Ask An Astrobiologist

Episode 46: December 16th, 2021

Dr. Natalie Batalha

NASA Astrobiology Program

1
00:00:01,120 --> 00:00:30,470
[Music]

2
00:00:34,950 --> 00:00:33,110
greetings friends fellow earthlings and

3
00:00:37,190 --> 00:00:34,960
maybe like me some other people out

4
00:00:39,190 --> 00:00:37,200
there who are going to

5
00:00:42,549 --> 00:00:39,200
hold your breaths in the upcoming launch

6
00:00:44,709 --> 00:00:42,559
of jwst very soon welcome to ask an

7
00:00:46,389 --> 00:00:44,719
astrobiologist the show that celebrates

8
00:00:47,830 --> 00:00:46,399
the science and celebrates the

9
00:00:49,990 --> 00:00:47,840
scientists

10
00:00:52,389 --> 00:00:50,000
involved in our quest to understand the

11
00:00:54,790 --> 00:00:52,399
nature of life in our universe

12
00:00:57,430 --> 00:00:54,800
i'm your host dr graham lau also known

13
00:00:59,590 --> 00:00:57,440

online as the cosmo biologist and we're

14
00:01:02,069 --> 00:00:59,600
brought to you by the nasa astrobiology

15
00:01:03,910 --> 00:01:02,079
program and saginet.org

16
00:01:06,390 --> 00:01:03,920
we also want to give a huge thanks to

17
00:01:08,870 --> 00:01:06,400
all of you out there in the interwebs

18
00:01:10,710 --> 00:01:08,880
who keep sharing about our show and

19
00:01:12,710 --> 00:01:10,720
interacting and engaging with our guests

20
00:01:14,789 --> 00:01:12,720
and fellow audience members

21
00:01:17,030 --> 00:01:14,799
engaging in this quest of understanding

22
00:01:19,670 --> 00:01:17,040
life we want to give a special shout out

23
00:01:21,270 --> 00:01:19,680
this month to aeronauto padar

24
00:01:24,550 --> 00:01:21,280
who is an undergraduate student in

25
00:01:25,670 --> 00:01:24,560
biotechnology at srm university in india

26
00:01:27,429 --> 00:01:25,680
so erin

27
00:01:30,469 --> 00:01:27,439
thank you very much for sharing about

28
00:01:33,030 --> 00:01:30,479
hashtag askastrobio

29
00:01:36,310 --> 00:01:33,040
now i'm old enough that i remember a

30
00:01:39,190 --> 00:01:36,320
time when we had no evidence at all for

31
00:01:41,670 --> 00:01:39,200
worlds to exist around other stars

32
00:01:42,789 --> 00:01:41,680
but since the early 1990s we've been

33
00:01:45,270 --> 00:01:42,799
detecting

34
00:01:47,830 --> 00:01:45,280
these exoplanets these extra solar

35
00:01:50,389 --> 00:01:47,840
worlds out there we now have detections

36
00:01:52,069 --> 00:01:50,399
confirmed of over 4 500

37
00:01:55,109 --> 00:01:52,079
of these worlds that we've detected

38
00:01:57,429 --> 00:01:55,119

through space telescopes like kepler and

39
00:02:00,709 --> 00:01:57,439
like tess and we'll be doing using the

40
00:02:02,950 --> 00:02:00,719
upcoming jwst to explore even more of

41
00:02:05,429 --> 00:02:02,960
these worlds and maybe even get better

42
00:02:06,830 --> 00:02:05,439
data about their atmospheres and whether

43
00:02:09,910 --> 00:02:06,840
or not they could potentially be

44
00:02:11,830 --> 00:02:09,920
habitable worlds and so for this episode

45
00:02:14,309 --> 00:02:11,840
we wanted to bring in an expert in

46
00:02:17,350 --> 00:02:14,319
exoplanets using telescopes to study

47
00:02:19,430 --> 00:02:17,360
them in astrophysics and astrobiology

48
00:02:20,949 --> 00:02:19,440
and so we brought onto the show dr

49
00:02:23,750 --> 00:02:20,959
natalie battaglia

50
00:02:25,750 --> 00:02:23,760
dr battaglia is a professor of astronomy

51
00:02:27,750 --> 00:02:25,760
and astrophysics at uc santa cruz

52
00:02:30,390 --> 00:02:27,760
specializing in detection and

53
00:02:32,309 --> 00:02:30,400
characterization of exoplanets

54
00:02:34,470 --> 00:02:32,319
she was previously a research astronomer

55
00:02:36,869 --> 00:02:34,480
at nasa's ames research center and held

56
00:02:38,790 --> 00:02:36,879
the positions of co-investigator and

57
00:02:40,630 --> 00:02:38,800
kepler mission scientist on the kepler

58
00:02:42,869 --> 00:02:40,640
mission which was the first mission

59
00:02:45,030 --> 00:02:42,879
capable of finding earth-sized planets

60
00:02:47,270 --> 00:02:45,040
around other stars

61
00:02:49,509 --> 00:02:47,280
dr battaglia now uses the world's most

62
00:02:50,790 --> 00:02:49,519
powerful ground-based telescopes to

63
00:02:52,790 --> 00:02:50,800

identify

64
00:02:55,030 --> 00:02:52,800
the planets that will be exploring more

65
00:02:56,869 --> 00:02:55,040
with the upcoming jwst

66
00:02:59,110 --> 00:02:56,879
and she has also previously been named

67
00:03:02,390 --> 00:02:59,120
by time magazine as one of the world's

68
00:03:04,149 --> 00:03:02,400
100 most influential people in 2017. uh

69
00:03:06,149 --> 00:03:04,159
dr battaglia thank you for joining us

70
00:03:07,750 --> 00:03:06,159
for ask an astrobiologist

71
00:03:09,270 --> 00:03:07,760
hi graham thank you for having me i'm

72
00:03:10,550 --> 00:03:09,280
very glad to be here

73
00:03:11,910 --> 00:03:10,560
i'm so glad we could have you on i've

74
00:03:14,070 --> 00:03:11,920
actually one of you on the show for some

75
00:03:16,830 --> 00:03:14,080
time now um so i'm so glad you could

76
00:03:19,509 --> 00:03:16,840
join us um what i love to do with our

77
00:03:21,750 --> 00:03:19,519
our guests when they first join us is to

78
00:03:24,229 --> 00:03:21,760
ask them about their their science

79
00:03:27,190 --> 00:03:24,239
origin story what really got them

80
00:03:29,670 --> 00:03:27,200
into a career a pathway that took them

81
00:03:31,430 --> 00:03:29,680
into astrobiology i wonder if you could

82
00:03:33,910 --> 00:03:31,440
share with us what was the inspiration

83
00:03:36,789 --> 00:03:33,920
for you to pursue the career that you

84
00:03:38,710 --> 00:03:36,799
now have in astrophysics and astronomy

85
00:03:41,270 --> 00:03:38,720
oh goodness that's such a complicated

86
00:03:43,750 --> 00:03:41,280
question because our our lives take

87
00:03:46,149 --> 00:03:43,760
various turns and and go down different

88
00:03:47,670 --> 00:03:46,159

pathways and we don't really understand

89
00:03:49,910 --> 00:03:47,680
always why

90
00:03:51,110 --> 00:03:49,920
i wasn't initially interested in science

91
00:03:53,830 --> 00:03:51,120
as a youth

92
00:03:57,110 --> 00:03:53,840
it wasn't on my mind at all i started

93
00:03:59,589 --> 00:03:57,120
college as a business major and

94
00:04:01,750 --> 00:03:59,599
it wasn't until kind of the middle of my

95
00:04:03,190 --> 00:04:01,760
undergrad that i took a physics class

96
00:04:08,229 --> 00:04:03,200
and

97
00:04:10,390 --> 00:04:08,239
often ask me what inspired you to take

98
00:04:13,030 --> 00:04:10,400
that physics class and

99
00:04:14,630 --> 00:04:13,040
that's a complicated question but i

100
00:04:16,150 --> 00:04:14,640
think a lot of it has to do with the

101
00:04:19,030 --> 00:04:16,160
space shuttle program which was the

102
00:04:21,749 --> 00:04:19,040
backdrop of the 1980s when i was in high

103
00:04:24,070 --> 00:04:21,759
school and and and also in college in

104
00:04:26,629 --> 00:04:24,080
the latter half of the 80s um

105
00:04:29,749 --> 00:04:26,639
the space program just seemed like the

106
00:04:32,469 --> 00:04:29,759
coolest job you could have

107
00:04:34,870 --> 00:04:32,479
um and when i saw sally ride go into

108
00:04:37,909 --> 00:04:34,880
space and also met

109
00:04:39,830 --> 00:04:37,919
ray sudden a former astronaut who was a

110
00:04:41,189 --> 00:04:39,840
berkeley alum and i met her when i was

111
00:04:43,030 --> 00:04:41,199
an undergrad

112
00:04:46,469 --> 00:04:43,040
it you know all of a sudden i could see

113
00:04:48,469 --> 00:04:46,479

myself being involved in some capacity i

114
00:04:50,710 --> 00:04:48,479
still didn't want to be a scientist when

115
00:04:52,629 --> 00:04:50,720
i took my first internship i told my

116
00:04:55,110 --> 00:04:52,639
research advisor that i wasn't like the

117
00:04:57,270 --> 00:04:55,120
other kids i wasn't going to do science

118
00:04:59,590 --> 00:04:57,280
i thought maybe i would somehow bridge

119
00:05:01,909 --> 00:04:59,600
business and science in some way and i

120
00:05:05,029 --> 00:05:01,919
didn't know that this idea of a project

121
00:05:07,590 --> 00:05:05,039
manager even existed at the time

122
00:05:09,430 --> 00:05:07,600
but he gave me a problem to solve and it

123
00:05:10,550 --> 00:05:09,440
introduced me to really what science is

124
00:05:13,029 --> 00:05:10,560
all about

125
00:05:16,150 --> 00:05:13,039
you know the scientific method this um

126
00:05:19,189 --> 00:05:16,160
the feeling of discovery of wonder and

127
00:05:20,710 --> 00:05:19,199
even of of beauty you know

128
00:05:23,189 --> 00:05:20,720
being able to see

129
00:05:25,270 --> 00:05:23,199
that what i was interested in or the

130
00:05:28,710 --> 00:05:25,280
beauty that i saw and

131
00:05:30,710 --> 00:05:28,720
was enhanced by being able to explain it

132
00:05:34,150 --> 00:05:30,720
and understand it

133
00:05:36,469 --> 00:05:34,160
the idea that understanding is a sort of

134
00:05:38,150 --> 00:05:36,479
ecstasy i think carl sagan said or

135
00:05:39,990 --> 00:05:38,160
euphoria

136
00:05:42,310 --> 00:05:40,000
uh just put all the puzzle pieces

137
00:05:44,469 --> 00:05:42,320
together for me and and so that's how my

138
00:05:46,629 --> 00:05:44,479

career started

139
00:05:47,990 --> 00:05:46,639
that's fantastic and i think for a lot

140
00:05:49,749 --> 00:05:48,000
of us who've come to the sciences you

141
00:05:51,909 --> 00:05:49,759
know you're right we have many pathways

142
00:05:53,909 --> 00:05:51,919
to get to where we are but there is that

143
00:05:55,350 --> 00:05:53,919
that joy you know the exploration and

144
00:05:57,270 --> 00:05:55,360
the power of explanation of what we're

145
00:05:59,110 --> 00:05:57,280
learning and like i mentioned earlier

146
00:06:02,309 --> 00:05:59,120
you know when i was a kid we didn't know

147
00:06:04,150 --> 00:06:02,319
of exoplanets and now a great portion of

148
00:06:06,469 --> 00:06:04,160
the human population have been born into

149
00:06:08,150 --> 00:06:06,479
a time when exoplanets we know

150
00:06:10,629 --> 00:06:08,160
they exist and that we've confirmed

151
00:06:12,150 --> 00:06:10,639
their detections uh i wonder can you

152
00:06:15,029 --> 00:06:12,160
give us kind of you know from your

153
00:06:17,430 --> 00:06:15,039
perspective what does it mean for us now

154
00:06:19,670 --> 00:06:17,440
as a species as a biosphere

155
00:06:21,350 --> 00:06:19,680
that that we know that exoplanets exist

156
00:06:25,110 --> 00:06:21,360
and and what is your your side of the

157
00:06:27,110 --> 00:06:25,120
research in looking into exoplanets

158
00:06:29,270 --> 00:06:27,120
when i started research there were no

159
00:06:31,830 --> 00:06:29,280
known exoplanets

160
00:06:33,830 --> 00:06:31,840
most of us in those days started out as

161
00:06:36,710 --> 00:06:33,840
stellar astrophysicists we were studying

162
00:06:38,870 --> 00:06:36,720
the stars that was helpful because the

163
00:06:41,029 --> 00:06:38,880

way that we were discovering planets was

164
00:06:43,270 --> 00:06:41,039
to observe something about the star that

165
00:06:45,830 --> 00:06:43,280
inferred the existence of the planet so

166
00:06:47,350 --> 00:06:45,840
that was my pathway to exoplanets i was

167
00:06:49,029 --> 00:06:47,360
actually at the conference in florence

168
00:06:51,350 --> 00:06:49,039
italy where michelle mayor announced the

169
00:06:53,670 --> 00:06:51,360
first exoplanet

170
00:06:57,430 --> 00:06:53,680
and so i feel like i've had a front row

171
00:06:59,749 --> 00:06:57,440
seat to this new field being born

172
00:07:02,070 --> 00:06:59,759
and then also becoming part of it and

173
00:07:04,550 --> 00:07:02,080
and you know not just observing from the

174
00:07:05,909 --> 00:07:04,560
sidelines but being enmeshed in it and

175
00:07:07,670 --> 00:07:05,919
understanding that feeling of

176
00:07:10,150 --> 00:07:07,680
discovering a new world and what that

177
00:07:12,550 --> 00:07:10,160
means starting out as an abstraction but

178
00:07:15,110 --> 00:07:12,560
as you learn more it becomes more less

179
00:07:17,589 --> 00:07:15,120
of an abstraction and more of an actual

180
00:07:19,909 --> 00:07:17,599
physical place that you can imagine you

181
00:07:21,830 --> 00:07:19,919
can use your empathy to actually place

182
00:07:25,270 --> 00:07:21,840
yourself there and and

183
00:07:26,469 --> 00:07:25,280
and imagine what it might be like

184
00:07:30,309 --> 00:07:26,479
so you know

185
00:07:32,550 --> 00:07:30,319
as that unfolds and as humans learn more

186
00:07:34,469 --> 00:07:32,560
it seeds the knowledge seeds itself into

187
00:07:36,309 --> 00:07:34,479
the our public consciousness our

188
00:07:39,749 --> 00:07:36,319

collective consciousness

189
00:07:41,990 --> 00:07:39,759
and it subtly slowly

190
00:07:44,150 --> 00:07:42,000
transforms how we see

191
00:07:45,589 --> 00:07:44,160
ourselves in the universe as part of the

192
00:07:48,550 --> 00:07:45,599
universe as

193
00:07:51,909 --> 00:07:48,560
as part of a living world not separate

194
00:07:53,670 --> 00:07:51,919
from that planet but part of it and i

195
00:07:55,670 --> 00:07:53,680
have certainly observed that happening

196
00:07:57,990 --> 00:07:55,680
with me and i've seen it happen with the

197
00:08:00,309 --> 00:07:58,000
people i talked to as well

198
00:08:01,670 --> 00:08:00,319
one of the most marked moments was after

199
00:08:03,830 --> 00:08:01,680
kepler launched and we had already

200
00:08:05,990 --> 00:08:03,840
discovered hundreds of planets and we

201
00:08:07,189 --> 00:08:06,000
were using that information to

202
00:08:09,430 --> 00:08:07,199
deduce

203
00:08:11,510 --> 00:08:09,440
how many planets are there for in the

204
00:08:13,990 --> 00:08:11,520
galaxy as a whole

205
00:08:15,670 --> 00:08:14,000
and one of the early results that i kept

206
00:08:17,589 --> 00:08:15,680
seeing over and over

207
00:08:19,749 --> 00:08:17,599
and probably didn't even appreciate at

208
00:08:23,189 --> 00:08:19,759
the time was that the average number of

209
00:08:24,390 --> 00:08:23,199
planets per star is greater than one

210
00:08:25,350 --> 00:08:24,400
and

211
00:08:28,150 --> 00:08:25,360
so

212
00:08:30,390 --> 00:08:28,160
as i look at the sky now i see the sky

213
00:08:31,670 --> 00:08:30,400

differently with that knowledge now i

214
00:08:33,509 --> 00:08:31,680
know that these

215
00:08:35,269 --> 00:08:33,519
stars are not just stars but planetary

216
00:08:37,670 --> 00:08:35,279
systems um

217
00:08:39,909 --> 00:08:37,680
and so it's a subtle thing you don't

218
00:08:41,350 --> 00:08:39,919
realize how much it impacts us as a

219
00:08:43,589 --> 00:08:41,360
species

220
00:08:45,910 --> 00:08:43,599
but now the narrative has changed so

221
00:08:47,829 --> 00:08:45,920
much now that kepler has finished

222
00:08:50,310 --> 00:08:47,839
it catalyzed the search for life you

223
00:08:52,310 --> 00:08:50,320
can't help but know

224
00:08:54,470 --> 00:08:52,320
knowing that the nearest potentially

225
00:08:55,910 --> 00:08:54,480
habitable planet is likely to be within

226
00:08:57,910 --> 00:08:55,920
10 light years

227
00:08:59,509 --> 00:08:57,920
that there are literally billions of

228
00:09:03,590 --> 00:08:59,519
potentially habitable worlds in our

229
00:09:06,150 --> 00:09:03,600
galaxy alone you can't help but wonder

230
00:09:07,590 --> 00:09:06,160
how many living worlds are out there so

231
00:09:09,269 --> 00:09:07,600
now we are just

232
00:09:11,350 --> 00:09:09,279
hyper focused and driven by this

233
00:09:12,250 --> 00:09:11,360
singular question and everything we're

234
00:09:13,350 --> 00:09:12,260
doing um

235
00:09:15,430 --> 00:09:13,360
[Music]

236
00:09:16,550 --> 00:09:15,440
is just a waypoint towards that broader

237
00:09:17,990 --> 00:09:16,560
goal

238
00:09:19,509 --> 00:09:18,000

yeah i love that vision too you know

239
00:09:21,030 --> 00:09:19,519
like looking at the nighttime sky when i

240
00:09:22,870 --> 00:09:21,040
was a kid you know i saw these dots of

241
00:09:25,030 --> 00:09:22,880
light and and now we can envision them

242
00:09:26,949 --> 00:09:25,040
as you know systems and stars with

243
00:09:29,269 --> 00:09:26,959
planets and maybe asteroids and comets

244
00:09:31,590 --> 00:09:29,279
of their own and maybe even

245
00:09:33,910 --> 00:09:31,600
in some of those worlds that's rather

246
00:09:36,470 --> 00:09:33,920
remarkable um some years ago i was

247
00:09:37,829 --> 00:09:36,480
taking a graduate course at cu boulder

248
00:09:39,990 --> 00:09:37,839
and nick schneider was one of the

249
00:09:41,829 --> 00:09:40,000
professors and and i remember nick said

250
00:09:43,110 --> 00:09:41,839
this really funny thing that like

251
00:09:45,190 --> 00:09:43,120
everything we thought we knew about

252
00:09:48,150 --> 00:09:45,200
planets changed once we started finding

253
00:09:49,670 --> 00:09:48,160
exoplanets and that that keeps changing

254
00:09:51,829 --> 00:09:49,680
i wonder is there anything that you

255
00:09:53,990 --> 00:09:51,839
think uh is changing right now in our

256
00:09:55,269 --> 00:09:54,000
understanding of worlds around stars

257
00:09:56,550 --> 00:09:55,279
because of all these detections of

258
00:09:58,710 --> 00:09:56,560
exoplanets

259
00:10:00,470 --> 00:09:58,720
absolutely i mean

260
00:10:03,030 --> 00:10:00,480
you go back to the very first planet

261
00:10:06,310 --> 00:10:03,040
discovery that hot jupiter 51 pig bee

262
00:10:09,190 --> 00:10:06,320
was already as a huge surprise and we

263
00:10:11,670 --> 00:10:09,200

are still reeling from it we think we

264
00:10:13,829 --> 00:10:11,680
have a decent explanation but we don't

265
00:10:15,269 --> 00:10:13,839
have concrete proof that our explanation

266
00:10:17,750 --> 00:10:15,279
is correct

267
00:10:20,710 --> 00:10:17,760
that will in part be tested by webb in

268
00:10:22,870 --> 00:10:20,720
the future how a giant planet can form

269
00:10:25,430 --> 00:10:22,880
10 times closer to its star than mercury

270
00:10:26,389 --> 00:10:25,440
is to our sun for example

271
00:10:29,910 --> 00:10:26,399
so

272
00:10:31,590 --> 00:10:29,920
the the entire field has been

273
00:10:34,069 --> 00:10:31,600
filled with surprises

274
00:10:36,550 --> 00:10:34,079
the most common type of planet that we

275
00:10:38,150 --> 00:10:36,560
know of so far in the galaxy

276
00:10:40,630 --> 00:10:38,160
is a kind of planet that we don't have

277
00:10:42,790 --> 00:10:40,640
in our own solar system where you have

278
00:10:44,630 --> 00:10:42,800
the small terrestrials orbiting close to

279
00:10:47,030 --> 00:10:44,640
the star and the large gas giants

280
00:10:49,829 --> 00:10:47,040
orbiting far away with nothing really in

281
00:10:52,790 --> 00:10:49,839
between in terms of size tiny versus

282
00:10:55,030 --> 00:10:52,800
large and yet in the galaxy again the

283
00:10:57,590 --> 00:10:55,040
most common type of planet orbiting

284
00:11:00,949 --> 00:10:57,600
within one astronomical unit is these

285
00:11:03,350 --> 00:11:00,959
this mysterious in between planet

286
00:11:06,069 --> 00:11:03,360
are they scaled up earths does that

287
00:11:07,910 --> 00:11:06,079
represent more real estate for life or

288
00:11:09,269 --> 00:11:07,920

are they the stripped

289
00:11:12,790 --> 00:11:09,279
cores of

290
00:11:14,790 --> 00:11:12,800
neptunes former neptunes and if so what

291
00:11:16,550 --> 00:11:14,800
are the implications for the evolution

292
00:11:17,910 --> 00:11:16,560
of life on such a world

293
00:11:24,069 --> 00:11:17,920
so

294
00:11:25,990 --> 00:11:24,079
these with webb

295
00:11:27,910 --> 00:11:26,000
but we've also learned from kepler that

296
00:11:29,509 --> 00:11:27,920
the diversity of planets in the galaxy

297
00:11:31,590 --> 00:11:29,519
is staggering

298
00:11:33,110 --> 00:11:31,600
you know that's just one example of a

299
00:11:35,190 --> 00:11:33,120
kind of planet we don't have in our own

300
00:11:37,829 --> 00:11:35,200
solar system but there are many others

301
00:11:40,630 --> 00:11:37,839
there are lava worlds with oceans the

302
00:11:42,790 --> 00:11:40,640
size of the pacific of of molten rock

303
00:11:43,829 --> 00:11:42,800
there are planets orbiting not one star

304
00:11:45,829 --> 00:11:43,839
but two

305
00:11:47,590 --> 00:11:45,839
there are planets the age of the galaxy

306
00:11:49,110 --> 00:11:47,600
itself which we didn't think was

307
00:11:51,990 --> 00:11:49,120
possible because we didn't think the raw

308
00:11:54,310 --> 00:11:52,000
materials would exist that early on so i

309
00:11:56,310 --> 00:11:54,320
mean the the list is endless so there

310
00:11:57,750 --> 00:11:56,320
are endless horizons to explore which is

311
00:11:59,829 --> 00:11:57,760
very exciting

312
00:12:01,509 --> 00:11:59,839
absolutely i i love that you know i

313
00:12:03,110 --> 00:12:01,519

think people hear about us detecting

314
00:12:05,190 --> 00:12:03,120
exoplanets but they're unaware that most

315
00:12:07,829 --> 00:12:05,200
of them are are very close to our own

316
00:12:09,350 --> 00:12:07,839
solar system in the galaxy we found some

317
00:12:11,269 --> 00:12:09,360
you know more towards the galaxy center

318
00:12:13,030 --> 00:12:11,279
but there's still so much more galaxy to

319
00:12:15,030 --> 00:12:13,040
explore yet and and so much more

320
00:12:16,790 --> 00:12:15,040
possibility and and kepler really

321
00:12:19,829 --> 00:12:16,800
brought the the explosion in our

322
00:12:21,910 --> 00:12:19,839
knowledge of the number of likely worlds

323
00:12:23,670 --> 00:12:21,920
out there a lot of our audience members

324
00:12:25,269 --> 00:12:23,680
are younger people maybe high school

325
00:12:27,269 --> 00:12:25,279
students college students recent

326
00:12:29,350 --> 00:12:27,279
graduates i know a lot of them want to

327
00:12:31,110 --> 00:12:29,360
be astrobiologists themselves and maybe

328
00:12:32,790 --> 00:12:31,120
even want to be involved as mission

329
00:12:34,150 --> 00:12:32,800
scientists one day

330
00:12:36,230 --> 00:12:34,160
i wonder could you just you know kind of

331
00:12:38,550 --> 00:12:36,240
explain for them what the pathway was

332
00:12:40,710 --> 00:12:38,560
for you to become a co-investigator on a

333
00:12:42,470 --> 00:12:40,720
mission um and what that's like for your

334
00:12:43,990 --> 00:12:42,480
career to kind of you know go along with

335
00:12:45,750 --> 00:12:44,000
a mission through its development into

336
00:12:47,590 --> 00:12:45,760
launch and then making these incredible

337
00:12:48,629 --> 00:12:47,600
discoveries like kepler did

338
00:12:50,949 --> 00:12:48,639

yeah

339
00:12:53,829 --> 00:12:50,959
i mean it all starts with that seed that

340
00:12:55,190 --> 00:12:53,839
is sprouting within you which is your

341
00:12:56,710 --> 00:12:55,200
passion

342
00:12:59,670 --> 00:12:56,720
what you

343
00:13:01,590 --> 00:12:59,680
know

344
00:13:04,629 --> 00:13:01,600
pursue what you love

345
00:13:06,710 --> 00:13:04,639
and the rest follows and you know maybe

346
00:13:09,509 --> 00:13:06,720
i wouldn't have i mean working on kepler

347
00:13:10,949 --> 00:13:09,519
was so lucky being in the right to some

348
00:13:13,990 --> 00:13:10,959
degree in the right place at the right

349
00:13:16,629 --> 00:13:14,000
time how did i get there

350
00:13:18,230 --> 00:13:16,639
i i was working as a postdoc in brazil

351
00:13:20,629 --> 00:13:18,240
at the time so i'm living in the middle

352
00:13:23,190 --> 00:13:20,639
of tajuka forest

353
00:13:24,069 --> 00:13:23,200
in the subtropical rainforest

354
00:13:25,829 --> 00:13:24,079
and

355
00:13:26,710 --> 00:13:25,839
doing my thing there i was studying

356
00:13:28,949 --> 00:13:26,720
young

357
00:13:30,150 --> 00:13:28,959
sun-like stars baby sons

358
00:13:31,430 --> 00:13:30,160
essentially

359
00:13:32,310 --> 00:13:31,440
and

360
00:13:51,670 --> 00:13:32,320
i

361
00:13:56,550 --> 00:13:51,680
and

362
00:13:59,189 --> 00:13:56,560
that an earth

363
00:14:01,350 --> 00:13:59,199

is tinier in projection

364
00:14:03,110 --> 00:14:01,360
than a typical star spot

365
00:14:04,949 --> 00:14:03,120
and star spots

366
00:14:07,670 --> 00:14:04,959
rotate in and out of view as the star

367
00:14:10,389 --> 00:14:07,680
spins so i wrote this just kind of cold

368
00:14:12,629 --> 00:14:10,399
turkey wrote an email to this gentleman

369
00:14:13,910 --> 00:14:12,639
at nasa ames whose name was william

370
00:14:16,629 --> 00:14:13,920
beruki

371
00:14:20,230 --> 00:14:16,639
and said i'm intrigued by this

372
00:14:23,189 --> 00:14:20,240
methodology but here's why i'm skeptical

373
00:14:25,590 --> 00:14:23,199
um and i've been studying star spots and

374
00:14:27,990 --> 00:14:25,600
and so this is why and he responded

375
00:14:29,750 --> 00:14:28,000
almost immediately and and said actually

376
00:14:32,870 --> 00:14:29,760
that was one of the reasons why our last

377
00:14:35,110 --> 00:14:32,880
proposal was rejected because ed weiler

378
00:14:36,949 --> 00:14:35,120
who was a stellar astrophysicist at the

379
00:14:39,350 --> 00:14:36,959
time and working at nasa headquarters

380
00:14:42,150 --> 00:14:39,360
and leading the discovery program

381
00:14:44,550 --> 00:14:42,160
had that that same skepticism

382
00:14:46,069 --> 00:14:44,560
so he invited me to come to nasa ames

383
00:14:47,750 --> 00:14:46,079
and work on the problem and then

384
00:14:50,470 --> 00:14:47,760
basically what we

385
00:14:52,870 --> 00:14:50,480
showed was that yes for some fraction of

386
00:14:54,629 --> 00:14:52,880
stars you won't be able to tell the

387
00:14:56,790 --> 00:14:54,639
difference between a transiting earth

388
00:14:58,389 --> 00:14:56,800

and a star spot rotating in and out of

389
00:15:00,550 --> 00:14:58,399
you

390
00:15:02,629 --> 00:15:00,560
that only happens when the stars are

391
00:15:04,870 --> 00:15:02,639
rapidly rotating and there are other

392
00:15:06,790 --> 00:15:04,880
ways to discern

393
00:15:08,629 --> 00:15:06,800
but then you can do a population

394
00:15:09,990 --> 00:15:08,639
synthesis model and say okay what

395
00:15:12,550 --> 00:15:10,000
fraction of the stars that we're

396
00:15:14,310 --> 00:15:12,560
observing will have that problem and it

397
00:15:16,389 --> 00:15:14,320
turns out to be a relatively small

398
00:15:19,269 --> 00:15:16,399
fraction so as long as we observed

399
00:15:20,470 --> 00:15:19,279
enough stars it wouldn't hurt us

400
00:15:23,269 --> 00:15:20,480
um

401
00:15:25,990 --> 00:15:23,279
so i i don't know my my advice to young

402
00:15:27,829 --> 00:15:26,000
people is um

403
00:15:30,069 --> 00:15:27,839
again just do what you love and you will

404
00:15:31,829 --> 00:15:30,079
find a way to express that if you know

405
00:15:33,910 --> 00:15:31,839
hopefully you will find a way to express

406
00:15:37,110 --> 00:15:33,920
that and i was very lucky i had no

407
00:15:38,870 --> 00:15:37,120
guarantee that kepler would get selected

408
00:15:40,389 --> 00:15:38,880
it did and it was unbelievable i

409
00:15:42,310 --> 00:15:40,399
couldn't believe that that had happened

410
00:15:45,670 --> 00:15:42,320
i still didn't know quite what it meant

411
00:15:47,829 --> 00:15:45,680
for me in terms of finding a long-term

412
00:15:50,470 --> 00:15:47,839
employment you know to support my family

413
00:15:52,150 --> 00:15:50,480

and and all of that so

414
00:15:53,990 --> 00:15:52,160
i was very lucky

415
00:15:55,670 --> 00:15:54,000
but if kepler hadn't come along i would

416
00:15:57,030 --> 00:15:55,680
have uh you know found a different

417
00:15:59,990 --> 00:15:57,040
pathway and

418
00:16:02,069 --> 00:16:00,000
and hopefully a way to also express

419
00:16:03,350 --> 00:16:02,079
these passions and and

420
00:16:04,790 --> 00:16:03,360
what i love and what i think is

421
00:16:05,990 --> 00:16:04,800
important

422
00:16:07,670 --> 00:16:06,000
you know i love though that you know

423
00:16:10,230 --> 00:16:07,680
your first connection was the potential

424
00:16:11,910 --> 00:16:10,240
for issues with the detection through

425
00:16:13,350 --> 00:16:11,920
the transit method i i love that that

426
00:16:15,269 --> 00:16:13,360
was the connection you know that you

427
00:16:17,189 --> 00:16:15,279
know in in science we need a healthy bit

428
00:16:19,189 --> 00:16:17,199
of skepticism and we need to consider

429
00:16:21,189 --> 00:16:19,199
all the possible issues that come up and

430
00:16:22,870 --> 00:16:21,199
how we apply our techniques and and so i

431
00:16:24,949 --> 00:16:22,880
i love that's also part of your route

432
00:16:27,030 --> 00:16:24,959
into them being involved in kepler which

433
00:16:27,910 --> 00:16:27,040
was such a powerful mission um we've

434
00:16:30,310 --> 00:16:27,920
since

435
00:16:31,509 --> 00:16:30,320
certainly had tests we have tests um

436
00:16:34,069 --> 00:16:31,519
we've done a lot of work from

437
00:16:36,230 --> 00:16:34,079
ground-based telescopes now but i wonder

438
00:16:38,470 --> 00:16:36,240

uh for our audience since you know jwst

439
00:16:40,550 --> 00:16:38,480
is coming up very soon it will launch uh

440
00:16:42,389 --> 00:16:40,560
no earlier than the 24th of december but

441
00:16:43,910 --> 00:16:42,399
we'll have a launch here soon and then

442
00:16:45,910 --> 00:16:43,920
roughly a month

443
00:16:47,269 --> 00:16:45,920
for the process of deployment of the

444
00:16:50,069 --> 00:16:47,279
telescope

445
00:16:52,550 --> 00:16:50,079
but then soon hopefully we'll have jwst

446
00:16:54,949 --> 00:16:52,560
looking at exoplanets uh would you mind

447
00:16:57,430 --> 00:16:54,959
explaining for our audience what's so

448
00:16:59,590 --> 00:16:57,440
important or powerful about this new

449
00:17:01,350 --> 00:16:59,600
telescope when it comes to understanding

450
00:17:03,749 --> 00:17:01,360
those alien worlds

451
00:17:05,909 --> 00:17:03,759
absolutely

452
00:17:08,309 --> 00:17:05,919
so webb you know what what is the

453
00:17:10,470 --> 00:17:08,319
telescope good for well telescopes are

454
00:17:12,390 --> 00:17:10,480
light buckets they collect photons and

455
00:17:13,510 --> 00:17:12,400
the bigger the bucket the more photons

456
00:17:16,789 --> 00:17:13,520
you collect

457
00:17:19,110 --> 00:17:16,799
so first and foremost webb is a huge

458
00:17:21,270 --> 00:17:19,120
light bucket and that allows us to see

459
00:17:23,829 --> 00:17:21,280
either fainter things

460
00:17:26,470 --> 00:17:23,839
or to see further which is also fainter

461
00:17:27,990 --> 00:17:26,480
right exoplanets are close the ones that

462
00:17:29,990 --> 00:17:28,000
we're studying but they're very faint

463
00:17:31,909 --> 00:17:30,000

they're very hard to detect so having

464
00:17:34,549 --> 00:17:31,919
that big bucket helps us

465
00:17:36,310 --> 00:17:34,559
having a big bucket also means that you

466
00:17:37,990 --> 00:17:36,320
can see finer detail

467
00:17:39,430 --> 00:17:38,000
so if you're interested in directly

468
00:17:41,510 --> 00:17:39,440
imaging

469
00:17:43,190 --> 00:17:41,520
the environs around a star that's really

470
00:17:44,630 --> 00:17:43,200
important

471
00:17:47,909 --> 00:17:44,640
web is

472
00:17:49,830 --> 00:17:47,919
thirdly webb is an infrared telescope

473
00:17:52,470 --> 00:17:49,840
and there's a huge payoff

474
00:17:55,430 --> 00:17:52,480
for observing exoplanets in the infrared

475
00:17:57,750 --> 00:17:55,440
because you know there's this 10 billion

476
00:17:59,990 --> 00:17:57,760
to one brightness contrast between a

477
00:18:01,669 --> 00:18:00,000
star like the sun and a tiny planet like

478
00:18:03,590 --> 00:18:01,679
earth

479
00:18:06,549 --> 00:18:03,600
that brightness contrast

480
00:18:07,350 --> 00:18:06,559
gets a little lesser maybe a million to

481
00:18:09,430 --> 00:18:07,360
one

482
00:18:11,430 --> 00:18:09,440
if you go to the infrared planets become

483
00:18:12,549 --> 00:18:11,440
brighter stars become fainter and that

484
00:18:15,110 --> 00:18:12,559
helps you

485
00:18:17,430 --> 00:18:15,120
so um also in the infrared there are

486
00:18:19,190 --> 00:18:17,440
many chemical fingerprints of molecules

487
00:18:21,190 --> 00:18:19,200
from like greenhouse gases in

488
00:18:22,390 --> 00:18:21,200

atmospheres that we care about for

489
00:18:24,470 --> 00:18:22,400
planets

490
00:18:25,830 --> 00:18:24,480
and so working in the infrared is the

491
00:18:28,230 --> 00:18:25,840
third thing

492
00:18:30,470 --> 00:18:28,240
infrared is just another color on the

493
00:18:33,029 --> 00:18:30,480
electromagnetic spectrum just beyond the

494
00:18:35,110 --> 00:18:33,039
red part that our eyes can see

495
00:18:38,950 --> 00:18:35,120
we our eyes cannot see infrared but we

496
00:18:41,750 --> 00:18:38,960
can build instruments that can

497
00:18:44,549 --> 00:18:41,760
and so the fourth thing that webb does

498
00:18:46,230 --> 00:18:44,559
that people might not appreciate

499
00:18:48,230 --> 00:18:46,240
it's really built to be

500
00:18:50,070 --> 00:18:48,240
a spectroscopic

501
00:18:51,830 --> 00:18:50,080
instrument or telescope

502
00:18:53,590 --> 00:18:51,840
a lot of what we do in astronomy is

503
00:18:55,430 --> 00:18:53,600
spectroscopic and

504
00:18:56,870 --> 00:18:55,440
i've been forbidden to say that word in

505
00:18:59,110 --> 00:18:56,880
some interviews

506
00:19:01,270 --> 00:18:59,120
but basically what spectroscopy is is

507
00:19:03,590 --> 00:19:01,280
the study of colors it's catching light

508
00:19:06,070 --> 00:19:03,600
and spreading it out into a rainbow when

509
00:19:09,510 --> 00:19:06,080
you look at that rainbow in great detail

510
00:19:11,350 --> 00:19:09,520
you see the chemical fingerprints of

511
00:19:14,070 --> 00:19:11,360
molecules and atoms that are in

512
00:19:15,430 --> 00:19:14,080
atmospheres or nebulae or you know

513
00:19:18,470 --> 00:19:15,440

whatever it is you're studying or a

514
00:19:19,750 --> 00:19:18,480
planet's atmosphere in this case

515
00:19:21,110 --> 00:19:19,760
so um

516
00:19:23,029 --> 00:19:21,120
you know hubble people are used to

517
00:19:25,430 --> 00:19:23,039
seeing all these amazing images from

518
00:19:27,270 --> 00:19:25,440
hubble and web will produce images too

519
00:19:28,990 --> 00:19:27,280
but i truly think that webb's greatest

520
00:19:31,270 --> 00:19:29,000
legacy is going to be in

521
00:19:33,430 --> 00:19:31,280
spectroscopy and certainly for

522
00:19:35,830 --> 00:19:33,440
exoplanets that rings true

523
00:19:37,909 --> 00:19:35,840
and so a lot of what webb will do is

524
00:19:40,470 --> 00:19:37,919
observe these planets that again are

525
00:19:42,470 --> 00:19:40,480
transiting in front of the star in that

526
00:19:44,549 --> 00:19:42,480
very special geometry some of the

527
00:19:46,710 --> 00:19:44,559
starlight is going to filter through the

528
00:19:48,150 --> 00:19:46,720
atmosphere you know that the planet is

529
00:19:50,789 --> 00:19:48,160
hugging

530
00:19:53,110 --> 00:19:50,799
on its limb and so that atmosphere will

531
00:19:54,070 --> 00:19:53,120
impart its chemical fingerprints onto

532
00:19:56,549 --> 00:19:54,080
the light

533
00:19:58,789 --> 00:19:56,559
we'll catch it spread it out disentangle

534
00:20:01,909 --> 00:19:58,799
the star from the planet and through

535
00:20:03,350 --> 00:20:01,919
this way we will see what chemical

536
00:20:05,830 --> 00:20:03,360
constituents are in the planet's

537
00:20:07,909 --> 00:20:05,840
atmosphere maybe even map out the

538
00:20:10,149 --> 00:20:07,919

temperature pressure profile as a

539
00:20:11,909 --> 00:20:10,159
function of altitude and all of this

540
00:20:14,070 --> 00:20:11,919
information combined in the best

541
00:20:15,669 --> 00:20:14,080
scenario could even give us

542
00:20:16,870 --> 00:20:15,679
some information about the surface

543
00:20:19,669 --> 00:20:16,880
conditions of a planet that's

544
00:20:23,590 --> 00:20:19,679
potentially habitable like the planets

545
00:20:24,870 --> 00:20:23,600
orbiting the very famous trappist 1

546
00:20:27,270 --> 00:20:24,880
which is a

547
00:20:29,029 --> 00:20:27,280
star that's about a very cool m type

548
00:20:31,510 --> 00:20:29,039
star that's only about 40 light years

549
00:20:33,669 --> 00:20:31,520
away that has seven planets known to be

550
00:20:35,909 --> 00:20:33,679
orbiting it three of which are in the

551
00:20:37,669 --> 00:20:35,919
goldilocks zone so that is one of the

552
00:20:39,029 --> 00:20:37,679
first things that will be studied with

553
00:20:45,909 --> 00:20:39,039
web

554
00:20:48,070 --> 00:20:45,919
the atmospheres and have a new lens on

555
00:20:49,909 --> 00:20:48,080
planet diversity that will teach us

556
00:20:52,149 --> 00:20:49,919
about the physical processes that yield

557
00:20:54,070 --> 00:20:52,159
that diversity we need to understand

558
00:20:56,390 --> 00:20:54,080
those physical processes

559
00:20:58,950 --> 00:20:56,400
before we can understand the most likely

560
00:21:02,070 --> 00:20:58,960
abodes of life so so webb is this way

561
00:21:03,830 --> 00:21:02,080
station towards a life detection

562
00:21:04,950 --> 00:21:03,840
and

563
00:21:09,430 --> 00:21:04,960

yeah

564
00:21:11,190 --> 00:21:09,440
another massive step along our way of

565
00:21:13,190 --> 00:21:11,200
learning too you know from from our

566
00:21:15,430 --> 00:21:13,200
earliest use of pointing a telescope to

567
00:21:17,750 --> 00:21:15,440
the heavens to start understanding other

568
00:21:20,070 --> 00:21:17,760
worlds and stars to things like kepler

569
00:21:21,750 --> 00:21:20,080
and then jwst and then other upcoming

570
00:21:23,430 --> 00:21:21,760
telescopes like nancy grace roman

571
00:21:25,190 --> 00:21:23,440
telescope and and now we might have

572
00:21:27,270 --> 00:21:25,200
something kind of like a lavoir style

573
00:21:29,190 --> 00:21:27,280
telescope in the coming decade decade

574
00:21:31,190 --> 00:21:29,200
and a half and so there's so much that

575
00:21:32,470 --> 00:21:31,200
we're progressing along the way and and

576
00:21:33,990 --> 00:21:32,480
i love too for our audience that you

577
00:21:35,830 --> 00:21:34,000
share you know that there's that little

578
00:21:37,830 --> 00:21:35,840
bit of light that's going through the

579
00:21:39,669 --> 00:21:37,840
atmosphere and coming to us

580
00:21:40,950 --> 00:21:39,679
um you know it's such a small amount

581
00:21:43,909 --> 00:21:40,960
that we're actually getting and so we

582
00:21:46,230 --> 00:21:43,919
can learn so much about those possible

583
00:21:47,909 --> 00:21:46,240
alien worlds out there and i think in

584
00:21:49,750 --> 00:21:47,919
some way that also

585
00:21:51,270 --> 00:21:49,760
it almost makes it feel magical i think

586
00:21:53,430 --> 00:21:51,280
for some of us you know that we're

587
00:21:54,789 --> 00:21:53,440
learning so much right now about our

588
00:21:57,669 --> 00:21:54,799

place in the universe through things

589
00:21:59,029 --> 00:21:57,679
like kepler and jwst and so i want to

590
00:22:01,510 --> 00:21:59,039
change this a little bit before we open

591
00:22:03,830 --> 00:22:01,520
it up to our audience questions here uh

592
00:22:06,950 --> 00:22:03,840
you before have have uh

593
00:22:09,430 --> 00:22:06,960
have spoken um have done spoken word uh

594
00:22:11,029 --> 00:22:09,440
reading famous poems and poems that mean

595
00:22:13,750 --> 00:22:11,039
a lot to you

596
00:22:15,830 --> 00:22:13,760
in the universe in verse uh an event

597
00:22:17,270 --> 00:22:15,840
that highlights the connections of our

598
00:22:18,950 --> 00:22:17,280
understanding through science and our

599
00:22:21,750 --> 00:22:18,960
understanding of ourselves through

600
00:22:23,190 --> 00:22:21,760
poetry through the written word and and

601
00:22:24,549 --> 00:22:23,200
so i love that you kind of have this

602
00:22:27,990 --> 00:22:24,559
connection as well

603
00:22:29,350 --> 00:22:28,000
to poetry and to art i wonder um for our

604
00:22:30,710 --> 00:22:29,360
audience can you you know kind of

605
00:22:33,510 --> 00:22:30,720
describe to us

606
00:22:36,230 --> 00:22:33,520
the importance in your life for poetry

607
00:22:37,510 --> 00:22:36,240
art and its meaning for you and how you

608
00:22:39,029 --> 00:22:37,520
found it so meaningful in the science

609
00:22:41,350 --> 00:22:39,039
that you do

610
00:22:43,190 --> 00:22:41,360
yeah absolutely uh you mentioned the

611
00:22:48,710 --> 00:22:43,200
universe in verse

612
00:22:51,510 --> 00:22:48,720
the brainchild of maria papova who

613
00:22:53,830 --> 00:22:51,520

writes uh the blog brain pickings well

614
00:22:55,750 --> 00:22:53,840
she's an author as well

615
00:22:58,310 --> 00:22:55,760
but and brain peckings is now called the

616
00:23:00,870 --> 00:22:58,320
marginalian so you can find her there

617
00:23:04,390 --> 00:23:00,880
she's a luminary um

618
00:23:05,830 --> 00:23:04,400
very interested in history in philosophy

619
00:23:08,390 --> 00:23:05,840
and art and

620
00:23:11,830 --> 00:23:08,400
and astronomy and so she's the one that

621
00:23:16,230 --> 00:23:11,840
has connected uh science and poetry in a

622
00:23:19,510 --> 00:23:16,240
very visceral way um that i i love

623
00:23:21,510 --> 00:23:19,520
poetry came late to me it's another

624
00:23:23,270 --> 00:23:21,520
thing like science i did not relate to

625
00:23:24,710 --> 00:23:23,280
science when i was a youngster because i

626
00:23:26,870 --> 00:23:24,720
didn't understand what the scientific

627
00:23:28,870 --> 00:23:26,880
method was i thought it was very sterile

628
00:23:30,789 --> 00:23:28,880
in the same way i didn't really

629
00:23:33,510 --> 00:23:30,799
understand poetry when i was young none

630
00:23:36,549 --> 00:23:33,520
of it that was presented to me as a

631
00:23:39,350 --> 00:23:36,559
child resonated with me poetry is very

632
00:23:41,350 --> 00:23:39,360
personal it wasn't until i read mary

633
00:23:43,669 --> 00:23:41,360
oliver around the time of the kepler

634
00:23:45,350 --> 00:23:43,679
lunch actually um i discovered mary

635
00:23:47,190 --> 00:23:45,360
oliver in particular a poem that she

636
00:23:49,750 --> 00:23:47,200
wrote called swan

637
00:23:52,230 --> 00:23:49,760
and kepler was observing sickness this

638
00:23:53,430 --> 00:23:52,240

one or stars in the cygnus part of the

639
00:23:55,269 --> 00:23:53,440
galaxy

640
00:23:56,149 --> 00:23:55,279
and i really thought when i read that

641
00:23:58,230 --> 00:23:56,159
poem

642
00:23:59,990 --> 00:23:58,240
that she was maybe even talking about

643
00:24:01,510 --> 00:24:00,000
sickness the constellation flying

644
00:24:05,110 --> 00:24:01,520
through the milky way

645
00:24:09,190 --> 00:24:05,120
um but but her poem is just the imagery

646
00:24:11,510 --> 00:24:09,200
of a swan on a dark river at night and

647
00:24:13,269 --> 00:24:11,520
and watching it take off and you know

648
00:24:15,269 --> 00:24:13,279
all of her poems are very ingrained in

649
00:24:16,390 --> 00:24:15,279
nature she's kind of the female walt

650
00:24:19,830 --> 00:24:16,400
whitman

651
00:24:22,789 --> 00:24:19,840
and um very simple language but very

652
00:24:25,269 --> 00:24:22,799
profound and she describes this swan and

653
00:24:27,110 --> 00:24:25,279
and the sound that it makes and so

654
00:24:29,110 --> 00:24:27,120
beautifully and and the very last

655
00:24:30,789 --> 00:24:29,120
sentence of the poem

656
00:24:32,470 --> 00:24:30,799
after she gives this description she

657
00:24:34,710 --> 00:24:32,480
says so

658
00:24:37,669 --> 00:24:34,720
and have you changed your life

659
00:24:40,070 --> 00:24:37,679
you know as as a result of this beauty

660
00:24:41,909 --> 00:24:40,080
and seeing that beauty and internalizing

661
00:24:43,269 --> 00:24:41,919
it you know what did you do did you

662
00:24:45,269 --> 00:24:43,279
change your life

663
00:24:47,669 --> 00:24:45,279

and and the answer is yes i mean

664
00:24:49,269 --> 00:24:47,679
absolutely you know for for me

665
00:24:52,070 --> 00:24:49,279
i couldn't get interested in science

666
00:24:55,269 --> 00:24:52,080
until i could connect the wonder of it

667
00:24:57,990 --> 00:24:55,279
all and and poetry did that for me um

668
00:24:59,830 --> 00:24:58,000
and then i also just wanna i in fact i

669
00:25:03,190 --> 00:24:59,840
brought the book thinking that you might

670
00:25:05,350 --> 00:25:03,200
ask about poetry um diane ackerman is

671
00:25:06,950 --> 00:25:05,360
one of my favorite poets this is a

672
00:25:07,909 --> 00:25:06,960
collection called jaguar of sweet

673
00:25:09,909 --> 00:25:07,919
laughter

674
00:25:12,630 --> 00:25:09,919
she was a student at cornell when carl

675
00:25:16,070 --> 00:25:12,640
sagan was there and she wrote a book of

676
00:25:17,269 --> 00:25:16,080
poems inspired by the solar system

677
00:25:20,149 --> 00:25:17,279
um

678
00:25:23,190 --> 00:25:20,159
and and uh

679
00:25:25,350 --> 00:25:23,200
i she's a genius um it's very beautiful

680
00:25:27,029 --> 00:25:25,360
i can read to you can i read to you one

681
00:25:28,390 --> 00:25:27,039
next absolutely yeah please please do

682
00:25:30,310 --> 00:25:28,400
that'd be wonderful

683
00:25:32,950 --> 00:25:30,320
she even has a poem in here called an

684
00:25:34,470 --> 00:25:32,960
ode to an alien

685
00:25:36,230 --> 00:25:34,480
which is very appropriate but this

686
00:25:39,269 --> 00:25:36,240
particular poem just because we were

687
00:25:42,789 --> 00:25:39,279
talking about the wonder and science

688
00:25:44,789 --> 00:25:42,799

um this is a poem called pluto actually

689
00:25:47,029 --> 00:25:44,799
um and i'm just going to read you one

690
00:25:49,669 --> 00:25:47,039
tiny excerpt

691
00:25:52,230 --> 00:25:49,679
those whom the darts of wonder never

692
00:25:55,190 --> 00:25:52,240
fret may think it odd

693
00:25:59,430 --> 00:25:55,200
that on a vapory midday in july a young

694
00:26:04,310 --> 00:26:01,190
i'll just stop there i mean it's just a

695
00:26:05,830 --> 00:26:04,320
few lines but it but it's it's this idea

696
00:26:08,070 --> 00:26:05,840
that um

697
00:26:10,710 --> 00:26:08,080
wonder and science are connected and

698
00:26:13,029 --> 00:26:10,720
that you can't have curiosity about the

699
00:26:15,110 --> 00:26:13,039
natural world without feeling that that

700
00:26:17,750 --> 00:26:15,120
sense of wonder so this book really

701
00:26:19,830 --> 00:26:17,760
resonates with me it's very beautiful

702
00:26:22,390 --> 00:26:19,840
well i will have to get the book first

703
00:26:24,149 --> 00:26:22,400
um that was lovely and and i love i love

704
00:26:26,789 --> 00:26:24,159
you know when we can use our language in

705
00:26:29,110 --> 00:26:26,799
so many ways to explain what it means to

706
00:26:31,350 --> 00:26:29,120
be human right now in the cosmos

707
00:26:32,470 --> 00:26:31,360
that's a really good point and i i want

708
00:26:34,230 --> 00:26:32,480
to make that

709
00:26:36,390 --> 00:26:34,240
repeat what you just said

710
00:26:38,950 --> 00:26:36,400
um because it's so important i think

711
00:26:41,110 --> 00:26:38,960
that um you know coming to uc santa cruz

712
00:26:44,470 --> 00:26:41,120
where i'm a professor of astrophysics

713
00:26:45,430 --> 00:26:44,480

and the director of astrobiology here

714
00:26:47,350 --> 00:26:45,440
i

715
00:26:50,230 --> 00:26:47,360
wanted to make sure that we were

716
00:26:53,430 --> 00:26:50,240
communicating scientific discovery to

717
00:26:55,510 --> 00:26:53,440
the public so science communications is

718
00:26:57,590 --> 00:26:55,520
very strong here at the university but i

719
00:27:00,630 --> 00:26:57,600
really think that communicating

720
00:27:02,710 --> 00:27:00,640
scientific discovery through the arts

721
00:27:07,029 --> 00:27:02,720
be it poetry or

722
00:27:09,990 --> 00:27:07,039
visual arts or music even is another way

723
00:27:11,430 --> 00:27:10,000
of communicating discovery that we often

724
00:27:13,590 --> 00:27:11,440
neglect

725
00:27:15,909 --> 00:27:13,600
and i think that that's so tremendously

726
00:27:18,950 --> 00:27:15,919
important so um

727
00:27:21,350 --> 00:27:18,960
i i hope that we will host the universe

728
00:27:23,190 --> 00:27:21,360
inverse here one day at uc santa cruz

729
00:27:24,710 --> 00:27:23,200
for that reason oh that'd be so lovely i

730
00:27:26,710 --> 00:27:24,720
i hope so hopefully maria will hear this

731
00:27:28,710 --> 00:27:26,720
and then and we want to do that as well

732
00:27:30,549 --> 00:27:28,720
um and i actually just had a very

733
00:27:33,029 --> 00:27:30,559
interesting uh semi conversation it

734
00:27:35,750 --> 00:27:33,039
wasn't very long last night on twitter

735
00:27:37,510 --> 00:27:35,760
with a poet named jared anderson

736
00:27:38,710 --> 00:27:37,520
he also hosts the podcast the crypto

737
00:27:40,870 --> 00:27:38,720
naturalist

738
00:27:43,029 --> 00:27:40,880

and we were discussing um

739
00:27:45,190 --> 00:27:43,039
you know specializing in science or

740
00:27:47,190 --> 00:27:45,200
poetry and then also you know how

741
00:27:48,710 --> 00:27:47,200
scientists can also express themselves

742
00:27:50,950 --> 00:27:48,720
through art in various ways and artists

743
00:27:53,029 --> 00:27:50,960
can certainly think scientifically can

744
00:27:54,310 --> 00:27:53,039
and can approach things scientifically

745
00:27:56,549 --> 00:27:54,320
but jared did make an interesting

746
00:27:58,070 --> 00:27:56,559
argument that our granting agencies our

747
00:27:59,990 --> 00:27:58,080
funding agencies

748
00:28:02,230 --> 00:28:00,000
should provide some funding to hire

749
00:28:03,750 --> 00:28:02,240
poets and to hire artists i just i

750
00:28:06,070 --> 00:28:03,760
wonder you know what is your take on

751
00:28:07,830 --> 00:28:06,080
that should we also bring in those who

752
00:28:12,149 --> 00:28:07,840
have a different perspective perhaps of

753
00:28:13,110 --> 00:28:12,159
sharing the language into our grants

754
00:28:18,389 --> 00:28:13,120
um

755
00:28:20,549 --> 00:28:18,399
you know we are

756
00:28:23,590 --> 00:28:20,559
we i feel like we're doing science on a

757
00:28:27,190 --> 00:28:23,600
shoestring budget to to large degree you

758
00:28:29,750 --> 00:28:27,200
know the selection rates for fellowships

759
00:28:30,870 --> 00:28:29,760
and for research grants is like ten

760
00:28:33,269 --> 00:28:30,880
percent

761
00:28:35,909 --> 00:28:33,279
so um it's very difficult we're trying

762
00:28:38,310 --> 00:28:35,919
to do the most we can with the minimal

763
00:28:41,110 --> 00:28:38,320

you know with the fewest resources

764
00:28:42,789 --> 00:28:41,120
um it's just the nature of the beast so

765
00:28:45,110 --> 00:28:42,799
um

766
00:28:46,630 --> 00:28:45,120
but but yes i i absolutely agree you

767
00:28:48,789 --> 00:28:46,640
know send a poet or they should have

768
00:28:50,710 --> 00:28:48,799
sent a poet i mean

769
00:28:52,630 --> 00:28:50,720
yes it is such a vital part of how we

770
00:28:55,190 --> 00:28:52,640
communicate um

771
00:28:58,389 --> 00:28:55,200
and it's it's growing i don't know where

772
00:29:00,950 --> 00:28:58,399
these young people are getting

773
00:29:04,549 --> 00:29:00,960
resources to do this but look at tracy k

774
00:29:06,870 --> 00:29:04,559
smith who's now our poet laureate

775
00:29:08,630 --> 00:29:06,880
she wrote a poem about the hubble space

776
00:29:10,950 --> 00:29:08,640
telescope her father was an engineer on

777
00:29:13,190 --> 00:29:10,960
the telescope and

778
00:29:15,029 --> 00:29:13,200
she was inspired on about that so i'm

779
00:29:17,750 --> 00:29:15,039
wondering what youngsters are out there

780
00:29:19,909 --> 00:29:17,760
today inspired by webb who might write

781
00:29:21,430 --> 00:29:19,919
poetry or see the poetry

782
00:29:23,430 --> 00:29:21,440
in it i mean even our science

783
00:29:25,750 --> 00:29:23,440
communicators natalie walclover wrote a

784
00:29:29,190 --> 00:29:25,760
wonderful article for quantum magazine

785
00:29:32,230 --> 00:29:29,200
where she likened uh webb to a lotus a

786
00:29:34,710 --> 00:29:32,240
golden lotus blooming on a silver leaf i

787
00:29:36,630 --> 00:29:34,720
mean the lyricism of that and the image

788
00:29:40,549 --> 00:29:36,640

that it invokes and

789
00:29:41,830 --> 00:29:40,559
is is quite remarkable so yeah

790
00:29:44,230 --> 00:29:41,840
yeah

791
00:29:47,029 --> 00:29:44,240
well i i i'm loving this conversation so

792
00:29:49,190 --> 00:29:47,039
much but part of our show is to open up

793
00:29:50,549 --> 00:29:49,200
uh the questions to our audience to

794
00:29:52,230 --> 00:29:50,559
allow them to ask you as the

795
00:29:53,750 --> 00:29:52,240
astrobiologist

796
00:29:56,230 --> 00:29:53,760
questions about your research about

797
00:29:57,190 --> 00:29:56,240
topics we've discussed so far about jwst

798
00:29:59,029 --> 00:29:57,200
and more

799
00:30:01,510 --> 00:29:59,039
and our first question comes from a

800
00:30:04,149 --> 00:30:01,520
longtime viewer of the show

801
00:30:06,950 --> 00:30:04,159
and the leader of the astro sociology

802
00:30:09,430 --> 00:30:06,960
research institute dr jim pass

803
00:30:11,190 --> 00:30:09,440
dr pass says that astronomy education

804
00:30:13,590 --> 00:30:11,200
consists of scientific discoveries of

805
00:30:15,350 --> 00:30:13,600
course but also involves the biographies

806
00:30:18,149 --> 00:30:15,360
of influential astronomers through the

807
00:30:19,990 --> 00:30:18,159
ages how can the social sciences add

808
00:30:22,710 --> 00:30:20,000
increased depth to the human dimension

809
00:30:25,430 --> 00:30:22,720
of astronomical knowledge

810
00:30:26,549 --> 00:30:25,440
oh goodness that's such a good question

811
00:30:27,909 --> 00:30:26,559
um

812
00:30:29,510 --> 00:30:27,919
it's hard for me to see the forest

813
00:30:31,590 --> 00:30:29,520

through the trees this is another thing

814
00:30:33,909 --> 00:30:31,600
that we're doing in the astrobiology

815
00:30:37,669 --> 00:30:33,919
program here we're

816
00:30:40,630 --> 00:30:37,679
we've collaborated with our humanists

817
00:30:42,710 --> 00:30:40,640
to talk about the societal impacts and

818
00:30:46,389 --> 00:30:42,720
also the ethics of space sciences we

819
00:30:49,909 --> 00:30:46,399
have a weekly ethics reading group

820
00:30:53,190 --> 00:30:49,919
and so this issue about the sociology of

821
00:30:56,710 --> 00:30:53,200
it comes up frequently

822
00:30:58,630 --> 00:30:56,720
i'm very intrigued in part reading maria

823
00:31:01,750 --> 00:30:58,640
popova's work because she dives into

824
00:31:04,230 --> 00:31:01,760
history so much and has really shined a

825
00:31:05,350 --> 00:31:04,240
spotlight on some of the luminaries of

826
00:31:08,549 --> 00:31:05,360
the past

827
00:31:10,789 --> 00:31:08,559
mariah mitchell for example um cecilia

828
00:31:11,990 --> 00:31:10,799
payne you know rachel somerville there

829
00:31:13,990 --> 00:31:12,000
are so many

830
00:31:15,830 --> 00:31:14,000
different

831
00:31:17,269 --> 00:31:15,840
scientists of the past that have been

832
00:31:18,549 --> 00:31:17,279
overlooked

833
00:31:22,470 --> 00:31:18,559
people like

834
00:31:24,789 --> 00:31:22,480
william and mary huggins who observed

835
00:31:26,789 --> 00:31:24,799
the chemical fingerprints of the first

836
00:31:28,950 --> 00:31:26,799
stars and showed that they were very

837
00:31:31,750 --> 00:31:28,960
much like the sun whose chemical

838
00:31:33,830 --> 00:31:31,760

fingerprints we share here on earth

839
00:31:35,669 --> 00:31:33,840
showing how everything is connected and

840
00:31:37,669 --> 00:31:35,679
of course cecilia payne

841
00:31:39,350 --> 00:31:37,679
who then took that information and

842
00:31:40,710 --> 00:31:39,360
showed that the universe is mostly

843
00:31:42,950 --> 00:31:40,720
hydrogen and that we are made of

844
00:31:46,950 --> 00:31:42,960
stardust i mean all of this kind of

845
00:31:49,430 --> 00:31:46,960
connected chain of human knowledge is

846
00:31:51,350 --> 00:31:49,440
i mean that's what it is to be human

847
00:31:53,190 --> 00:31:51,360
as a scientist i know that i'm going to

848
00:31:55,110 --> 00:31:53,200
end my life with more questions left

849
00:31:57,509 --> 00:31:55,120
unanswered than answered

850
00:31:59,909 --> 00:31:57,519
i take solace in that knowing that my

851
00:32:01,350 --> 00:31:59,919
daughter is also an astrophysicist but

852
00:32:03,990 --> 00:32:01,360
so there it's more

853
00:32:06,630 --> 00:32:04,000
direct the connection the generational

854
00:32:08,070 --> 00:32:06,640
continuation continuity of human

855
00:32:09,990 --> 00:32:08,080
knowledge

856
00:32:13,029 --> 00:32:10,000
but also i see that through my students

857
00:32:15,750 --> 00:32:13,039
and knowing that it will carry on

858
00:32:17,029 --> 00:32:15,760
somehow gives me soulless

859
00:32:18,950 --> 00:32:17,039
um

860
00:32:19,909 --> 00:32:18,960
that's not a direct ques answer to his

861
00:32:21,669 --> 00:32:19,919
question

862
00:32:25,830 --> 00:32:21,679
but i i do think that it's very

863
00:32:29,110 --> 00:32:25,840

important to kind of um

864
00:32:31,029 --> 00:32:29,120
i mean we we are humans doing science

865
00:32:33,750 --> 00:32:31,039
and you can't escape the fact that we

866
00:32:35,590 --> 00:32:33,760
are humans we're kind of embedded in it

867
00:32:37,269 --> 00:32:35,600
and part of it we're trying to

868
00:32:39,830 --> 00:32:37,279
disentangle something that is also

869
00:32:42,230 --> 00:32:39,840
ourselves and we're part of it so um i

870
00:32:45,110 --> 00:32:42,240
think it's helpful to have the humanists

871
00:32:47,029 --> 00:32:45,120
and philosophers sociologists kind of

872
00:32:49,750 --> 00:32:47,039
observing from the outside and also

873
00:32:52,710 --> 00:32:49,760
helping us to figure out and guide us

874
00:32:54,870 --> 00:32:52,720
give us an ethical framework

875
00:32:56,630 --> 00:32:54,880
especially with planet hunting hunting

876
00:32:59,350 --> 00:32:56,640
they use this word hunting

877
00:33:01,669 --> 00:32:59,360
i'm really trying to be purposeful about

878
00:33:03,990 --> 00:33:01,679
that getting away from the colonial

879
00:33:05,909 --> 00:33:04,000
language that we use when we talk about

880
00:33:08,389 --> 00:33:05,919
other planets because

881
00:33:10,870 --> 00:33:08,399
if we do find a living world by

882
00:33:12,710 --> 00:33:10,880
definition it's not ours for the taking

883
00:33:14,950 --> 00:33:12,720
and yet people are talking about planet

884
00:33:17,830 --> 00:33:14,960
b and you know as if we need a backup

885
00:33:19,590 --> 00:33:17,840
plan and could we go there and when can

886
00:33:20,950 --> 00:33:19,600
i pack my you know can i pack my bags

887
00:33:22,149 --> 00:33:20,960
when can i go

888
00:33:24,310 --> 00:33:22,159

um

889
00:33:26,630 --> 00:33:24,320
that's not what it's about either so

890
00:33:27,350 --> 00:33:26,640
having these conversations with the with

891
00:33:29,190 --> 00:33:27,360
the

892
00:33:30,950 --> 00:33:29,200
humanists has been

893
00:33:32,470 --> 00:33:30,960
very very helpful

894
00:33:34,470 --> 00:33:32,480
that's lovely as it's so important to

895
00:33:35,669 --> 00:33:34,480
connect in that way and i hadn't even

896
00:33:37,269 --> 00:33:35,679
thought of that myself in that

897
00:33:39,350 --> 00:33:37,279
connection with hunting for exoplanets

898
00:33:41,590 --> 00:33:39,360
and potential issues in in that

899
00:33:42,950 --> 00:33:41,600
terminology the language that we use

900
00:33:44,070 --> 00:33:42,960
um when explaining the science that

901
00:33:46,310 --> 00:33:44,080
we're doing

902
00:33:48,630 --> 00:33:46,320
um if i can so a question came in from

903
00:33:49,590 --> 00:33:48,640
reddit from beck beliefs uh user beck

904
00:33:55,110 --> 00:33:49,600
beliefs

905
00:33:57,590 --> 00:33:55,120
will cooperate with other space and

906
00:34:01,509 --> 00:33:57,600
ground-based observatories uh to do

907
00:34:03,269 --> 00:34:01,519
follow-up investigations on exoplanets

908
00:34:04,830 --> 00:34:03,279
we're doing that already and web hasn't

909
00:34:07,669 --> 00:34:04,840
even launched

910
00:34:09,669 --> 00:34:07,679
um as you you mentioned this in the

911
00:34:12,710 --> 00:34:09,679
introduction that i'm

912
00:34:14,710 --> 00:34:12,720
utilizing ground-based telescopes um so

913
00:34:17,750 --> 00:34:14,720

what we're doing is

914
00:34:19,430 --> 00:34:17,760
we've identified planets that are nearby

915
00:34:21,750 --> 00:34:19,440
and that are perfect candidates for

916
00:34:24,069 --> 00:34:21,760
being subjected to atmospheric

917
00:34:26,389 --> 00:34:24,079
characterization with web

918
00:34:28,550 --> 00:34:26,399
but in order to disambiguate the

919
00:34:31,030 --> 00:34:28,560
atmospheric properties

920
00:34:33,109 --> 00:34:31,040
you you need to know something about the

921
00:34:35,349 --> 00:34:33,119
planet that you're looking at

922
00:34:37,510 --> 00:34:35,359
and so it's very helpful if you can know

923
00:34:39,430 --> 00:34:37,520
both radius and the mass

924
00:34:41,430 --> 00:34:39,440
that gives you together those two

925
00:34:43,909 --> 00:34:41,440
properties tell us what the surface

926
00:34:45,990 --> 00:34:43,919
gravity is likely to be if the surface

927
00:34:47,990 --> 00:34:46,000
gravity is really high

928
00:34:49,430 --> 00:34:48,000
it will compress the atmosphere if the

929
00:34:51,829 --> 00:34:49,440
surface gravity is really low the

930
00:34:53,829 --> 00:34:51,839
atmosphere will be more lofted so that's

931
00:34:57,109 --> 00:34:53,839
important to know in order to interpret

932
00:34:59,990 --> 00:34:57,119
the atmospheric properties so with

933
00:35:02,790 --> 00:35:00,000
space missions like tess and kepler that

934
00:35:04,790 --> 00:35:02,800
measure these dimmings of light due to

935
00:35:05,829 --> 00:35:04,800
transits you get the radius of the

936
00:35:07,750 --> 00:35:05,839
planet

937
00:35:09,990 --> 00:35:07,760
but it's only with these large

938
00:35:11,990 --> 00:35:10,000

ground-based telescopes like keck that

939
00:35:13,510 --> 00:35:12,000
we can measure the doppler wobble which

940
00:35:16,470 --> 00:35:13,520
tells us the mass

941
00:35:20,950 --> 00:35:16,480
so we've been spending a lot of time now

942
00:35:22,630 --> 00:35:20,960
for two years observing the best targets

943
00:35:24,790 --> 00:35:22,640
from tests that were identified mostly

944
00:35:26,870 --> 00:35:24,800
from tests

945
00:35:27,990 --> 00:35:26,880
whose planets can be subjected to

946
00:35:30,230 --> 00:35:28,000
atmospheric

947
00:35:32,870 --> 00:35:30,240
characterization with web so that's one

948
00:35:34,310 --> 00:35:32,880
example of the kind of synergy between

949
00:35:36,230 --> 00:35:34,320
space telescopes and ground-based

950
00:35:37,670 --> 00:35:36,240
telescopes

951
00:35:39,589 --> 00:35:37,680
that's fantastic

952
00:35:41,430 --> 00:35:39,599
um a question just came in from jeff

953
00:35:43,270 --> 00:35:41,440
neal on youtube

954
00:35:44,310 --> 00:35:43,280
um one jeff just says that he's

955
00:35:45,589 --> 00:35:44,320
appreciated the background that we've

956
00:35:46,550 --> 00:35:45,599
given so far

957
00:35:48,230 --> 00:35:46,560
um

958
00:35:50,710 --> 00:35:48,240
oh sorry helps the background behind you

959
00:35:52,870 --> 00:35:50,720
oh sorry um jeff jeff wants to know if

960
00:35:54,310 --> 00:35:52,880
that's a kepler-10b globe or a clapper

961
00:35:58,790 --> 00:35:54,320
kepler-22

962
00:36:00,630 --> 00:35:58,800
uh b throw pillow it is not a kepler-10b

963
00:36:02,790 --> 00:36:00,640

globe it is the

964
00:36:05,829 --> 00:36:02,800
captain b globe i think it's the only

965
00:36:09,510 --> 00:36:05,839
one in existence um and it was painted

966
00:36:12,630 --> 00:36:09,520
um by dana berry who did the 3d

967
00:36:14,710 --> 00:36:12,640
rendering of the surface of 10b

968
00:36:16,790 --> 00:36:14,720
after or when it was discovered and and

969
00:36:19,670 --> 00:36:16,800
we went to communicate that to the

970
00:36:23,030 --> 00:36:19,680
public and he used that artistry for his

971
00:36:23,990 --> 00:36:23,040
own documentary which was called uh

972
00:36:26,310 --> 00:36:24,000
gosh

973
00:36:28,310 --> 00:36:26,320
finding the next earth i think it was i

974
00:36:30,310 --> 00:36:28,320
think it's had a couple of generations

975
00:36:32,230 --> 00:36:30,320
to have a couple of different names um

976
00:36:37,030 --> 00:36:32,240
and then yes you see my round water

977
00:36:41,430 --> 00:36:39,510
i love it that's fantastic yeah i think

978
00:36:43,430 --> 00:36:41,440
amongst us scientists and space nerds we

979
00:36:44,950 --> 00:36:43,440
have lots of gear

980
00:36:46,390 --> 00:36:44,960
around our favorite pursuits you know

981
00:36:49,030 --> 00:36:46,400
for me i have lots of meteorites and

982
00:36:50,069 --> 00:36:49,040
rocks being a geologist in my office

983
00:36:52,790 --> 00:36:50,079
um

984
00:36:56,630 --> 00:36:52,800
a question came in from indrajit laha on

985
00:36:58,390 --> 00:36:56,640
on youtube indrajit wants to know um

986
00:37:01,510 --> 00:36:58,400
they want to be involved in the human

987
00:37:03,670 --> 00:37:01,520
exploration of the moon and mars and so

988
00:37:05,430 --> 00:37:03,680

their question is if they want to be an

989
00:37:07,750 --> 00:37:05,440
astrobiologist exploring the moon and

990
00:37:09,990 --> 00:37:07,760
mars what kinds of science do you think

991
00:37:12,349 --> 00:37:10,000
they should pursue

992
00:37:13,910 --> 00:37:12,359
astrobiology is inherently in

993
00:37:16,150 --> 00:37:13,920
interdisciplinary

994
00:37:17,990 --> 00:37:16,160
so we in order to understand the most

995
00:37:19,910 --> 00:37:18,000
likely abodes of life

996
00:37:22,230 --> 00:37:19,920
in order to understand the origin and

997
00:37:24,069 --> 00:37:22,240
the distribution of life and its

998
00:37:26,550 --> 00:37:24,079
evolution in

999
00:37:27,349 --> 00:37:26,560
in the cosmos

1000
00:37:32,069 --> 00:37:27,359
you

1001
00:37:34,150 --> 00:37:32,079
cosmic objects

1002
00:37:35,589 --> 00:37:34,160
you have to do planetary sciences

1003
00:37:36,390 --> 00:37:35,599
because you need to understand their

1004
00:37:38,790 --> 00:37:36,400
geology

1005
00:37:40,069 --> 00:37:38,800
and how planets are can be diverse and

1006
00:37:42,230 --> 00:37:40,079
in what ways

1007
00:37:44,550 --> 00:37:42,240
you have to be an earth scientist as

1008
00:37:46,870 --> 00:37:44,560
well because we need to you know earth

1009
00:37:50,390 --> 00:37:46,880
is the only place where we have

1010
00:37:53,030 --> 00:37:50,400
life and we can observe how the

1011
00:37:54,870 --> 00:37:53,040
interior or geology of a planet

1012
00:37:57,750 --> 00:37:54,880
interacts with the atmosphere and the

1013
00:37:59,270 --> 00:37:57,760

biosphere in between how those elements

1014
00:38:01,349 --> 00:37:59,280
co-evolve

1015
00:38:03,430 --> 00:38:01,359
with time not just

1016
00:38:05,190 --> 00:38:03,440
over hundreds of years but over deep

1017
00:38:08,710 --> 00:38:05,200
time going all the way back to the

1018
00:38:10,950 --> 00:38:08,720
beginning of earth when microbes ruled

1019
00:38:14,630 --> 00:38:10,960
the land i guess microbes still rule the

1020
00:38:17,349 --> 00:38:14,640
land but back then that's all we had

1021
00:38:19,910 --> 00:38:17,359
and so we want to understand that whole

1022
00:38:21,430 --> 00:38:19,920
geological picture going back in deep

1023
00:38:23,109 --> 00:38:21,440
time

1024
00:38:25,430 --> 00:38:23,119
so and then of course you've got the

1025
00:38:27,270 --> 00:38:25,440
life sciences you've got biochemistry

1026
00:38:29,109 --> 00:38:27,280
you know the rise of molecular

1027
00:38:30,950 --> 00:38:29,119
complexity

1028
00:38:34,150 --> 00:38:30,960
we see we observe

1029
00:38:35,990 --> 00:38:34,160
amino acids some amino acids in space in

1030
00:38:37,430 --> 00:38:36,000
the interstellar medium

1031
00:38:39,910 --> 00:38:37,440
nucleic

1032
00:38:42,710 --> 00:38:39,920
nucleobases you know these building

1033
00:38:43,990 --> 00:38:42,720
blocks of life are out in the cosmos but

1034
00:38:47,190 --> 00:38:44,000
how do they

1035
00:38:50,230 --> 00:38:47,200
self-assemble how do you create

1036
00:38:52,390 --> 00:38:50,240
rna for example you know the enzymes

1037
00:38:53,109 --> 00:38:52,400
that are used i mean this is a subject

1038
00:38:54,310 --> 00:38:53,119

of

1039
00:38:56,790 --> 00:38:54,320
you know this

1040
00:38:57,910 --> 00:38:56,800
this early biochemistry and how the

1041
00:39:00,550 --> 00:38:57,920
original

1042
00:39:02,550 --> 00:39:00,560
building blocks came to be is we have to

1043
00:39:04,870 --> 00:39:02,560
understand that

1044
00:39:07,829 --> 00:39:04,880
we want to know how a single-celled

1045
00:39:11,510 --> 00:39:07,839
microbe evolved after two billion years

1046
00:39:13,270 --> 00:39:11,520
on planet earth once oxygen

1047
00:39:16,069 --> 00:39:13,280
was released into the atmosphere in

1048
00:39:18,870 --> 00:39:16,079
great quantities um single-celled life

1049
00:39:21,430 --> 00:39:18,880
evolved into multi-celled life and the

1050
00:39:23,270 --> 00:39:21,440
eukaryote came to be and that's what

1051
00:39:24,950 --> 00:39:23,280
created the tree of branch of the tree

1052
00:39:25,670 --> 00:39:24,960
of life that led to

1053
00:39:27,430 --> 00:39:25,680
us

1054
00:39:29,430 --> 00:39:27,440
and you know intelligence what we think

1055
00:39:31,589 --> 00:39:29,440
of as intelligence at least

1056
00:39:34,470 --> 00:39:31,599
so all of these things are necessary to

1057
00:39:35,910 --> 00:39:34,480
understand so you could really study

1058
00:39:37,510 --> 00:39:35,920
anything

1059
00:39:39,670 --> 00:39:37,520
in the sciences

1060
00:39:43,829 --> 00:39:39,680
um and as we discussed you can even

1061
00:39:46,390 --> 00:39:43,839
study be a humanist and be part of it

1062
00:39:48,950 --> 00:39:46,400
again it's just really to find what you

1063
00:39:51,510 --> 00:39:48,960

love and what interests you and then to

1064
00:39:54,550 --> 00:39:51,520
find the pathways that kind of make all

1065
00:39:58,150 --> 00:39:54,560
of these elements diverge into what

1066
00:40:00,950 --> 00:39:58,160
you're passionate about that's

1067
00:40:04,309 --> 00:40:00,960
absolutely it's like mary voitek often

1068
00:40:06,630 --> 00:40:04,319
said everyone can be an astrobiologist

1069
00:40:09,349 --> 00:40:06,640
um we have another question on youtube

1070
00:40:11,349 --> 00:40:09,359
from t venus reddy uh

1071
00:40:13,910 --> 00:40:11,359
and he would like to know

1072
00:40:15,510 --> 00:40:13,920
if we find a planet that appears to have

1073
00:40:17,030 --> 00:40:15,520
life um

1074
00:40:18,150 --> 00:40:17,040
and we would assume um perhaps

1075
00:40:21,030 --> 00:40:18,160
non-intelligent life if we're not

1076
00:40:23,510 --> 00:40:21,040
finding signs of techno signatures

1077
00:40:25,589 --> 00:40:23,520
if that world is so far away that we

1078
00:40:27,589 --> 00:40:25,599
can't go say hi

1079
00:40:29,349 --> 00:40:27,599
what more do you think we would do once

1080
00:40:31,589 --> 00:40:29,359
we had a detection or a potential

1081
00:40:34,790 --> 00:40:31,599
detection i think is the better language

1082
00:40:38,550 --> 00:40:36,870
i don't think that the that finding

1083
00:40:40,870 --> 00:40:38,560
evidence of life is going to be a

1084
00:40:43,750 --> 00:40:40,880
singular aha moment

1085
00:40:46,069 --> 00:40:43,760
like ah we have it i think it's going to

1086
00:40:48,550 --> 00:40:46,079
be very gradual we're going to build up

1087
00:40:49,910 --> 00:40:48,560
that evidence we're going to confirm it

1088
00:40:51,589 --> 00:40:49,920

we're going to look at it in different

1089
00:40:52,950 --> 00:40:51,599
ways we're going to rule out other

1090
00:40:55,270 --> 00:40:52,960
scenarios

1091
00:40:57,190 --> 00:40:55,280
this is exactly how exoplanet discovery

1092
00:40:59,190 --> 00:40:57,200
was done you know you see a signal it

1093
00:41:00,870 --> 00:40:59,200
looks like an exoplanet but there are

1094
00:41:03,190 --> 00:41:00,880
myriad other ways

1095
00:41:05,190 --> 00:41:03,200
of creating that same signal

1096
00:41:07,030 --> 00:41:05,200
through just normal astrophysics and you

1097
00:41:08,950 --> 00:41:07,040
have to weed out all of the

1098
00:41:10,230 --> 00:41:08,960
astrophysical false positives to be

1099
00:41:13,349 --> 00:41:10,240
certain that what you're seeing is a

1100
00:41:16,069 --> 00:41:13,359
planet so that very careful work will be

1101
00:41:18,630 --> 00:41:16,079
also applied to finding evidence of life

1102
00:41:20,790 --> 00:41:18,640
beyond earth and it will it'll be this

1103
00:41:23,030 --> 00:41:20,800
gradual process and and i think

1104
00:41:25,589 --> 00:41:23,040
initially we will see

1105
00:41:28,710 --> 00:41:25,599
a group maybe we'll do a statistical

1106
00:41:30,950 --> 00:41:28,720
sample observations of many potentially

1107
00:41:32,950 --> 00:41:30,960
habitable planets will understand their

1108
00:41:35,589 --> 00:41:32,960
surface conditions

1109
00:41:36,950 --> 00:41:35,599
maybe we'll find an oxygen signal we'll

1110
00:41:39,349 --> 00:41:36,960
weed out other

1111
00:41:41,829 --> 00:41:39,359
potential false positives maybe there

1112
00:41:44,230 --> 00:41:41,839
will be a subset of planets that stand

1113
00:41:46,710 --> 00:41:44,240

out in some way as being very different

1114
00:41:48,309 --> 00:41:46,720
from most of the other planets that

1115
00:41:50,309 --> 00:41:48,319
could be indicative of some

1116
00:41:53,349 --> 00:41:50,319
disequilibrium chemistry happening on

1117
00:41:56,150 --> 00:41:53,359
the surface that we think is life and we

1118
00:41:57,430 --> 00:41:56,160
will study them we'll study them in more

1119
00:41:59,430 --> 00:41:57,440
detail

1120
00:42:01,190 --> 00:41:59,440
i could even imagine

1121
00:42:02,630 --> 00:42:01,200
instruments that we put into space

1122
00:42:08,790 --> 00:42:02,640
beyond

1123
00:42:10,470 --> 00:42:08,800
we eventually want to put a network of

1124
00:42:12,390 --> 00:42:10,480
interferometers in space that could

1125
00:42:14,550 --> 00:42:12,400
resolve the surfaces of planets and

1126
00:42:17,670 --> 00:42:14,560
actually see the reflectant signature of

1127
00:42:20,950 --> 00:42:17,680
large forests or microbial mats or

1128
00:42:23,670 --> 00:42:20,960
whatever they are that exists there

1129
00:42:25,670 --> 00:42:23,680
so that will be a process that stretches

1130
00:42:26,790 --> 00:42:25,680
generations and generations into the

1131
00:42:29,270 --> 00:42:26,800
future

1132
00:42:32,470 --> 00:42:29,280
will we eventually go there

1133
00:42:34,630 --> 00:42:32,480
i think that once we can point to stars

1134
00:42:37,750 --> 00:42:34,640
that we know have living worlds it's

1135
00:42:42,069 --> 00:42:37,760
going to really motivate humans around

1136
00:42:43,430 --> 00:42:42,079
the globe to work towards that goal

1137
00:42:46,630 --> 00:42:43,440
just because

1138
00:42:48,950 --> 00:42:46,640

you can't help but want to reach out

1139
00:42:51,670 --> 00:42:48,960
um or no more

1140
00:42:53,750 --> 00:42:51,680
connect in some way i mean that's also

1141
00:42:54,870 --> 00:42:53,760
part of what makes us human

1142
00:42:56,950 --> 00:42:54,880
so

1143
00:42:58,630 --> 00:42:56,960
whether or not that'll ever happen i i

1144
00:43:00,470 --> 00:42:58,640
don't know i do know that earth has a

1145
00:43:01,990 --> 00:43:00,480
finite lifetime so eventually we'll have

1146
00:43:03,510 --> 00:43:02,000
to get off this planet it's probably

1147
00:43:05,190 --> 00:43:03,520
sooner than we think

1148
00:43:07,430 --> 00:43:05,200
so uh it'd be good to have that

1149
00:43:08,950 --> 00:43:07,440
capability eventually but it'll be a

1150
00:43:11,030 --> 00:43:08,960
slow process

1151
00:43:11,990 --> 00:43:11,040
absolutely um

1152
00:43:14,069 --> 00:43:12,000
and

1153
00:43:15,270 --> 00:43:14,079
so we have many more questions i promise

1154
00:43:17,109 --> 00:43:15,280
our audience i'll try my hardest to get

1155
00:43:18,230 --> 00:43:17,119
to all of them i can um i do want to

1156
00:43:19,750 --> 00:43:18,240
know though so

1157
00:43:21,829 --> 00:43:19,760
um you know so

1158
00:43:23,829 --> 00:43:21,839
what your opinion then is on concepts

1159
00:43:25,030 --> 00:43:23,839
like medi messaging access terrestrial

1160
00:43:26,790 --> 00:43:25,040
intelligence

1161
00:43:28,309 --> 00:43:26,800
um sending messages out there

1162
00:43:29,990 --> 00:43:28,319
intentionally right now if we find a

1163
00:43:31,270 --> 00:43:30,000

world that appears to potentially have

1164
00:43:33,030 --> 00:43:31,280
life

1165
00:43:36,230 --> 00:43:33,040
should we ought be

1166
00:43:38,630 --> 00:43:36,240
to send a message towards it or do we

1167
00:43:40,870 --> 00:43:38,640
know it perhaps to ourselves to first

1168
00:43:41,750 --> 00:43:40,880
consider you know who speaks for earth

1169
00:43:43,589 --> 00:43:41,760
and

1170
00:43:45,910 --> 00:43:43,599
is it an existential threat for us to

1171
00:43:49,109 --> 00:43:45,920
try to speak to someone else out there

1172
00:43:52,230 --> 00:43:49,910
um

1173
00:43:54,870 --> 00:43:52,240
i i don't know that it's an

1174
00:43:56,870 --> 00:43:54,880
existential threat i personally don't

1175
00:44:01,910 --> 00:43:56,880
hold that view but

1176
00:44:03,270 --> 00:44:01,920
i could be naive and i also don't feel

1177
00:44:06,470 --> 00:44:03,280
compelled

1178
00:44:08,150 --> 00:44:06,480
to send messages out although there is

1179
00:44:09,750 --> 00:44:08,160
something interesting about this idea of

1180
00:44:11,829 --> 00:44:09,760
a message in a bottle

1181
00:44:13,510 --> 00:44:11,839
you know we did put a message on pioneer

1182
00:44:16,230 --> 00:44:13,520
we did put a message on the voyager

1183
00:44:17,910 --> 00:44:16,240
spacecraft why do we feel compelled to

1184
00:44:18,950 --> 00:44:17,920
do that it's

1185
00:44:21,030 --> 00:44:18,960
kind of like

1186
00:44:22,470 --> 00:44:21,040
writing graffiti on a wall you know we

1187
00:44:25,510 --> 00:44:22,480
were here

1188
00:44:31,109 --> 00:44:27,990

so it's probably more of an

1189
00:44:33,270 --> 00:44:31,119
uh philosopher existential reasons for

1190
00:44:35,670 --> 00:44:33,280
doing so for communicating not

1191
00:44:37,910 --> 00:44:35,680
necessarily intentionally trying to

1192
00:44:39,670 --> 00:44:37,920
signal you know where we're here is

1193
00:44:41,990 --> 00:44:39,680
anybody out there

1194
00:44:44,069 --> 00:44:42,000
should we do that i don't feel compelled

1195
00:44:46,470 --> 00:44:44,079
to right now

1196
00:44:47,910 --> 00:44:46,480
if we do learn about living worlds out

1197
00:44:50,470 --> 00:44:47,920
there i could see that that's going to

1198
00:44:52,309 --> 00:44:50,480
become much more compelling to do that

1199
00:44:53,829 --> 00:44:52,319
but i think we need to learn

1200
00:44:55,750 --> 00:44:53,839
more first

1201
00:44:57,910 --> 00:44:55,760
and then approach it slowly

1202
00:45:00,470 --> 00:44:57,920
it'd be great if humanity could

1203
00:45:02,309 --> 00:45:00,480
collectively come together and decide

1204
00:45:04,550 --> 00:45:02,319
who speaks for earth and what that

1205
00:45:06,790 --> 00:45:04,560
message would be i

1206
00:45:08,390 --> 00:45:06,800
i'm not sure i see that happening

1207
00:45:11,270 --> 00:45:08,400
there's a lot of science fiction stories

1208
00:45:14,470 --> 00:45:11,280
that have been written on the subject

1209
00:45:17,270 --> 00:45:14,480
and i'm also not sure one could argue

1210
00:45:18,390 --> 00:45:17,280
that um an alien species wouldn't be

1211
00:45:21,349 --> 00:45:18,400
able to

1212
00:45:23,190 --> 00:45:21,359
decipher such a message but but just

1213
00:45:24,470 --> 00:45:23,200

knowing that somebody's there is also

1214
00:45:27,910 --> 00:45:24,480
comforting

1215
00:45:31,750 --> 00:45:27,920
you know knowing that they see us

1216
00:45:34,230 --> 00:45:31,760
is also could be comforting in a way

1217
00:45:35,109 --> 00:45:34,240
even if we don't communicate so i i

1218
00:45:37,030 --> 00:45:35,119
don't know

1219
00:45:39,109 --> 00:45:37,040
we'll see i love the idea of the message

1220
00:45:40,870 --> 00:45:39,119
in a bottle it reminds me of the the

1221
00:45:42,390 --> 00:45:40,880
sting and the police song message in a

1222
00:45:43,589 --> 00:45:42,400
bottle where at the end of the song

1223
00:45:45,510 --> 00:45:43,599
there's a hundred thousand bottles

1224
00:45:47,030 --> 00:45:45,520
washed up on the shore uh sending

1225
00:45:48,630 --> 00:45:47,040
messages back and so maybe we'll have a

1226
00:45:50,390 --> 00:45:48,640
hundred thousand voyagers from other

1227
00:45:51,270 --> 00:45:50,400
species coming to visit us soon who

1228
00:45:53,510 --> 00:45:51,280
knows

1229
00:45:55,349 --> 00:45:53,520
um we have a question i'm not quite sure

1230
00:45:57,270 --> 00:45:55,359
that i understand here it comes from tom

1231
00:45:59,030 --> 00:45:57,280
caruso on facebook

1232
00:46:01,349 --> 00:45:59,040
tom wants to know if you could describe

1233
00:46:02,710 --> 00:46:01,359
recent discoveries of super puffy mini

1234
00:46:04,630 --> 00:46:02,720
neptunes

1235
00:46:07,270 --> 00:46:04,640
um i've not heard that term could you

1236
00:46:09,750 --> 00:46:07,280
describe that more for us yeah

1237
00:46:12,069 --> 00:46:09,760
um i alluded to this before that the

1238
00:46:13,430 --> 00:46:12,079

diversity of planets out there is so

1239
00:46:16,150 --> 00:46:13,440
much larger than the diversity of

1240
00:46:19,030 --> 00:46:16,160
planets in our in our solar system

1241
00:46:21,030 --> 00:46:19,040
um and and i also alluded to the fact

1242
00:46:23,190 --> 00:46:21,040
that we have these um

1243
00:46:24,630 --> 00:46:23,200
either super earths or sub neptunes

1244
00:46:26,309 --> 00:46:24,640
their intermediate right these in

1245
00:46:31,430 --> 00:46:26,319
between planets

1246
00:46:33,510 --> 00:46:31,440
there's a large diversity the masses of

1247
00:46:36,230 --> 00:46:33,520
the mass of a sub-neptune planet can

1248
00:46:38,630 --> 00:46:36,240
range from four times the earth's mass

1249
00:46:40,870 --> 00:46:38,640
all the way up to 20 times the earth's

1250
00:46:43,030 --> 00:46:40,880
mass so that's a factor of five

1251
00:46:45,349 --> 00:46:43,040
indifference so but but yet they can

1252
00:46:48,470 --> 00:46:45,359
have the same radius but a factor of

1253
00:46:51,430 --> 00:46:48,480
five difference in mass so the the super

1254
00:46:54,390 --> 00:46:51,440
puffs are those that are on that low end

1255
00:46:58,230 --> 00:46:54,400
they have a large radius but their mass

1256
00:47:01,190 --> 00:46:58,240
is low so they have very low average

1257
00:47:04,230 --> 00:47:01,200
density and that's puzzling so what are

1258
00:47:06,230 --> 00:47:04,240
they made out of it it suggests that

1259
00:47:10,230 --> 00:47:06,240
they have um

1260
00:47:12,150 --> 00:47:10,240
high hydrogen content in relation to

1261
00:47:14,550 --> 00:47:12,160
rock or silicates you know iron

1262
00:47:17,589 --> 00:47:14,560
magnesium nickel for example

1263
00:47:19,349 --> 00:47:17,599

um so maybe

1264
00:47:21,430 --> 00:47:19,359
well we don't know

1265
00:47:23,670 --> 00:47:21,440
so that that again is part of what we

1266
00:47:26,069 --> 00:47:23,680
want to do with web in fact

1267
00:47:28,790 --> 00:47:26,079
one of those super puffs is going to be

1268
00:47:30,309 --> 00:47:28,800
observed in year one

1269
00:47:32,390 --> 00:47:30,319
and

1270
00:47:35,109 --> 00:47:32,400
studying the atmosphere will give a new

1271
00:47:37,750 --> 00:47:35,119
lens on that diversity you know is it

1272
00:47:39,109 --> 00:47:37,760
does it have a hydrogen rich atmosphere

1273
00:47:42,150 --> 00:47:39,119
for example

1274
00:47:43,829 --> 00:47:42,160
would help us to understand the

1275
00:47:45,430 --> 00:47:43,839
structure of that planet

1276
00:47:47,829 --> 00:47:45,440
that's so awesome yeah i just imagine

1277
00:47:49,990 --> 00:47:47,839
like giant puffballs in space now um but

1278
00:47:52,390 --> 00:47:50,000
i love that so much um we have a

1279
00:47:54,150 --> 00:47:52,400
question from arunava padar

1280
00:47:56,230 --> 00:47:54,160
so recently there was the announcement

1281
00:47:57,670 --> 00:47:56,240
of a potential detection of an exoplanet

1282
00:48:00,309 --> 00:47:57,680
in another galaxy

1283
00:48:01,670 --> 00:48:00,319
um from x-rays um and i believe it was

1284
00:48:04,470 --> 00:48:01,680
the transit method with the x-rays as

1285
00:48:05,829 --> 00:48:04,480
well perhaps i'm wrong there

1286
00:48:07,270 --> 00:48:05,839
and aaronvo wants to know what the

1287
00:48:09,030 --> 00:48:07,280
implications are for that kind of

1288
00:48:11,829 --> 00:48:09,040

discovery of an exoplanet in another

1289
00:48:13,589 --> 00:48:11,839
galaxy um and whether jwst will help us

1290
00:48:16,630 --> 00:48:13,599
to understand more about that kind of

1291
00:48:18,950 --> 00:48:16,640
world that's that far away

1292
00:48:21,270 --> 00:48:18,960
there's no reason to think that we would

1293
00:48:23,910 --> 00:48:21,280
have billions of planets in the milky

1294
00:48:25,430 --> 00:48:23,920
way and none elsewhere none in other

1295
00:48:26,630 --> 00:48:25,440
galaxies so

1296
00:48:28,630 --> 00:48:26,640
you know

1297
00:48:31,510 --> 00:48:28,640
the physics should be the same

1298
00:48:34,630 --> 00:48:31,520
so what we find here should be reflected

1299
00:48:36,950 --> 00:48:34,640
in other galaxies that's not a surprise

1300
00:48:38,950 --> 00:48:36,960
but finding planets is very difficult

1301
00:48:41,990 --> 00:48:38,960
planets are tiny

1302
00:48:44,870 --> 00:48:42,000
their impact on stars is very tiny in

1303
00:48:47,430 --> 00:48:44,880
the x-ray it was a larger fraction so

1304
00:48:49,829 --> 00:48:47,440
it's easier to see

1305
00:48:52,309 --> 00:48:49,839
that's that's how that methodology was

1306
00:48:54,150 --> 00:48:52,319
capable of finding a signal uh in

1307
00:48:59,829 --> 00:48:54,160
another associated with a star in

1308
00:49:04,230 --> 00:49:01,829
i think that there are so many planets

1309
00:49:06,230 --> 00:49:04,240
in our own galaxy that are easier to see

1310
00:49:09,990 --> 00:49:06,240
and to study that will probably spend

1311
00:49:11,910 --> 00:49:10,000
most of our resources doing that

1312
00:49:13,430 --> 00:49:11,920
but

1313
00:49:14,829 --> 00:49:13,440

i don't know i'm trying to think if

1314
00:49:17,510 --> 00:49:14,839
there's

1315
00:49:19,829 --> 00:49:17,520
strategically an advantage of observing

1316
00:49:22,950 --> 00:49:19,839
planets in other galaxies and i don't

1317
00:49:24,710 --> 00:49:22,960
it's not apparent to me

1318
00:49:26,630 --> 00:49:24,720
why we would spend a lot of resources

1319
00:49:27,829 --> 00:49:26,640
doing that but it's it's

1320
00:49:29,589 --> 00:49:27,839
romantic

1321
00:49:30,710 --> 00:49:29,599
right to think of

1322
00:49:31,910 --> 00:49:30,720
another

1323
00:49:34,150 --> 00:49:31,920
culture or

1324
00:49:35,109 --> 00:49:34,160
other planets in other galaxies

1325
00:49:36,470 --> 00:49:35,119
but

1326
00:49:38,069 --> 00:49:36,480
let's let's figure out what's in our

1327
00:49:40,470 --> 00:49:38,079
milky way first

1328
00:49:42,230 --> 00:49:40,480
absolutely um we have another uh

1329
00:49:43,430 --> 00:49:42,240
question from reddit from user holy

1330
00:49:45,030 --> 00:49:43,440
triple m

1331
00:49:46,790 --> 00:49:45,040
uh they would like to know how we'd be

1332
00:49:48,390 --> 00:49:46,800
able to uh oh what we're gonna be able

1333
00:49:49,990 --> 00:49:48,400
to find out about the atmospheres of

1334
00:49:52,069 --> 00:49:50,000
specific exoplanets we haven't known

1335
00:49:54,390 --> 00:49:52,079
before um i think their question is

1336
00:49:56,470 --> 00:49:54,400
specifically what more capabilities does

1337
00:49:58,470 --> 00:49:56,480
jwst actually give us in looking at

1338
00:50:01,829 --> 00:49:58,480

atmospheres compared to other

1339
00:50:03,510 --> 00:50:01,839
ground-based and space-based telescopes

1340
00:50:05,670 --> 00:50:03,520
looking at the atmospheres of planets

1341
00:50:09,510 --> 00:50:05,680
from the ground is really difficult

1342
00:50:11,270 --> 00:50:09,520
as i said you want to go in the infrared

1343
00:50:14,150 --> 00:50:11,280
there are you know our atmosphere

1344
00:50:17,030 --> 00:50:14,160
obscures a lot of the infrared we want

1345
00:50:19,030 --> 00:50:17,040
to detect for example water features

1346
00:50:20,870 --> 00:50:19,040
you know water molecules or from water

1347
00:50:23,430 --> 00:50:20,880
vapor that could be in the atmosphere

1348
00:50:26,309 --> 00:50:23,440
but our own atmosphere of our planet

1349
00:50:28,549 --> 00:50:26,319
also has water vapor so that wreaks

1350
00:50:31,430 --> 00:50:28,559
havoc with your observations so it's

1351
00:50:33,109 --> 00:50:31,440
better to do it from space well i mean

1352
00:50:35,510 --> 00:50:33,119
it's complementary we will do this from

1353
00:50:38,069 --> 00:50:35,520
ground-based telescopes as well

1354
00:50:40,870 --> 00:50:38,079
but it's a little easier from space

1355
00:50:42,710 --> 00:50:40,880
we've done it with hubble hubble has

1356
00:50:44,870 --> 00:50:42,720
looked has studied the atmospheres of

1357
00:50:46,950 --> 00:50:44,880
giant planets like these hot jupiters

1358
00:50:50,790 --> 00:50:46,960
for example

1359
00:50:54,549 --> 00:50:50,800
in a very narrow range of color space

1360
00:50:57,589 --> 00:50:54,559
around one micron we call it and

1361
00:50:59,910 --> 00:50:57,599
webb is going to break that open and

1362
00:51:02,390 --> 00:50:59,920
look at a very broad range of color

1363
00:51:05,109 --> 00:51:02,400

space also in the infrared but extending

1364
00:51:06,630 --> 00:51:05,119
much further out so hubble could see

1365
00:51:08,549 --> 00:51:06,640
water features

1366
00:51:11,589 --> 00:51:08,559
but webb will be able to see water

1367
00:51:13,829 --> 00:51:11,599
carbon dioxide methane co you know there

1368
00:51:15,510 --> 00:51:13,839
will be many more molecules that will be

1369
00:51:18,870 --> 00:51:15,520
available to web

1370
00:51:20,870 --> 00:51:18,880
than we could do with hubble so that's

1371
00:51:22,549 --> 00:51:20,880
one of the reasons why we're excited

1372
00:51:23,670 --> 00:51:22,559
about webb

1373
00:51:25,990 --> 00:51:23,680
you know people that were studying

1374
00:51:29,990 --> 00:51:26,000
atmospheres with hubble would look at

1375
00:51:32,630 --> 00:51:30,000
these water features and run models to

1376
00:51:34,549 --> 00:51:32,640
predict okay given this hydrogen and

1377
00:51:35,670 --> 00:51:34,559
oxygen abundance through the water

1378
00:51:36,390 --> 00:51:35,680
feature

1379
00:51:39,109 --> 00:51:36,400
what

1380
00:51:42,069 --> 00:51:39,119
how much carbon do we expect there to be

1381
00:51:43,270 --> 00:51:42,079
so they have predictions already but no

1382
00:51:48,230 --> 00:51:43,280
access

1383
00:51:49,510 --> 00:51:48,240
that actually contain carbon now we'll

1384
00:51:52,069 --> 00:51:49,520
be able to do that so we'll be able to

1385
00:51:54,230 --> 00:51:52,079
test those models those predictions from

1386
00:51:56,150 --> 00:51:54,240
the observations with hubble

1387
00:51:57,670 --> 00:51:56,160
so those are some examples

1388
00:51:58,790 --> 00:51:57,680

that's fantastic

1389
00:52:01,670 --> 00:51:58,800
i wonder

1390
00:52:03,109 --> 00:52:01,680
can jwst detect techno signatures

1391
00:52:06,309 --> 00:52:03,119
could we find potential signs of

1392
00:52:07,829 --> 00:52:06,319
industrial gases or similar features

1393
00:52:10,309 --> 00:52:07,839
with jwst

1394
00:52:12,549 --> 00:52:10,319
yeah great question i i should say from

1395
00:52:14,470 --> 00:52:12,559
the beginning that um

1396
00:52:17,190 --> 00:52:14,480
for me the distinction between

1397
00:52:18,790 --> 00:52:17,200
biosignature and techno signature is

1398
00:52:21,109 --> 00:52:18,800
weakening

1399
00:52:24,069 --> 00:52:21,119
it also

1400
00:52:26,790 --> 00:52:24,079
kind of reinforces this idea that

1401
00:52:29,190 --> 00:52:26,800
humans and nature are somehow separate

1402
00:52:30,549 --> 00:52:29,200
and distinct and they're not

1403
00:52:32,630 --> 00:52:30,559
so

1404
00:52:35,430 --> 00:52:32,640
if we put pollutants out into the

1405
00:52:37,190 --> 00:52:35,440
atmosphere that's it's not a metabolic

1406
00:52:39,030 --> 00:52:37,200
byproduct maybe that's the difference

1407
00:52:41,109 --> 00:52:39,040
when we think of biosignatures we think

1408
00:52:43,030 --> 00:52:41,119
of the metabolic byproducts that end up

1409
00:52:44,470 --> 00:52:43,040
in an atmosphere whereas a techno

1410
00:52:47,510 --> 00:52:44,480
signature is

1411
00:52:50,069 --> 00:52:47,520
perhaps the result of building or

1412
00:52:52,470 --> 00:52:50,079
communicating

1413
00:52:53,910 --> 00:52:52,480

engineering but that distinction is

1414
00:52:54,790 --> 00:52:53,920
fuzzy as well

1415
00:52:57,030 --> 00:52:54,800
um

1416
00:52:58,630 --> 00:52:57,040
so could we see a techno signature with

1417
00:53:00,950 --> 00:52:58,640
web well you're not going to get me to

1418
00:53:03,829 --> 00:53:00,960
say no because i think that there will

1419
00:53:05,109 --> 00:53:03,839
be a lot of surprises with webb but keep

1420
00:53:07,589 --> 00:53:05,119
in mind that if you're looking for

1421
00:53:08,710 --> 00:53:07,599
atmospheric signatures they have to be

1422
00:53:13,349 --> 00:53:08,720
global

1423
00:53:16,470 --> 00:53:13,359
structures you have to have

1424
00:53:18,870 --> 00:53:16,480
um you have to have

1425
00:53:21,270 --> 00:53:18,880
a large abundance of that molecule

1426
00:53:21,720 --> 00:53:21,280
available in order to see it

1427
00:53:23,109 --> 00:53:21,730
um

1428
00:53:24,870 --> 00:53:23,119
[Music]

1429
00:53:25,829 --> 00:53:24,880
so it's so it's tricky

1430
00:53:27,030 --> 00:53:25,839
um

1431
00:53:29,270 --> 00:53:27,040
there are other

1432
00:53:32,069 --> 00:53:29,280
physical things like the physics of how

1433
00:53:33,750 --> 00:53:32,079
these lines are created matters as well

1434
00:53:36,309 --> 00:53:33,760
like for example we have a lot of

1435
00:53:39,349 --> 00:53:36,319
nitrogen in our atmosphere but nitrogen

1436
00:53:41,589 --> 00:53:39,359
molecules n2 is very difficult to detect

1437
00:53:43,510 --> 00:53:41,599
because it doesn't create certain strong

1438
00:53:45,829 --> 00:53:43,520

chemical fingerprints or as strong of

1439
00:53:47,829 --> 00:53:45,839
chemical fingerprints so there's little

1440
00:53:51,349 --> 00:53:47,839
subtleties that you have to worry about

1441
00:53:53,510 --> 00:53:51,359
but um so i won't say no but i think

1442
00:53:54,870 --> 00:53:53,520
it's difficult

1443
00:53:56,630 --> 00:53:54,880
that's good to know

1444
00:53:59,109 --> 00:53:56,640
we are running down on time and so i

1445
00:54:00,790 --> 00:53:59,119
want to ask one more question and i do

1446
00:54:02,470 --> 00:54:00,800
apologize to all of our audience who've

1447
00:54:04,150 --> 00:54:02,480
asked so many incredible questions i

1448
00:54:06,230 --> 00:54:04,160
really appreciate everything

1449
00:54:09,109 --> 00:54:06,240
i hope you reach out to myself to nasa

1450
00:54:10,870 --> 00:54:09,119
astrobiology to dr batalia in the future

1451
00:54:12,790 --> 00:54:10,880
and ask more of your questions and get

1452
00:54:14,950 --> 00:54:12,800
involved in this process

1453
00:54:17,270 --> 00:54:14,960
but i see that there's a question from

1454
00:54:18,549 --> 00:54:17,280
penny boston on youtube that i wanted to

1455
00:54:20,549 --> 00:54:18,559
share with you

1456
00:54:22,710 --> 00:54:20,559
so penny first says hi natalie

1457
00:54:24,870 --> 00:54:22,720
and then penny asks what it what is your

1458
00:54:27,589 --> 00:54:24,880
personally preferred next

1459
00:54:28,950 --> 00:54:27,599
in space telescope project from all the

1460
00:54:31,190 --> 00:54:28,960
various concepts that are that are

1461
00:54:32,069 --> 00:54:31,200
competing right now and i might even ask

1462
00:54:34,230 --> 00:54:32,079
um

1463
00:54:36,470 --> 00:54:34,240

if if someone came out tomorrow you know

1464
00:54:39,030 --> 00:54:36,480
and just offered you like your your

1465
00:54:40,950 --> 00:54:39,040
lifetime dream mission what would be the

1466
00:54:42,549 --> 00:54:40,960
one mission you'd want to send to space

1467
00:54:44,069 --> 00:54:42,559
if you could choose like the ultimate

1468
00:54:45,270 --> 00:54:44,079
mission right now

1469
00:54:47,990 --> 00:54:45,280
so easy

1470
00:54:50,549 --> 00:54:48,000
i i want a 12 meter telescope in space

1471
00:54:52,630 --> 00:54:50,559
with star suppression technology to

1472
00:54:55,109 --> 00:54:52,640
directly image

1473
00:54:57,430 --> 00:54:55,119
terrestrial sized planets orbiting in

1474
00:54:59,270 --> 00:54:57,440
the habitable zone i want to find a

1475
00:55:00,630 --> 00:54:59,280
couple hundred of

1476
00:55:03,589 --> 00:55:00,640
a few hundred

1477
00:55:06,470 --> 00:55:03,599
um in the solar neighborhood to study so

1478
00:55:07,990 --> 00:55:06,480
that we have a statistical sample of

1479
00:55:09,030 --> 00:55:08,000
such planets that are potentially

1480
00:55:11,190 --> 00:55:09,040
habitable

1481
00:55:13,589 --> 00:55:11,200
so that we can pick out the ones that

1482
00:55:15,589 --> 00:55:13,599
seem to stick out like a sore thumb so

1483
00:55:17,829 --> 00:55:15,599
that we can identify what fraction of

1484
00:55:19,510 --> 00:55:17,839
those are likely to be living worlds but

1485
00:55:21,829 --> 00:55:19,520
also see

1486
00:55:23,750 --> 00:55:21,839
oxygen you know see the tiny signature

1487
00:55:25,430 --> 00:55:23,760
of oxygen maybe even

1488
00:55:27,990 --> 00:55:25,440

the red edge or

1489
00:55:30,069 --> 00:55:28,000
you know or or seasonal variations with

1490
00:55:32,870 --> 00:55:30,079
a 12 meter class telescope you can also

1491
00:55:36,230 --> 00:55:32,880
see seasonal variations or things like

1492
00:55:37,750 --> 00:55:36,240
the glint off of water like an ocean

1493
00:55:39,990 --> 00:55:37,760
so i mean that is exactly what the

1494
00:55:41,829 --> 00:55:40,000
tequila survey recommended with the one

1495
00:55:43,190 --> 00:55:41,839
distinction that it's not 12 meters they

1496
00:55:45,430 --> 00:55:43,200
recommended a

1497
00:55:48,230 --> 00:55:45,440
six seven meter class telescope

1498
00:55:50,630 --> 00:55:48,240
so um that's the bare minimum of what we

1499
00:55:53,030 --> 00:55:50,640
need i

1500
00:55:55,030 --> 00:55:53,040
hope that in the decades that it will

1501
00:55:57,270 --> 00:55:55,040
take to plan such a mission because

1502
00:55:59,190 --> 00:55:57,280
these things do take a long time that

1503
00:56:00,390 --> 00:55:59,200
putting such a space telescope into

1504
00:56:02,549 --> 00:56:00,400
space

1505
00:56:04,549 --> 00:56:02,559
will become cheaper and that we'll be

1506
00:56:06,390 --> 00:56:04,559
able to scale it up a little bit to

1507
00:56:08,950 --> 00:56:06,400
really do a robust

1508
00:56:10,710 --> 00:56:08,960
astrobiology search for evidence of life

1509
00:56:13,109 --> 00:56:10,720
beyond earth that's my hope that's

1510
00:56:14,470 --> 00:56:13,119
fantastic i i hope to see that too

1511
00:56:15,910 --> 00:56:14,480
uh for all of our audience who are

1512
00:56:18,069 --> 00:56:15,920
watching if you'd like to know more

1513
00:56:18,950 --> 00:56:18,079

about jwst which should be launching

1514
00:56:20,510 --> 00:56:18,960
soon

1515
00:56:22,789 --> 00:56:20,520
you can go to

1516
00:56:24,230 --> 00:56:22,799
jwst.nasa.gov there's really great

1517
00:56:26,309 --> 00:56:24,240
information there

1518
00:56:28,069 --> 00:56:26,319
you can go to the launch profile to

1519
00:56:30,630 --> 00:56:28,079
learn more about what happens on launch

1520
00:56:33,030 --> 00:56:30,640
day there's also a really beautiful uh

1521
00:56:34,710 --> 00:56:33,040
animation video created from nasa where

1522
00:56:37,349 --> 00:56:34,720
you can watch uh the process of

1523
00:56:39,910 --> 00:56:37,359
deployment again jwst it's gonna take

1524
00:56:43,190 --> 00:56:39,920
some time to fully deploy one to its

1525
00:56:44,870 --> 00:56:43,200
position but also to unfurl um to open

1526
00:56:47,109 --> 00:56:44,880
up for for collecting light and so there

1527
00:56:48,549 --> 00:56:47,119
will be some time six months actually

1528
00:56:50,710 --> 00:56:48,559
it's six months where we'll get the

1529
00:56:52,549 --> 00:56:50,720
first observations yeah

1530
00:56:54,390 --> 00:56:52,559
yeah and so we have some time to wait

1531
00:56:57,030 --> 00:56:54,400
but plenty of things to be excited about

1532
00:56:58,870 --> 00:56:57,040
as this mission gets underway and starts

1533
00:57:01,349 --> 00:56:58,880
collecting light and starts sharing more

1534
00:57:02,710 --> 00:57:01,359
for us to learn more about our place in

1535
00:57:04,390 --> 00:57:02,720
the universe

1536
00:57:05,910 --> 00:57:04,400
for those who'd like to stay in the loop

1537
00:57:08,549 --> 00:57:05,920
about current events with nasa

1538
00:57:10,950 --> 00:57:08,559

astrobiology as well as for sagging net

1539
00:57:13,190 --> 00:57:10,960
you can sign up now to join the nasa

1540
00:57:14,470 --> 00:57:13,200
astrobiology mailing list

1541
00:57:16,069 --> 00:57:14,480
you should see it in your screen right

1542
00:57:17,349 --> 00:57:16,079
now if you're listening to this in the

1543
00:57:19,910 --> 00:57:17,359
podcast you can go to ask

1544
00:57:22,390 --> 00:57:19,920
astrobiology.nasa.gov

1545
00:57:25,030 --> 00:57:22,400
to learn more about nasa astrobiology

1546
00:57:27,349 --> 00:57:25,040
and to sign up again for the newsletter

1547
00:57:29,829 --> 00:57:27,359
dr batalia thank you so much for joining

1548
00:57:31,270 --> 00:57:29,839
us ask an astrobiologist thank you for

1549
00:57:33,190 --> 00:57:31,280
having me graham and thank you for all

1550
00:57:34,309 --> 00:57:33,200
the questions from from your listeners i

1551
00:57:35,430 --> 00:57:34,319
really appreciate them they were

1552
00:57:37,109 --> 00:57:35,440
fantastic

1553
00:57:39,430 --> 00:57:37,119
awesome thank you so much thank you to

1554
00:57:46,030 --> 00:57:39,440
everyone for watching until next time