
00:21:59,909 --> 00:21:57,360
um that if if you were to see those in

672
00:22:02,070 --> 00:21:59,919
a planet's atmosphere that might be

673
00:22:04,230 --> 00:22:02,080
either sign of industrial pollution

674
00:22:06,470 --> 00:22:04,240
maybe they're they're also potent

675
00:22:08,630 --> 00:22:06,480
greenhouse gases so maybe they're

676
00:22:09,510 --> 00:22:08,640
you know a civilization is using this to

677
00:22:11,310 --> 00:22:09,520
terraform

678
00:22:13,430 --> 00:22:11,320
a planet you could put a bunch of

679
00:22:14,630 --> 00:22:13,440
chlorofluorocarbons in mars for example

680
00:22:16,390 --> 00:22:14,640
to help warm

681
00:22:17,750 --> 00:22:16,400
that up if if that were something we

682
00:22:20,630 --> 00:22:17,760
were trying to do

683
00:22:22,710 --> 00:22:20,640
um but but there's other examples it

684
00:22:25,350 --> 00:22:22,720
could be a geoengineering

685
00:22:26,870 --> 00:22:25,360
maybe there's this proposal that i i

686
00:22:28,950 --> 00:22:26,880
don't really think we should do

687
00:22:31,590 --> 00:22:28,960
but it's this idea of putting uh

688
00:22:32,870 --> 00:22:31,600

essentially dust like aerosol particles

689
00:22:34,549 --> 00:22:32,880
up in the upper

690
00:22:37,110 --> 00:22:34,559
stratosphere layer of the earth's

691
00:22:38,710 --> 00:22:37,120
atmosphere to reflect away sunlight to

692
00:22:40,230 --> 00:22:38,720
offset climate change

693
00:22:42,789 --> 00:22:40,240
i've been some people are researching

694
00:22:44,950 --> 00:22:42,799
this and so if you were to do this

695
00:22:47,110 --> 00:22:44,960
you know over long time skills you might

696
00:22:48,630 --> 00:22:47,120
be able to detect evidence of that as a

697
00:22:49,909 --> 00:22:48,640
techno signature

698
00:22:52,149 --> 00:22:49,919
so there's there's things in the

699
00:22:53,750 --> 00:22:52,159
atmosphere itself that could be detected

700
00:22:55,990 --> 00:22:53,760
but then move a little ways out

701
00:22:58,950 --> 00:22:56,000
we have lots of satellites orbiting

702
00:23:00,950 --> 00:22:58,960
earth um

703
00:23:03,590 --> 00:23:00,960
our satellites may only be dimly

704
00:23:05,909 --> 00:23:03,600
detectable it depends on on what kind of

705
00:23:07,190 --> 00:23:05,919
instrument our hypothetical alien

706
00:23:10,070 --> 00:23:07,200
observers are using

707
00:23:11,669 --> 00:23:10,080
but you could imagine a much thicker

708
00:23:13,270 --> 00:23:11,679
satellite belt

709
00:23:15,270 --> 00:23:13,280
in orbit either around the planet or

710
00:23:18,310 --> 00:23:15,280
even at a greater orbit

711
00:23:20,789 --> 00:23:18,320
that you know further distant out orbit

712
00:23:22,710 --> 00:23:20,799
and that could certainly be detectable

713
00:23:24,870 --> 00:23:22,720

we talked about you know

714
00:23:26,310 --> 00:23:24,880
this kardashev type one and type two

715
00:23:28,390 --> 00:23:26,320
well how do you harness

716
00:23:30,870 --> 00:23:28,400
all the energy coming from your sign

717
00:23:33,430 --> 00:23:30,880
well you you build what's called a

718
00:23:35,029 --> 00:23:33,440
dyson sphere or a dyson swarm named

719
00:23:36,470 --> 00:23:35,039
after physicist freeman dyson he

720
00:23:38,549 --> 00:23:36,480
proposed the idea

721
00:23:39,669 --> 00:23:38,559
and so this is building giant solar

722
00:23:42,149 --> 00:23:39,679
collectors

723
00:23:42,870 --> 00:23:42,159
that orbit you know and essentially

724
00:23:45,909 --> 00:23:42,880
enclose

725
00:23:48,070 --> 00:23:45,919
the whole star if possible at

726
00:23:49,430 --> 00:23:48,080
some orbit and you're collecting vast

727
00:23:52,789 --> 00:23:49,440
amount of energy

728
00:23:55,269 --> 00:23:52,799
to support and support your

729
00:23:56,950 --> 00:23:55,279
your civilization so those are are some

730
00:23:57,830 --> 00:23:56,960
types of techno signatures we might

731
00:24:00,230 --> 00:23:57,840
imagine

732
00:24:00,950 --> 00:24:00,240
um now another thing we could think

733
00:24:04,070 --> 00:24:00,960
about too

734
00:24:05,750 --> 00:24:04,080
is the idea if if i was an

735
00:24:07,590 --> 00:24:05,760
you know alien in one of these

736
00:24:09,750 --> 00:24:07,600
long-lived civilizations

737
00:24:11,269 --> 00:24:09,760
out uh 100 light years away especially

738
00:24:12,950 --> 00:24:11,279

you picked a very short distance 100

739
00:24:13,830 --> 00:24:12,960
light years away which is good for this

740
00:24:16,310 --> 00:24:13,840
experiment

741
00:24:17,909 --> 00:24:16,320
so uh i might want to send an

742
00:24:20,870 --> 00:24:17,919
exploratory probe

743
00:24:22,549 --> 00:24:20,880
to this the earth to to the solar system

744
00:24:26,230 --> 00:24:22,559
and see what's going on there

745
00:24:28,149 --> 00:24:26,240
um we've sent spacecraft out of the

746
00:24:29,990 --> 00:24:28,159
solar system not necessarily to any

747
00:24:31,990 --> 00:24:30,000
other stars yet but the voyager and

748
00:24:33,510 --> 00:24:32,000
pioneer spacecraft

749
00:24:35,350 --> 00:24:33,520
have left or are leaving the solar

750
00:24:36,470 --> 00:24:35,360
system and so we know this is the thing

751
00:24:38,390 --> 00:24:36,480
you can do

752
00:24:39,510 --> 00:24:38,400
breakthrough star shot is a privately

753
00:24:41,510 --> 00:24:39,520
funded mission

754
00:24:43,190 --> 00:24:41,520
that's at least developing the concept

755
00:24:46,549 --> 00:24:43,200
for how you would send little

756
00:24:49,990 --> 00:24:46,559
postage stamp size probes to alpha

757
00:24:51,669 --> 00:24:50,000
centauri proxima centauri system

758
00:24:53,669 --> 00:24:51,679
so this is a thing we could do and so

759
00:24:55,909 --> 00:24:53,679
that's the thing you could search for

760
00:24:56,710 --> 00:24:55,919
in the solar system is well is there

761
00:24:59,510 --> 00:24:56,720
evidence

762
00:25:00,390 --> 00:24:59,520
of extraterrestrial spacecraft in the

763
00:25:02,230 --> 00:25:00,400

solar system

764
00:25:03,750 --> 00:25:02,240
they might not even work anymore it

765
00:25:05,510 --> 00:25:03,760
could be the end of life

766
00:25:08,230 --> 00:25:05,520
of their mission but there's these

767
00:25:10,470 --> 00:25:08,240
stable lagrange points they're called

768
00:25:11,190 --> 00:25:10,480
there's stable gravitational positions

769
00:25:12,710 --> 00:25:11,200
between

770
00:25:14,549 --> 00:25:12,720
planets it's kind of a weird thing to

771
00:25:15,510 --> 00:25:14,559
think about but there's certain places

772
00:25:17,029 --> 00:25:15,520
in space where

773
00:25:19,029 --> 00:25:17,039
you just get asteroids and junk

774
00:25:21,190 --> 00:25:19,039
collecting and it just sits there

775
00:25:22,549 --> 00:25:21,200
because even though it's just outside of

776
00:25:24,950 --> 00:25:22,559
the planet that's a

777
00:25:26,230 --> 00:25:24,960
stable orbit for it so there could be

778
00:25:28,070 --> 00:25:26,240
alien garbage

779
00:25:29,669 --> 00:25:28,080
floating around in some of these places

780
00:25:30,870 --> 00:25:29,679
and we just need to find the right way

781
00:25:32,789 --> 00:25:30,880
to look for it

782
00:25:34,070 --> 00:25:32,799
i don't know how likely these hypotheses

783
00:25:35,350 --> 00:25:34,080
are but these are things we can think

784
00:25:37,269 --> 00:25:35,360
about doing now

785
00:25:39,669 --> 00:25:37,279
and and that's one way to think about

786
00:25:42,630 --> 00:25:39,679
techno signatures we're not saying

787
00:25:43,990 --> 00:25:42,640
we as humans can imagine every possible

788
00:25:45,909 --> 00:25:44,000

technology out there

789
00:25:47,350 --> 00:25:45,919
what we're actually saying is we can we

790
00:25:50,710 --> 00:25:47,360
know what we can do

791
00:25:53,110 --> 00:25:50,720
and we know what we could do with

792
00:25:54,630 --> 00:25:53,120
a lot of funding or just a bunch more

793
00:25:56,390 --> 00:25:54,640
time

794
00:25:58,470 --> 00:25:56,400
and those are at least things that are

795
00:26:00,070 --> 00:25:58,480
plausible they are consistent with the

796
00:26:01,669 --> 00:26:00,080
laws of physics that we know

797
00:26:03,430 --> 00:26:01,679
there might be other things out there i

798
00:26:04,950 --> 00:26:03,440
would love to know about them but that's

799
00:26:08,390 --> 00:26:04,960
at least a great way to start

800
00:26:09,669 --> 00:26:08,400
thinking about this is what's plausible

801
00:26:11,430 --> 00:26:09,679
what's physically possible

802
00:26:13,269 --> 00:26:11,440
it's harder to rule things out but you

803
00:26:14,950 --> 00:26:13,279
can at least make plausibility arguments

804
00:26:16,789 --> 00:26:14,960
and try to search for those things

805
00:26:18,070 --> 00:26:16,799
and i guess one other thing i'll say

806
00:26:20,149 --> 00:26:18,080
from this meeting

807
00:26:21,510 --> 00:26:20,159
it's directly related to that is you

808
00:26:23,909 --> 00:26:21,520
can't always have

809
00:26:26,310 --> 00:26:23,919
a neat hypothesis driven investigation

810
00:26:29,110 --> 00:26:26,320
like that for techno signature science

811
00:26:29,990 --> 00:26:29,120
a lot of astronomy was was serendipity

812
00:26:32,710 --> 00:26:30,000
it was a

813
00:26:36,070 --> 00:26:32,720

an unprecedented discovery of something

814
00:26:39,190 --> 00:26:36,080
weird and you did not necessarily have

815
00:26:41,669 --> 00:26:39,200
theory for that observation at the time

816
00:26:43,510 --> 00:26:41,679
and that had to come second and so we

817
00:26:45,990 --> 00:26:43,520
should do both we should look

818
00:26:47,669 --> 00:26:46,000
for plausible things that we can think

819
00:26:48,149 --> 00:26:47,679
of for techno signatures we should also

820
00:26:51,350 --> 00:26:48,159
look for

821
00:26:53,269 --> 00:26:51,360
weird things everywhere not jump to the

822
00:26:54,789 --> 00:26:53,279
conclusion that it must be aliens

823
00:26:57,029 --> 00:26:54,799
but look for weird things you're going

824
00:26:58,870 --> 00:26:57,039
to learn interesting science anyway

825
00:27:00,789 --> 00:26:58,880
and you know the discovery of ex of the

826
00:27:01,269 --> 00:27:00,799
techno signature it could come from some

827
00:27:03,190 --> 00:27:01,279
field

828
00:27:05,029 --> 00:27:03,200
that's not doing astrobiology right now

829
00:27:07,110 --> 00:27:05,039
and they find something weird

830
00:27:09,029 --> 00:27:07,120
and hopefully eventually talk to some

831
00:27:11,750 --> 00:27:09,039
astrobiologists who helped sort it out

832
00:27:12,870 --> 00:27:11,760
and probably spent decades arguing about

833
00:27:15,990 --> 00:27:12,880
it but you know

834
00:27:18,830 --> 00:27:16,000
maybe that's what what it'll really be

835
00:27:20,389 --> 00:27:18,840
is not this nice neat we've discovered

836
00:27:21,909 --> 00:27:20,399
chlorofluorocarbons on

837
00:27:23,510 --> 00:27:21,919
you know another planet but it'll be

838
00:27:24,549 --> 00:27:23,520

just something totally weird that we

839
00:27:26,310 --> 00:27:24,559
didn't expect

840
00:27:28,310 --> 00:27:26,320
yeah that's awesome i mean you know you

841
00:27:29,430 --> 00:27:28,320
have those eureka moments right um

842
00:27:31,350 --> 00:27:29,440
and sometimes it's like well why didn't

843
00:27:32,630 --> 00:27:31,360
i think of that because there are things

844
00:27:33,830 --> 00:27:32,640
that we just don't know yet

845
00:27:35,029 --> 00:27:33,840
we humans are learning we're always

846
00:27:36,870 --> 00:27:35,039
curious we're always learning so i'm

847
00:27:38,230 --> 00:27:36,880
very glad to hear you frame it that way

848
00:27:39,750 --> 00:27:38,240
uh also glad to hear that you brought

849
00:27:40,630 --> 00:27:39,760
freeman dyson in the idea of the dyson

850
00:27:42,630 --> 00:27:40,640
sphere since

851
00:27:44,070 --> 00:27:42,640
it was originally his idea just for why

852
00:27:46,230 --> 00:27:44,080
we should be looking for

853
00:27:47,350 --> 00:27:46,240
alien technology outside of just radio

854
00:27:49,590 --> 00:27:47,360
waves right we should look in

855
00:27:51,430 --> 00:27:49,600
infrared as well to find something like

856
00:27:53,909 --> 00:27:51,440
a dyson sphere yes you're

857
00:27:55,029 --> 00:27:53,919
awesome i have this uh nice model of a

858
00:27:56,630 --> 00:27:55,039
dyson sphere

859
00:27:58,870 --> 00:27:56,640
ryan felton made this he was on our

860
00:28:02,549 --> 00:27:58,880
organizing committee so we have

861
00:28:05,029 --> 00:28:02,559
life looks for life it's a

862
00:28:07,110 --> 00:28:05,039
say a carl sacon quote and yeah it spins

863
00:28:08,789 --> 00:28:07,120

around so we've got a little 3d printed

864
00:28:10,789 --> 00:28:08,799
dyson sphere here it's very cool yeah we

865
00:28:12,230 --> 00:28:10,799
can go into philosophy forever of

866
00:28:14,149 --> 00:28:12,240
whether or not it's like you know that

867
00:28:15,110 --> 00:28:14,159
life actually does have to look for life

868
00:28:17,029 --> 00:28:15,120
is that part of

869
00:28:18,549 --> 00:28:17,039
something that's innate and born into us

870
00:28:21,029 --> 00:28:18,559
uh we don't have much more time yet

871
00:28:22,710 --> 00:28:21,039
uh just you and i uh conversing here i

872
00:28:23,430 --> 00:28:22,720
see lots of questions coming in from our

873
00:28:25,029 --> 00:28:23,440
audience

874
00:28:26,230 --> 00:28:25,039
uh a reminder for those watching if you

875
00:28:27,350 --> 00:28:26,240
haven't asked the question or would like

876
00:28:29,669 --> 00:28:27,360
to ask a question for dick

877
00:28:32,070 --> 00:28:29,679
for dr hawk misra you can ask in the

878
00:28:33,669 --> 00:28:32,080
chat on facebook or on segonnet

879
00:28:36,310 --> 00:28:33,679
or if you like you can use hashtag

880
00:28:38,389 --> 00:28:36,320
askastrobio on twitter to ask a question

881
00:28:39,669 --> 00:28:38,399
uh those are starting to peel in now in

882
00:28:42,549 --> 00:28:39,679
my teleprompter

883
00:28:43,830 --> 00:28:42,559
uh before we go to the q a though i have

884
00:28:45,590 --> 00:28:43,840
a few more things i'd love to talk about

885
00:28:46,630 --> 00:28:45,600
with you uh one of those i know that

886
00:28:48,549 --> 00:28:46,640
right now

887
00:28:50,549 --> 00:28:48,559
you're working on a book on mars

888
00:28:52,549 --> 00:28:50,559

settlement specifically focusing

889
00:28:54,149 --> 00:28:52,559
on the governance of mars uh and i'm

890
00:28:56,389 --> 00:28:54,159
wondering if you could talk to us about

891
00:28:58,149 --> 00:28:56,399
why that issue is so important to you

892
00:29:00,230 --> 00:28:58,159
uh and what you envisioned for the for

893
00:29:03,750 --> 00:29:00,240
the future of human exploration of mars

894
00:29:04,470 --> 00:29:03,760
especially mars governance i think a lot

895
00:29:06,470 --> 00:29:04,480
of us

896
00:29:08,230 --> 00:29:06,480
are interested in this idea of where are

897
00:29:10,470 --> 00:29:08,240
humans going to go in space

898
00:29:11,990 --> 00:29:10,480
and you know that's not what that's

899
00:29:13,750 --> 00:29:12,000
separate from this idea of planetary

900
00:29:15,190 --> 00:29:13,760
habitability but but it is related in

901
00:29:15,990 --> 00:29:15,200
the sense to what extent does the

902
00:29:17,909 --> 00:29:16,000
species

903
00:29:19,510 --> 00:29:17,919
leave its planet and is that possible

904
00:29:20,710 --> 00:29:19,520
because that would inform what kind of

905
00:29:24,149 --> 00:29:20,720
techno signatures

906
00:29:26,310 --> 00:29:24,159
we would look for um but um you know as

907
00:29:27,830 --> 00:29:26,320
these private investors uh

908
00:29:29,510 --> 00:29:27,840
well you know there's companies like

909
00:29:30,950 --> 00:29:29,520
spacex um

910
00:29:32,630 --> 00:29:30,960
and others that are interested in either

911
00:29:35,669 --> 00:29:32,640
going to mars or asteroids

912
00:29:37,110 --> 00:29:35,679
and uh nasa and china and and um the

913
00:29:41,029 --> 00:29:37,120

united arab emirates

914
00:29:43,190 --> 00:29:41,039
mission uh they're planning on sending

915
00:29:44,630 --> 00:29:43,200
humans to mars by 2117.

916
00:29:46,549 --> 00:29:44,640
so there's this interest in sending

917
00:29:46,950 --> 00:29:46,559
people to mars and i started wondering

918
00:29:49,830 --> 00:29:46,960
well

919
00:29:51,830 --> 00:29:49,840
how does you know governance who owns

920
00:29:53,350 --> 00:29:51,840
mars was my first question and i started

921
00:29:54,950 --> 00:29:53,360
you know getting deeper into it and

922
00:29:55,990 --> 00:29:54,960
learning that well there's this outer

923
00:29:58,789 --> 00:29:56,000
space treaty

924
00:30:01,269 --> 00:29:58,799
that says that you can't have space

925
00:30:04,149 --> 00:30:01,279
appropriated by a sovereign nation

926
00:30:05,909 --> 00:30:04,159
so it can't be claimed by anybody but

927
00:30:07,350 --> 00:30:05,919
you know it's it's not just as cut as

928
00:30:10,710 --> 00:30:07,360
dry as that because you're still

929
00:30:12,950 --> 00:30:10,720
there's there's momentum in building um

930
00:30:14,389 --> 00:30:12,960
essentially space settlements as i

931
00:30:15,990 --> 00:30:14,399
learned more about it

932
00:30:17,830 --> 00:30:16,000
this outer space treaty was written

933
00:30:20,389 --> 00:30:17,840
during the middle of the cold war

934
00:30:21,029 --> 00:30:20,399
uh when the the real interest in space

935
00:30:24,950 --> 00:30:21,039
was

936
00:30:25,669 --> 00:30:24,960
space the united states or the soviet

937
00:30:26,870 --> 00:30:25,679
union

938
00:30:28,710 --> 00:30:26,880

and they were afraid of the

939
00:30:30,149 --> 00:30:28,720
militarization of space they're afraid

940
00:30:33,190 --> 00:30:30,159
of the moon becoming

941
00:30:37,190 --> 00:30:33,200
either the 51st state or another

942
00:30:39,590 --> 00:30:37,200
um you know annex of russia um

943
00:30:41,110 --> 00:30:39,600
so so that was part of the motivation

944
00:30:42,789 --> 00:30:41,120
there was nobody was thinking about

945
00:30:44,789 --> 00:30:42,799
commercial space exploration

946
00:30:46,149 --> 00:30:44,799
when this was written and so that's

947
00:30:49,350 --> 00:30:46,159
really what motivated me

948
00:30:52,070 --> 00:30:49,360
to to to work on studying this

949
00:30:53,510 --> 00:30:52,080
and um so it's kind of the nutshell of

950
00:30:55,990 --> 00:30:53,520
the book is what can we learn from

951
00:30:56,549 --> 00:30:56,000
governance on earth where we have you

952
00:30:59,110 --> 00:30:56,559
know

953
00:31:00,950 --> 00:30:59,120
sharing of resources where we're where

954
00:31:02,789 --> 00:31:00,960
it's not just one nation owns everything

955
00:31:04,630 --> 00:31:02,799
but are there places we can look

956
00:31:06,389 --> 00:31:04,640
where there's this sharing either

957
00:31:08,710 --> 00:31:06,399
successfully or unsuccessfully and what

958
00:31:11,110 --> 00:31:08,720
can we learn from that for what might

959
00:31:13,110 --> 00:31:11,120
apply to the mars environment so one

960
00:31:16,389 --> 00:31:13,120
example is antarctica

961
00:31:17,430 --> 00:31:16,399
where it's mars-like in the sense that

962
00:31:19,750 --> 00:31:17,440
it's very remote

963
00:31:21,750 --> 00:31:19,760

you have to have all your supplies

964
00:31:24,870 --> 00:31:21,760
delivered on a regular basis

965
00:31:27,669 --> 00:31:24,880
the the conditions for survival are not

966
00:31:29,430 --> 00:31:27,679
uh really they don't really promote

967
00:31:29,990 --> 00:31:29,440
human flourishing you really have to

968
00:31:31,590 --> 00:31:30,000
have

969
00:31:34,070 --> 00:31:31,600
be prepared in order to survive in

970
00:31:35,909 --> 00:31:34,080
antarctica and also

971
00:31:37,830 --> 00:31:35,919
most of what goes on in antarctica is

972
00:31:39,909 --> 00:31:37,840
science research and that

973
00:31:41,430 --> 00:31:39,919
may be at least you know for the

974
00:31:43,750 --> 00:31:41,440
near-term future a lot of what happens

975
00:31:47,909 --> 00:31:43,760
in space too and is happening in space

976
00:31:49,750 --> 00:31:47,919
um so the antarctic treaty system

977
00:31:51,029 --> 00:31:49,760
kind of is a weird model we won't get

978
00:31:52,470 --> 00:31:51,039
into all the details

979
00:31:55,669 --> 00:31:52,480
but there actually are claims in

980
00:31:57,509 --> 00:31:55,679
antarctica and the treaty came later

981
00:31:58,710 --> 00:31:57,519
some of those claims conflict with each

982
00:32:01,990 --> 00:31:58,720
other but

983
00:32:04,070 --> 00:32:02,000
the treaty it suspends those

984
00:32:05,830 --> 00:32:04,080
claims so that's kind of the world we're

985
00:32:07,909 --> 00:32:05,840
living in now is where there are claims

986
00:32:09,750 --> 00:32:07,919
in the antarctic uh you if you go to

987
00:32:11,110 --> 00:32:09,760
for example the argentine sector i

988
00:32:12,789 --> 00:32:11,120

believe they will stamp your passport

989
00:32:14,549 --> 00:32:12,799
with an argentinian stand

990
00:32:15,830 --> 00:32:14,559
but it's meaningless in the sense that

991
00:32:18,470 --> 00:32:15,840
the treaty says that

992
00:32:19,750 --> 00:32:18,480
no one can assert that they control any

993
00:32:22,149 --> 00:32:19,760
part of antarctica

994
00:32:23,029 --> 00:32:22,159
um the prerequisites to be part of the

995
00:32:25,430 --> 00:32:23,039
treaty

996
00:32:26,310 --> 00:32:25,440
uh is to have the science base in

997
00:32:28,950 --> 00:32:26,320
antarctica

998
00:32:29,350 --> 00:32:28,960
so it's an interesting solution also

999
00:32:31,509 --> 00:32:29,360
where

1000
00:32:33,110 --> 00:32:31,519
it's not a united nations treaty but

1001
00:32:33,990 --> 00:32:33,120
anybody could collaborate with any

1002
00:32:36,950 --> 00:32:34,000
nation

1003
00:32:38,789 --> 00:32:36,960
to to have scientists in antarctica to

1004
00:32:41,750 --> 00:32:38,799
be part of that organization

1005
00:32:43,909 --> 00:32:41,760
um the reality of that is it it's

1006
00:32:46,070 --> 00:32:43,919
included most nations other than

1007
00:32:47,269 --> 00:32:46,080
uh almost all of africa except for south

1008
00:32:49,509 --> 00:32:47,279
africa who

1009
00:32:51,029 --> 00:32:49,519
probably doesn't have resources to

1010
00:32:54,710 --> 00:32:51,039
invest in antarctic

1011
00:32:55,269 --> 00:32:54,720
research program um so there's a lot

1012
00:32:57,029 --> 00:32:55,279
there

1013
00:32:58,710 --> 00:32:57,039

obviously that we won't unpack right now

1014
00:32:59,830 --> 00:32:58,720
but you can see where an example like

1015
00:33:02,470 --> 00:32:59,840
that there's some

1016
00:33:04,789 --> 00:33:02,480
some benefits and and maybe some aspects

1017
00:33:07,190 --> 00:33:04,799
to avoid with what we would do on mars

1018
00:33:07,830 --> 00:33:07,200
i'm not saying my book will solve the

1019
00:33:10,710 --> 00:33:07,840
problem

1020
00:33:12,710 --> 00:33:10,720
my goal is to to start this discussion

1021
00:33:14,389 --> 00:33:12,720
well in advance of when the first humans

1022
00:33:15,430 --> 00:33:14,399
actually go to mars that's awesome

1023
00:33:17,430 --> 00:33:15,440
i definitely look forward to reading the

1024
00:33:17,909 --> 00:33:17,440
book too the first that comes to mind

1025
00:33:20,310 --> 00:33:17,919
for me

1026
00:33:21,190 --> 00:33:20,320
is how governments through time have for

1027
00:33:23,350 --> 00:33:21,200
instance taken over

1028
00:33:25,350 --> 00:33:23,360
the lands of indigenous peoples uh and

1029
00:33:26,630 --> 00:33:25,360
then relegated them to other areas or

1030
00:33:28,230 --> 00:33:26,640
not at all

1031
00:33:30,070 --> 00:33:28,240
and just wiped them out and then chose

1032
00:33:31,909 --> 00:33:30,080
that they own this land now and

1033
00:33:33,590 --> 00:33:31,919
and how that those land laws have worked

1034
00:33:35,830 --> 00:33:33,600
through time based on

1035
00:33:36,950 --> 00:33:35,840
conquerors and things like that so i

1036
00:33:37,590 --> 00:33:36,960
look forward to reading the book for

1037
00:33:39,990 --> 00:33:37,600
sure

1038
00:33:41,509 --> 00:33:40,000

i'd love to talk more about that but i

1039
00:33:42,870 --> 00:33:41,519
really want to get into the q a soon one

1040
00:33:45,590 --> 00:33:42,880
more thing i want to bring up with you

1041
00:33:47,269 --> 00:33:45,600
before i open it up to our audience here

1042
00:33:48,710 --> 00:33:47,279
uh you know you're such a well-rounded

1043
00:33:49,509 --> 00:33:48,720
scientist you do all these really cool

1044
00:33:51,909 --> 00:33:49,519
things and

1045
00:33:52,870 --> 00:33:51,919
biosignatures and exoplanets and techno

1046
00:33:54,630 --> 00:33:52,880
signatures

1047
00:33:55,909 --> 00:33:54,640
and mars governance and these things

1048
00:33:57,669 --> 00:33:55,919
like this um

1049
00:33:59,269 --> 00:33:57,679
but you're also really into music and

1050
00:34:01,669 --> 00:33:59,279
you play with a band

1051
00:34:02,549 --> 00:34:01,679
tell us about that what drives you to be

1052
00:34:03,990 --> 00:34:02,559
involved in

1053
00:34:07,269 --> 00:34:04,000
enjoying this band and traveling around

1054
00:34:09,190 --> 00:34:07,279
making music i've played music for

1055
00:34:10,950 --> 00:34:09,200
most of my life you know i started

1056
00:34:12,710 --> 00:34:10,960
briefly on trombone but then moved to

1057
00:34:14,790 --> 00:34:12,720
percussion and i play

1058
00:34:15,750 --> 00:34:14,800
you know auxiliary percussion and drum

1059
00:34:18,149 --> 00:34:15,760
set and

1060
00:34:19,589 --> 00:34:18,159
mallet instruments and so i play in the

1061
00:34:21,750 --> 00:34:19,599
band is mystery train

1062
00:34:23,270 --> 00:34:21,760
and that's even how i met my wife gina

1063
00:34:25,909 --> 00:34:23,280

uh she's the keyboard player

1064
00:34:27,109 --> 00:34:25,919
and so i play you know uh percussion i

1065
00:34:29,669 --> 00:34:27,119
have a vibraphone

1066
00:34:30,230 --> 00:34:29,679
uh we have a drum set player we have uh

1067
00:34:34,069 --> 00:34:30,240
you know

1068
00:34:35,990 --> 00:34:34,079
rhythm guitar lead guitar and bass um

1069
00:34:38,069 --> 00:34:36,000
we're all original we're you know

1070
00:34:40,710 --> 00:34:38,079
stylistically along the lines of like

1071
00:34:42,790 --> 00:34:40,720
grateful dead almond brothers pink floyd

1072
00:34:43,750 --> 00:34:42,800
but it's all original music our lead

1073
00:34:45,909 --> 00:34:43,760
guitar dan

1074
00:34:48,790 --> 00:34:45,919
writes a lot of the songs gina writes an

1075
00:34:50,230 --> 00:34:48,800
awful lot i write a few songs um

1076
00:34:52,310 --> 00:34:50,240
and and yeah you know we play a lot of

1077
00:34:53,589 --> 00:34:52,320
festivals we'll play indoor shows over

1078
00:34:55,270 --> 00:34:53,599
the winter time

1079
00:34:57,109 --> 00:34:55,280
um you know we've we've been around for

1080
00:34:58,950 --> 00:34:57,119
11 years now and we've had some fun

1081
00:35:01,270 --> 00:34:58,960
shows we opened for the dark star

1082
00:35:02,150 --> 00:35:01,280
orchestra and rusted root and the mickey

1083
00:35:04,710 --> 00:35:02,160
heart band

1084
00:35:06,310 --> 00:35:04,720
and and yeah seeing a lot of fun places

1085
00:35:06,950 --> 00:35:06,320
been around the central pennsylvania

1086
00:35:09,750 --> 00:35:06,960
region

1087
00:35:11,589 --> 00:35:09,760
and you know into some other states um

1088
00:35:14,870 --> 00:35:11,599

right now of course with the pandemic

1089
00:35:15,270 --> 00:35:14,880
we are not uh uh playing shows but we

1090
00:35:17,510 --> 00:35:15,280
did

1091
00:35:19,349 --> 00:35:17,520
you know after 11 years we've put out a

1092
00:35:21,030 --> 00:35:19,359
lot of live recordings but we've never

1093
00:35:23,190 --> 00:35:21,040
really done a proper

1094
00:35:24,550 --> 00:35:23,200
you know mixed studio recording so

1095
00:35:26,870 --> 00:35:24,560
that's what we're doing now

1096
00:35:28,310 --> 00:35:26,880
and so we will be available uh to listen

1097
00:35:29,510 --> 00:35:28,320
to on spotify so too

1098
00:35:31,349 --> 00:35:29,520
oh that's wonderful i look forward to

1099
00:35:32,870 --> 00:35:31,359
listening to it then i've seen some of

1100
00:35:34,630 --> 00:35:32,880
the videos of you guys playing live but

1101
00:35:35,910 --> 00:35:34,640
yeah a studio recording be awesome

1102
00:35:37,750 --> 00:35:35,920
uh i'll definitely help with ask an

1103
00:35:39,670 --> 00:35:37,760
astro biologist to share that

1104
00:35:40,950 --> 00:35:39,680
um well let's go let's go to the q a now

1105
00:35:41,670 --> 00:35:40,960
since we do have a bunch of questions

1106
00:35:43,030 --> 00:35:41,680
pouring in

1107
00:35:45,589 --> 00:35:43,040
i know we don't have time for all of

1108
00:35:47,349 --> 00:35:45,599
them but everyone at home please asking

1109
00:35:48,870 --> 00:35:47,359
keep asking your questions if we don't

1110
00:35:50,310 --> 00:35:48,880
get to them we'll also share them with

1111
00:35:51,589 --> 00:35:50,320
jacob and he can answer them online

1112
00:35:53,430 --> 00:35:51,599
potentially later

1113
00:35:54,870 --> 00:35:53,440

um let's start off with a question from

1114
00:35:56,950 --> 00:35:54,880
marianne denton

1115
00:35:57,990 --> 00:35:56,960
a longtime viewer of the show she's at

1116
00:36:00,950 --> 00:35:58,000
astro limno

1117
00:36:01,589 --> 00:36:00,960
our astro underscore leno on twitter

1118
00:36:04,790 --> 00:36:01,599
marianne

1119
00:36:07,349 --> 00:36:04,800
asks is there an earth orbiter satellite

1120
00:36:08,150 --> 00:36:07,359
that shows our level of or rate of

1121
00:36:11,270 --> 00:36:08,160
change

1122
00:36:13,510 --> 00:36:11,280
in anthropogenic co2 that could help us

1123
00:36:14,589 --> 00:36:13,520
model for atmospheres of exoplanets that

1124
00:36:17,270 --> 00:36:14,599
may infer the presence of

1125
00:36:18,870 --> 00:36:17,280
industrialization

1126
00:36:21,030 --> 00:36:18,880
well they're definitely satellites that

1127
00:36:22,069 --> 00:36:21,040
measure co2 from space i think there's

1128
00:36:23,430 --> 00:36:22,079
several of them

1129
00:36:26,069 --> 00:36:23,440
i'm not going to be able to name them

1130
00:36:29,750 --> 00:36:26,079
off the top of my head but that is how

1131
00:36:32,630 --> 00:36:29,760
we we do you know as scientists earth

1132
00:36:34,310 --> 00:36:32,640
planetary scale monitoring and how we

1133
00:36:35,670 --> 00:36:34,320
determine not just what the co2

1134
00:36:37,829 --> 00:36:35,680
concentration is

1135
00:36:39,430 --> 00:36:37,839
on on the global scale but but on a

1136
00:36:40,870 --> 00:36:39,440
regional scale as well

1137
00:36:42,630 --> 00:36:40,880
so yeah there's there's a lot of people

1138
00:36:43,670 --> 00:36:42,640

building their careers off of those kind

1139
00:36:44,710 --> 00:36:43,680
of measurements and that kind of

1140
00:36:47,270 --> 00:36:44,720
analysis

1141
00:36:48,470 --> 00:36:47,280
um the second part of your question um

1142
00:36:50,150 --> 00:36:48,480
yet to some extent

1143
00:36:52,790 --> 00:36:50,160
what we're dealing with with climate

1144
00:36:53,349 --> 00:36:52,800
change or how we respond to it that does

1145
00:36:55,349 --> 00:36:53,359
teach us

1146
00:36:57,270 --> 00:36:55,359
a lot about you know how does an

1147
00:37:00,470 --> 00:36:57,280
industrial civilization

1148
00:37:01,349 --> 00:37:00,480
develop so we're using you know much of

1149
00:37:04,630 --> 00:37:01,359
climate change

1150
00:37:06,790 --> 00:37:04,640
is related to fossil fuels there's also

1151
00:37:08,230 --> 00:37:06,800
changes in land use deforestation but

1152
00:37:11,270 --> 00:37:08,240
the part that's about

1153
00:37:13,190 --> 00:37:11,280
uh fossil fuels fossil fuels are an

1154
00:37:15,030 --> 00:37:13,200
ancient fuel source come from ancient

1155
00:37:17,829 --> 00:37:15,040
plants that took a long time

1156
00:37:18,390 --> 00:37:17,839
to develop so that's that's the issue is

1157
00:37:21,430 --> 00:37:18,400
that we

1158
00:37:22,870 --> 00:37:21,440
our use of them is much much faster than

1159
00:37:24,470 --> 00:37:22,880
the rated which fossil fuels are

1160
00:37:26,550 --> 00:37:24,480
replenished which is incredibly slow

1161
00:37:30,550 --> 00:37:26,560
over geologic time scales

1162
00:37:32,950 --> 00:37:30,560
so how we deal with that

1163
00:37:33,670 --> 00:37:32,960

is at least a case study in how any

1164
00:37:36,230 --> 00:37:33,680
other

1165
00:37:37,190 --> 00:37:36,240
civilization deals with having this

1166
00:37:40,310 --> 00:37:37,200
really rapid

1167
00:37:41,109 --> 00:37:40,320
energy intense phase with a fuel that

1168
00:37:44,150 --> 00:37:41,119
doesn't have an

1169
00:37:46,950 --> 00:37:44,160
infinite supply um so so

1170
00:37:47,670 --> 00:37:46,960
how our story unfolds will help us with

1171
00:37:49,349 --> 00:37:47,680
the search

1172
00:37:50,630 --> 00:37:49,359
that's really cool yeah that's a great

1173
00:37:51,670 --> 00:37:50,640
quote too i might have to steal that one

1174
00:37:53,589 --> 00:37:51,680
for later

1175
00:37:54,950 --> 00:37:53,599
uh another question and this goes back

1176
00:37:56,710 --> 00:37:54,960
to mars governance

1177
00:37:58,550 --> 00:37:56,720
uh from one of our ambassadors and

1178
00:38:01,270 --> 00:37:58,560
actually a research associate with me

1179
00:38:03,910 --> 00:38:01,280
uh anna root mojante wants to know uh if

1180
00:38:05,510 --> 00:38:03,920
humans ever colonize another planet what

1181
00:38:07,990 --> 00:38:05,520
do you think the ideal system of

1182
00:38:09,990 --> 00:38:08,000
governance might be

1183
00:38:12,710 --> 00:38:10,000
that's a big question well i'll i will

1184
00:38:14,790 --> 00:38:12,720
plug my book with that i think the ideal

1185
00:38:16,710 --> 00:38:14,800
system of governance would be to let

1186
00:38:19,510 --> 00:38:16,720
mars be sovereign

1187
00:38:20,310 --> 00:38:19,520
so that once you set foot on mars as a

1188
00:38:23,349 --> 00:38:20,320

settler

1189
00:38:25,910 --> 00:38:23,359
you are now a planetary citizen of mars

1190
00:38:27,990 --> 00:38:25,920
you don't get to have property on earth

1191
00:38:29,910 --> 00:38:28,000
earthlings don't get to control mars

1192
00:38:31,589 --> 00:38:29,920
and the martians get to decide what

1193
00:38:34,150 --> 00:38:31,599
works best for them

1194
00:38:35,589 --> 00:38:34,160
that's it's an ambitious project it's

1195
00:38:37,670 --> 00:38:35,599
ambitious because

1196
00:38:39,030 --> 00:38:37,680
you're so resource limited on mars so

1197
00:38:41,349 --> 00:38:39,040
when would that happen

1198
00:38:42,069 --> 00:38:41,359
i don't know but yeah i don't i actually

1199
00:38:44,069 --> 00:38:42,079
don't

1200
00:38:45,589 --> 00:38:44,079
have one particular governance model but

1201
00:38:45,990 --> 00:38:45,599
i think the martians are going to be the

1202
00:38:48,870 --> 00:38:46,000
best

1203
00:38:49,910 --> 00:38:48,880
to determine that that's cool yeah solve

1204
00:38:52,390 --> 00:38:49,920
sovereignty

1205
00:38:54,630 --> 00:38:52,400
let them do it themselves another

1206
00:38:57,190 --> 00:38:54,640
question from sudita biswas

1207
00:38:58,230 --> 00:38:57,200
uh coming in from saginet uh sudhita

1208
00:39:00,630 --> 00:38:58,240
wants to know

1209
00:39:01,990 --> 00:39:00,640
how does one confirm an exoplanet might

1210
00:39:04,069 --> 00:39:02,000
be more habitable

1211
00:39:05,829 --> 00:39:04,079
than the earth which is an interesting

1212
00:39:09,430 --> 00:39:05,839
question

1213
00:39:12,150 --> 00:39:09,440

are some scientists

1214
00:39:13,910 --> 00:39:12,160
that are trying to quantify this uh evel

1215
00:39:15,510 --> 00:39:13,920
mendes at the university of puerto rico

1216
00:39:16,630 --> 00:39:15,520
is really interested in habitability

1217
00:39:20,790 --> 00:39:16,640
metrics

1218
00:39:24,470 --> 00:39:20,800
um but uh so so a simpler answer

1219
00:39:27,589 --> 00:39:24,480
from my work with climate models

1220
00:39:30,069 --> 00:39:27,599
is you could say something like how

1221
00:39:30,950 --> 00:39:30,079
what fraction of the time does this

1222
00:39:33,829 --> 00:39:30,960
planet

1223
00:39:35,430 --> 00:39:33,839
have liquid water on it that's just one

1224
00:39:38,630 --> 00:39:35,440
type of scenario the bigger

1225
00:39:39,349 --> 00:39:38,640
and suture question is is we're thinking

1226
00:39:41,510 --> 00:39:39,359
about it

1227
00:39:43,750 --> 00:39:41,520
we actually just need to have more

1228
00:39:44,550 --> 00:39:43,760
observations of exoplanets to really be

1229
00:39:47,910 --> 00:39:44,560
able to

1230
00:39:49,589 --> 00:39:47,920
to compare what you know that might be

1231
00:39:51,750 --> 00:39:49,599
you could also think about a planet that

1232
00:39:53,750 --> 00:39:51,760
has less water available

1233
00:39:55,670 --> 00:39:53,760
on certain areas of its surface than

1234
00:39:56,310 --> 00:39:55,680
others but there's going to be a lot of

1235
00:39:58,230 --> 00:39:56,320
factors

1236
00:40:00,150 --> 00:39:58,240
so not not just any one of those but but

1237
00:40:02,150 --> 00:40:00,160
many factors that would that would do

1238
00:40:04,230 --> 00:40:02,160

do that people even ask is earth as

1239
00:40:05,910 --> 00:40:04,240
habitable as it could be

1240
00:40:07,910 --> 00:40:05,920
uh that's an interesting question and

1241
00:40:10,150 --> 00:40:07,920
maybe you know you could imagine where

1242
00:40:13,349 --> 00:40:10,160
there was a little less ice and

1243
00:40:15,030 --> 00:40:13,359
more jungle but but um those those are

1244
00:40:17,109 --> 00:40:15,040
the fun questions that

1245
00:40:18,870 --> 00:40:17,119
you know you get to ask at astrobiology

1246
00:40:20,309 --> 00:40:18,880
yeah it's a cool question and actually

1247
00:40:22,069 --> 00:40:20,319
that really leads well into our next

1248
00:40:24,630 --> 00:40:22,079
question from my co-host

1249
00:40:26,309 --> 00:40:24,640
uh and a good friend sanjoy sam uh

1250
00:40:27,190 --> 00:40:26,319
sanjoy asks can you speak a little bit

1251
00:40:29,990 --> 00:40:27,200
more to our

1252
00:40:34,390 --> 00:40:30,000
own planet as a lab for understanding

1253
00:40:39,109 --> 00:40:37,510
yeah so uh sanjoy definitely knows that

1254
00:40:40,309 --> 00:40:39,119
i've spent some time thinking about

1255
00:40:42,390 --> 00:40:40,319
early earth maybe not

1256
00:40:43,829 --> 00:40:42,400
as much as he does he's definitely a

1257
00:40:46,870 --> 00:40:43,839
good friend and colleague

1258
00:40:49,270 --> 00:40:46,880
um but i so i

1259
00:40:50,069 --> 00:40:49,280
i did a project in my masters where i

1260
00:40:53,270 --> 00:40:50,079
looked at

1261
00:40:54,150 --> 00:40:53,280
the role of of methane in keeping earth

1262
00:40:57,190 --> 00:40:54,160
warm

1263
00:40:57,990 --> 00:40:57,200

uh if you go backwards in time uh the

1264
00:41:00,150 --> 00:40:58,000
sun

1265
00:41:02,069 --> 00:41:00,160
is is thought to have been less bright

1266
00:41:03,829 --> 00:41:02,079
then and i won't get into the details of

1267
00:41:04,230 --> 00:41:03,839
that that has to do with just how stars

1268
00:41:07,190 --> 00:41:04,240
work

1269
00:41:08,069 --> 00:41:07,200
and and and are powered by by nuclear

1270
00:41:11,829 --> 00:41:08,079
fusion

1271
00:41:13,190 --> 00:41:11,839
so so um a younger star is just not

1272
00:41:15,910 --> 00:41:13,200
quite as bright

1273
00:41:17,589 --> 00:41:15,920
and how did our planet then stay warm

1274
00:41:19,030 --> 00:41:17,599
and so one of the ideas i explored was

1275
00:41:21,430 --> 00:41:19,040
the role of methane

1276
00:41:24,630 --> 00:41:21,440
and the formation of a haze layer like

1277
00:41:28,069 --> 00:41:24,640
you might see on the planet titan

1278
00:41:29,510 --> 00:41:28,079
which has both positive effects and

1279
00:41:30,390 --> 00:41:29,520
helping keep the planet warm and

1280
00:41:32,470 --> 00:41:30,400
protected by

1281
00:41:34,870 --> 00:41:32,480
ultraviolet radiation and negative

1282
00:41:36,390 --> 00:41:34,880
effects of reflecting away sunlight and

1283
00:41:39,589 --> 00:41:36,400
cooling the planet

1284
00:41:40,870 --> 00:41:39,599
and so um and the other feature of this

1285
00:41:42,230 --> 00:41:40,880
the reason you even get the haze is

1286
00:41:44,710 --> 00:41:42,240
because this early earth

1287
00:41:46,230 --> 00:41:44,720
was it was a very very low oxygen

1288
00:41:48,069 --> 00:41:46,240

environment you had life

1289
00:41:49,750 --> 00:41:48,079
you may have had dissolved oxygen in

1290
00:41:52,309 --> 00:41:49,760
some places in the ocean

1291
00:41:53,589 --> 00:41:52,319
localized but but this would have been

1292
00:41:56,630 --> 00:41:53,599
before

1293
00:41:59,990 --> 00:41:56,640
large scale plant life or photosynthesis

1294
00:42:02,390 --> 00:42:00,000
emerged uh so early earth i think would

1295
00:42:05,670 --> 00:42:02,400
be more difficult to detect

1296
00:42:07,349 --> 00:42:05,680
as as a as a really strong biosignature

1297
00:42:09,990 --> 00:42:07,359
maybe but i mean i think this is again a

1298
00:42:12,630 --> 00:42:10,000
problem in astrobiology that's really

1299
00:42:14,150 --> 00:42:12,640
worth studying more if we found a

1300
00:42:16,950 --> 00:42:14,160
haze-covered planet

1301
00:42:18,630 --> 00:42:16,960
around another star in the habitable

1302
00:42:20,230 --> 00:42:18,640
zone i would get really excited

1303
00:42:21,829 --> 00:42:20,240
it wouldn't mean there must be life but

1304
00:42:24,069 --> 00:42:21,839
that would be a great

1305
00:42:25,510 --> 00:42:24,079
an analog for an early earth and we

1306
00:42:26,790 --> 00:42:25,520
could try to think about what else would

1307
00:42:30,069 --> 00:42:26,800
we look for

1308
00:42:32,069 --> 00:42:30,079
to determine if life is there or not

1309
00:42:33,109 --> 00:42:32,079
i am it's cool to think about right like

1310
00:42:35,109 --> 00:42:33,119
i don't know at what point do we

1311
00:42:37,589 --> 00:42:35,119
actually become detectable anywhere

1312
00:42:39,589 --> 00:42:37,599
um another question this comes in from

1313
00:42:42,790 --> 00:42:39,599

pritha jaipal and secondnet

1314
00:42:44,150 --> 00:42:42,800
uh pritha asks uh inspired by the series

1315
00:42:46,230 --> 00:42:44,160
the expanse

1316
00:42:47,190 --> 00:42:46,240
uh approximately how far away do you

1317
00:42:49,430 --> 00:42:47,200
think we are from

1318
00:42:50,630 --> 00:42:49,440
needing to make use of resources in our

1319
00:42:52,390 --> 00:42:50,640
solar system

1320
00:42:55,510 --> 00:42:52,400
uh after we've depleted the resources

1321
00:42:59,349 --> 00:42:58,470
i think we are close to needing rare

1322
00:43:03,270 --> 00:42:59,359
earth

1323
00:43:05,030 --> 00:43:03,280
metals for all our smartphones and

1324
00:43:08,069 --> 00:43:05,040
electronics

1325
00:43:11,109 --> 00:43:08,079
most of them on earth are in china

1326
00:43:13,670 --> 00:43:11,119
and that raises unique political

1327
00:43:14,950 --> 00:43:13,680
issues in accessing them and even the

1328
00:43:16,470 --> 00:43:14,960
ones that are there are still being

1329
00:43:19,109 --> 00:43:16,480
depleted on earth

1330
00:43:19,829 --> 00:43:19,119
so i think there's there's a lot of

1331
00:43:21,829 --> 00:43:19,839
investors

1332
00:43:23,430 --> 00:43:21,839
interested in asteroid mining now the

1333
00:43:25,990 --> 00:43:23,440
main product they're interested in

1334
00:43:26,710 --> 00:43:26,000
is water and i believe the water stays

1335
00:43:29,589 --> 00:43:26,720
in space

1336
00:43:30,870 --> 00:43:29,599
so it would be profitable to to harvest

1337
00:43:33,589 --> 00:43:30,880
water from asteroids

1338
00:43:35,510 --> 00:43:33,599

to use for for astronauts and whether

1339
00:43:38,390 --> 00:43:35,520
you drink the water you make oxygen

1340
00:43:41,349 --> 00:43:38,400
um so that's the first product but but

1341
00:43:43,510 --> 00:43:41,359
then you can get both precious metals

1342
00:43:44,630 --> 00:43:43,520
and rear earth metals rare earth

1343
00:43:47,990 --> 00:43:44,640
minerals uh

1344
00:43:50,150 --> 00:43:48,000
from asteroids i think that is going to

1345
00:43:52,230 --> 00:43:50,160
become increasingly important

1346
00:43:54,470 --> 00:43:52,240
in you know the next century i don't

1347
00:43:55,750 --> 00:43:54,480
know in the next five to ten years but

1348
00:43:59,190 --> 00:43:55,760
in the next century

1349
00:44:01,430 --> 00:43:59,200
i think that'll be uh that'll be

1350
00:44:03,430 --> 00:44:01,440
coupled with our our industries space

1351
00:44:04,950 --> 00:44:03,440
resources that may be like the next big

1352
00:44:06,790 --> 00:44:04,960
issue for our own sovereignty and our

1353
00:44:08,230 --> 00:44:06,800
governance right is trying to figure out

1354
00:44:09,349 --> 00:44:08,240
how do we actually bring more resources

1355
00:44:11,270 --> 00:44:09,359
that we need

1356
00:44:12,550 --> 00:44:11,280
uh another question from anna roop and i

1357
00:44:15,430 --> 00:44:12,560
should mention auto roof is that

1358
00:44:16,470 --> 00:44:15,440
strayologist on twitter and instagram uh

1359
00:44:17,430 --> 00:44:16,480
and this is going to make you put on

1360
00:44:20,069 --> 00:44:17,440
your your cosm

1361
00:44:21,190 --> 00:44:20,079
cosmology hat for a moment uh honor

1362
00:44:23,670 --> 00:44:21,200
wants to know

1363
00:44:24,790 --> 00:44:23,680

uh we have a speed limit in the universe

1364
00:44:26,870 --> 00:44:24,800
with light

1365
00:44:29,670 --> 00:44:26,880
do we have any limit on how far we can

1366
00:44:36,950 --> 00:44:32,870
well those things are related in fact so

1367
00:44:40,470 --> 00:44:36,960
if we're looking at the andromeda galaxy

1368
00:44:43,990 --> 00:44:40,480
25 million light years away

1369
00:44:45,109 --> 00:44:44,000
we're seeing the galaxy as it was 25

1370
00:44:46,550 --> 00:44:45,119
million years ago

1371
00:44:48,230 --> 00:44:46,560
because that's how long it took that

1372
00:44:51,750 --> 00:44:48,240
light to reach us

1373
00:44:54,790 --> 00:44:51,760
so the farther astronomy is actually

1374
00:44:56,710 --> 00:44:54,800
one of the only real ways to do

1375
00:44:58,630 --> 00:44:56,720
time travel even more so than

1376
00:45:00,630 --> 00:44:58,640
archaeology in a sense or maybe they're

1377
00:45:03,510 --> 00:45:00,640
very comparable in this sense

1378
00:45:04,870 --> 00:45:03,520
that with with astronomy the further

1379
00:45:07,589 --> 00:45:04,880
away you look

1380
00:45:08,710 --> 00:45:07,599
the further back in time you're looking

1381
00:45:11,510 --> 00:45:08,720
so the furthest back

1382
00:45:12,150 --> 00:45:11,520
you can look is just after the big bang

1383
00:45:15,190 --> 00:45:12,160
because

1384
00:45:17,190 --> 00:45:15,200
before that there was and it's there you

1385
00:45:19,510 --> 00:45:17,200
can get into the cosmology details about

1386
00:45:23,109 --> 00:45:19,520
exactly when there was luminosity to to

1387
00:45:25,109 --> 00:45:23,119
be observed but but you can't the yeah

1388
00:45:26,150 --> 00:45:25,119

that's how far you can observe because

1389
00:45:29,910 --> 00:45:26,160
that's how

1390
00:45:31,430 --> 00:45:29,920
old the universe is oh yeah it's cool

1391
00:45:32,630 --> 00:45:31,440
i mean everyone you know you go out at

1392
00:45:34,230 --> 00:45:32,640
night you look at the stars you're

1393
00:45:36,630 --> 00:45:34,240
looking back in time so

1394
00:45:37,750 --> 00:45:36,640
astronomy is this time machine um so

1395
00:45:39,349 --> 00:45:37,760
it's kind of fun to think about you know

1396
00:45:40,230 --> 00:45:39,359
that we are limited but we also are

1397
00:45:42,870 --> 00:45:40,240
looking back

1398
00:45:44,550 --> 00:45:42,880
uh so far in time uh here's a question

1399
00:45:45,589 --> 00:45:44,560
that's kind of off topic but kind of fun

1400
00:45:48,309 --> 00:45:45,599
to think about

1401
00:45:50,550 --> 00:45:48,319
uh it comes from tom caruso on facebook

1402
00:45:52,309 --> 00:45:50,560
uh tom state's recent discoveries

1403
00:45:54,710 --> 00:45:52,319
they show that you know we have icy you

1404
00:45:56,790 --> 00:45:54,720
know bodies these icy ocean worlds

1405
00:45:58,069 --> 00:45:56,800
uh all over in our solar system alone

1406
00:46:00,470 --> 00:45:58,079
and they're most likely

1407
00:46:02,470 --> 00:46:00,480
you know abundant elsewhere and on earth

1408
00:46:03,430 --> 00:46:02,480
we humans have put a lot of noise into

1409
00:46:05,190 --> 00:46:03,440
our oceans

1410
00:46:07,030 --> 00:46:05,200
uh and i would also add that also a lot

1411
00:46:07,910 --> 00:46:07,040
of other things have put noise into our

1412
00:46:09,910 --> 00:46:07,920
oceans

1413
00:46:12,309 --> 00:46:09,920

uh and so tom wants to know if we should

1414
00:46:14,309 --> 00:46:12,319
start a program of trying to listen

1415
00:46:15,349 --> 00:46:14,319
through the ice on some of these icy

1416
00:46:17,190 --> 00:46:15,359
worlds

1417
00:46:18,550 --> 00:46:17,200
for sounds below perhaps by

1418
00:46:21,990 --> 00:46:18,560
technological activity

1419
00:46:23,430 --> 00:46:22,000
of a subsurface being

1420
00:46:25,430 --> 00:46:23,440
i mean we really don't know what's out

1421
00:46:26,870 --> 00:46:25,440
there so um

1422
00:46:28,470 --> 00:46:26,880
you know one of the things that came

1423
00:46:29,750 --> 00:46:28,480
from the workshop

1424
00:46:32,150 --> 00:46:29,760
or at least was introduced to the

1425
00:46:35,190 --> 00:46:32,160
workshop by sophia sheikh

1426
00:46:37,030 --> 00:46:35,200
who's a phd student at penn state she's

1427
00:46:40,230 --> 00:46:37,040
developed the techno signature

1428
00:46:41,990 --> 00:46:40,240
axes of merit and this is

1429
00:46:43,910 --> 00:46:42,000
you know we can imagine so many

1430
00:46:47,030 --> 00:46:43,920
different techno signatures

1431
00:46:47,829 --> 00:46:47,040
and we really can't say that they must

1432
00:46:49,829 --> 00:46:47,839
be false

1433
00:46:51,430 --> 00:46:49,839
until we do a really thorough search and

1434
00:46:54,309 --> 00:46:51,440
we put some limits on

1435
00:46:55,670 --> 00:46:54,319
on what might be there so you you should

1436
00:46:57,670 --> 00:46:55,680
be able to

1437
00:46:59,270 --> 00:46:57,680
brainstorm as many types but then how do

1438
00:46:59,750 --> 00:46:59,280

you actually decide what's worth looking

1439
00:47:01,510 --> 00:46:59,760
for

1440
00:47:03,750 --> 00:47:01,520
and so she's got this nine access

1441
00:47:05,990 --> 00:47:03,760
framework that takes into account

1442
00:47:08,150 --> 00:47:06,000
just you know how expensive is the

1443
00:47:08,950 --> 00:47:08,160
search does it have ancillary benefits

1444
00:47:11,349 --> 00:47:08,960
to science

1445
00:47:12,230 --> 00:47:11,359
versus not you know what would the

1446
00:47:14,069 --> 00:47:12,240
impact be

1447
00:47:16,069 --> 00:47:14,079
there's there's some other criteria and

1448
00:47:17,510 --> 00:47:16,079
so um you know i think

1449
00:47:18,710 --> 00:47:17,520
i think all of these ideas are worth

1450
00:47:19,589 --> 00:47:18,720
talking about but then you know what do

1451
00:47:21,670 --> 00:47:19,599
you actually do

1452
00:47:22,710 --> 00:47:21,680
especially since resources and funding

1453
00:47:26,230 --> 00:47:22,720
is limited

1454
00:47:28,230 --> 00:47:26,240
um that's where you know the development

1455
00:47:31,030 --> 00:47:28,240
of theory comes into play

1456
00:47:33,430 --> 00:47:31,040
is you know would you expect what type

1457
00:47:36,950 --> 00:47:33,440
of signal would you expect under the ice

1458
00:47:38,069 --> 00:47:36,960
and why um if you were exploring for

1459
00:47:39,829 --> 00:47:38,079
other reasons and you found some

1460
00:47:40,950 --> 00:47:39,839
anomalies that would also be interesting

1461
00:47:43,109 --> 00:47:40,960
but if you were going to do an

1462
00:47:45,670 --> 00:47:43,119
intended search that would probably need

1463
00:47:47,430 --> 00:47:45,680

to be a more hypothesis-driven approach

1464
00:47:48,870 --> 00:47:47,440
interesting yeah it makes me think a lot

1465
00:47:50,950 --> 00:47:48,880
you know with the idea of sound in our

1466
00:47:51,990 --> 00:47:50,960
ocean from our technology and submarines

1467
00:47:53,349 --> 00:47:52,000
and things like that

1468
00:47:55,829 --> 00:47:53,359
we also have a lot of sound in our

1469
00:47:57,910 --> 00:47:55,839
oceans from shrimp and fish and whales

1470
00:47:59,589 --> 00:47:57,920
and other things that makes me wonder

1471
00:48:01,589 --> 00:47:59,599
has there been much discussion about

1472
00:48:03,750 --> 00:48:01,599
potential false positives and techno

1473
00:48:05,430 --> 00:48:03,760
signature research

1474
00:48:07,270 --> 00:48:05,440
is there a good chance there are signs

1475
00:48:09,190 --> 00:48:07,280
out there that would appear to us

1476
00:48:11,589 --> 00:48:09,200
at first flush as being technological

1477
00:48:13,829 --> 00:48:11,599
but maybe they aren't

1478
00:48:15,109 --> 00:48:13,839
absolutely yes tech false positives for

1479
00:48:17,109 --> 00:48:15,119
for techno signatures

1480
00:48:18,790 --> 00:48:17,119
are just like with biosignatures we

1481
00:48:19,990 --> 00:48:18,800
don't fully know what we're looking for

1482
00:48:22,309 --> 00:48:20,000
we can come up with some

1483
00:48:24,069 --> 00:48:22,319
some hypotheses but you have to take

1484
00:48:28,230 --> 00:48:24,079
into account the possibility

1485
00:48:29,349 --> 00:48:28,240
that what you see it may not fully be

1486
00:48:31,510 --> 00:48:29,359
explained by the

1487
00:48:32,630 --> 00:48:31,520
the biological or technological

1488
00:48:34,790 --> 00:48:32,640

mechanism you're

1489
00:48:36,950 --> 00:48:34,800
you're looking at um so you showed the

1490
00:48:39,589 --> 00:48:36,960
the photograph of italy at night

1491
00:48:40,470 --> 00:48:39,599
in the introduction or for the yesterday

1492
00:48:43,430 --> 00:48:40,480
on twitter

1493
00:48:44,710 --> 00:48:43,440
and so there's there's also evidence uh

1494
00:48:46,950 --> 00:48:44,720
over australia

1495
00:48:48,390 --> 00:48:46,960
from the same sets of photos of

1496
00:48:49,510 --> 00:48:48,400
wildfires

1497
00:48:51,190 --> 00:48:49,520
and you know i found this really

1498
00:48:53,270 --> 00:48:51,200
interesting i didn't realize that the

1499
00:48:54,710 --> 00:48:53,280
fires had been that bad in australia at

1500
00:48:57,829 --> 00:48:54,720
that time that they were

1501
00:48:58,390 --> 00:48:57,839
that detectable from space so if we were

1502
00:48:59,829 --> 00:48:58,400
to see

1503
00:49:02,230 --> 00:48:59,839
something you know build the right kind

1504
00:49:03,510 --> 00:49:02,240
of optical telescope image some of these

1505
00:49:06,309 --> 00:49:03,520
nearby planets

1506
00:49:08,150 --> 00:49:06,319
hypothetically and you were to see

1507
00:49:09,990 --> 00:49:08,160
bright lights like that

1508
00:49:12,630 --> 00:49:10,000
that would be a discussion then if let's

1509
00:49:15,910 --> 00:49:12,640
say it was unambiguously this

1510
00:49:16,790 --> 00:49:15,920
lights at night well are those sustained

1511
00:49:19,109 --> 00:49:16,800
fires

1512
00:49:20,470 --> 00:49:19,119
or are they city lights and and there

1513
00:49:22,549 --> 00:49:20,480

are ways that you could

1514
00:49:25,270 --> 00:49:22,559
could determine between those two things

1515
00:49:28,470 --> 00:49:25,280
but if that one image was all you had

1516
00:49:29,349 --> 00:49:28,480
that would be a discussion um now one of

1517
00:49:31,910 --> 00:49:29,359
the uh the

1518
00:49:33,270 --> 00:49:31,920
the workshop presenters thomas beatty he

1519
00:49:36,309 --> 00:49:33,280
has this great idea

1520
00:49:37,030 --> 00:49:36,319
showing that sodium lights have are

1521
00:49:39,270 --> 00:49:37,040
really

1522
00:49:40,870 --> 00:49:39,280
uh easy to pick out with with the right

1523
00:49:41,990 --> 00:49:40,880
astronomy tools with the spectrometer

1524
00:49:43,990 --> 00:49:42,000
you get a very

1525
00:49:45,349 --> 00:49:44,000
clear signature that this is a sodium

1526
00:49:47,910 --> 00:49:45,359
light those are those bright orange

1527
00:49:50,710 --> 00:49:47,920
lights you see in in cities and places

1528
00:49:51,670 --> 00:49:50,720
so um we do you know would aliens use

1529
00:49:53,589 --> 00:49:51,680
sodium lights

1530
00:49:55,030 --> 00:49:53,599
we don't know but at least if let's say

1531
00:49:58,150 --> 00:49:55,040
we found this

1532
00:49:59,990 --> 00:49:58,160
this you know proxima at night picture

1533
00:50:01,750 --> 00:50:00,000
um well you could do things like that we

1534
00:50:02,309 --> 00:50:01,760
don't know if these are fires or not but

1535
00:50:05,190 --> 00:50:02,319
let's

1536
00:50:06,309 --> 00:50:05,200
do follow-up observations and see does

1537
00:50:08,230 --> 00:50:06,319
this have

1538
00:50:09,670 --> 00:50:08,240

the signature of a fire that we would

1539
00:50:11,030 --> 00:50:09,680
expect through a telescope or the

1540
00:50:14,390 --> 00:50:11,040
signature of

1541
00:50:16,470 --> 00:50:14,400
a light bulb or something else and then

1542
00:50:17,750 --> 00:50:16,480
so it would take a while if we detect

1543
00:50:19,750 --> 00:50:17,760
something like this there would be a

1544
00:50:21,349 --> 00:50:19,760
period of prolonged discussion

1545
00:50:22,870 --> 00:50:21,359
among scientists and you know that would

1546
00:50:23,670 --> 00:50:22,880
be great because that's how science

1547
00:50:26,790 --> 00:50:23,680
works

1548
00:50:28,950 --> 00:50:26,800
but but unfortunately it means that the

1549
00:50:30,710 --> 00:50:28,960
the confirmation of a biosignature or

1550
00:50:32,150 --> 00:50:30,720
techno signature will be a slower

1551
00:50:35,589 --> 00:50:32,160
process probably

1552
00:50:37,190 --> 00:50:35,599
than we would like it to be um

1553
00:50:38,630 --> 00:50:37,200
yeah that first brings to mind you know

1554
00:50:40,470 --> 00:50:38,640
in the past on earth

1555
00:50:41,910 --> 00:50:40,480
we've had geological deposits that most

1556
00:50:43,190 --> 00:50:41,920
likely were creating heat potentially

1557
00:50:44,790 --> 00:50:43,200
creating light

1558
00:50:47,030 --> 00:50:44,800
there was a natural deposit rich in

1559
00:50:48,950 --> 00:50:47,040
uranium in africa for instance that

1560
00:50:50,549 --> 00:50:48,960
underwent nuclear fission and started

1561
00:50:51,589 --> 00:50:50,559
becoming its own geological nuclear

1562
00:50:53,829 --> 00:50:51,599
reactor could

1563
00:50:55,270 --> 00:50:53,839

alien worlds have nuclear reactors going

1564
00:50:55,750 --> 00:50:55,280
on the surface that we would recognize

1565
00:50:57,750 --> 00:50:55,760
and

1566
00:50:59,349 --> 00:50:57,760
think maybe that's technological it's

1567
00:51:00,790 --> 00:50:59,359
and so that brings a lot of questions to

1568
00:51:02,150 --> 00:51:00,800
mind for what's possible out there as

1569
00:51:03,349 --> 00:51:02,160
you mentioned earlier there's

1570
00:51:05,670 --> 00:51:03,359
there's so much that we can think about

1571
00:51:07,030 --> 00:51:05,680
that could be possible

1572
00:51:09,510 --> 00:51:07,040
uh here's another question this one's

1573
00:51:11,510 --> 00:51:09,520
from satyam tewari asking on sega net

1574
00:51:13,670 --> 00:51:11,520
and satyam wants to know

1575
00:51:15,349 --> 00:51:13,680
how we can use machine learning and

1576
00:51:17,589 --> 00:51:15,359
artificial intelligence to help us in

1577
00:51:20,710 --> 00:51:17,599
detecting extraterrestrial life

1578
00:51:22,069 --> 00:51:20,720
and add on also techno signatures

1579
00:51:23,990 --> 00:51:22,079
well that's a great question and i

1580
00:51:25,910 --> 00:51:24,000
promise i didn't plant that question

1581
00:51:28,230 --> 00:51:25,920
because satiem works for me and he also

1582
00:51:29,589 --> 00:51:28,240
attended technoclimb so he knows

1583
00:51:31,430 --> 00:51:29,599
that there was an awful lot of

1584
00:51:34,549 --> 00:51:31,440
discussion at our workshop

1585
00:51:37,270 --> 00:51:34,559
about machine learning um one

1586
00:51:38,790 --> 00:51:37,280
idea uh daniel angerhausen who's a blue

1587
00:51:41,829 --> 00:51:38,800
marble space scientist uh

1588
00:51:45,190 --> 00:51:41,839

he has is developing tools

1589
00:51:47,349 --> 00:51:45,200
to look at the moon and then uh possibly

1590
00:51:50,549 --> 00:51:47,359
other surfaces but but the moon

1591
00:51:52,870 --> 00:51:50,559
uh has been uh the lunar reconnaissance

1592
00:51:54,309 --> 00:51:52,880
reconnaissance orbiter has mapped the

1593
00:51:57,589 --> 00:51:54,319
surface of the moon to

1594
00:51:59,030 --> 00:51:57,599
to a pretty high resolution and so

1595
00:52:00,710 --> 00:51:59,040
one thing you could think about is this

1596
00:52:03,270 --> 00:52:00,720
idea of artifacts our

1597
00:52:04,549 --> 00:52:03,280
have extraterrestrials sent spacecraft

1598
00:52:06,309 --> 00:52:04,559
to explore

1599
00:52:08,549 --> 00:52:06,319
you know our solar system could there be

1600
00:52:10,230 --> 00:52:08,559
some unknown artifact on the moon for

1601
00:52:11,190 --> 00:52:10,240
example or elsewhere but starting with

1602
00:52:12,390 --> 00:52:11,200
the moon

1603
00:52:14,470 --> 00:52:12,400
one thing you could do is go through

1604
00:52:16,230 --> 00:52:14,480
these pictures one by one and

1605
00:52:17,990 --> 00:52:16,240
look through them and see if you can

1606
00:52:21,109 --> 00:52:18,000
figure out see if there's anything

1607
00:52:22,309 --> 00:52:21,119
weird on them but there's too many

1608
00:52:23,990 --> 00:52:22,319
pictures to really be me

1609
00:52:25,589 --> 00:52:24,000
you could do this in a crowd-funded way

1610
00:52:27,109 --> 00:52:25,599
perhaps but what daniel's doing is

1611
00:52:30,150 --> 00:52:27,119
developing machine learning

1612
00:52:33,670 --> 00:52:30,160
algorithms to sort through these images

1613
00:52:35,990 --> 00:52:33,680

and and do not not a

1614
00:52:37,589 --> 00:52:36,000
not a trained machine learning where you

1615
00:52:39,430 --> 00:52:37,599
you tell it what an artifact is but

1616
00:52:41,589 --> 00:52:39,440
truly in an unsupervised

1617
00:52:43,349 --> 00:52:41,599
machine learning algorithm where it's

1618
00:52:44,710 --> 00:52:43,359
just taking all the data in

1619
00:52:46,470 --> 00:52:44,720
and just trying to tell you what

1620
00:52:47,910 --> 00:52:46,480
anomalies are there and so i think i

1621
00:52:49,109 --> 00:52:47,920
believe he's working on it right now i

1622
00:52:51,030 --> 00:52:49,119
think he's validated

1623
00:52:53,430 --> 00:52:51,040
the algorithm so it'll pick out some of

1624
00:52:54,309 --> 00:52:53,440
the artifacts humans have set there

1625
00:52:56,549 --> 00:52:54,319
perhaps

1626
00:52:57,670 --> 00:52:56,559
um so you know that's one idea you could

1627
00:53:00,870 --> 00:52:57,680
think about doing this

1628
00:53:03,109 --> 00:53:00,880
for um for for for other types of

1629
00:53:06,549 --> 00:53:03,119
problems maybe if you're analyzing like

1630
00:53:07,510 --> 00:53:06,559
uh um you're trying to think about about

1631
00:53:10,710 --> 00:53:07,520
a large

1632
00:53:12,150 --> 00:53:10,720
number of types of planetary atmospheres

1633
00:53:12,950 --> 00:53:12,160
you might be able to use machine

1634
00:53:16,470 --> 00:53:12,960
learning

1635
00:53:18,309 --> 00:53:16,480
in a way to help uh to help explore

1636
00:53:19,829 --> 00:53:18,319
a really large sample space that'd be

1637
00:53:22,390 --> 00:53:19,839
really difficult to do

1638
00:53:23,589 --> 00:53:22,400

uh by yourself so i'm you know this is

1639
00:53:26,470 --> 00:53:23,599
this is an interesting

1640
00:53:29,190 --> 00:53:26,480
i guess one other way to do that that's

1641
00:53:31,670 --> 00:53:29,200
being done now is this the the radio

1642
00:53:33,510 --> 00:53:31,680
techno signatures which is searching for

1643
00:53:34,950 --> 00:53:33,520
either direct transmissions from other

1644
00:53:37,589 --> 00:53:34,960
star systems uh

1645
00:53:38,150 --> 00:53:37,599
other civilizations or sort of their

1646
00:53:41,109 --> 00:53:38,160
radio

1647
00:53:42,390 --> 00:53:41,119
leakage their their transmission towers

1648
00:53:44,309 --> 00:53:42,400
and things like we're using where we're

1649
00:53:46,549 --> 00:53:44,319
just putting radio waves into space

1650
00:53:47,750 --> 00:53:46,559
because of our communication and and

1651
00:53:51,030 --> 00:53:47,760
other activities

1652
00:53:52,150 --> 00:53:51,040
um so there's there's astronomers the

1653
00:53:54,549 --> 00:53:52,160
breakthrough listen team

1654
00:53:55,670 --> 00:53:54,559
in particular is taking huge amounts of

1655
00:53:58,710 --> 00:53:55,680
data

1656
00:54:00,069 --> 00:53:58,720
by pointing radio telescopes at hundreds

1657
00:54:01,990 --> 00:54:00,079
and thousands of stars

1658
00:54:03,670 --> 00:54:02,000
and so sorting through that data to

1659
00:54:05,990 --> 00:54:03,680
identify what might be

1660
00:54:07,750 --> 00:54:06,000
a possible techno signature a message or

1661
00:54:08,150 --> 00:54:07,760
you know some something that indicates

1662
00:54:11,190 --> 00:54:08,160
it was

1663
00:54:11,990 --> 00:54:11,200

intentionally transmitted um that's

1664
00:54:15,910 --> 00:54:12,000
something you could

1665
00:54:17,829 --> 00:54:15,920
use machine learning for to take the the

1666
00:54:19,030 --> 00:54:17,839
to automate the process of sorting

1667
00:54:20,790 --> 00:54:19,040
through that and looking for

1668
00:54:22,950 --> 00:54:20,800
any patterns or anomalies that might

1669
00:54:24,390 --> 00:54:22,960
stick out yeah and there's so much data

1670
00:54:26,309 --> 00:54:24,400
in that realm too

1671
00:54:27,910 --> 00:54:26,319
we're not even listening to all of the

1672
00:54:29,349 --> 00:54:27,920
sky and all the bandwidths all the time

1673
00:54:30,069 --> 00:54:29,359
if we started doing that it'd be so much

1674
00:54:32,069 --> 00:54:30,079
data

1675
00:54:33,670 --> 00:54:32,079
so having machine learning having this

1676
00:54:35,510 --> 00:54:33,680
to help us process those data would be

1677
00:54:37,670 --> 00:54:35,520
huge i would imagine

1678
00:54:39,670 --> 00:54:37,680
yeah there's really a data problem too

1679
00:54:42,069 --> 00:54:39,680
in many fields in science where

1680
00:54:42,789 --> 00:54:42,079
the collection of data is outpacing the

1681
00:54:44,630 --> 00:54:42,799
analysis

1682
00:54:46,549 --> 00:54:44,640
and so that's where these machine

1683
00:54:49,349 --> 00:54:46,559
learning tools can be really useful

1684
00:54:50,710 --> 00:54:49,359
is if if you understand the data set and

1685
00:54:52,150 --> 00:54:50,720
you're really clever about

1686
00:54:54,230 --> 00:54:52,160
how to use your machine learning you

1687
00:54:55,990 --> 00:54:54,240
might be able to go to a data set

1688
00:54:56,710 --> 00:54:56,000

whether it's in astronomy or some other

1689
00:54:58,150 --> 00:54:56,720
field

1690
00:54:59,430 --> 00:54:58,160
and learn something new based on

1691
00:55:00,069 --> 00:54:59,440
measurement someone else has already

1692
00:55:01,190 --> 00:55:00,079
taken

1693
00:55:03,430 --> 00:55:01,200
and that's very cool how that happens

1694
00:55:03,829 --> 00:55:03,440
the sciences too and this kind of leads

1695
00:55:06,710 --> 00:55:03,839
into

1696
00:55:08,069 --> 00:55:06,720
our next question from jamie stankovic

1697
00:55:10,390 --> 00:55:08,079
on facebook

1698
00:55:11,910 --> 00:55:10,400
jamie wants to know besides machine

1699
00:55:13,430 --> 00:55:11,920
learning here what instruments what

1700
00:55:15,430 --> 00:55:13,440
technologies

1701
00:55:16,630 --> 00:55:15,440
do you think we really need or are going

1702
00:55:20,150 --> 00:55:16,640
to need to

1703
00:55:21,750 --> 00:55:20,160
find life beyond the earth well i

1704
00:55:24,470 --> 00:55:21,760
promise that's not a setup question

1705
00:55:27,109 --> 00:55:24,480
either because that is a great question

1706
00:55:28,150 --> 00:55:27,119
nasa invests in these giant space

1707
00:55:29,670 --> 00:55:28,160
telescopes

1708
00:55:31,190 --> 00:55:29,680
and they're never big enough for what we

1709
00:55:33,430 --> 00:55:31,200
want to do now um

1710
00:55:35,270 --> 00:55:33,440
so the theory always is kind of ahead of

1711
00:55:37,430 --> 00:55:35,280
what we can really observe

1712
00:55:38,630 --> 00:55:37,440
the james webb telescope is the next big

1713
00:55:41,589 --> 00:55:38,640

one that's set

1714
00:55:43,190 --> 00:55:41,599
to launch um i believe later this year i

1715
00:55:44,069 --> 00:55:43,200
don't know how the pandemic is affecting

1716
00:55:46,630 --> 00:55:44,079
that

1717
00:55:48,150 --> 00:55:46,640
um but the james webb telescope would be

1718
00:55:51,589 --> 00:55:48,160
a huge advancement over

1719
00:55:54,470 --> 00:55:51,599
what's been flown before as far as

1720
00:55:56,470 --> 00:55:54,480
bio signatures and techno signatures go

1721
00:55:58,150 --> 00:55:56,480
i think it will not be able to take a

1722
00:56:01,670 --> 00:55:58,160
large large number

1723
00:56:02,150 --> 00:56:01,680
of observations of many many earth-sized

1724
00:56:04,150 --> 00:56:02,160
planets

1725
00:56:05,430 --> 00:56:04,160
i think the discussions i have seen

1726
00:56:08,549 --> 00:56:05,440
suggest that it might be

1727
00:56:09,829 --> 00:56:08,559
you know one or two so the trappist-1

1728
00:56:13,190 --> 00:56:09,839
system which is a

1729
00:56:15,510 --> 00:56:13,200
planetary system uh with with you know

1730
00:56:16,630 --> 00:56:15,520
several rocky planets orbiting a red

1731
00:56:18,390 --> 00:56:16,640
dwarf star

1732
00:56:19,750 --> 00:56:18,400
one of which is seems to be within the

1733
00:56:21,670 --> 00:56:19,760
habitable zone

1734
00:56:22,950 --> 00:56:21,680
we might be able to really understand

1735
00:56:25,750 --> 00:56:22,960
that system

1736
00:56:27,589 --> 00:56:25,760
with james webb telescope maybe one or

1737
00:56:29,510 --> 00:56:27,599
two others maybe

1738
00:56:30,950 --> 00:56:29,520

now maybe we get lucky and there's life

1739
00:56:33,030 --> 00:56:30,960
on that planet we find

1740
00:56:34,150 --> 00:56:33,040
you know some bio signatures that are

1741
00:56:37,270 --> 00:56:34,160
within

1742
00:56:38,870 --> 00:56:37,280
what james webb can detect um

1743
00:56:40,549 --> 00:56:38,880
maybe there's tactical signatures i

1744
00:56:41,510 --> 00:56:40,559
can't say there's not i can't say that

1745
00:56:43,109 --> 00:56:41,520
there will be

1746
00:56:44,710 --> 00:56:43,119
but but at least you know if we saw

1747
00:56:45,670 --> 00:56:44,720
something weird with james webb that

1748
00:56:47,829 --> 00:56:45,680
would be really

1749
00:56:49,349 --> 00:56:47,839
interesting and worth following up on

1750
00:56:50,549 --> 00:56:49,359
but there's a series of missions that

1751
00:56:54,069 --> 00:56:50,559
are being planned now

1752
00:56:57,109 --> 00:56:54,079
uh in design phase there's uh luvoir

1753
00:56:59,349 --> 00:56:57,119
the um which is a large optical

1754
00:57:01,270 --> 00:56:59,359
ultraviolet infrared telescope so it

1755
00:57:02,630 --> 00:57:01,280
spans a wide range of wavelengths that's

1756
00:57:04,390 --> 00:57:02,640
the biggest

1757
00:57:06,630 --> 00:57:04,400
beast sort of and that would get about

1758
00:57:09,670 --> 00:57:06,640
60 observations of

1759
00:57:12,870 --> 00:57:09,680
of earth-like planets

1760
00:57:15,750 --> 00:57:12,880
the habex is a smaller version of that

1761
00:57:16,710 --> 00:57:15,760
in a way that could get about i think 30

1762
00:57:18,390 --> 00:57:16,720
to 40.

1763
00:57:20,630 --> 00:57:18,400

so so those would be really interesting

1764
00:57:22,950 --> 00:57:20,640
and there's the origin space telescope

1765
00:57:24,870 --> 00:57:22,960
which that one actually goes out does

1766
00:57:26,470 --> 00:57:24,880
more infrared observations which

1767
00:57:27,950 --> 00:57:26,480
potentially could be interesting for

1768
00:57:30,390 --> 00:57:27,960
techno signatures things like

1769
00:57:32,470 --> 00:57:30,400
chlorofluorocarbons i was talking about

1770
00:57:33,910 --> 00:57:32,480
would probably have more of more

1771
00:57:37,030 --> 00:57:33,920
evidence at those

1772
00:57:39,430 --> 00:57:37,040
infrared areas

1773
00:57:40,309 --> 00:57:39,440
in the wave in this in the spectrum um

1774
00:57:42,150 --> 00:57:40,319
so

1775
00:57:44,630 --> 00:57:42,160
and then there's the life mission which

1776
00:57:46,870 --> 00:57:44,640
is is a european mission and that's

1777
00:57:48,549 --> 00:57:46,880
similar in some ways that it has

1778
00:57:49,829 --> 00:57:48,559
capabilities for this infrared

1779
00:57:51,589 --> 00:57:49,839
observation that might be really

1780
00:57:53,030 --> 00:57:51,599
interesting protective signatures

1781
00:57:54,870 --> 00:57:53,040
so those are the interesting missions

1782
00:57:55,750 --> 00:57:54,880
they're all in design phase they're not

1783
00:57:57,829 --> 00:57:55,760
all going to get

1784
00:57:58,870 --> 00:57:57,839
selected to be built but hopefully one

1785
00:58:01,510 --> 00:57:58,880
of them will

1786
00:58:03,510 --> 00:58:01,520
and that would be cool because you would

1787
00:58:04,230 --> 00:58:03,520
not be able to just study one or two but

1788
00:58:06,789 --> 00:58:04,240

but a

1789
00:58:09,670 --> 00:58:06,799
population of earth-sized planets to

1790
00:58:12,150 --> 00:58:09,680
really say how common is a biosignature

1791
00:58:13,829 --> 00:58:12,160
maybe how common is the techno signature

1792
00:58:15,270 --> 00:58:13,839
yeah it makes me wonder sometimes like

1793
00:58:16,710 --> 00:58:15,280
what the future is for astronomy and

1794
00:58:18,230 --> 00:58:16,720
looking at exoplanets and

1795
00:58:19,910 --> 00:58:18,240
what science lies ahead of some of these

1796
00:58:21,109 --> 00:58:19,920
great telescopes we're planning or

1797
00:58:23,349 --> 00:58:21,119
we haven't even thought of yet that are

1798
00:58:24,710 --> 00:58:23,359
coming down the line uh jacob we are

1799
00:58:26,230 --> 00:58:24,720
running low on time i have one more

1800
00:58:27,829 --> 00:58:26,240
question i want to get to

1801
00:58:29,750 --> 00:58:27,839
uh and this one comes from ariana

1802
00:58:31,510 --> 00:58:29,760
patterson on second net

1803
00:58:32,950 --> 00:58:31,520
uh we were speaking earlier about

1804
00:58:34,789 --> 00:58:32,960
running out of resources here on the

1805
00:58:37,750 --> 00:58:34,799
earth and going out and harvesting

1806
00:58:39,430 --> 00:58:37,760
for instance heavy metals from asteroids

1807
00:58:42,390 --> 00:58:39,440
for us to have here

1808
00:58:44,069 --> 00:58:42,400
ariana asked an intriguing question

1809
00:58:46,789 --> 00:58:44,079
about how we balance

1810
00:58:48,230 --> 00:58:46,799
our commercial interests in exploiting

1811
00:58:50,870 --> 00:58:48,240
you know other worlds with

1812
00:58:52,789 --> 00:58:50,880
our scientific interests so what do you

1813
00:58:53,430 --> 00:58:52,799

see is the risks in terms of planetary

1814
00:58:55,670 --> 00:58:53,440
protection

1815
00:58:57,430 --> 00:58:55,680
and ethics versus the benefits to our

1816
00:58:59,190 --> 00:58:57,440
advancement

1817
00:59:00,390 --> 00:58:59,200
yeah that's a great question and i'm

1818
00:59:00,870 --> 00:59:00,400
certainly not going to be able to

1819
00:59:03,349 --> 00:59:00,880
address

1820
00:59:05,270 --> 00:59:03,359
all of that but that's an important

1821
00:59:08,390 --> 00:59:05,280
tension that's emerged so

1822
00:59:10,150 --> 00:59:08,400
space was really the domain of science

1823
00:59:11,670 --> 00:59:10,160
up until very recently and this

1824
00:59:14,710 --> 00:59:11,680
commercial interests

1825
00:59:18,069 --> 00:59:14,720
are a new phenomenon so there

1826
00:59:20,710 --> 00:59:18,079
are going to be some some tensions

1827
00:59:24,230 --> 00:59:20,720
between those interests uh one idea

1828
00:59:25,990 --> 00:59:24,240
charles cacao uh in the uk has suggested

1829
00:59:28,150 --> 00:59:26,000
the idea of planetary parks

1830
00:59:30,069 --> 00:59:28,160
maybe like on earth we have you know

1831
00:59:32,150 --> 00:59:30,079
various national and state parks

1832
00:59:33,829 --> 00:59:32,160
uh you might have planetary parks that

1833
00:59:35,349 --> 00:59:33,839
are reserved for science or maybe even

1834
00:59:37,109 --> 00:59:35,359
places that scientists don't go very

1835
00:59:38,630 --> 00:59:37,119
often to really preserve the martian

1836
00:59:40,069 --> 00:59:38,640
environment but

1837
00:59:41,510 --> 00:59:40,079
we are going to have to have these

1838
00:59:42,470 --> 00:59:41,520

conversations and there will be

1839
00:59:44,789 --> 00:59:42,480
trade-offs

1840
00:59:46,630 --> 00:59:44,799
uh and it won't always be clear as to

1841
00:59:48,230 --> 00:59:46,640
which way to tip that balance

1842
00:59:50,789 --> 00:59:48,240
that's cool planetary parks makes me

1843
00:59:52,710 --> 00:59:50,799
think that what happens if we're a park

1844
00:59:54,630 --> 00:59:52,720
like the planetary zoo hypothesis this

1845
00:59:56,150 --> 00:59:54,640
idea that aliens from outside are

1846
00:59:58,309 --> 00:59:56,160
are keeping us closed off and just

1847
00:59:59,270 --> 00:59:58,319
watching what we do are we a science

1848
01:00:01,430 --> 00:59:59,280
experiment

1849
01:00:03,030 --> 01:00:01,440
um it's kind of cool to think about well

1850
01:00:05,109 --> 01:00:03,040
jacob it's been such a pleasure

1851
01:00:06,549 --> 01:00:05,119
having you on the show thanks so much

1852
01:00:08,150 --> 01:00:06,559
for joining us i know we couldn't get to

1853
01:00:09,829 --> 01:00:08,160
all the questions everyone out there

1854
01:00:11,510 --> 01:00:09,839
uh please feel free to reach out to

1855
01:00:14,390 --> 01:00:11,520
jacob uh

1856
01:00:15,510 --> 01:00:14,400
jacob how can they reach you online you

1857
01:00:17,190 --> 01:00:15,520
know if you just want to send me a

1858
01:00:18,870 --> 01:00:17,200
message on twitter then i'll take a look

1859
01:00:21,190 --> 01:00:18,880
at it and i'll reply to your question

1860
01:00:22,870 --> 01:00:21,200
that's wonderful he's at hawkmisra on

1861
01:00:24,309 --> 01:00:22,880
twitter you guys can reach him there

1862
01:00:26,630 --> 01:00:24,319
uh also a member of the blue marble

1863
01:00:28,230 --> 01:00:26,640

space institute of science uh jacob it's

1864
01:00:29,910 --> 01:00:28,240
been so great having you on the show

1865
01:00:31,829 --> 01:00:29,920
thank you for joining us

1866
01:00:33,510 --> 01:00:31,839
thanks again graham it's been fun

1867
01:00:35,270 --> 01:00:33,520
awesome and for those viewing at home we

1868
01:00:36,670 --> 01:00:35,280
have a fun question for you

1869
01:00:38,309 --> 01:00:36,680
uh you can reach out to me at

1870
01:00:41,030 --> 01:00:38,319
cosmobiologist

1871
01:00:43,670 --> 01:00:41,040
you can reach us at seganorg on twitter

1872
01:00:46,309 --> 01:00:43,680
as well as at nasa astrobio on twitter

1873
01:00:48,309 --> 01:00:46,319
uh our question for you is what signs of

1874
01:00:50,390 --> 01:00:48,319
technological civilizations

1875
01:00:51,910 --> 01:00:50,400
do you think we are most likely to find

1876
01:00:53,030 --> 01:00:51,920
and might drive us to figuring out that

1877
01:00:54,789 --> 01:00:53,040
there are other technological

1878
01:00:56,549 --> 01:00:54,799
civilizations out there

1879
01:00:58,950 --> 01:00:56,559
uh so if you have an idea about that

1880
01:01:00,630 --> 01:00:58,960
feel free to reach out and hit us up

1881
01:01:02,789 --> 01:01:00,640
thank you as always for joining ask an

1882
01:01:11,500 --> 01:01:02,799
astrobiologist and as always