Ask An Astrobiologist

Episode 53: October 18th, 2022

Dr. Michael Wong

NASA Astrobiology Program

1
00:00:30,130 --> 00:00:24,910
[Music]

2
00:00:35,930 --> 00:00:33,290
greetings friends fellow earthlings and

3
00:00:38,209 --> 00:00:35,940
those who wish to boldly explore strange

4
00:00:39,950 --> 00:00:38,219
new worlds welcome to ask an

5
00:00:42,170 --> 00:00:39,960
astrobiologist the show that celebrates

6
00:00:44,090 --> 00:00:42,180
the science and celebrates the

7
00:00:46,490 --> 00:00:44,100
scientists involved in our quest to

8
00:00:49,670 --> 00:00:46,500
understand the nature of life I'm your

9
00:00:51,590 --> 00:00:49,680
host Dr Graham the cosmo biologist Lao

10
00:00:54,430 --> 00:00:51,600
and we're brought to you as always by

11
00:00:57,110 --> 00:00:54,440
the NASA astrobiology program

12
00:00:59,450 --> 00:00:57,120
nsagnet.org now before I introduce Our

13
00:01:01,369 --> 00:00:59,460

Guest for today as always we want to

14
00:01:03,470 --> 00:01:01,379
thank those of you out there who

15
00:01:04,969 --> 00:01:03,480
interact with our guests by asking

16
00:01:06,950 --> 00:01:04,979
questions through the chat during the

17
00:01:09,289 --> 00:01:06,960
live show on YouTube who reach out to

18
00:01:11,990 --> 00:01:09,299
them after the show to ask questions or

19
00:01:14,330 --> 00:01:12,000
who use the hashtag ask astrobio on

20
00:01:15,649 --> 00:01:14,340
Twitter before the show just let us know

21
00:01:17,390 --> 00:01:15,659
that you you love what we're doing and

22
00:01:19,490 --> 00:01:17,400
that you you enjoy hearing from our

23
00:01:21,950 --> 00:01:19,500
guests about astrobiology about their

24
00:01:24,770 --> 00:01:21,960
careers and their passions uh this month

25
00:01:27,770 --> 00:01:24,780
we want to thank at Prince underscore

26
00:01:30,950 --> 00:01:27,780
indrajit on Twitter uh Prince injured

27
00:01:33,289 --> 00:01:30,960
parentheses law on Twitter for sharing

28
00:01:35,690 --> 00:01:33,299
about our show again if you ask really

29
00:01:37,910 --> 00:01:35,700
cool questions or you have cool ideas to

30
00:01:39,469 --> 00:01:37,920
share about astrobiology with our guests

31
00:01:41,210 --> 00:01:39,479
we're more than happy to give you a

32
00:01:44,450 --> 00:01:41,220
shout out on our show

33
00:01:47,330 --> 00:01:44,460
now in astrobiology many of us want to

34
00:01:50,749 --> 00:01:47,340
explore strange new worlds to seek out

35
00:01:53,749 --> 00:01:50,759
new life and new civilizations and so we

36
00:01:56,510 --> 00:01:53,759
boldly go doing the work of exploring

37
00:01:58,310 --> 00:01:56,520
diverse topics and and adding our own

38
00:02:00,950 --> 00:01:58,320

little piece to our Collective human

39
00:02:03,170 --> 00:02:00,960
knowledge about life in the universe and

40
00:02:05,690 --> 00:02:03,180
our place in the cosmos and today's

41
00:02:07,670 --> 00:02:05,700
guest is certainly someone who has a

42
00:02:11,029 --> 00:02:07,680
breadth of interest and throughout

43
00:02:13,369 --> 00:02:11,039
planetary science and astrobiology Dr

44
00:02:15,710 --> 00:02:13,379
Michael L Wong is a NASA saggin

45
00:02:18,350 --> 00:02:15,720
post-doctoral fellow at Carnegie Science

46
00:02:21,410 --> 00:02:18,360
Earth and planets laboratory studying

47
00:02:24,229 --> 00:02:21,420
planetary atmospheres habitability bio

48
00:02:26,270 --> 00:02:24,239
signatures and the emergence of life he

49
00:02:28,550 --> 00:02:26,280
earned his bachelor's at UC Berkeley and

50
00:02:31,070 --> 00:02:28,560
then a masters and a PhD in planetary

51
00:02:32,809 --> 00:02:31,080
science at Caltech he was then also

52
00:02:34,790 --> 00:02:32,819
previously a researcher at University of

53
00:02:36,290 --> 00:02:34,800
Washington before taking on his current

54
00:02:38,390 --> 00:02:36,300
role at Carnegie

55
00:02:39,890 --> 00:02:38,400
in his spare time

56
00:02:42,229 --> 00:02:39,900
um and I know a lot of our audience

57
00:02:44,990 --> 00:02:42,239
watching love this he hosts a podcast

58
00:02:47,210 --> 00:02:45,000
called strange new worlds where they

59
00:02:50,809 --> 00:02:47,220
examine the science and technology and

60
00:02:52,970 --> 00:02:50,819
culture through the lens of Star Trek so

61
00:02:55,610 --> 00:02:52,980
uh Dr Michael Wong welcome to ask an

62
00:02:57,890 --> 00:02:55,620
astrobiologist thanks Graham it's

63
00:03:00,290 --> 00:02:57,900

wonderful to be here with the cosmo

64
00:03:02,570 --> 00:03:00,300
biologist himself I'm such a big fan of

65
00:03:04,430 --> 00:03:02,580
all of your work and this show too ask

66
00:03:06,530 --> 00:03:04,440
an astrobiologist is one of my favorites

67
00:03:08,930 --> 00:03:06,540
I love tuning in and it's just such an

68
00:03:10,550 --> 00:03:08,940
honor to be here myself you know thank

69
00:03:11,809 --> 00:03:10,560
you so much for that I know our audience

70
00:03:13,850 --> 00:03:11,819
is super excited to hear about

71
00:03:15,410 --> 00:03:13,860
everything you do and they want to hear

72
00:03:17,990 --> 00:03:15,420
about Star Trek and I I promise we'll

73
00:03:19,750 --> 00:03:18,000
get to that but first before we get

74
00:03:22,070 --> 00:03:19,760
there we love to just humanize

75
00:03:24,710 --> 00:03:22,080
scientists those working in astrobiology

76
00:03:26,630 --> 00:03:24,720
people want to know like how do you get

77
00:03:28,490 --> 00:03:26,640
there and what really what really you

78
00:03:30,410 --> 00:03:28,500
know Strokes your passion to become this

79
00:03:31,910 --> 00:03:30,420
kind of person in the world and so the

80
00:03:34,309 --> 00:03:31,920
one thing I love to ask everyone when

81
00:03:36,229 --> 00:03:34,319
they first come on the show is what was

82
00:03:38,690 --> 00:03:36,239
your origin story that got you in

83
00:03:40,610 --> 00:03:38,700
involved in this career Pursuit

84
00:03:42,470 --> 00:03:40,620
well I mean I guess we're going to jump

85
00:03:44,390 --> 00:03:42,480
straight to Star Trek because it all

86
00:03:47,149 --> 00:03:44,400
started when I was really young just uh

87
00:03:49,369 --> 00:03:47,159
you know a little kid uh watching Star

88
00:03:51,110 --> 00:03:49,379

Trek with my dad

89
00:03:53,690 --> 00:03:51,120
um you know getting really inspired I

90
00:03:56,089 --> 00:03:53,700
grew up in the 90s so surrounded by the

91
00:03:58,789 --> 00:03:56,099
Next Generation Deep Space Nine Voyager

92
00:04:01,550 --> 00:03:58,799
that kind of like ethos of Star Trek all

93
00:04:03,949 --> 00:04:01,560
around me and uh you know just fell in

94
00:04:06,470 --> 00:04:03,959
love with outer space and the idea of

95
00:04:08,149 --> 00:04:06,480
you know seeking out new life and new

96
00:04:11,030 --> 00:04:08,159
civilizations exploring strange new

97
00:04:13,610 --> 00:04:11,040
worlds and I thought what career path is

98
00:04:15,589 --> 00:04:13,620
that and you know uh when I got to

99
00:04:17,270 --> 00:04:15,599
college I was shopping around for a

100
00:04:19,310 --> 00:04:17,280
major I thought you know I heard about

101
00:04:21,289 --> 00:04:19,320
this astrobiology thing I really want to

102
00:04:24,230 --> 00:04:21,299
be an astrobiologist because they sound

103
00:04:27,110 --> 00:04:24,240
like they do really cool things can I do

104
00:04:29,510 --> 00:04:27,120
that and it turned out that no where I

105
00:04:31,909 --> 00:04:29,520
went to college UC Berkeley at the time

106
00:04:34,249 --> 00:04:31,919
and I think it still is the case as as

107
00:04:37,070 --> 00:04:34,259
with many places uh around the globe

108
00:04:39,590 --> 00:04:37,080
doesn't have an astrobiology major so I

109
00:04:43,850 --> 00:04:39,600
was sort of like bummed out and stumbled

110
00:04:47,629 --> 00:04:43,860
upon the geobiology desk and and the

111
00:04:49,189 --> 00:04:47,639
geobiology folks told me hey you know uh

112
00:04:50,689 --> 00:04:49,199
you you might be interested in this new

113
00:04:52,730 --> 00:04:50,699

major we're starting called planetary

114
00:04:55,249 --> 00:04:52,740
science uh it sort of is a mix of

115
00:04:56,930 --> 00:04:55,259
disciplines very interdisciplinary and

116
00:04:58,430 --> 00:04:56,940
the more I learned about it the more I

117
00:05:00,409 --> 00:04:58,440
fell in love with planetary science and

118
00:05:02,150 --> 00:05:00,419
I said to myself hey if I can't be an

119
00:05:03,950 --> 00:05:02,160
astrobiologist if I can't study aliens

120
00:05:06,050 --> 00:05:03,960
yet maybe I'll just study where aliens

121
00:05:09,110 --> 00:05:06,060
might live and so I majored in planetary

122
00:05:11,629 --> 00:05:09,120
science that took me to do a PhD in

123
00:05:14,150 --> 00:05:11,639
planetary science as well but all the

124
00:05:15,830 --> 00:05:14,160
while I I really wanted to chase those

125
00:05:17,870 --> 00:05:15,840
ask for biological questions you know

126
00:05:20,090 --> 00:05:17,880
are we alone and where did we come from

127
00:05:22,550 --> 00:05:20,100
so we made sure to try to steer my path

128
00:05:24,950 --> 00:05:22,560
in planetary science towards projects in

129
00:05:26,930 --> 00:05:24,960
my PhD that had something to do with

130
00:05:29,090 --> 00:05:26,940
astrobiology whether it was the

131
00:05:30,890 --> 00:05:29,100
formation of organic molecules and

132
00:05:33,170 --> 00:05:30,900
Titans atmosphere and Pluto's atmosphere

133
00:05:35,450 --> 00:05:33,180
or the creation of potentially

134
00:05:38,510 --> 00:05:35,460
protobiotic molecules on the early Earth

135
00:05:40,129 --> 00:05:38,520
and early Mars so I I view I I come to

136
00:05:41,749 --> 00:05:40,139
ask for about biology through the lens

137
00:05:44,090 --> 00:05:41,759
of planetary atmospheres that's what I

138
00:05:46,129 --> 00:05:44,100

did my PhD studying and then that

139
00:05:47,629 --> 00:05:46,139
launched me into my postdoc my first

140
00:05:50,570 --> 00:05:47,639
postdoc at the University of Washington

141
00:05:53,570 --> 00:05:50,580
where I thought about biosignatures on

142
00:05:56,510 --> 00:05:53,580
exoplanets and now to where I am at

143
00:05:58,850 --> 00:05:56,520
Carnegie where I'm continuing that trend

144
00:06:00,770 --> 00:05:58,860
oh that's so cool and I will say in prep

145
00:06:02,570 --> 00:06:00,780
for this episode I looked at your CV and

146
00:06:05,930 --> 00:06:02,580
two things one it's the most beautiful

147
00:06:07,670 --> 00:06:05,940
CV I've ever seen oh thanks

148
00:06:08,930 --> 00:06:07,680
um but two I noticed in your

149
00:06:10,670 --> 00:06:08,940
Publications like you really have

150
00:06:12,950 --> 00:06:10,680
touched on so many different planetary

151
00:06:16,070 --> 00:06:12,960
bodies you've done work on exoplanets

152
00:06:17,390 --> 00:06:16,080
and Pluto and Titan and Mars and Earth

153
00:06:18,350 --> 00:06:17,400
um you know what was that pathway for

154
00:06:19,850 --> 00:06:18,360
you that you really thought to yourself

155
00:06:21,110 --> 00:06:19,860
like I'm going to work on a little bit

156
00:06:23,450 --> 00:06:21,120
of everything

157
00:06:25,249 --> 00:06:23,460
yeah it's a winding pathway and to be

158
00:06:27,050 --> 00:06:25,259
honest you don't always get to choose

159
00:06:29,809 --> 00:06:27,060
especially when you're in grad school

160
00:06:31,490 --> 00:06:29,819
and you know you're kind of uh in a

161
00:06:34,249 --> 00:06:31,500
research group and you're trying to you

162
00:06:36,350 --> 00:06:34,259
have to fit into the the larger groups

163
00:06:38,570 --> 00:06:36,360

direction right and so sometimes you get

164
00:06:39,830 --> 00:06:38,580
handed a project from your Pi but the

165
00:06:41,390 --> 00:06:39,840
further and further that I get in

166
00:06:43,909 --> 00:06:41,400
Academia the more I kind of have control

167
00:06:46,610 --> 00:06:43,919
over things and you're right I do try to

168
00:06:48,710 --> 00:06:46,620
touch upon everything uh anything that

169
00:06:51,170 --> 00:06:48,720
is astrobiologically interesting right

170
00:06:54,110 --> 00:06:51,180
um and so like one of the recent papers

171
00:06:57,230 --> 00:06:54,120
that I published was actually uh led by

172
00:07:00,290 --> 00:06:57,240
a student Adriana Gomez Buckley uh

173
00:07:02,150 --> 00:07:00,300
simulating a virus fear on Europa and

174
00:07:03,050 --> 00:07:02,160
you know I study planetary atmospheres

175
00:07:06,170 --> 00:07:03,060
mostly

176
00:07:09,050 --> 00:07:06,180
um and it it turns out that you know the

177
00:07:11,090 --> 00:07:09,060
types of equations that uh describe

178
00:07:12,830 --> 00:07:11,100
bacterial viral interactions these

179
00:07:14,689 --> 00:07:12,840
differential equations that describe

180
00:07:17,029 --> 00:07:14,699
their Dynamics are not too dissimilar

181
00:07:19,129 --> 00:07:17,039
from the types of equations that you use

182
00:07:20,870 --> 00:07:19,139
to model chemical reactions within an

183
00:07:23,029 --> 00:07:20,880
atmosphere so I thought that you know

184
00:07:25,610 --> 00:07:23,039
hey we could actually do this project

185
00:07:27,589 --> 00:07:25,620
Adriana was just so enthusiastic about

186
00:07:30,770 --> 00:07:27,599
it and really took charge developing the

187
00:07:32,570 --> 00:07:30,780
model uh and you know now I can say I've

188
00:07:35,290 --> 00:07:32,580

published on Europa too even though that

189
00:07:37,969 --> 00:07:35,300
body barely has an atmosphere

190
00:07:40,070 --> 00:07:37,979
I love that so much and I I will say I

191
00:07:41,870 --> 00:07:40,080
know Adriana uh she was in our young

192
00:07:43,969 --> 00:07:41,880
scientist program at Blue Marble space

193
00:07:45,350 --> 00:07:43,979
this past summer she's now a visiting

194
00:07:47,210 --> 00:07:45,360
scholar at the Blue Marble space

195
00:07:49,370 --> 00:07:47,220
Institute of Science and she's working

196
00:07:50,749 --> 00:07:49,380
through the center for Life detection on

197
00:07:52,490 --> 00:07:50,759
a web tool called the life detection

198
00:07:54,050 --> 00:07:52,500
knowledge base that I am also part of

199
00:07:55,850 --> 00:07:54,060
and so it's really cool to know her I

200
00:07:58,129 --> 00:07:55,860
know her father Ray Buckley also watches

201
00:08:00,170 --> 00:07:58,139
ask an astrobiologist and so maybe

202
00:08:01,370 --> 00:08:00,180
tuning in right now yeah

203
00:08:02,749 --> 00:08:01,380
um and so it's very cool to hear that

204
00:08:04,969 --> 00:08:02,759
and I think for the young people maybe

205
00:08:06,770 --> 00:08:04,979
viewing who are maybe in high school or

206
00:08:08,689 --> 00:08:06,780
undergraduate college students there are

207
00:08:10,850 --> 00:08:08,699
lots of ways to get involved in really

208
00:08:13,070 --> 00:08:10,860
cool research like that and if you feel

209
00:08:14,749 --> 00:08:13,080
like there's not astrobiology at your

210
00:08:16,969 --> 00:08:14,759
college or you want to go to a college

211
00:08:18,710 --> 00:08:16,979
that doesn't have astrobiology just like

212
00:08:20,869 --> 00:08:18,720
Mike and myself even I didn't get a

213
00:08:23,029 --> 00:08:20,879

degree in astrobiology and yet many of

214
00:08:25,189 --> 00:08:23,039
us come to astrobiology through other

215
00:08:27,710 --> 00:08:25,199
Pursuits and we we reach out to people

216
00:08:29,450 --> 00:08:27,720
to work on projects and so Mike I think

217
00:08:31,670 --> 00:08:29,460
a question I have there as well then for

218
00:08:34,310 --> 00:08:31,680
you for those who are watching who maybe

219
00:08:35,630 --> 00:08:34,320
want to become astrobiologists do you

220
00:08:38,269 --> 00:08:35,640
have any recommendations for them and

221
00:08:40,250 --> 00:08:38,279
how to find good mentors how to find

222
00:08:43,550 --> 00:08:40,260
programs that really really fit their

223
00:08:45,710 --> 00:08:43,560
passions yeah so I I like to say that

224
00:08:48,050 --> 00:08:45,720
astrobiology is a science of questions

225
00:08:50,210 --> 00:08:48,060
you know and and there's so many ways to

226
00:08:52,370 --> 00:08:50,220
be an astrobiologist you could come at

227
00:08:55,550 --> 00:08:52,380
it from geology from astronomy from

228
00:08:57,170 --> 00:08:55,560
biology chemistry computer science you

229
00:08:58,550 --> 00:08:57,180
can come from any kind of background so

230
00:09:01,009 --> 00:08:58,560
go and major in something that you're

231
00:09:03,170 --> 00:09:01,019
really passionate about and then use the

232
00:09:06,050 --> 00:09:03,180
tools and knowledge that you're gaining

233
00:09:08,090 --> 00:09:06,060
in school to ask an astrobiological

234
00:09:09,350 --> 00:09:08,100
question because as no matter what kind

235
00:09:11,389 --> 00:09:09,360
of science you're doing whether it's in

236
00:09:13,310 --> 00:09:11,399
a lab or in the field or at a telescope

237
00:09:15,949 --> 00:09:13,320
or just on your computer if you're

238
00:09:17,810 --> 00:09:15,959

asking an astrobiology question then you

239
00:09:20,269 --> 00:09:17,820
are an astrobiologist

240
00:09:23,150 --> 00:09:20,279
yeah absolutely as Mary vojtek always

241
00:09:24,710 --> 00:09:23,160
says anyone can be an astrobiologist you

242
00:09:26,329 --> 00:09:24,720
don't have to have necessary certain

243
00:09:27,410 --> 00:09:26,339
degrees in the sciences and things like

244
00:09:28,610 --> 00:09:27,420
that

245
00:09:30,530 --> 00:09:28,620
um so it's so cool to hear about you

246
00:09:32,329 --> 00:09:30,540
know some of your your pathway doing you

247
00:09:34,070 --> 00:09:32,339
know from Berkeley to Caltech to

248
00:09:35,630 --> 00:09:34,080
University of Washington and now to the

249
00:09:37,130 --> 00:09:35,640
Carnegie Institute

250
00:09:38,810 --> 00:09:37,140
um I'm curious you know what does a day

251
00:09:40,389 --> 00:09:38,820
in the life look like for you when

252
00:09:44,690 --> 00:09:40,399
you're working at Carnegie

253
00:09:46,070 --> 00:09:44,700
wow uh it's it's so varied you know and

254
00:09:49,190 --> 00:09:46,080
the most exciting thing for me is

255
00:09:50,630 --> 00:09:49,200
getting to talk to other people

256
00:09:52,190 --> 00:09:50,640
um and the beautiful thing about

257
00:09:54,290 --> 00:09:52,200
astrobiology is that it's so

258
00:09:57,230 --> 00:09:54,300
interdisciplinary on any given week you

259
00:10:00,050 --> 00:09:57,240
know I'll be talking to mineralogists or

260
00:10:02,630 --> 00:10:00,060
organic chemists uh talking to data

261
00:10:04,490 --> 00:10:02,640
scientists and to philosophers and

262
00:10:06,650 --> 00:10:04,500
mathematicians too

263
00:10:08,630 --> 00:10:06,660

um so A Day in the Life honestly looks

264
00:10:10,009 --> 00:10:08,640
like trading ideas with other people and

265
00:10:12,170 --> 00:10:10,019
then of course taking those ideas and

266
00:10:13,850 --> 00:10:12,180
doing the hard work of calculating you

267
00:10:16,690 --> 00:10:13,860
know simulating an atmosphere in the

268
00:10:19,610 --> 00:10:16,700
case of uh of of myself and also

269
00:10:21,710 --> 00:10:19,620
advising students uh you know I'm I'm

270
00:10:23,210 --> 00:10:21,720
advising several students right now and

271
00:10:25,009 --> 00:10:23,220
we're all we're working on exciting

272
00:10:27,650 --> 00:10:25,019
projects again simulating the

273
00:10:28,970 --> 00:10:27,660
atmospheres of planetary bodies within

274
00:10:29,930 --> 00:10:28,980
and Beyond the shores of our solar

275
00:10:31,610 --> 00:10:29,940
system

276
00:10:34,970 --> 00:10:31,620
um so it's a lot of computer work for me

277
00:10:36,829 --> 00:10:34,980
but then a lot of really just joy in in

278
00:10:38,690 --> 00:10:36,839
trading ideas with other people and

279
00:10:39,769 --> 00:10:38,700
trying to learn honestly from all of

280
00:10:41,509 --> 00:10:39,779
these different people I think I'm going

281
00:10:43,730 --> 00:10:41,519
to be a lifelong learner because I know

282
00:10:46,790 --> 00:10:43,740
there is so much I don't know

283
00:10:48,410 --> 00:10:46,800
um but that is important to this Quest I

284
00:10:50,690 --> 00:10:48,420
love that so much there's so much that

285
00:10:52,430 --> 00:10:50,700
we can bring in from other people and so

286
00:10:53,810 --> 00:10:52,440
many ways for us to sculpt our ideas by

287
00:10:55,550 --> 00:10:53,820
talking to people especially those from

288
00:10:56,690 --> 00:10:55,560

different backgrounds

289
00:10:57,829 --> 00:10:56,700
um and I love that I see that we

290
00:10:59,690 --> 00:10:57,839
actually have a bunch of audience

291
00:11:01,670 --> 00:10:59,700
questions rolling in already through the

292
00:11:03,110 --> 00:11:01,680
chat and YouTube we have a few from

293
00:11:04,370 --> 00:11:03,120
Twitter already

294
00:11:06,050 --> 00:11:04,380
um but before we open up to the audience

295
00:11:08,509 --> 00:11:06,060
q a we have a bunch more to talk about

296
00:11:11,030 --> 00:11:08,519
one I want to hear a bit more about some

297
00:11:12,829 --> 00:11:11,040
of your recent research two of your

298
00:11:13,970 --> 00:11:12,839
papers that I read that really intrigue

299
00:11:15,710 --> 00:11:13,980
me one

300
00:11:18,230 --> 00:11:15,720
um you had a paper from 2020 called

301
00:11:20,150 --> 00:11:18,240
defining life in the universe from three

302
00:11:21,889 --> 00:11:20,160
privileged functions to four pillars

303
00:11:24,290 --> 00:11:21,899
yeah and I'd like to talk a little bit

304
00:11:25,850 --> 00:11:24,300
about that with you one the title of

305
00:11:30,050 --> 00:11:25,860
this paper says defining life but it's

306
00:11:32,509 --> 00:11:30,060
life with an a why yeah why right why is

307
00:11:34,370 --> 00:11:32,519
that that's a great question Graham so

308
00:11:36,230 --> 00:11:34,380
basically this this paper which I

309
00:11:37,910 --> 00:11:36,240
co-authored with uh Dr Stewart Bartlett

310
00:11:40,910 --> 00:11:37,920
one of my closest friends and colleagues

311
00:11:42,710 --> 00:11:40,920
he's a staff scientist at Caltech uh we

312
00:11:44,509 --> 00:11:42,720
were trying to just think about you know

313
00:11:46,490 --> 00:11:44,519

when we search for life in the universe

314
00:11:48,889 --> 00:11:46,500
what are we actually talking about and

315
00:11:50,630 --> 00:11:48,899
when we are asking questions about the

316
00:11:52,430 --> 00:11:50,640
origin of life on Earth or on other

317
00:11:54,230 --> 00:11:52,440
planets what are we talking about there

318
00:11:56,269 --> 00:11:54,240
and there are kind of two separate

319
00:11:57,829 --> 00:11:56,279
questions we think one is you know the

320
00:12:00,050 --> 00:11:57,839
historical question of how did life

321
00:12:02,449 --> 00:12:00,060
exactly as we know it here on Earth come

322
00:12:04,250 --> 00:12:02,459
about and that question you know has

323
00:12:06,230 --> 00:12:04,260
attracted the attention of thousands of

324
00:12:08,810 --> 00:12:06,240
Scholars over many years writing about

325
00:12:10,670 --> 00:12:08,820
this uh conundrum of where did we come

326
00:12:13,610 --> 00:12:10,680
from but then there's also the question

327
00:12:15,769 --> 00:12:13,620
of how in general might a living system

328
00:12:17,630 --> 00:12:15,779
one that looks like us or one that

329
00:12:20,630 --> 00:12:17,640
produces a completely different kind of

330
00:12:23,210 --> 00:12:20,640
biochemistry and operation come about

331
00:12:24,889 --> 00:12:23,220
and what are the general principles of

332
00:12:26,870 --> 00:12:24,899
life and what are the general principles

333
00:12:29,030 --> 00:12:26,880
of life that you might look for in an

334
00:12:31,970 --> 00:12:29,040
alien biosphere that has taken many

335
00:12:34,490 --> 00:12:31,980
different evolutionary terms and so how

336
00:12:35,870 --> 00:12:34,500
can we Define life or characterize life

337
00:12:38,930 --> 00:12:35,880
or come up with some just tentative

338
00:12:41,030 --> 00:12:38,940

criteria for what life might be that

339
00:12:44,750 --> 00:12:41,040
doesn't use our specific you know

340
00:12:48,110 --> 00:12:44,760
molecular toolbox and you use DNA and

341
00:12:50,690 --> 00:12:48,120
proteins and Etc maybe not it's not even

342
00:12:53,569 --> 00:12:50,700
Cellular in nature what are the kind of

343
00:12:56,449 --> 00:12:53,579
like abstract general principles that we

344
00:12:58,430 --> 00:12:56,459
want to look for when we are asking did

345
00:13:01,910 --> 00:12:58,440
I find life out there or did I make life

346
00:13:04,490 --> 00:13:01,920
in my lab from scratch and so we Define

347
00:13:06,769 --> 00:13:04,500
life with a Y as any system that

348
00:13:08,509 --> 00:13:06,779
performs uh for just fundamental

349
00:13:10,009 --> 00:13:08,519
processes we like to say life is a verb

350
00:13:11,930 --> 00:13:10,019
not a noun you know it's not specific

351
00:13:13,430 --> 00:13:11,940
substrate but it's it's anything that

352
00:13:15,590 --> 00:13:13,440
does these four things one is

353
00:13:18,889 --> 00:13:15,600
dissipation that's basically harnessing

354
00:13:20,990 --> 00:13:18,899
energy right Auto catalysis the ability

355
00:13:23,870 --> 00:13:21,000
to grow exponentially under ideal

356
00:13:26,150 --> 00:13:23,880
conditions homeostasis the ability to

357
00:13:27,829 --> 00:13:26,160
kind of you know buffer yourself against

358
00:13:30,290 --> 00:13:27,839
external changes fluctuations

359
00:13:32,090 --> 00:13:30,300
perturbations and then the last one is

360
00:13:33,949 --> 00:13:32,100
learning the ability to intake and

361
00:13:36,769 --> 00:13:33,959
process information to increase your

362
00:13:40,550 --> 00:13:36,779
survival and persistence and Life as We

363
00:13:42,590 --> 00:13:40,560

Know It life of the eye is one subset of

364
00:13:45,230 --> 00:13:42,600
the possibilities the grand

365
00:13:46,850 --> 00:13:45,240
possibilities for life of the Y and we

366
00:13:48,650 --> 00:13:46,860
just wanted to introduce this new term

367
00:13:50,449 --> 00:13:48,660
to the community so that somebody could

368
00:13:53,389 --> 00:13:50,459
say I'm designing a biosignature

369
00:13:55,069 --> 00:13:53,399
technique to look for life with a Y you

370
00:13:56,930 --> 00:13:55,079
know which is perhaps a different kind

371
00:13:59,870 --> 00:13:56,940
of technique than you would use to look

372
00:14:01,550 --> 00:13:59,880
specifically for life with an eye yeah I

373
00:14:04,069 --> 00:14:01,560
love that so much and it makes me wonder

374
00:14:05,690 --> 00:14:04,079
so so uh viruses where would you see

375
00:14:07,310 --> 00:14:05,700
viruses kind of falling in that scale

376
00:14:09,650 --> 00:14:07,320
especially with regard to learning and

377
00:14:11,629 --> 00:14:09,660
to information processing oh such a good

378
00:14:13,490 --> 00:14:11,639
question yeah so we devote a paragraph

379
00:14:17,030 --> 00:14:13,500
in the paper to this where we kind of

380
00:14:20,150 --> 00:14:17,040
walk ourselves through okay viruses so a

381
00:14:22,610 --> 00:14:20,160
single virion alone just like in

382
00:14:24,949 --> 00:14:22,620
isolation does none of the four pillars

383
00:14:27,470 --> 00:14:24,959
of life right it just sits there but if

384
00:14:28,970 --> 00:14:27,480
you put that variant in contact with the

385
00:14:30,470 --> 00:14:28,980
bacterium and give it the necessary

386
00:14:32,210 --> 00:14:30,480
nutrients and energy source that the

387
00:14:33,829 --> 00:14:32,220
bacterium would need and the the virus

388
00:14:36,230 --> 00:14:33,839

could infect the bacterium create a

389
00:14:37,970 --> 00:14:36,240
viral Factory that does dissipation

390
00:14:39,410 --> 00:14:37,980
through the metabolism of the bacterium

391
00:14:41,569 --> 00:14:39,420
and auto catalysis through the

392
00:14:44,449 --> 00:14:41,579
replication of the virus

393
00:14:46,370 --> 00:14:44,459
um and then if you have a system of

394
00:14:47,569 --> 00:14:46,380
viruses and bacteria in a changing

395
00:14:49,670 --> 00:14:47,579
environment where they're kind of

396
00:14:52,730 --> 00:14:49,680
adapting to each other's strategies of

397
00:14:54,530 --> 00:14:52,740
infection and defense that could also be

398
00:14:56,509 --> 00:14:54,540
uh you could tack on learning there

399
00:14:58,550 --> 00:14:56,519
through Evolution right so evolution is

400
00:14:59,810 --> 00:14:58,560
the primary learning process here on

401
00:15:02,509 --> 00:14:59,820
Earth throughout out to billions of

402
00:15:04,430 --> 00:15:02,519
years of our plants history so okay so

403
00:15:06,530 --> 00:15:04,440
that's three of them and then you know

404
00:15:08,930 --> 00:15:06,540
we already talked about Adriana's paper

405
00:15:12,290 --> 00:15:08,940
about how viruses can create homeostatic

406
00:15:14,329 --> 00:15:12,300
uh mechanisms in a system you know by

407
00:15:16,009 --> 00:15:14,339
recycling certain nutrients dissolved

408
00:15:17,689 --> 00:15:16,019
organic matter for instance that keep

409
00:15:19,430 --> 00:15:17,699
the system actually propped up and

410
00:15:22,850 --> 00:15:19,440
surviving longer than if the viruses

411
00:15:24,290 --> 00:15:22,860
weren't there uh and so that is you know

412
00:15:26,389 --> 00:15:24,300
that that is all four pillars

413
00:15:28,970 --> 00:15:26,399

dissipation Auto catalysis homeostasis

414
00:15:30,769 --> 00:15:28,980
and learning so the example of viruses

415
00:15:33,230 --> 00:15:30,779
is really fun to think about but I also

416
00:15:35,389 --> 00:15:33,240
think it really gets at this fundamental

417
00:15:37,550 --> 00:15:35,399
idea that you want to look at life at

418
00:15:40,129 --> 00:15:37,560
the system level because actually

419
00:15:42,650 --> 00:15:40,139
nothing is going to be alive for very

420
00:15:44,689 --> 00:15:42,660
long in isolation even myself if I

421
00:15:46,490 --> 00:15:44,699
blocked myself off from like all of the

422
00:15:48,470 --> 00:15:46,500
people that support me through the

423
00:15:50,750 --> 00:15:48,480
various activities farming or from the

424
00:15:52,670 --> 00:15:50,760
trees they create oxygen for me to

425
00:15:54,110 --> 00:15:52,680
breathe I'm gonna be dead very soon so

426
00:15:56,389 --> 00:15:54,120
we got to assess life at the system

427
00:15:58,189 --> 00:15:56,399
level potentially even at the planetary

428
00:16:00,769 --> 00:15:58,199
level and that gives us hope for looking

429
00:16:02,569 --> 00:16:00,779
for life say on exoplanets

430
00:16:04,730 --> 00:16:02,579
yeah I love that concept so much you

431
00:16:06,470 --> 00:16:04,740
know life happens to a planet not just

432
00:16:08,870 --> 00:16:06,480
on a planet you know like worlds become

433
00:16:11,090 --> 00:16:08,880
living things themselves almost

434
00:16:12,949 --> 00:16:11,100
um and so I really like like that and I

435
00:16:14,750 --> 00:16:12,959
like this this thing in astrobiology

436
00:16:16,069 --> 00:16:14,760
that really you know it kind of got me

437
00:16:17,870 --> 00:16:16,079
interested right away is that you know

438
00:16:19,430 --> 00:16:17,880

we don't know but here's how we could

439
00:16:20,810 --> 00:16:19,440
find out here's how we can start

440
00:16:23,210 --> 00:16:20,820
approaching some of these problems about

441
00:16:26,150 --> 00:16:23,220
things like figuring out what's alive

442
00:16:27,769 --> 00:16:26,160
and what's not alive out there it's also

443
00:16:29,269 --> 00:16:27,779
you know for a very long time we've been

444
00:16:31,850 --> 00:16:29,279
wondering when we look up at the sky at

445
00:16:34,069 --> 00:16:31,860
night why haven't we really found

446
00:16:36,590 --> 00:16:34,079
definitive evidence yet why haven't we

447
00:16:38,090 --> 00:16:36,600
met E.T you know and and some people

448
00:16:39,769 --> 00:16:38,100
argue that they're visiting us right now

449
00:16:42,769 --> 00:16:39,779
but we really don't have definitive

450
00:16:44,449 --> 00:16:42,779
evidence that it's happening yet and so

451
00:16:46,730 --> 00:16:44,459
I want to talk a little bit then um

452
00:16:49,550 --> 00:16:46,740
about your 2022 paper from earlier this

453
00:16:52,009 --> 00:16:49,560
year asymptotic burnout and homeostatic

454
00:16:54,650 --> 00:16:52,019
Awakening a possible solution to the

455
00:16:56,269 --> 00:16:54,660
Fermi Paradox yeah now I really love

456
00:16:58,129 --> 00:16:56,279
this paper it kind of speaks to me as a

457
00:16:59,749 --> 00:16:58,139
nerd for science fiction but also

458
00:17:02,449 --> 00:16:59,759
someone who really likes applying

459
00:17:04,250 --> 00:17:02,459
science to what's possible you know so

460
00:17:06,650 --> 00:17:04,260
we don't know but here's how we can find

461
00:17:08,390 --> 00:17:06,660
out now in this paper you both and then

462
00:17:10,250 --> 00:17:08,400
again this is also co-authored to Stuart

463
00:17:12,169 --> 00:17:10,260

Bartlett uh you start off in this paper

464
00:17:14,150 --> 00:17:12,179
making an analogy to the growth of

465
00:17:16,189 --> 00:17:14,160
cities uh and how there are

466
00:17:18,289 --> 00:17:16,199
singularities and growth or crises that

467
00:17:20,270 --> 00:17:18,299
can occur and then there there needs to

468
00:17:22,490 --> 00:17:20,280
be some kind of innovative reset

469
00:17:24,230 --> 00:17:22,500
occurring that kind of allows for the

470
00:17:26,030 --> 00:17:24,240
population to continue going and to

471
00:17:27,770 --> 00:17:26,040
continue growing without hitting this

472
00:17:29,330 --> 00:17:27,780
crisis in population growth that could

473
00:17:30,590 --> 00:17:29,340
be detrimental

474
00:17:32,450 --> 00:17:30,600
um and then you apply that to planetary

475
00:17:34,310 --> 00:17:32,460
civilizations I'd love to hear your

476
00:17:35,930 --> 00:17:34,320
thoughts for how we can apply that to a

477
00:17:38,630 --> 00:17:35,940
planetary civilization and what that

478
00:17:41,450 --> 00:17:38,640
means then for for answering the Fermi

479
00:17:43,549 --> 00:17:41,460
Paradox right so as you said Graham you

480
00:17:45,529 --> 00:17:43,559
know uh it's it's there's an analogy

481
00:17:48,230 --> 00:17:45,539
that can be made between cities and

482
00:17:50,029 --> 00:17:48,240
stars where stars are these like nuclear

483
00:17:52,490 --> 00:17:50,039
reactors and we know from astrophysics

484
00:17:54,409 --> 00:17:52,500
that the larger a star is the faster it

485
00:17:56,090 --> 00:17:54,419
burns its Fuel and the sooner it dies

486
00:17:58,549 --> 00:17:56,100
out and explodes

487
00:18:01,789 --> 00:17:58,559
um cities too um you know the larger a

488
00:18:03,770 --> 00:18:01,799

city is the more so social interactions

489
00:18:06,230 --> 00:18:03,780
happen for a time and so the the life

490
00:18:08,510 --> 00:18:06,240
the the pace of life in cities actually

491
00:18:09,830 --> 00:18:08,520
increases the larger a city is people

492
00:18:12,049 --> 00:18:09,840
actually have been measured to walk

493
00:18:15,350 --> 00:18:12,059
faster in larger cities

494
00:18:17,570 --> 00:18:15,360
um and so you know as As Cities grow uh

495
00:18:19,850 --> 00:18:17,580
on the Earth but then also As Cities

496
00:18:22,730 --> 00:18:19,860
start to talk to one another this these

497
00:18:24,710 --> 00:18:22,740
are us the social agents you know uh I'm

498
00:18:26,150 --> 00:18:24,720
sitting probably thousands of miles away

499
00:18:28,549 --> 00:18:26,160
from where you are right now but we're

500
00:18:32,270 --> 00:18:28,559
talking through our computers isn't that

501
00:18:34,669 --> 00:18:32,280
amazing no longer do we need to have

502
00:18:36,890 --> 00:18:34,679
these um physical constraints on human

503
00:18:39,289 --> 00:18:36,900
interactions through our technology and

504
00:18:41,690 --> 00:18:39,299
what uh Dr Caleb Scharf also an

505
00:18:43,730 --> 00:18:41,700
astrobiologist calls the data ohm we are

506
00:18:45,470 --> 00:18:43,740
able to share information and have these

507
00:18:48,230 --> 00:18:45,480
social interactions

508
00:18:51,230 --> 00:18:48,240
um at uh unprecedented rate and scale

509
00:18:52,850 --> 00:18:51,240
and that could drive then this sort of

510
00:18:56,090 --> 00:18:52,860
uh this this

511
00:18:58,669 --> 00:18:56,100
um Singularity this burnout to occur at

512
00:19:00,409 --> 00:18:58,679
the planetary scale um this is just a

513
00:19:03,049 --> 00:19:00,419

hypothesis of course the whole paper is

514
00:19:05,210 --> 00:19:03,059
really a hypothesis for where we might

515
00:19:06,529 --> 00:19:05,220
be going as a planetary civilization and

516
00:19:08,810 --> 00:19:06,539
if you can extrapolate that and

517
00:19:11,390 --> 00:19:08,820
generalize it to EXO civilizations too

518
00:19:13,250 --> 00:19:11,400
under these principles as long as there

519
00:19:16,070 --> 00:19:13,260
are social interacting agents that

520
00:19:17,870 --> 00:19:16,080
aren't physically Limited in those

521
00:19:20,270 --> 00:19:17,880
social interactions once they develop

522
00:19:22,190 --> 00:19:20,280
essentially the alien equivalent of Zoom

523
00:19:24,830 --> 00:19:22,200
or Microsoft teams

524
00:19:26,990 --> 00:19:24,840
um uh then you know you might get some

525
00:19:30,350 --> 00:19:27,000
kind of scaling law that causes them to

526
00:19:33,529 --> 00:19:30,360
grow in this super linear fashion that

527
00:19:35,690 --> 00:19:33,539
ends up causing a potential catastrophe

528
00:19:37,549 --> 00:19:35,700
that's fantastic before we talk then

529
00:19:38,930 --> 00:19:37,559
about this possibility for a homeostatic

530
00:19:39,770 --> 00:19:38,940
Awakening

531
00:19:41,330 --> 00:19:39,780
um you wrote something they're

532
00:19:43,250 --> 00:19:41,340
interesting like people walk faster in

533
00:19:44,870 --> 00:19:43,260
cities in general and that makes me

534
00:19:46,490 --> 00:19:44,880
wonder about alien civilizations and

535
00:19:47,450 --> 00:19:46,500
perception of time

536
00:19:49,070 --> 00:19:47,460
um could it be that you know a

537
00:19:51,110 --> 00:19:49,080
civilization that's growing faster or

538
00:19:52,970 --> 00:19:51,120

growing larger or a world that's growing

539
00:19:55,370 --> 00:19:52,980
faster growing quicker and progressing

540
00:19:57,230 --> 00:19:55,380
quicker perceives time differently

541
00:19:59,630 --> 00:19:57,240
because of how it's developed its

542
00:20:01,909 --> 00:19:59,640
society around it yeah I think that's a

543
00:20:04,250 --> 00:20:01,919
really intriguing question and I

544
00:20:06,529 --> 00:20:04,260
wouldn't be surprised I'm not exactly

545
00:20:08,270 --> 00:20:06,539
sure if I'm qualified to talk about this

546
00:20:11,029 --> 00:20:08,280
not a you know I'm not a psychologist or

547
00:20:13,730 --> 00:20:11,039
a social scientist in any any fashion

548
00:20:15,950 --> 00:20:13,740
and I I certainly perceive my my

549
00:20:19,490 --> 00:20:15,960
knowledge of the perception of time is

550
00:20:21,950 --> 00:20:19,500
Super local to myself I don't study uh

551
00:20:23,810 --> 00:20:21,960
this uh as an academic discipline

552
00:20:25,490 --> 00:20:23,820
um but you know just knowing about the

553
00:20:26,870 --> 00:20:25,500
pace of life in the various places that

554
00:20:29,750 --> 00:20:26,880
I've lived and also the various stages

555
00:20:31,610 --> 00:20:29,760
of my own life how you know class would

556
00:20:34,549 --> 00:20:31,620
just tick on forever when I was young

557
00:20:36,230 --> 00:20:34,559
but nowadays an hour-long talk talk just

558
00:20:37,789 --> 00:20:36,240
goes by in a Flash and I'm like where

559
00:20:39,890 --> 00:20:37,799
did the time go

560
00:20:41,690 --> 00:20:39,900
um you know I I I can definitely see

561
00:20:43,370 --> 00:20:41,700
that yeah awesome

562
00:20:44,930 --> 00:20:43,380
um so I I do see more questions coming

563
00:20:46,970 --> 00:20:44,940

in from the audience I promise everyone

564
00:20:48,770 --> 00:20:46,980
I will get to your questions very soon I

565
00:20:50,630 --> 00:20:48,780
will say though uh one of my favorite

566
00:20:52,250 --> 00:20:50,640
things in this paper Mike

567
00:20:55,730 --> 00:20:52,260
um there's a figure where where you show

568
00:20:58,310 --> 00:20:55,740
like a bimodal distribution of possible

569
00:20:59,870 --> 00:20:58,320
lifetimes of civilizations then you show

570
00:21:01,789 --> 00:20:59,880
how like there's a large clump that

571
00:21:03,529 --> 00:21:01,799
maybe maybe that they they burn out

572
00:21:05,810 --> 00:21:03,539
maybe they come through this asymptotic

573
00:21:07,370 --> 00:21:05,820
burnout and then there's another Clump

574
00:21:09,430 --> 00:21:07,380
where they've gone through this process

575
00:21:12,650 --> 00:21:09,440
of homeostatic Awakening longer live

576
00:21:14,450 --> 00:21:12,660
civilizations and I I love the L factor

577
00:21:15,890 --> 00:21:14,460
in the Drake equation it's always been

578
00:21:18,710 --> 00:21:15,900
my favorite part of that equation

579
00:21:21,590 --> 00:21:18,720
because it speaks so much to our

580
00:21:24,529 --> 00:21:21,600
existential understanding of our own

581
00:21:26,570 --> 00:21:24,539
mortality uh as individuals but also our

582
00:21:28,430 --> 00:21:26,580
own lifetime as a civilization

583
00:21:31,130 --> 00:21:28,440
um possibly being impacted by things

584
00:21:32,810 --> 00:21:31,140
like nuclear warfare and our inability

585
00:21:34,789 --> 00:21:32,820
to change ourselves

586
00:21:37,010 --> 00:21:34,799
um so how how do you envision this

587
00:21:39,110 --> 00:21:37,020
homeostatic Awakening impacting

588
00:21:40,789 --> 00:21:39,120

civilizations once they become aware of

589
00:21:43,970 --> 00:21:40,799
this existential process this is

590
00:21:46,250 --> 00:21:43,980
understanding yeah exactly so um we

591
00:21:48,350 --> 00:21:46,260
Define this homeostatic Awakening as the

592
00:21:50,930 --> 00:21:48,360
idea that you can consciously you know

593
00:21:53,210 --> 00:21:50,940
transition yourself and rewrite the

594
00:21:55,190 --> 00:21:53,220
fundamental way that Society Works in a

595
00:21:57,350 --> 00:21:55,200
way that isn't going to hit a burnout

596
00:21:59,930 --> 00:21:57,360
and that you can then start exploring

597
00:22:02,990 --> 00:21:59,940
other ways of you know knowing and

598
00:22:06,169 --> 00:22:03,000
expanding throughout the Universe uh and

599
00:22:08,750 --> 00:22:06,179
I I think that the the actually well

600
00:22:10,549 --> 00:22:08,760
just going back to the L uh the the L

601
00:22:13,250 --> 00:22:10,559
factor and the Drake equation this whole

602
00:22:16,190 --> 00:22:13,260
thing started when I was invited to

603
00:22:18,289 --> 00:22:16,200
speak about the L variable

604
00:22:20,930 --> 00:22:18,299
um on a panel at a conference and I was

605
00:22:23,210 --> 00:22:20,940
like what can I possibly say about this

606
00:22:25,850 --> 00:22:23,220
thing like there is no way to estimate

607
00:22:28,190 --> 00:22:25,860
it but maybe what I can say is that it

608
00:22:30,049 --> 00:22:28,200
could be bimodal

609
00:22:33,470 --> 00:22:30,059
um and and that you know there will be a

610
00:22:36,289 --> 00:22:33,480
subset of planetary civilizations that

611
00:22:37,970 --> 00:22:36,299
don't get a chance to realize that

612
00:22:40,310 --> 00:22:37,980
they're on a burnout trajectory or maybe

613
00:22:42,529 --> 00:22:40,320

do realize it but aren't able to

614
00:22:45,409 --> 00:22:42,539
reorient themselves to prioritize

615
00:22:49,070 --> 00:22:45,419
homeostasis over uh this kind of

616
00:22:51,710 --> 00:22:49,080
flagrant uh autocatalysis growth with no

617
00:22:53,450 --> 00:22:51,720
end except then you fall off a cliff

618
00:22:55,490 --> 00:22:53,460
um and then there's the other Compass

619
00:22:58,010 --> 00:22:55,500
civilizations that sort of realize

620
00:23:00,529 --> 00:22:58,020
awaken to the fact that hey we're in

621
00:23:02,570 --> 00:23:00,539
charge of our planetary civilization uh

622
00:23:04,070 --> 00:23:02,580
of our of our planet we're into we're

623
00:23:06,430 --> 00:23:04,080
going to integrate ourselves into our

624
00:23:10,010 --> 00:23:06,440
planets geospheres in a self-productive

625
00:23:12,350 --> 00:23:10,020
self-maintaining way consciously uh and

626
00:23:14,210 --> 00:23:12,360
then as as David grinspoon and Adam

627
00:23:17,510 --> 00:23:14,220
Frank and others have written you may

628
00:23:21,110 --> 00:23:17,520
enter a completely new eon of of of

629
00:23:22,610 --> 00:23:21,120
being at the planetary scale where you

630
00:23:24,110 --> 00:23:22,620
are essentially

631
00:23:27,710 --> 00:23:24,120
um you know

632
00:23:30,470 --> 00:23:27,720
I I don't want to say like just not able

633
00:23:33,169 --> 00:23:30,480
to be killed or go away because who

634
00:23:35,270 --> 00:23:33,179
knows what might happen uh but uh but

635
00:23:37,490 --> 00:23:35,280
but if but if a conscious civilization

636
00:23:40,010 --> 00:23:37,500
is able to integrate itself very

637
00:23:42,649 --> 00:23:40,020
productively uh intimately into its

638
00:23:45,110 --> 00:23:42,659

natural environment it could last for a

639
00:23:47,810 --> 00:23:45,120
very long time and also be potentially

640
00:23:49,669 --> 00:23:47,820
be very difficult to to detect right

641
00:23:51,070 --> 00:23:49,679
because it may be indistinguishable from

642
00:23:53,090 --> 00:23:51,080
nature

643
00:23:54,289 --> 00:23:53,100
indeed and you mentioned something that

644
00:23:56,210 --> 00:23:54,299
just like popped in my head you

645
00:23:58,130 --> 00:23:56,220
mentioned a conscious civilization yeah

646
00:24:01,010 --> 00:23:58,140
it reminds me you know we don't really

647
00:24:03,350 --> 00:24:01,020
know what life is yet and we also don't

648
00:24:04,610 --> 00:24:03,360
really know what Consciousness is either

649
00:24:06,470 --> 00:24:04,620
so for those watching if you're

650
00:24:08,690 --> 00:24:06,480
interested there's a whole realm of

651
00:24:10,789 --> 00:24:08,700
astrobiology to study in the realm of

652
00:24:13,370 --> 00:24:10,799
what life is and what Consciousness is

653
00:24:15,409 --> 00:24:13,380
and whether we are fully conscious or if

654
00:24:16,909 --> 00:24:15,419
there's some other realm of it there

655
00:24:18,289 --> 00:24:16,919
um I will say in this paper one thing

656
00:24:19,610 --> 00:24:18,299
that like sprung into my mind while I

657
00:24:21,710 --> 00:24:19,620
was reading it

658
00:24:25,730 --> 00:24:21,720
um is the the the species called the

659
00:24:27,770 --> 00:24:25,740
Knox in this in the show Stargate SG-1

660
00:24:30,049 --> 00:24:27,780
um they're like this this species that

661
00:24:32,450 --> 00:24:30,059
humans meet on another planet

662
00:24:35,149 --> 00:24:32,460
um they're humanoid and they seem very

663
00:24:36,890 --> 00:24:35,159

like primitive basic and later in the

664
00:24:39,590 --> 00:24:36,900
show you find out that they're extremely

665
00:24:41,090 --> 00:24:39,600
technologically advanced but they're so

666
00:24:43,610 --> 00:24:41,100
Advanced that that their technology

667
00:24:45,230 --> 00:24:43,620
appears like magic and it reminds me of

668
00:24:47,390 --> 00:24:45,240
that quote from Arthur C Clarke that any

669
00:24:49,789 --> 00:24:47,400
sufficiently advanced technology is

670
00:24:51,110 --> 00:24:49,799
indistinguishable from Magic and it

671
00:24:53,149 --> 00:24:51,120
makes me wonder when reading your paper

672
00:24:54,770 --> 00:24:53,159
do you feel like they're these worlds

673
00:24:57,110 --> 00:24:54,780
have gone through homeostatic Awakening

674
00:24:58,730 --> 00:24:57,120
will we even recognize them or would

675
00:25:01,010 --> 00:24:58,740
they be magic would they be something

676
00:25:02,630 --> 00:25:01,020
kind of beyond our comprehension yeah I

677
00:25:05,270 --> 00:25:02,640
mean that's a really great question and

678
00:25:07,909 --> 00:25:05,280
I think that what we're looking at here

679
00:25:09,950 --> 00:25:07,919
is just the the idea that life on Earth

680
00:25:11,990 --> 00:25:09,960
throughout its four billion years or so

681
00:25:15,830 --> 00:25:12,000
of evolution has gone through many major

682
00:25:18,830 --> 00:25:15,840
transitions you know in in uh

683
00:25:21,049 --> 00:25:18,840
ways of processing information ways of

684
00:25:24,769 --> 00:25:21,059
harnessing energy and units of selection

685
00:25:27,370 --> 00:25:24,779
as well and so you know just as you know

686
00:25:30,470 --> 00:25:27,380
a colony of bacteria couldn't have

687
00:25:33,649 --> 00:25:30,480
predicted ant colonies and just as an

688
00:25:36,950 --> 00:25:33,659

ant colony couldn't have predicted a a a

689
00:25:39,169 --> 00:25:36,960
a city right what can't we predict about

690
00:25:42,409 --> 00:25:39,179
what next major transition in evolution

691
00:25:44,690 --> 00:25:42,419
and organizational scale uh will will

692
00:25:46,190 --> 00:25:44,700
will come you know it's it's hard for us

693
00:25:48,409 --> 00:25:46,200
to do that kind of prediction when these

694
00:25:49,130 --> 00:25:48,419
things are sort of Step functions or you

695
00:25:51,830 --> 00:25:49,140
know

696
00:25:54,169 --> 00:25:51,840
um just because of the way that

697
00:25:56,810 --> 00:25:54,179
emergence happens it's just so difficult

698
00:25:58,730 --> 00:25:56,820
to know and one thing that I just want

699
00:26:00,830 --> 00:25:58,740
to emphasize about this paper is that

700
00:26:03,289 --> 00:26:00,840
you look back through these series of

701
00:26:05,149 --> 00:26:03,299
major transitions uh and there's no

702
00:26:06,409 --> 00:26:05,159
reason to believe that we're done with

703
00:26:07,970 --> 00:26:06,419
them in fact I think we're going through

704
00:26:09,590 --> 00:26:07,980
one right now with this technological

705
00:26:13,430 --> 00:26:09,600
Revolution

706
00:26:15,350 --> 00:26:13,440
um and so where exactly is that going to

707
00:26:17,390 --> 00:26:15,360
lead us could be leading us to something

708
00:26:19,610 --> 00:26:17,400
like the Ox could be leading us to any

709
00:26:21,830 --> 00:26:19,620
number of other possibilities but to

710
00:26:24,409 --> 00:26:21,840
Simply extrapolate okay because human

711
00:26:27,590 --> 00:26:24,419
civilization spread across our globe in

712
00:26:30,289 --> 00:26:27,600
this sort of like uh colonialistic

713
00:26:32,330 --> 00:26:30,299

um Manner and then just to say okay well

714
00:26:33,890 --> 00:26:32,340
then therefore other civilizations out

715
00:26:35,690 --> 00:26:33,900
there that have achieved some kind of

716
00:26:37,970 --> 00:26:35,700
planetary

717
00:26:39,590 --> 00:26:37,980
um you know dominance will then continue

718
00:26:42,710 --> 00:26:39,600
to try to just go and dominate other

719
00:26:44,630 --> 00:26:42,720
planets in that same sort of manner is

720
00:26:46,130 --> 00:26:44,640
pretty naive I think when we realize

721
00:26:48,289 --> 00:26:46,140
okay maybe there's something that

722
00:26:51,110 --> 00:26:48,299
necessitates a new transition to

723
00:26:52,850 --> 00:26:51,120
something else and in in the case of our

724
00:26:55,070 --> 00:26:52,860
paper we suggest uh homeostatic

725
00:26:57,350 --> 00:26:55,080
Awakening that then changes the behavior

726
00:26:58,130 --> 00:26:57,360
of civilizations as they explore the

727
00:27:00,350 --> 00:26:58,140
Galaxy

728
00:27:01,850 --> 00:27:00,360
and I love that now I will say just for

729
00:27:03,710 --> 00:27:01,860
time's sake I do have to bring it back

730
00:27:04,789 --> 00:27:03,720
to Earth a little bit now I just want to

731
00:27:07,370 --> 00:27:04,799
hear a little bit more about your

732
00:27:09,110 --> 00:27:07,380
current research you know recently we've

733
00:27:11,029 --> 00:27:09,120
now I mean James Webb Space Telescope

734
00:27:12,590 --> 00:27:11,039
has only been operating for a few months

735
00:27:14,990 --> 00:27:12,600
really like you know since it first

736
00:27:17,570 --> 00:27:15,000
started collecting light and already we

737
00:27:20,630 --> 00:27:17,580
we have data from exoplanet atmospheres

738
00:27:23,450 --> 00:27:20,640

about water and hazes and the very first

739
00:27:26,149 --> 00:27:23,460
carbon dioxide detection in an exoplanet

740
00:27:28,130 --> 00:27:26,159
atmosphere from jwst there's more data

741
00:27:29,210 --> 00:27:28,140
certainly coming around the corner

742
00:27:30,230 --> 00:27:29,220
um you know I know that we've already

743
00:27:32,690 --> 00:27:30,240
looked at a few of the really

744
00:27:34,490 --> 00:27:32,700
interesting worlds in the Goldilocks

745
00:27:35,810 --> 00:27:34,500
zone around their stars

746
00:27:37,310 --> 00:27:35,820
um and so I'm curious you know you

747
00:27:39,350 --> 00:27:37,320
talked to me before the show about your

748
00:27:41,390 --> 00:27:39,360
current work and looking at exoplanet

749
00:27:42,350 --> 00:27:41,400
biosignatures exoplanet gases I'd love

750
00:27:44,029 --> 00:27:42,360
to hear a bit more about what you're

751
00:27:46,250 --> 00:27:44,039
currently working on and what we might

752
00:27:49,190 --> 00:27:46,260
expect in the coming year or so from you

753
00:27:52,190 --> 00:27:49,200
for sure so you know you mentioned jwst

754
00:27:55,190 --> 00:27:52,200
uh what a wonderful instrument

755
00:27:57,529 --> 00:27:55,200
um with this telescope we are finally

756
00:27:59,630 --> 00:27:57,539
able to sort of scratch the surface of

757
00:28:02,330 --> 00:27:59,640
the question of whether or not there are

758
00:28:04,490 --> 00:28:02,340
biosignatures on exoplanets previous to

759
00:28:06,710 --> 00:28:04,500
this we really couldn't do that kind of

760
00:28:08,690 --> 00:28:06,720
measurement so now we're finally able to

761
00:28:11,149 --> 00:28:08,700
to try to answer that question and it's

762
00:28:13,070 --> 00:28:11,159
mainly by looking at the chemistry of

763
00:28:15,649 --> 00:28:13,080

those planets atmospheres can we detect

764
00:28:18,110 --> 00:28:15,659
the metabolic gases that are indicative

765
00:28:20,390 --> 00:28:18,120
of life so CO2 for instance is one

766
00:28:22,490 --> 00:28:20,400
really good one looking for water vapor

767
00:28:24,830 --> 00:28:22,500
looking for methane looking for oxygen

768
00:28:26,930 --> 00:28:24,840
these are others one thing that I'm

769
00:28:29,630 --> 00:28:26,940
trying to Pioneer right now is using the

770
00:28:31,130 --> 00:28:29,640
tools of network science to try to

771
00:28:34,010 --> 00:28:31,140
understand if there's something about

772
00:28:35,990 --> 00:28:34,020
the holistic network of atmospheric

773
00:28:38,990 --> 00:28:36,000
chemistry that we might one day detect

774
00:28:40,549 --> 00:28:39,000
in an exoplanet's atmosphere using jwst

775
00:28:42,049 --> 00:28:40,559
but also using things that will come

776
00:28:43,610 --> 00:28:42,059
after it's an extremely large

777
00:28:45,529 --> 00:28:43,620
ground-based telescopes that are being

778
00:28:48,710 --> 00:28:45,539
built around the world whatever comes

779
00:28:51,890 --> 00:28:48,720
after JW University in space will be

780
00:28:53,930 --> 00:28:51,900
required to get the full picture of what

781
00:28:55,190 --> 00:28:53,940
all of the atmospheric chemistry on a

782
00:28:57,049 --> 00:28:55,200
planet is doing and the reason why we're

783
00:28:58,970 --> 00:28:57,059
looking at this holistic picture is

784
00:29:00,649 --> 00:28:58,980
again to try to identify Signs of Life

785
00:29:03,289 --> 00:29:00,659
as we don't know at life with a why

786
00:29:05,690 --> 00:29:03,299
maybe life on other planets in other

787
00:29:07,730 --> 00:29:05,700
geochemical contexts start to use

788
00:29:09,950 --> 00:29:07,740

different molecules in their metabolisms

789
00:29:13,130 --> 00:29:09,960
and put different gases into their

790
00:29:16,010 --> 00:29:13,140
atmospheres but in general also we're

791
00:29:18,049 --> 00:29:16,020
also thinking about this idea that what

792
00:29:19,909 --> 00:29:18,059
does life do what actually you know what

793
00:29:21,610 --> 00:29:19,919
what does life do to chemistry in

794
00:29:25,130 --> 00:29:21,620
general and I think that life

795
00:29:27,590 --> 00:29:25,140
reorganizes the structures of flows of

796
00:29:30,409 --> 00:29:27,600
matter and energy and information into a

797
00:29:32,450 --> 00:29:30,419
highly non-random complex functional

798
00:29:33,710 --> 00:29:32,460
Network and you can see this even at the

799
00:29:35,149 --> 00:29:33,720
biochemical scale if you look at

800
00:29:36,529 --> 00:29:35,159
biochemical networks like all the

801
00:29:38,750 --> 00:29:36,539
chemistry that happens inside of a cell

802
00:29:41,269 --> 00:29:38,760
it's not a random Network it's highly

803
00:29:43,370 --> 00:29:41,279
sculpted by the enzymes and the proteins

804
00:29:45,529 --> 00:29:43,380
in that cell the activities of those

805
00:29:48,529 --> 00:29:45,539
molecular machines if you look at the

806
00:29:50,330 --> 00:29:48,539
networks of our neurons our brains they

807
00:29:52,610 --> 00:29:50,340
have a very telling architecture it's

808
00:29:55,970 --> 00:29:52,620
not random either if you look at the

809
00:29:58,370 --> 00:29:55,980
networks of food webs you know uh in

810
00:30:00,769 --> 00:29:58,380
ecosystems again you see this very

811
00:30:02,450 --> 00:30:00,779
similar kind of network structure and

812
00:30:04,970 --> 00:30:02,460
what we're finding in our research right

813
00:30:06,649 --> 00:30:04,980

now is that Earth's atmospheric chemical

814
00:30:07,970 --> 00:30:06,659
Network all of the chemistry that is

815
00:30:11,930 --> 00:30:07,980
happening in front of your face right

816
00:30:14,510 --> 00:30:11,940
now you know uh also has some of those

817
00:30:16,789 --> 00:30:14,520
Network structural motifs so could it be

818
00:30:19,090 --> 00:30:16,799
that what life does is it reorganizes

819
00:30:21,649 --> 00:30:19,100
flows of matter energy and information

820
00:30:24,590 --> 00:30:21,659
at every single scale from the tiniest

821
00:30:26,930 --> 00:30:24,600
microscopic scale to the planetary scale

822
00:30:28,789 --> 00:30:26,940
as a whole to basically perform its

823
00:30:30,289 --> 00:30:28,799
functions and maintain homeostasis and

824
00:30:32,570 --> 00:30:30,299
increase the amount of learning that it

825
00:30:34,430 --> 00:30:32,580
does and so that's something that we're

826
00:30:36,409 --> 00:30:34,440
chasing it's giving us a window into

827
00:30:38,570 --> 00:30:36,419
exoplanet biosignatures that hasn't

828
00:30:40,909 --> 00:30:38,580
really been developed so far and I think

829
00:30:42,769 --> 00:30:40,919
the Mantra and biosignatures is multiple

830
00:30:45,169 --> 00:30:42,779
lines of evidence right there may not be

831
00:30:46,909 --> 00:30:45,179
one Smoking Gun biosignature for any

832
00:30:49,970 --> 00:30:46,919
given world but if you're able to

833
00:30:51,350 --> 00:30:49,980
approach it from different kinds of with

834
00:30:54,049 --> 00:30:51,360
different kinds of techniques and

835
00:30:56,210 --> 00:30:54,059
different kinds of measurements then you

836
00:30:57,830 --> 00:30:56,220
can raise your confidence in the idea

837
00:30:59,990 --> 00:30:57,840
that we've detected life on a certain

838
00:31:01,669 --> 00:31:00,000

planet and this network biosignature

839
00:31:03,769 --> 00:31:01,679
technique that we're developing right

840
00:31:05,930 --> 00:31:03,779
now hopefully adds to our arsenal of

841
00:31:08,450 --> 00:31:05,940
ways to scan for biosignatures on

842
00:31:10,310 --> 00:31:08,460
exoplanets oh that's a that's a great

843
00:31:12,289 --> 00:31:10,320
segue for us to then discuss some Star

844
00:31:13,730 --> 00:31:12,299
Trek too sure look at Star Trek we can

845
00:31:15,529 --> 00:31:13,740
you know fly a spaceship up to a world

846
00:31:17,570 --> 00:31:15,539
and just scan the world from above and

847
00:31:19,310 --> 00:31:17,580
say oh yeah there's life signs scanning

848
00:31:21,769 --> 00:31:19,320
for Life signs right

849
00:31:24,350 --> 00:31:21,779
um on Twitter on the at Nasa Astro bio

850
00:31:26,149 --> 00:31:24,360
account we we asked our audience

851
00:31:28,850 --> 00:31:26,159
um of some certain Star Trek

852
00:31:31,010 --> 00:31:28,860
Technologies which is actually based on

853
00:31:34,789 --> 00:31:31,020
known science and the options were

854
00:31:37,310 --> 00:31:34,799
Hollow deck replicator tricorder or

855
00:31:39,529 --> 00:31:37,320
tractor beam now I will say that

856
00:31:41,990 --> 00:31:39,539
tricorder one by a good bit it was 38

857
00:31:43,549 --> 00:31:42,000
for the tricorder second place was

858
00:31:45,710 --> 00:31:43,559
replicator and then Hollow deck and

859
00:31:47,750 --> 00:31:45,720
tractor beam are kind of together but

860
00:31:49,430 --> 00:31:47,760
even within our team at ask an

861
00:31:51,889 --> 00:31:49,440
astrobiologist and with NASA

862
00:31:54,110 --> 00:31:51,899
astrobiology and Sega net we've been

863
00:31:55,610 --> 00:31:54,120

kind of arguing over what might be the

864
00:31:57,830 --> 00:31:55,620
right answer here

865
00:32:00,529 --> 00:31:57,840
um so how would you answer that question

866
00:32:03,590 --> 00:32:00,539
wow so the four options love them all I

867
00:32:06,590 --> 00:32:03,600
love those texts on Star Trek uh I think

868
00:32:08,930 --> 00:32:06,600
that each one of them has a little

869
00:32:10,789 --> 00:32:08,940
glimmer of truth to it you know there's

870
00:32:12,889 --> 00:32:10,799
something you can point to in our

871
00:32:15,409 --> 00:32:12,899
technosphere right now that you could

872
00:32:18,289 --> 00:32:15,419
say that is a really really primitive

873
00:32:20,810 --> 00:32:18,299
precursor of blah you know one of those

874
00:32:25,190 --> 00:32:20,820
one of those uh options there you know

875
00:32:26,269 --> 00:32:25,200
so we've got like uh uh the 3D printing

876
00:32:28,130 --> 00:32:26,279
right so that's sort of like a

877
00:32:29,810 --> 00:32:28,140
replicator I like to think of replicator

878
00:32:31,430 --> 00:32:29,820
and Holodeck technology is actually like

879
00:32:32,870 --> 00:32:31,440
two sides of the same coin I feel like

880
00:32:34,490 --> 00:32:32,880
they're they're kind of the same in Star

881
00:32:36,409 --> 00:32:34,500
Trek we can talk about that later

882
00:32:38,810 --> 00:32:36,419
um but then you know when we're talking

883
00:32:41,090 --> 00:32:38,820
about tricorders as an astrobiologist I

884
00:32:42,590 --> 00:32:41,100
wish I had a tricorder but the uh truth

885
00:32:44,330 --> 00:32:42,600
of the matter is we're still developing

886
00:32:46,250 --> 00:32:44,340
those techniques to go and look for life

887
00:32:49,990 --> 00:32:46,260
out there uh that hopefully will be

888
00:32:52,370 --> 00:32:50,000

cataloged in um that uh that that uh

889
00:32:55,070 --> 00:32:52,380
biosignatures I'm blanking on the name

890
00:32:57,590 --> 00:32:55,080
right now I should know this uh the the

891
00:32:59,090 --> 00:32:57,600
thing that you're all building at enfold

892
00:33:00,289 --> 00:32:59,100
um yeah the knowledge base the knowledge

893
00:33:02,990 --> 00:33:00,299
base of course yeah the knowledge base

894
00:33:04,850 --> 00:33:03,000
right so that could actually be the

895
00:33:06,409 --> 00:33:04,860
first sort of database for a tricorder

896
00:33:09,049 --> 00:33:06,419
right I I would love to see that happen

897
00:33:11,570 --> 00:33:09,059
but we're still building it right now uh

898
00:33:14,509 --> 00:33:11,580
and then what do we have uh you know the

899
00:33:16,669 --> 00:33:14,519
the tractor beam you know at the at the

900
00:33:19,009 --> 00:33:16,679
tiniest scales I feel like we can do

901
00:33:20,570 --> 00:33:19,019
sort of tractor technology but nowhere

902
00:33:23,330 --> 00:33:20,580
near doing it with the spacecraft yet

903
00:33:25,490 --> 00:33:23,340
yeah now those are great answers um I

904
00:33:27,470 --> 00:33:25,500
agree entirely there's little bits of

905
00:33:28,669 --> 00:33:27,480
the real science going in on all of

906
00:33:30,230 --> 00:33:28,679
these things in science fiction and

907
00:33:32,389 --> 00:33:30,240
Science and science fiction have always

908
00:33:34,130 --> 00:33:32,399
kind of paired off together and you are

909
00:33:36,289 --> 00:33:34,140
someone who is great to ask questions

910
00:33:39,110 --> 00:33:36,299
about Star Trek since you are the host

911
00:33:40,850 --> 00:33:39,120
of the podcast strange new worlds

912
00:33:43,430 --> 00:33:40,860
um and so I'd love to one just hear

913
00:33:45,409 --> 00:33:43,440

about you know your view your vision of

914
00:33:46,909 --> 00:33:45,419
what this podcast is and and maybe even

915
00:33:48,649 --> 00:33:46,919
tell our audience why should they go

916
00:33:51,590 --> 00:33:48,659
listen to the podcast immediately after

917
00:33:53,029 --> 00:33:51,600
this show oh wow yeah so thanks thanks

918
00:33:55,370 --> 00:33:53,039
for letting me talk about it a little

919
00:33:58,850 --> 00:33:55,380
bit it's one of my passions to help

920
00:34:00,710 --> 00:33:58,860
share science you know um so I'm a NASA

921
00:34:03,230 --> 00:34:00,720
fellow right now so that means my money

922
00:34:05,389 --> 00:34:03,240
comes from you like this the citizens

923
00:34:08,990 --> 00:34:05,399
right your taxpayer dollars at work and

924
00:34:12,589 --> 00:34:09,000
so I actually feel a really strong long

925
00:34:13,849 --> 00:34:12,599
um you know urge to share the wonders of

926
00:34:16,490 --> 00:34:13,859
the universe with everybody because

927
00:34:18,710 --> 00:34:16,500
everybody is deserving of it and in fact

928
00:34:22,609 --> 00:34:18,720
many of you contribute to it um and so

929
00:34:24,349 --> 00:34:22,619
it's really a passion of mine and so the

930
00:34:26,329 --> 00:34:24,359
way that this originated was when I was

931
00:34:28,129 --> 00:34:26,339
in grad school I was thinking about oh

932
00:34:30,710 --> 00:34:28,139
gosh I don't have a lot of opportunities

933
00:34:33,889 --> 00:34:30,720
to do science communication maybe I

934
00:34:36,829 --> 00:34:33,899
should just start a podcast that blends

935
00:34:38,869 --> 00:34:36,839
two things that I love so much that I

936
00:34:41,270 --> 00:34:38,879
just cannot stop talking about so it's

937
00:34:43,609 --> 00:34:41,280
gonna go well of course right uh Star

938
00:34:46,970 --> 00:34:43,619

Trek and science

939
00:34:50,389 --> 00:34:46,980
um and so uh over the years we've had

940
00:34:52,550 --> 00:34:50,399
lots of guests who've uh or scientists

941
00:34:54,710 --> 00:34:52,560
like myself who are inspired by Star

942
00:34:57,230 --> 00:34:54,720
Trek but also recently we've we've had

943
00:34:59,270 --> 00:34:57,240
people who have helped craft the Star

944
00:35:01,730 --> 00:34:59,280
Trek universe some of the actual science

945
00:35:03,530 --> 00:35:01,740
Consultants on the show

946
00:35:06,170 --> 00:35:03,540
um you know Dr Aaron McDonald an

947
00:35:08,570 --> 00:35:06,180
astrophysicist Dr Mohammed Noor who is a

948
00:35:10,190 --> 00:35:08,580
geneticist have come on board to tell us

949
00:35:12,170 --> 00:35:10,200
about how they've injected a little bit

950
00:35:14,569 --> 00:35:12,180
of science into the latest Star Trek

951
00:35:16,970 --> 00:35:14,579
series and also some of the writers of

952
00:35:18,950 --> 00:35:16,980
the Star Trek novels and some of the

953
00:35:21,710 --> 00:35:18,960
Star Trek cast members themselves who

954
00:35:23,569 --> 00:35:21,720
portray science officers so it's been a

955
00:35:24,589 --> 00:35:23,579
real blast if you like Star Trek or

956
00:35:25,910 --> 00:35:24,599
you're interested in learning more about

957
00:35:28,670 --> 00:35:25,920
Star Trek or just want to hear about

958
00:35:30,349 --> 00:35:28,680
science through through a unique lens

959
00:35:32,030 --> 00:35:30,359
then I encourage you to check out

960
00:35:34,370 --> 00:35:32,040
strange new Worlds the science and Star

961
00:35:35,930 --> 00:35:34,380
Trek podcast awesome I love it and

962
00:35:37,670 --> 00:35:35,940
you've also now given talks about

963
00:35:41,329 --> 00:35:37,680

science at Star Trek conventions too

964
00:35:43,730 --> 00:35:41,339
right yes oh that's such a thrill too

965
00:35:45,890 --> 00:35:43,740
um to to be able to engage the fan base

966
00:35:50,150 --> 00:35:45,900
and you know at the the latest

967
00:35:53,210 --> 00:35:50,160
convention in Chicago uh May 2022 you

968
00:35:55,910 --> 00:35:53,220
know they put me actually uh opposite of

969
00:35:58,370 --> 00:35:55,920
these strange new worlds TV show panel

970
00:36:00,890 --> 00:35:58,380
uh where Anson Mound captain pike

971
00:36:03,050 --> 00:36:00,900
himself was uh was giving a talk in in

972
00:36:04,910 --> 00:36:03,060
the big ballroom and I was you know in a

973
00:36:06,589 --> 00:36:04,920
much smaller room and I was worried that

974
00:36:08,450 --> 00:36:06,599
nobody was going to show up but uh

975
00:36:10,310 --> 00:36:08,460
apparently quite a few people I wanted

976
00:36:13,990 --> 00:36:10,320
to hear about astrobiology overseeing

977
00:36:16,790 --> 00:36:14,000
ants in Mountain life so I'm like okay

978
00:36:18,829 --> 00:36:16,800
I love it and I love that your podcast

979
00:36:21,109 --> 00:36:18,839
it's not just the science it's also

980
00:36:23,510 --> 00:36:21,119
talking to the writers and the creators

981
00:36:25,910 --> 00:36:23,520
I'm talking about you know issues in

982
00:36:27,589 --> 00:36:25,920
inclusion and diversity in the show in

983
00:36:29,030 --> 00:36:27,599
the world and philosophy in Star Trek

984
00:36:30,290 --> 00:36:29,040
and things like that

985
00:36:32,150 --> 00:36:30,300
um you know one of my favorite scenes

986
00:36:34,130 --> 00:36:32,160
from all of track is in the second

987
00:36:37,190 --> 00:36:34,140
season of TNG there's an episode called

988
00:36:39,170 --> 00:36:37,200

Samaritan snare the episode itself it's

989
00:36:41,390 --> 00:36:39,180
not the best episode but there's a scene

990
00:36:42,829 --> 00:36:41,400
in that episode where Captain Picard and

991
00:36:44,810 --> 00:36:42,839
Wesley Crusher are in a shuttle craft

992
00:36:46,849 --> 00:36:44,820
together and they're flying to this star

993
00:36:49,430 --> 00:36:46,859
base and they have a conversation where

994
00:36:51,349 --> 00:36:49,440
Captain Picard asks a young Crusher if

995
00:36:53,390 --> 00:36:51,359
he read this book of poetry that he gave

996
00:36:55,430 --> 00:36:53,400
him and Wesley says you know no it's not

997
00:36:57,109 --> 00:36:55,440
going to be on my exams and there's this

998
00:36:59,270 --> 00:36:57,119
moment where Captain Picard kind of like

999
00:37:00,349 --> 00:36:59,280
looks out at the stars around and he

1000
00:37:02,690 --> 00:37:00,359
says like the most important things

1001
00:37:05,210 --> 00:37:02,700
won't be that anyone can learn to Pilot

1002
00:37:06,710 --> 00:37:05,220
a Starship but to really you know make

1003
00:37:10,010 --> 00:37:06,720
sense of it you have to do more you have

1004
00:37:11,810 --> 00:37:10,020
to take in r and history and culture and

1005
00:37:13,730 --> 00:37:11,820
then that makes all of this make sense

1006
00:37:15,950 --> 00:37:13,740
and so I love that you're kind of

1007
00:37:17,329 --> 00:37:15,960
engaging with that as well and I'd also

1008
00:37:19,010 --> 00:37:17,339
like to just talk just for a moment

1009
00:37:21,290 --> 00:37:19,020
before we move on

1010
00:37:23,510 --> 00:37:21,300
um a bit about you you're also a really

1011
00:37:25,250 --> 00:37:23,520
good graphic designer and you're really

1012
00:37:27,050 --> 00:37:25,260
into photography like your Twitter feed

1013
00:37:28,130 --> 00:37:27,060

is incredible

1014
00:37:30,230 --> 00:37:28,140
um I'd love to hear a bit about like

1015
00:37:31,849 --> 00:37:30,240
what was your interest in that realm of

1016
00:37:35,210 --> 00:37:31,859
our art and graphic design and

1017
00:37:38,990 --> 00:37:35,220
photography oh yeah yeah thanks thanks

1018
00:37:40,609 --> 00:37:39,000
uh I mean it's I view science as a human

1019
00:37:42,950 --> 00:37:40,619
endeavor it's just one of the things

1020
00:37:46,069 --> 00:37:42,960
that I do as a human being and I've got

1021
00:37:48,170 --> 00:37:46,079
other interests too so when I was in

1022
00:37:50,750 --> 00:37:48,180
high school throughout college and then

1023
00:37:53,210 --> 00:37:50,760
also in graduate school I was a part of

1024
00:37:56,210 --> 00:37:53,220
the yearbook team at all of those

1025
00:37:59,870 --> 00:37:56,220
various institutions uh we're learning

1026
00:38:01,430 --> 00:37:59,880
graphic design typography journalism I

1027
00:38:02,750 --> 00:38:01,440
really love journalism again it plays

1028
00:38:05,630 --> 00:38:02,760
into my passion for science

1029
00:38:07,370 --> 00:38:05,640
communication and photography as well

1030
00:38:08,930 --> 00:38:07,380
just like capturing the moment of all

1031
00:38:11,630 --> 00:38:08,940
the cool cool things that we do as

1032
00:38:14,329 --> 00:38:11,640
humans and also of Mother Earth you know

1033
00:38:17,510 --> 00:38:14,339
nature and things like that and I found

1034
00:38:19,970 --> 00:38:17,520
that actually all of those other

1035
00:38:23,450 --> 00:38:19,980
activities and talents that I developed

1036
00:38:25,609 --> 00:38:23,460
play a huge role in science now because

1037
00:38:27,109 --> 00:38:25,619
you know as scientists we're not just

1038
00:38:29,510 --> 00:38:27,119

responsible for doing science we are

1039
00:38:32,930 --> 00:38:29,520
responsible for so many other things too

1040
00:38:35,150 --> 00:38:32,940
when we craft a talk or prepare a paper

1041
00:38:37,069 --> 00:38:35,160
for submission we have to do a little

1042
00:38:40,130 --> 00:38:37,079
bit of graphic design to make figures

1043
00:38:43,250 --> 00:38:40,140
look accessible and appealing to people

1044
00:38:44,930 --> 00:38:43,260
um and when we uh are engaging with the

1045
00:38:47,210 --> 00:38:44,940
public right now you know we're we're

1046
00:38:48,710 --> 00:38:47,220
public speakers we're storytellers and

1047
00:38:50,930 --> 00:38:48,720
spokespeople

1048
00:38:53,150 --> 00:38:50,940
um for for ambassadors for science

1049
00:38:55,970 --> 00:38:53,160
essentially and so learning about the

1050
00:38:57,770 --> 00:38:55,980
humanities learning about how to engage

1051
00:39:01,310 --> 00:38:57,780
with other people learning about

1052
00:39:03,589 --> 00:39:01,320
Aesthetics and art can actually enhance

1053
00:39:06,230 --> 00:39:03,599
I think a scientist and the scientific

1054
00:39:09,650 --> 00:39:06,240
experience and so I try to wrap all of

1055
00:39:11,810 --> 00:39:09,660
that together into uh who I am and

1056
00:39:13,550 --> 00:39:11,820
embrace it all and and try to you know

1057
00:39:14,870 --> 00:39:13,560
ignore all the haters who say like if

1058
00:39:16,370 --> 00:39:14,880
you spend too much time doing something

1059
00:39:17,810 --> 00:39:16,380
else you're not being a serious

1060
00:39:20,990 --> 00:39:17,820
scientist because it all actually

1061
00:39:22,490 --> 00:39:21,000
contributes to my science and who I am I

1062
00:39:24,290 --> 00:39:22,500
appreciate that so much I'm so glad to

1063
00:39:26,630 --> 00:39:24,300

have you on the show to hear of your

1064
00:39:28,550 --> 00:39:26,640
unique perspective now much like in Star

1065
00:39:30,710 --> 00:39:28,560
Trek with warp drive taking the Stars

1066
00:39:32,569 --> 00:39:30,720
flying past us really quick we now want

1067
00:39:34,550 --> 00:39:32,579
to jump to our faster than light segment

1068
00:39:36,230 --> 00:39:34,560
so I'm going to ask a few questions and

1069
00:39:38,089 --> 00:39:36,240
if you could get the answers to like 30

1070
00:39:39,230 --> 00:39:38,099
seconds or so sure

1071
00:39:41,030 --> 00:39:39,240
um just you know it's kind of fun just

1072
00:39:43,430 --> 00:39:41,040
for the audience to hear kind of your

1073
00:39:44,569 --> 00:39:43,440
thoughts about some of these questions

1074
00:39:47,030 --> 00:39:44,579
um first off we might know the answer

1075
00:39:48,470 --> 00:39:47,040
the answer to this already what's your

1076
00:39:51,890 --> 00:39:48,480
favorite answer to fermi's question

1077
00:39:54,050 --> 00:39:51,900
where are they yeah so uh I think my

1078
00:39:56,089 --> 00:39:54,060
favorite answer to this is that we're

1079
00:39:57,950 --> 00:39:56,099
just we're just too young as a

1080
00:40:01,069 --> 00:39:57,960
civilization you know we haven't been

1081
00:40:04,069 --> 00:40:01,079
around long enough to explore and listen

1082
00:40:05,990 --> 00:40:04,079
to a large enough volume of space or

1083
00:40:08,390 --> 00:40:06,000
hyper volume of space and frequencies

1084
00:40:10,010 --> 00:40:08,400
and all this other things uh and we also

1085
00:40:12,290 --> 00:40:10,020
haven't been long enough around long

1086
00:40:13,730 --> 00:40:12,300
enough to just learn how to best listen

1087
00:40:15,770 --> 00:40:13,740
you know if something goes through a

1088
00:40:18,710 --> 00:40:15,780

homeostatic Awakening it may no longer

1089
00:40:21,470 --> 00:40:18,720
be emitting or transmitting on the types

1090
00:40:23,150 --> 00:40:21,480
of uh frequencies or technologies that

1091
00:40:25,370 --> 00:40:23,160
we're used to so I think we just need to

1092
00:40:27,650 --> 00:40:25,380
literally become what we're trying to

1093
00:40:30,050 --> 00:40:27,660
find a long-lived planetary civilization

1094
00:40:31,010 --> 00:40:30,060
before we can go and find it

1095
00:40:33,650 --> 00:40:31,020
um

1096
00:40:35,750 --> 00:40:33,660
so what stories have inspired you to

1097
00:40:36,770 --> 00:40:35,760
want to explore more about life in the

1098
00:40:41,089 --> 00:40:36,780
universe

1099
00:40:42,290 --> 00:40:41,099
I mean Star Trek right so uh one one of

1100
00:40:44,030 --> 00:40:42,300
the one of the

1101
00:40:46,069 --> 00:40:44,040
my favorite characters on Star Trek is

1102
00:40:50,030 --> 00:40:46,079
the doctor from Star Trek Voyager so

1103
00:40:51,890 --> 00:40:50,040
this is a hologram uh and uh he was

1104
00:40:53,510 --> 00:40:51,900
programmed for just one thing and one

1105
00:40:55,910 --> 00:40:53,520
thing only to do medicine really really

1106
00:40:57,770 --> 00:40:55,920
well but throughout the course of the

1107
00:40:59,630 --> 00:40:57,780
seven seasons of Star Trek Voyage or he

1108
00:41:02,630 --> 00:40:59,640
starts to add new subroutines to his

1109
00:41:04,250 --> 00:41:02,640
program and you know becomes a singer a

1110
00:41:07,790 --> 00:41:04,260
photographer

1111
00:41:09,109 --> 00:41:07,800
um you know just a dreamer and I for me

1112
00:41:10,490 --> 00:41:09,119
I think this ties into what we were

1113
00:41:12,770 --> 00:41:10,500

talking about just before was like

1114
00:41:15,170 --> 00:41:12,780
trying to integrate all these aspects of

1115
00:41:17,870 --> 00:41:15,180
humanity into oneself and to realize

1116
00:41:20,450 --> 00:41:17,880
that um you know you have you get to

1117
00:41:22,190 --> 00:41:20,460
Define who you are not some programmer

1118
00:41:23,690 --> 00:41:22,200
or Creator or teacher or mentor of yours

1119
00:41:25,310 --> 00:41:23,700
telling you what you need to do but you

1120
00:41:27,470 --> 00:41:25,320
get to choose what your path looks like

1121
00:41:30,349 --> 00:41:27,480
and what you like to do

1122
00:41:32,390 --> 00:41:30,359
I love that I will say I'm now a father

1123
00:41:33,710 --> 00:41:32,400
I have a three-year-old child now

1124
00:41:35,690 --> 00:41:33,720
um I went back recently and did a

1125
00:41:38,210 --> 00:41:35,700
re-watch of Voyager the episode where

1126
00:41:39,710 --> 00:41:38,220
the doctor creates his own family

1127
00:41:42,230 --> 00:41:39,720
um I'm almost gonna cry right now it

1128
00:41:44,630 --> 00:41:42,240
really it hit very hard yeah being a

1129
00:41:45,890 --> 00:41:44,640
father and so if you enjoy the emotional

1130
00:41:48,290 --> 00:41:45,900
things too there's also a lot of great

1131
00:41:50,089 --> 00:41:48,300
depth of emotion in Star Trek to explore

1132
00:41:52,550 --> 00:41:50,099
for our audience

1133
00:41:54,349 --> 00:41:52,560
um so if you could go back in time and

1134
00:41:58,550 --> 00:41:54,359
visit yourself at the very beginning of

1135
00:42:03,170 --> 00:42:00,230
um take more computer science courses

1136
00:42:06,530 --> 00:42:03,180
because programming is a large chunk of

1137
00:42:09,770 --> 00:42:06,540
what I do and honestly it's kind of

1138
00:42:13,550 --> 00:42:09,780

painful sometimes I won't lie

1139
00:42:16,010 --> 00:42:13,560
um so I think that a lot of the subjects

1140
00:42:17,630 --> 00:42:16,020
that I've had uh in classes that really

1141
00:42:19,790 --> 00:42:17,640
inspired me were because of the teachers

1142
00:42:21,770 --> 00:42:19,800
uh and so I was really lucky to have

1143
00:42:24,230 --> 00:42:21,780
great biology teachers great physics

1144
00:42:26,630 --> 00:42:24,240
teachers great chemistry teachers

1145
00:42:28,849 --> 00:42:26,640
um but uh I I think I I would have

1146
00:42:30,530 --> 00:42:28,859
wanted to give myself more of a chance

1147
00:42:33,230 --> 00:42:30,540
to get really inspired as a computer

1148
00:42:34,910 --> 00:42:33,240
scientist too that's something that I

1149
00:42:36,530 --> 00:42:34,920
would go back in time and tell myself to

1150
00:42:38,150 --> 00:42:36,540
do more of

1151
00:42:39,829 --> 00:42:38,160
all right what is something that excites

1152
00:42:41,870 --> 00:42:39,839
you about the future

1153
00:42:43,970 --> 00:42:41,880
something that excites me about the

1154
00:42:45,770 --> 00:42:43,980
future wow uh I think that we're

1155
00:42:48,470 --> 00:42:45,780
entering a golden age of astrobiology

1156
00:42:51,170 --> 00:42:48,480
you know we're building missions uh and

1157
00:42:52,970 --> 00:42:51,180
and telescopes that will be tasked

1158
00:42:54,950 --> 00:42:52,980
literally with the job of trying to

1159
00:42:57,230 --> 00:42:54,960
identify habitable environments and look

1160
00:43:01,190 --> 00:42:57,240
for signs of life in other worlds

1161
00:43:03,530 --> 00:43:01,200
um and you know this from Europa to uh

1162
00:43:06,410 --> 00:43:03,540
Titan to exoplanets it's just going to

1163
00:43:08,329 --> 00:43:06,420

be a glorious next couple of decades and

1164
00:43:10,910 --> 00:43:08,339
I can't wait to see what what surprises

1165
00:43:13,910 --> 00:43:10,920
find us because if anything uh has been

1166
00:43:16,190 --> 00:43:13,920
learned from our uh our history and

1167
00:43:17,870 --> 00:43:16,200
exploring planetary sciences that we've

1168
00:43:19,609 --> 00:43:17,880
got to expect the unexpected there are

1169
00:43:21,050 --> 00:43:19,619
so many wonders out there not all of

1170
00:43:22,730 --> 00:43:21,060
which will be due to life you know there

1171
00:43:24,829 --> 00:43:22,740
will be unexpected geology too and so

1172
00:43:26,750 --> 00:43:24,839
our task is really hard to disentangle

1173
00:43:29,270 --> 00:43:26,760
unexpected geological findings and

1174
00:43:31,910 --> 00:43:29,280
Atmospheric findings from those truly

1175
00:43:34,370 --> 00:43:31,920
wondrous biological findings

1176
00:43:36,650 --> 00:43:34,380
I love that so much all right one more

1177
00:43:38,510 --> 00:43:36,660
question okay what's an unbelievable

1178
00:43:40,550 --> 00:43:38,520
science fact that still blows your mind

1179
00:43:42,530 --> 00:43:40,560
wow

1180
00:43:44,690 --> 00:43:42,540
um it's so hard to pick just one you

1181
00:43:46,309 --> 00:43:44,700
know if you think about any science fact

1182
00:43:49,790 --> 00:43:46,319
long enough I feel like it'll blow your

1183
00:43:52,790 --> 00:43:49,800
mind and I say that science is the

1184
00:43:56,450 --> 00:43:52,800
greatest Underdog Story ever you know

1185
00:43:59,750 --> 00:43:56,460
our senses our minds we're not evolved

1186
00:44:01,730 --> 00:43:59,760
to you know characterize exoplanets or

1187
00:44:03,950 --> 00:44:01,740
understand quantum mechanics or know

1188
00:44:05,690 --> 00:44:03,960

about neutrinos or dark matter and yet

1189
00:44:07,069 --> 00:44:05,700
we do anyway

1190
00:44:09,589 --> 00:44:07,079
um and so I think that there are still

1191
00:44:12,470 --> 00:44:09,599
so many unknowns but the fact that we

1192
00:44:15,109 --> 00:44:12,480
are on this journey trying to identify

1193
00:44:16,970 --> 00:44:15,119
our place in the universe asking these

1194
00:44:20,030 --> 00:44:16,980
Cosmic questions and the fact that we

1195
00:44:22,309 --> 00:44:20,040
know anything at all is is the science

1196
00:44:24,470 --> 00:44:22,319
fact that blows my mind the most

1197
00:44:26,510 --> 00:44:24,480
um that we are here part of the universe

1198
00:44:28,790 --> 00:44:26,520
understanding itself

1199
00:44:31,910 --> 00:44:28,800
I love that so much we we think

1200
00:44:33,349 --> 00:44:31,920
therefore we are right yeah I love it so

1201
00:44:35,150 --> 00:44:33,359
I will go to the audience q a now I

1202
00:44:36,950 --> 00:44:35,160
realized I stole so much of our time

1203
00:44:38,870 --> 00:44:36,960
here just talking to you I could nerd

1204
00:44:40,670 --> 00:44:38,880
out with you for hours honestly over

1205
00:44:42,589 --> 00:44:40,680
lots of things Star Trek exoplanets

1206
00:44:43,730 --> 00:44:42,599
astrobiology and more

1207
00:44:45,109 --> 00:44:43,740
um but I do want to give the audience

1208
00:44:47,750 --> 00:44:45,119
their their chance to ask some questions

1209
00:44:50,329 --> 00:44:47,760
and the first one comes from Jim pass

1210
00:44:52,609 --> 00:44:50,339
who heads the Astro sociology Research

1211
00:44:54,589 --> 00:44:52,619
Institute and usually ask very good

1212
00:44:56,450 --> 00:44:54,599
questions about sociology and how they

1213
00:44:58,630 --> 00:44:56,460

kind of impact our science in this case

1214
00:45:00,650 --> 00:44:58,640
he has a star a Star Trek question

1215
00:45:03,650 --> 00:45:00,660
regarding the prime directive and first

1216
00:45:05,809 --> 00:45:03,660
Contact if we detect intelligent life

1217
00:45:07,849 --> 00:45:05,819
maybe through evidence of techno

1218
00:45:11,210 --> 00:45:07,859
signatures how do you think we should

1219
00:45:13,250 --> 00:45:11,220
move forward as human Starfleet yeah

1220
00:45:16,010 --> 00:45:13,260
that's a great question Jim uh love

1221
00:45:19,309 --> 00:45:16,020
thinking about it I think in in the near

1222
00:45:21,349 --> 00:45:19,319
term you know real the reality of a

1223
00:45:24,650 --> 00:45:21,359
techno signature will be that there's

1224
00:45:26,569 --> 00:45:24,660
probably no imminent need to take any

1225
00:45:29,089 --> 00:45:26,579
kind of action if we get a signal from

1226
00:45:31,309 --> 00:45:29,099
very far away you know it might be uh

1227
00:45:32,809 --> 00:45:31,319
dozens to hundreds maybe a thousands

1228
00:45:35,030 --> 00:45:32,819
light years away however along the way

1229
00:45:36,470 --> 00:45:35,040
it is you know the travel time is going

1230
00:45:38,270 --> 00:45:36,480
to be so long it's not going to be like

1231
00:45:40,069 --> 00:45:38,280
talking over Zoom with with a buddy

1232
00:45:41,510 --> 00:45:40,079
right um so we have time to figure

1233
00:45:44,530 --> 00:45:41,520
things out and I think the most

1234
00:45:49,130 --> 00:45:44,540
important thing that we need to do is to

1235
00:45:52,550 --> 00:45:49,140
collectively as a planetary civilization

1236
00:45:53,450 --> 00:45:52,560
um as ambassadors of Earth decide what

1237
00:45:55,849 --> 00:45:53,460
to do

1238
00:45:57,109 --> 00:45:55,859

um together and I think that one of the

1239
00:45:59,630 --> 00:45:57,119
most amazing things that a techno

1240
00:46:02,450 --> 00:45:59,640
signature could give us is that kind of

1241
00:46:04,790 --> 00:46:02,460
opportunity that table around which to

1242
00:46:07,069 --> 00:46:04,800
to to congregate and have those

1243
00:46:09,109 --> 00:46:07,079
meaningful conversations as a species

1244
00:46:10,609 --> 00:46:09,119
not as you know a bunch of people from

1245
00:46:13,250 --> 00:46:10,619
this nation and that Nation but really

1246
00:46:15,770 --> 00:46:13,260
all of us as citizens from Earth so I

1247
00:46:18,349 --> 00:46:15,780
hope that we take the time to craft our

1248
00:46:21,230 --> 00:46:18,359
message together with intent and purpose

1249
00:46:22,790 --> 00:46:21,240
and compassion because we probably will

1250
00:46:25,430 --> 00:46:22,800
have that time

1251
00:46:26,990 --> 00:46:25,440
um and and yeah that's that's basically

1252
00:46:28,670 --> 00:46:27,000
my hope I don't know what we would say

1253
00:46:30,710 --> 00:46:28,680
necessarily

1254
00:46:32,930 --> 00:46:30,720
um but I I hope we take the opportunity

1255
00:46:35,210 --> 00:46:32,940
to use it to bind our species together

1256
00:46:38,210 --> 00:46:35,220
more I love that

1257
00:46:39,770 --> 00:46:38,220
um user at hazy Wu on Twitter they ask a

1258
00:46:40,970 --> 00:46:39,780
few questions about your background that

1259
00:46:42,650 --> 00:46:40,980
you've already addressed in the episode

1260
00:46:44,510 --> 00:46:42,660
but one thing that they wanted to know

1261
00:46:47,210 --> 00:46:44,520
is if you would recommend a certain area

1262
00:46:49,430 --> 00:46:47,220
at the University that students who want

1263
00:46:51,290 --> 00:46:49,440

to study astrobiology should study

1264
00:46:54,950 --> 00:46:51,300
themselves to learn more about a certain

1265
00:46:56,990 --> 00:46:54,960
realm of astrobiology well so um like I

1266
00:46:59,809 --> 00:46:57,000
said anybody can be an astrobiologist

1267
00:47:03,050 --> 00:46:59,819
you can come at it from any major uh but

1268
00:47:06,170 --> 00:47:03,060
what I did actually to learn more about

1269
00:47:09,410 --> 00:47:06,180
astrobiology at my institutions was to

1270
00:47:11,809 --> 00:47:09,420
start a journal Club to start a weekly

1271
00:47:13,609 --> 00:47:11,819
series of meetings and invite people

1272
00:47:16,130 --> 00:47:13,619
from all sorts of different disciplines

1273
00:47:17,450 --> 00:47:16,140
to come together we'd read a paper and

1274
00:47:18,950 --> 00:47:17,460
we'd learn from each other because

1275
00:47:20,510 --> 00:47:18,960
everybody has something different to

1276
00:47:22,130 --> 00:47:20,520
bring to the table a different insight

1277
00:47:23,270 --> 00:47:22,140
there are lots of times when I was

1278
00:47:24,530 --> 00:47:23,280
confused and I was like I don't

1279
00:47:26,030 --> 00:47:24,540
understand this word does anybody know

1280
00:47:28,309 --> 00:47:26,040
what this word means and somebody would

1281
00:47:30,530 --> 00:47:28,319
uh and so it's because astrobiology is

1282
00:47:32,089 --> 00:47:30,540
so interdisciplinary I would say it's

1283
00:47:34,309 --> 00:47:32,099
not a single area of study that you need

1284
00:47:35,930 --> 00:47:34,319
to look for it is a group of people who

1285
00:47:38,210 --> 00:47:35,940
are all interested in the same Grand

1286
00:47:40,069 --> 00:47:38,220
astrological questions as you who come

1287
00:47:42,950 --> 00:47:40,079
from different areas of study so if you

1288
00:47:44,630 --> 00:47:42,960

can craft that network of peers and

1289
00:47:47,569 --> 00:47:44,640
Friends uh that could be really

1290
00:47:50,809 --> 00:47:47,579
beneficial learning astrobiology yeah I

1291
00:47:52,430 --> 00:47:50,819
love at the end of your life paper you

1292
00:47:54,290 --> 00:47:52,440
had an acknowledgment to the I think it

1293
00:47:55,910 --> 00:47:54,300
was the cow attack astrobiology reading

1294
00:47:57,410 --> 00:47:55,920
group so it's cool to see that because

1295
00:47:59,150 --> 00:47:57,420
like book clubs Journal clubs they

1296
00:48:00,950 --> 00:47:59,160
really can help in your own your own

1297
00:48:03,050 --> 00:48:00,960
learning and your own reading for sure

1298
00:48:05,750 --> 00:48:03,060
our next question comes from rendering

1299
00:48:07,670 --> 00:48:05,760
reality 3D animations on YouTube they

1300
00:48:09,710 --> 00:48:07,680
ask to understand climate change we

1301
00:48:12,710 --> 00:48:09,720
separate climate forcing and variability

1302
00:48:14,870 --> 00:48:12,720
from human impact often how do long

1303
00:48:16,670 --> 00:48:14,880
slash short-term climate studies help us

1304
00:48:18,410 --> 00:48:16,680
in understanding and searching for

1305
00:48:21,530 --> 00:48:18,420
biosignatures

1306
00:48:24,609 --> 00:48:21,540
wow what a fantastic question you know I

1307
00:48:28,250 --> 00:48:24,619
I often say that uh you know

1308
00:48:31,970 --> 00:48:28,260
astrobiology like science fiction is the

1309
00:48:35,930 --> 00:48:31,980
best when it is using far away questions

1310
00:48:38,510 --> 00:48:35,940
to examine close to home issues right

1311
00:48:41,390 --> 00:48:38,520
and habitability and climate is one of

1312
00:48:43,970 --> 00:48:41,400
those we can't ask about habitability of

1313
00:48:46,069 --> 00:48:43,980

exoplanets without becoming acutely

1314
00:48:51,050 --> 00:48:46,079
aware of the climate physics that is

1315
00:48:52,849 --> 00:48:51,060
contributing to our own uh you know a

1316
00:48:54,710 --> 00:48:52,859
climate crisis right now and how we're

1317
00:48:57,170 --> 00:48:54,720
kind of rooting the habitability of our

1318
00:49:01,370 --> 00:48:57,180
own planet for ourselves

1319
00:49:03,589 --> 00:49:01,380
um and so that is uh now I've lost the

1320
00:49:05,450 --> 00:49:03,599
question already what was the question

1321
00:49:06,349 --> 00:49:05,460
basically how do our current climate

1322
00:49:08,630 --> 00:49:06,359
studies help us looking for

1323
00:49:10,370 --> 00:49:08,640
biosignatures yeah okay well so here's

1324
00:49:12,770 --> 00:49:10,380
the great thing is that a lot of the

1325
00:49:15,050 --> 00:49:12,780
tools that we use in climate science

1326
00:49:17,210 --> 00:49:15,060
here for Earth get adapted for

1327
00:49:19,250 --> 00:49:17,220
exoplanetary studies so the general

1328
00:49:21,309 --> 00:49:19,260
circulation model roles in the

1329
00:49:24,470 --> 00:49:21,319
photochemical models that were first

1330
00:49:26,690 --> 00:49:24,480
developed and used to describe the

1331
00:49:30,829 --> 00:49:26,700
variations on our own world those

1332
00:49:32,690 --> 00:49:30,839
mathematical and computational tools are

1333
00:49:35,089 --> 00:49:32,700
then ported to other planets because

1334
00:49:37,069 --> 00:49:35,099
what you do is you just you change the

1335
00:49:39,109 --> 00:49:37,079
values in those equations the parameters

1336
00:49:41,270 --> 00:49:39,119
the initial conditions to reflect not

1337
00:49:44,030 --> 00:49:41,280
Earth but in EXO Earth around some other

1338
00:49:46,309 --> 00:49:44,040

star change the Stellar input like like

1339
00:49:48,050 --> 00:49:46,319
changing a light bulb and and then you

1340
00:49:49,670 --> 00:49:48,060
are simulating another world with

1341
00:49:51,829 --> 00:49:49,680
potentially a different biosphere

1342
00:49:53,510 --> 00:49:51,839
different fluxes of gases and that can

1343
00:49:56,390 --> 00:49:53,520
tell you about what kinds of variations

1344
00:49:58,430 --> 00:49:56,400
to look for on those planets um and and

1345
00:50:00,650 --> 00:49:58,440
we try to model their evolution over

1346
00:50:02,870 --> 00:50:00,660
time to know if they you know remain

1347
00:50:05,750 --> 00:50:02,880
habitable over time things like this so

1348
00:50:07,670 --> 00:50:05,760
it really is a tight-knit community of

1349
00:50:10,309 --> 00:50:07,680
people who are studying earth science

1350
00:50:12,109 --> 00:50:10,319
especially climate and our atmosphere

1351
00:50:14,210 --> 00:50:12,119
and those who are trying to understand

1352
00:50:16,750 --> 00:50:14,220
the climate's inhabitability of other

1353
00:50:20,329 --> 00:50:16,760
worlds yeah there's so many connections

1354
00:50:22,430 --> 00:50:20,339
our next user uh Sila on YouTube I hope

1355
00:50:24,050 --> 00:50:22,440
I pronounced that correctly they

1356
00:50:25,790 --> 00:50:24,060
basically want to know and so in your

1357
00:50:28,190 --> 00:50:25,800
life paper you kind of have a

1358
00:50:30,290 --> 00:50:28,200
description of of life you know with an

1359
00:50:32,390 --> 00:50:30,300
eye and life with a why

1360
00:50:34,190 --> 00:50:32,400
um Silo wants to know with the the NASA

1361
00:50:35,690 --> 00:50:34,200
definition as it's sometimes called that

1362
00:50:38,210 --> 00:50:35,700
life is a self-sustaining chemical

1363
00:50:39,710 --> 00:50:38,220

system capable of darwinian evolution

1364
00:50:43,450 --> 00:50:39,720
um if you could just explain kind of

1365
00:50:45,770 --> 00:50:43,460
that idea to them yeah absolutely so uh

1366
00:50:47,990 --> 00:50:45,780
self-sustaining chemical system capable

1367
00:50:49,430 --> 00:50:48,000
of darwinian evolution right so that's

1368
00:50:52,490 --> 00:50:49,440
NASA's definition of life and I think

1369
00:50:54,770 --> 00:50:52,500
it's a very good definition for the kind

1370
00:50:56,990 --> 00:50:54,780
of life that we see here on Earth now

1371
00:50:59,150 --> 00:50:57,000
the issue with uh definitions though is

1372
00:51:00,890 --> 00:50:59,160
it's hard to generalize from n equals

1373
00:51:03,530 --> 00:51:00,900
one to that grander scope of things

1374
00:51:05,930 --> 00:51:03,540
that's what we attempt to do in the uh

1375
00:51:08,690 --> 00:51:05,940
the the Lyfe paper

1376
00:51:10,549 --> 00:51:08,700
um but uh but but some of the things

1377
00:51:11,930 --> 00:51:10,559
that give me pause about NASA's

1378
00:51:16,130 --> 00:51:11,940
definition

1379
00:51:17,630 --> 00:51:16,140
um you know acknowledging that you know

1380
00:51:20,870 --> 00:51:17,640
it is something that can evolve and

1381
00:51:22,970 --> 00:51:20,880
change with time with new discoveries is

1382
00:51:25,250 --> 00:51:22,980
the idea that okay so it's maybe a

1383
00:51:27,049 --> 00:51:25,260
chemical system but um but does that

1384
00:51:29,990 --> 00:51:27,059
mean you know maybe we should discount

1385
00:51:32,390 --> 00:51:30,000
uh robotic life or or

1386
00:51:33,710 --> 00:51:32,400
um in silico life computer computerized

1387
00:51:35,569 --> 00:51:33,720
life forms

1388
00:51:37,970 --> 00:51:35,579

um and also capable of darwinian

1389
00:51:39,890 --> 00:51:37,980
evolution what if there are other

1390
00:51:43,069 --> 00:51:39,900
mechanisms of evolution that do not

1391
00:51:45,109 --> 00:51:43,079
follow precisely the darwinian molds

1392
00:51:47,750 --> 00:51:45,119
here on Earth there's actually a really

1393
00:51:49,849 --> 00:51:47,760
uh interesting paper that just came out

1394
00:51:51,770 --> 00:51:49,859
a couple of weeks ago by Professor

1395
00:51:53,270 --> 00:51:51,780
Muhammad Noor again one of the science

1396
00:51:55,430 --> 00:51:53,280
consultants for Star Trek titled

1397
00:51:57,470 --> 00:51:55,440
Thinking Outside Earth's box how

1398
00:51:59,450 --> 00:51:57,480
Evolution and heredity could differ on

1399
00:52:02,329 --> 00:51:59,460
other worlds and so this is again trying

1400
00:52:04,250 --> 00:52:02,339
to imagine other possibilities that may

1401
00:52:06,410 --> 00:52:04,260
fall slightly outside of the bounds of

1402
00:52:08,329 --> 00:52:06,420
NASA's definition of life because it

1403
00:52:10,190 --> 00:52:08,339
doesn't strictly due to darwinian

1404
00:52:12,049 --> 00:52:10,200
Evolution per se

1405
00:52:13,970 --> 00:52:12,059
um but but may nonetheless you know

1406
00:52:15,770 --> 00:52:13,980
actually be what we would consider a

1407
00:52:17,690 --> 00:52:15,780
living being when we take a kind of

1408
00:52:21,109 --> 00:52:17,700
grander more encompassing more inclusive

1409
00:52:23,630 --> 00:52:21,119
definite mission of life with a Y very

1410
00:52:25,430 --> 00:52:23,640
cool so we have a question from Imani

1411
00:52:27,290 --> 00:52:25,440
Mehta they want to know how we could

1412
00:52:29,150 --> 00:52:27,300
identify biological markers on

1413
00:52:29,990 --> 00:52:29,160

exoplanets that differ from Life as we

1414
00:52:31,849 --> 00:52:30,000
know it

1415
00:52:35,150 --> 00:52:31,859
um how can we look for that

1416
00:52:37,370 --> 00:52:35,160
yeah so again this uh this this is about

1417
00:52:39,589 --> 00:52:37,380
uh developing what astrobiologists call

1418
00:52:41,390 --> 00:52:39,599
agnostic biosignatures agnostic meaning

1419
00:52:44,930 --> 00:52:41,400
that we can look for life not

1420
00:52:47,030 --> 00:52:44,940
necessarily as our own and so again this

1421
00:52:50,150 --> 00:52:47,040
is all very intimately tied into our

1422
00:52:52,010 --> 00:52:50,160
definition for life and I love the idea

1423
00:52:54,290 --> 00:52:52,020
of developing agnostic bio signatures

1424
00:52:56,390 --> 00:52:54,300
because it actually really gets us to

1425
00:52:58,910 --> 00:52:56,400
think about those fundamental principles

1426
00:53:01,010 --> 00:52:58,920
of what life is what do we expect life

1427
00:53:02,990 --> 00:53:01,020
everywhere to do no matter what kind of

1428
00:53:04,670 --> 00:53:03,000
environment it is in that would classify

1429
00:53:07,609 --> 00:53:04,680
it as life and what are those things

1430
00:53:09,530 --> 00:53:07,619
that we can then look for and so we hope

1431
00:53:11,930 --> 00:53:09,540
that the network kind of biosignatures

1432
00:53:14,510 --> 00:53:11,940
that we are developing right now will

1433
00:53:17,150 --> 00:53:14,520
allow us to identify life forms that

1434
00:53:18,950 --> 00:53:17,160
exist in different environments and

1435
00:53:21,950 --> 00:53:18,960
affect their environment in slightly

1436
00:53:25,430 --> 00:53:21,960
different ways but still maintain a sort

1437
00:53:28,670 --> 00:53:25,440
of like abstract kind of complexity uh

1438
00:53:31,010 --> 00:53:28,680

that makes it a a an identifiable living

1439
00:53:33,890 --> 00:53:31,020
system that maybe maybe complexity or

1440
00:53:36,230 --> 00:53:33,900
maybe information and content can be

1441
00:53:40,309 --> 00:53:36,240
sort of a Hallmark of life that is

1442
00:53:41,690 --> 00:53:40,319
independent of specific molecules a lot

1443
00:53:43,849 --> 00:53:41,700
of work still needs to be done in this

1444
00:53:46,309 --> 00:53:43,859
area agnostic biosignatures is a

1445
00:53:48,829 --> 00:53:46,319
relatively new science and I'm sure we

1446
00:53:52,069 --> 00:53:48,839
have we'll have many updates for you in

1447
00:53:54,650 --> 00:53:52,079
years to come awesome our next user

1448
00:53:56,030 --> 00:53:54,660
corvus on YouTube wants to know if

1449
00:53:57,470 --> 00:53:56,040
there's any any work being done on

1450
00:54:00,290 --> 00:53:57,480
theoretical biosignatures for

1451
00:54:01,910 --> 00:54:00,300
silicon-based life I will say first that

1452
00:54:04,670 --> 00:54:01,920
I would recommend a review paper from

1453
00:54:06,410 --> 00:54:04,680
petkowski Baines and Seeger on the

1454
00:54:08,569 --> 00:54:06,420
potential for silicon as a building

1455
00:54:10,790 --> 00:54:08,579
block for life they really did a great

1456
00:54:13,150 --> 00:54:10,800
job kind of reviewing everything that we

1457
00:54:16,010 --> 00:54:13,160
know right now based on chemistry about

1458
00:54:18,109 --> 00:54:16,020
silicon-based life if it's possible but

1459
00:54:19,609 --> 00:54:18,119
but Mike is is there any way of us to

1460
00:54:21,710 --> 00:54:19,619
look for kind of silicon-based Life on

1461
00:54:23,390 --> 00:54:21,720
another world yet yeah that's a really

1462
00:54:24,950 --> 00:54:23,400
good question and I was also going to

1463
00:54:26,750 --> 00:54:24,960

point to that paper because you know

1464
00:54:29,089 --> 00:54:26,760
again an excellent review of the state

1465
00:54:30,530 --> 00:54:29,099
of the art and our knowledge and sort of

1466
00:54:33,170 --> 00:54:30,540
expectations and guesses for what

1467
00:54:35,569 --> 00:54:33,180
silicon-based life could be like

1468
00:54:36,910 --> 00:54:35,579
um I think again uh very similar to the

1469
00:54:40,250 --> 00:54:36,920
previous question

1470
00:54:43,190 --> 00:54:40,260
if we are looking for silicon-based life

1471
00:54:45,049 --> 00:54:43,200
we're just Life As We Don't Know It uh

1472
00:54:48,470 --> 00:54:45,059
embedded in a different kind of

1473
00:54:50,809 --> 00:54:48,480
substrate well we would need to look for

1474
00:54:53,809 --> 00:54:50,819
these kind of abstract principles of

1475
00:54:57,069 --> 00:54:53,819
life that aren't reliant on specific

1476
00:55:00,829 --> 00:54:57,079
molecules themselves I would also

1477
00:55:04,010 --> 00:55:00,839
potentially throw out the provocative

1478
00:55:06,589 --> 00:55:04,020
idea that we are creating silicon-based

1479
00:55:09,290 --> 00:55:06,599
life right now through our technology uh

1480
00:55:11,870 --> 00:55:09,300
a lot of thought has been given to the

1481
00:55:16,130 --> 00:55:11,880
idea that maybe our technological

1482
00:55:18,950 --> 00:55:16,140
entities are kind of like evolving in a

1483
00:55:21,710 --> 00:55:18,960
very biological fashion I saw a paper uh

1484
00:55:24,650 --> 00:55:21,720
recently about how if you make like a

1485
00:55:27,470 --> 00:55:24,660
phylogenetic tree an evolutionary tree

1486
00:55:31,730 --> 00:55:27,480
of computer code languages it looks very

1487
00:55:33,650 --> 00:55:31,740
much like the phylogenetic trees of uh

1488
00:55:35,990 --> 00:55:33,660

biological organisms the tree of life

1489
00:55:39,530 --> 00:55:36,000
that we all know and you know when I was

1490
00:55:40,970 --> 00:55:39,540
when I was young we all had iPods right

1491
00:55:43,490 --> 00:55:40,980
we all walked around with iPods

1492
00:55:46,370 --> 00:55:43,500
listening to music these days very few

1493
00:55:49,250 --> 00:55:46,380
iPods exist because they were sort of uh

1494
00:55:51,230 --> 00:55:49,260
driven to extinction by these phone-like

1495
00:55:53,089 --> 00:55:51,240
devices that do more than just allow you

1496
00:55:54,410 --> 00:55:53,099
to listen to music but also enable you

1497
00:55:55,849 --> 00:55:54,420
to do all sorts of different functions

1498
00:55:59,049 --> 00:55:55,859
so we do see a kind of like an

1499
00:56:02,390 --> 00:55:59,059
evolutionary process occurring uh

1500
00:56:05,210 --> 00:56:02,400
through our technology as well that is

1501
00:56:07,010 --> 00:56:05,220
sort of like embedded upon or within our

1502
00:56:09,530 --> 00:56:07,020
biosphere so our technosphere and our

1503
00:56:12,109 --> 00:56:09,540
biosphere are constantly co-evolving uh

1504
00:56:14,450 --> 00:56:12,119
and so you know that our silicon chips

1505
00:56:15,849 --> 00:56:14,460
our silicon-based devices might be the

1506
00:56:18,109 --> 00:56:15,859
Silicon life

1507
00:56:20,349 --> 00:56:18,119
which is you know very different from

1508
00:56:23,329 --> 00:56:20,359
like the horcha from Star Trek

1509
00:56:25,250 --> 00:56:23,339
but nonetheless uh very intriguing and

1510
00:56:27,290 --> 00:56:25,260
thought provoking to think about

1511
00:56:30,290 --> 00:56:27,300
awesome our next question comes from

1512
00:56:31,730 --> 00:56:30,300
arunova padar on YouTube arunova

1513
00:56:33,770 --> 00:56:31,740

basically is asking a question kind of

1514
00:56:35,270 --> 00:56:33,780
merging the concepts of life as you

1515
00:56:37,430 --> 00:56:35,280
presented along with your idea of like a

1516
00:56:39,829 --> 00:56:37,440
network concept for for planetary

1517
00:56:41,510 --> 00:56:39,839
systems Arena wants to know if there

1518
00:56:43,790 --> 00:56:41,520
could be a definition of life based on

1519
00:56:45,589 --> 00:56:43,800
an ordered Network concept for a

1520
00:56:47,510 --> 00:56:45,599
planetary system

1521
00:56:50,569 --> 00:56:47,520
yeah I mean that's something that we're

1522
00:56:53,569 --> 00:56:50,579
we're working on how uh networks sort of

1523
00:56:55,970 --> 00:56:53,579
reflect those fundamental pillars of

1524
00:56:58,790 --> 00:56:55,980
Life uh can we see evidence for for

1525
00:57:01,609 --> 00:56:58,800
instance homeostasis within uh different

1526
00:57:04,370 --> 00:57:01,619
networks I think uh we we do absolutely

1527
00:57:05,270 --> 00:57:04,380
at the biological scales right it would

1528
00:57:08,210 --> 00:57:05,280
be

1529
00:57:11,630 --> 00:57:08,220
a really bad network if you just took

1530
00:57:14,690 --> 00:57:11,640
out one node so in a Cell maybe just one

1531
00:57:16,130 --> 00:57:14,700
uh um metabolite you took it out and the

1532
00:57:19,309 --> 00:57:16,140
whole cell collapsed it would be a

1533
00:57:21,349 --> 00:57:19,319
really bad uh neural network if if

1534
00:57:24,049 --> 00:57:21,359
suddenly one of your neurons shut off

1535
00:57:26,450 --> 00:57:24,059
you couldn't think anymore be really a

1536
00:57:28,069 --> 00:57:26,460
poor food web if you just took out one

1537
00:57:30,589 --> 00:57:28,079
species and then the whole ecosystem

1538
00:57:31,849 --> 00:57:30,599

collapses and so at the same time you

1539
00:57:33,829 --> 00:57:31,859
know maybe there is something at the

1540
00:57:36,530 --> 00:57:33,839
planetary scale in our biogeochemical

1541
00:57:39,410 --> 00:57:36,540
cycles where um sort of like some kind

1542
00:57:42,230 --> 00:57:39,420
of homeostasis is achieved some kind of

1543
00:57:45,230 --> 00:57:42,240
robustness to that Network and then this

1544
00:57:46,730 --> 00:57:45,240
gets into the again intriguing and uh

1545
00:57:48,470 --> 00:57:46,740
provocative concept of the Gaia

1546
00:57:50,990 --> 00:57:48,480
hypothesis that what life does as it

1547
00:57:52,910 --> 00:57:51,000
embeds itself into the geochemical

1548
00:57:55,069 --> 00:57:52,920
systems is to actually prop them up to

1549
00:57:57,470 --> 00:57:55,079
keep them going to maintain itself and

1550
00:58:00,290 --> 00:57:57,480
to persist into the future

1551
00:58:02,569 --> 00:58:00,300
um and so you know again open questions

1552
00:58:04,069 --> 00:58:02,579
we're working on them and we hope to

1553
00:58:06,230 --> 00:58:04,079
have some more answers in the years to

1554
00:58:07,910 --> 00:58:06,240
come awesome we getting very close to

1555
00:58:09,589 --> 00:58:07,920
the top of the hour we have just a few

1556
00:58:10,849 --> 00:58:09,599
questions left if you have a moment I'd

1557
00:58:13,309 --> 00:58:10,859
love to ask at least two of these

1558
00:58:15,170 --> 00:58:13,319
remaining questions maybe three I'm game

1559
00:58:18,049 --> 00:58:15,180
let's do it okay this one question comes

1560
00:58:19,250 --> 00:58:18,059
from upgrade me BB on YouTube I'm not

1561
00:58:21,770 --> 00:58:19,260
quite sure if I understand the question

1562
00:58:24,170 --> 00:58:21,780
they say is it possible that because we

1563
00:58:25,849 --> 00:58:24,180

may not understand alien technology that

1564
00:58:27,349 --> 00:58:25,859
something as large as a star may be

1565
00:58:29,569 --> 00:58:27,359
inorganic

1566
00:58:31,069 --> 00:58:29,579
um I think what they're asking is could

1567
00:58:33,010 --> 00:58:31,079
it be that something as large as a star

1568
00:58:36,349 --> 00:58:33,020
might be living

1569
00:58:40,130 --> 00:58:36,359
okay I love this question because uh

1570
00:58:42,829 --> 00:58:40,140
when I was teaching astrobiology to

1571
00:58:44,630 --> 00:58:42,839
college students one of the one of the

1572
00:58:46,849 --> 00:58:44,640
first things activities that we did was

1573
00:58:48,109 --> 00:58:46,859
can you define life right so I ask all

1574
00:58:49,789 --> 00:58:48,119
the students to write down their own

1575
00:58:51,109 --> 00:58:49,799
definition and then they get in groups

1576
00:58:52,430 --> 00:58:51,119
and share their definitions with their

1577
00:58:53,930 --> 00:58:52,440
groups and come up with a group

1578
00:58:55,430 --> 00:58:53,940
definition that they can all agree upon

1579
00:58:56,870 --> 00:58:55,440
and then the groups write their

1580
00:58:59,630 --> 00:58:56,880
definitions on the Whiteboard and then

1581
00:59:02,809 --> 00:58:59,640
hear uh responses and criticisms from

1582
00:59:05,809 --> 00:59:02,819
the rest of the class and what struck me

1583
00:59:07,430 --> 00:59:05,819
was that nearly every single one of

1584
00:59:11,870 --> 00:59:07,440
those definitions that the groups came

1585
00:59:14,750 --> 00:59:11,880
up with stars satisfied right and I was

1586
00:59:16,309 --> 00:59:14,760
like oh my God like our Stars alive I

1587
00:59:17,329 --> 00:59:16,319
don't think we should consider stars

1588
00:59:19,370 --> 00:59:17,339

alive

1589
00:59:21,289 --> 00:59:19,380
um but it really pointed out how stars

1590
00:59:24,230 --> 00:59:21,299
are what Stuart Bartlett and I would

1591
00:59:27,230 --> 00:59:24,240
call sub life sub life of the Y because

1592
00:59:28,250 --> 00:59:27,240
they do perform some of the pillars of

1593
00:59:30,589 --> 00:59:28,260
life

1594
00:59:31,670 --> 00:59:30,599
um but not all of them and so the main

1595
00:59:32,870 --> 00:59:31,680
one that I think they're missing is

1596
00:59:35,390 --> 00:59:32,880
learning right they don't do information

1597
00:59:37,190 --> 00:59:35,400
processing they don't do the kind of

1598
00:59:38,569 --> 00:59:37,200
evolution that where they can pass on

1599
00:59:41,630 --> 00:59:38,579
information things like that all those

1600
00:59:44,690 --> 00:59:41,640
stars do evolve in a chemical sense

1601
00:59:46,430 --> 00:59:44,700
um they don't uh they don't do harness

1602
00:59:48,650 --> 00:59:46,440
information in the way that we would

1603
00:59:51,289 --> 00:59:48,660
expect a living system to do but they

1604
00:59:53,450 --> 00:59:51,299
are you know different phenomena in the

1605
00:59:55,370 --> 00:59:53,460
universe do similar things to life and

1606
00:59:57,470 --> 00:59:55,380
so we should consider ourselves as a

1607
01:00:00,530 --> 00:59:57,480
part of a larger family of complex

1608
01:00:02,450 --> 01:00:00,540
systems uh maybe one that just does all

1609
01:00:03,710 --> 01:00:02,460
four of these pillars rather than two of

1610
01:00:05,089 --> 01:00:03,720
them or three of them

1611
01:00:06,109 --> 01:00:05,099
awesome

1612
01:00:08,930 --> 01:00:06,119
um our next question comes from

1613
01:00:10,670 --> 01:00:08,940

muhoodles uh on YouTube Mojito's also is

1614
01:00:12,410 --> 01:00:10,680
a twitch streamer

1615
01:00:13,609 --> 01:00:12,420
um and has a great presence on social

1616
01:00:15,289 --> 01:00:13,619
media

1617
01:00:16,609 --> 01:00:15,299
um she wants to know she says one it's

1618
01:00:18,170 --> 01:00:16,619
been awesome

1619
01:00:20,809 --> 01:00:18,180
um and then they want to know what exact

1620
01:00:22,430 --> 01:00:20,819
programming have you done so they're a

1621
01:00:24,230 --> 01:00:22,440
software engineer and would love to help

1622
01:00:26,210 --> 01:00:24,240
with any astrobiology stuff that they

1623
01:00:27,410 --> 01:00:26,220
can so what kind of Realm of programming

1624
01:00:28,849 --> 01:00:27,420
would you recommend for someone who

1625
01:00:29,870 --> 01:00:28,859
wants to get involved in astrobiology

1626
01:00:33,950 --> 01:00:29,880
work

1627
01:00:37,910 --> 01:00:33,960
do you know Fortran because

1628
01:00:40,910 --> 01:00:37,920
a lot of our models are are built in in

1629
01:00:42,289 --> 01:00:40,920
Fortran um and you know we do so when I

1630
01:00:45,289 --> 01:00:42,299
say programming you know we're running

1631
01:00:47,329 --> 01:00:45,299
these very highly complex models for

1632
01:00:49,789 --> 01:00:47,339
simulating all of the physics and the

1633
01:00:51,170 --> 01:00:49,799
chemistry in uh for for myself in

1634
01:00:52,910 --> 01:00:51,180
particular planetary atmospheres but

1635
01:00:55,549 --> 01:00:52,920
other people you know do the Interiors

1636
01:00:57,170 --> 01:00:55,559
of planets and other things like that uh

1637
01:00:59,089 --> 01:00:57,180
and and so these are all you know

1638
01:01:00,530 --> 01:00:59,099

complex computer models that solve

1639
01:01:01,970 --> 01:01:00,540
hundreds of coupled differential

1640
01:01:03,950 --> 01:01:01,980
equations

1641
01:01:06,589 --> 01:01:03,960
um and so you know every once in a while

1642
01:01:08,870 --> 01:01:06,599
the program breaks or it crashes or you

1643
01:01:11,450 --> 01:01:08,880
know we get a segmentation fault and

1644
01:01:13,490 --> 01:01:11,460
those are no fun to diagnose but hey you

1645
01:01:16,789 --> 01:01:13,500
know if if you want to help let's uh

1646
01:01:18,289 --> 01:01:16,799
let's chat I love it I'm going to ask

1647
01:01:19,609 --> 01:01:18,299
one more question

1648
01:01:21,230 --> 01:01:19,619
um for those who ask other questions I

1649
01:01:22,730 --> 01:01:21,240
do apologize but we are running over on

1650
01:01:24,950 --> 01:01:22,740
time a little bit now

1651
01:01:27,470 --> 01:01:24,960
um I love this last question though uh

1652
01:01:29,510 --> 01:01:27,480
kashish Gupta on YouTube has asked um

1653
01:01:31,730 --> 01:01:29,520
throughout your your career as an

1654
01:01:33,890 --> 01:01:31,740
astrobiologist and planetary science uh

1655
01:01:36,470 --> 01:01:33,900
scientist up until now what is your fav

1656
01:01:38,990 --> 01:01:36,480
favorite scientific tool or technique

1657
01:01:40,510 --> 01:01:39,000
with which you've worked or want to work

1658
01:01:44,930 --> 01:01:40,520
in the future

1659
01:01:45,970 --> 01:01:44,940
wow oh my goodness uh what a great

1660
01:01:50,630 --> 01:01:45,980
question

1661
01:01:52,849 --> 01:01:50,640
I would love to uh

1662
01:01:55,130 --> 01:01:52,859
I'm gonna answer this from the what do I

1663
01:01:59,390 --> 01:01:55,140

want to work on in the future I would

1664
01:02:01,069 --> 01:01:59,400
love to be able to work on say samples

1665
01:02:02,870 --> 01:02:01,079
from

1666
01:02:05,390 --> 01:02:02,880
just say Enceladus you know the

1667
01:02:07,970 --> 01:02:05,400
Enceladus orbelander that uh that the

1668
01:02:10,010 --> 01:02:07,980
latest the Catal survey uh has

1669
01:02:11,569 --> 01:02:10,020
recommended be built launched and sent

1670
01:02:14,030 --> 01:02:11,579
to and so let us look for biosignatures

1671
01:02:16,190 --> 01:02:14,040
I wouldn't be great to get some of those

1672
01:02:19,370 --> 01:02:16,200
samples and then really analyze them and

1673
01:02:21,829 --> 01:02:19,380
see if any of our like complexity

1674
01:02:24,589 --> 01:02:21,839
techniques for looking for life actually

1675
01:02:26,809 --> 01:02:24,599
can be found in in those types of

1676
01:02:28,789 --> 01:02:26,819
samples uh right now what we're doing at

1677
01:02:31,430 --> 01:02:28,799
Carnegie actually is a really exciting

1678
01:02:32,329 --> 01:02:31,440
project where we're analyzing all sorts

1679
01:02:38,150 --> 01:02:32,339
of

1680
01:02:39,530 --> 01:02:38,160
and non-living samples here on Earth and

1681
01:02:41,270 --> 01:02:39,540
running them through the exact same kind

1682
01:02:44,270 --> 01:02:41,280
of instrument that will be flown to

1683
01:02:45,950 --> 01:02:44,280
Europa on the Europa Clipper to try to

1684
01:02:47,870 --> 01:02:45,960
identify whether or not there are

1685
01:02:49,670 --> 01:02:47,880
certain patterns in the chemistry that

1686
01:02:52,069 --> 01:02:49,680
are indicative of life versus non-life

1687
01:02:54,770 --> 01:02:52,079
so that kind of excitement where you're

1688
01:02:57,650 --> 01:02:54,780

getting something raw from another world

1689
01:02:59,510 --> 01:02:57,660
and asking is there life there directly

1690
01:03:01,370 --> 01:02:59,520
is something that I hope to be able to

1691
01:03:03,109 --> 01:03:01,380
do in my career

1692
01:03:06,650 --> 01:03:03,119
awesome you have to keep boldly going

1693
01:03:08,930 --> 01:03:06,660
yeah so so thank you so much Mike and

1694
01:03:10,490 --> 01:03:08,940
thanks to everyone for tuning in

1695
01:03:13,609 --> 01:03:10,500
um you can always reach out to us on

1696
01:03:16,069 --> 01:03:13,619
Twitter at Nasa astrobio at saginorg or

1697
01:03:19,309 --> 01:03:16,079
find me at cosmobiologist you can also

1698
01:03:20,809 --> 01:03:19,319
drop us a line at segonnet.org uh a fun

1699
01:03:22,190 --> 01:03:20,819
question I have for the audience who are

1700
01:03:24,710 --> 01:03:22,200
watching now you can answer now in

1701
01:03:26,930 --> 01:03:24,720
YouTube or you know send us an email or

1702
01:03:29,930 --> 01:03:26,940
hit us up on Twitter uh what science

1703
01:03:32,510 --> 01:03:29,940
fiction shows or movies novels or or

1704
01:03:35,270 --> 01:03:32,520
other works of fiction do you think have

1705
01:03:37,270 --> 01:03:35,280
the best representation of astrobiology

1706
01:03:39,530 --> 01:03:37,280
as a science and that could be

1707
01:03:40,970 --> 01:03:39,540
astrobiologists it could be the study of

1708
01:03:41,930 --> 01:03:40,980
alien life the kinds of aliens they're

1709
01:03:44,390 --> 01:03:41,940
finding

1710
01:03:45,710 --> 01:03:44,400
um just let us know what you think and

1711
01:03:47,270 --> 01:03:45,720
if you'd like to learn more about Dr

1712
01:03:52,609 --> 01:03:47,280
Michael Wong you can follow him on

1713
01:03:54,049 --> 01:03:52,619

Twitter at mikwai it's at m i q u a l uh

1714
01:03:57,049 --> 01:03:54,059
and it also links to his website there

1715
01:03:58,490 --> 01:03:57,059
in his profile we also recommend I

1716
01:04:00,890 --> 01:03:58,500
highly recommend checking out the

1717
01:04:03,230 --> 01:04:00,900
podcast strange new worlds and your

1718
01:04:04,789 --> 01:04:03,240
favorite pod podcast player so once

1719
01:04:07,250 --> 01:04:04,799
again Mike thank you so much for joining

1720
01:04:09,109 --> 01:04:07,260
us for asking astrobiologist

1721
01:04:11,450 --> 01:04:09,119
thanks so much for having me this has

1722
01:04:12,589 --> 01:04:11,460
been a blast yeah it's been great

1723
01:04:13,910 --> 01:04:12,599
um and for those of you out there who

1724
01:04:15,230 --> 01:04:13,920
might want to stay in the loop on

1725
01:04:17,630 --> 01:04:15,240
upcoming episodes of ask an

1726
01:04:20,329 --> 01:04:17,640
astrobiologist or even find out more

1727
01:04:22,130 --> 01:04:20,339
information about opportunities and

1728
01:04:24,470 --> 01:04:22,140
events and things like that with NASA

1729
01:04:26,089 --> 01:04:24,480
astrobiology the NASA astrobiology

1730
01:04:28,010 --> 01:04:26,099
program does a lot of really cool stuff

1731
01:04:30,049 --> 01:04:28,020
so you can use the link on your screen

1732
01:04:32,270 --> 01:04:30,059
to sign up for the official mailing list

1733
01:04:34,730 --> 01:04:32,280
to get lots of information from NASA

1734
01:04:37,210 --> 01:04:34,740
astrobiology so thank you all for

1735
01:04:38,760 --> 01:04:37,220
joining in and until next time as always

1736
01:04:41,630 --> 01:04:38,770
stay curious