Ask An Astrobiologist

Episode 33: June 16th, 2020

Dr. Eddie Schwieterman

NASA Astrobiology Program

1
00:00:35,880 --> 00:00:33,620
[Music]

2
00:00:38,310 --> 00:00:35,890
greetings to my friends and fellow

3
00:00:40,680 --> 00:00:38,320
earthlings and welcome to ask an

4
00:00:43,979 --> 00:00:40,690
astrobiologist the show that celebrates

5
00:00:46,410 --> 00:00:43,989
the science and the scientists involved

6
00:00:47,700 --> 00:00:46,420
in our quest to understand the nature of

7
00:00:50,369 --> 00:00:47,710
life in the cosmos

8
00:00:53,100 --> 00:00:50,379
I'm your host Graham Lau also known

9
00:00:55,200 --> 00:00:53,110
online as the Cosmo biologist and we're

10
00:00:58,140 --> 00:00:55,210
brought to you by Sagan net org and the

11
00:00:59,880 --> 00:00:58,150
NASA Astrobiology program now I've got

12
00:01:01,680 --> 00:00:59,890
to tell you for all of our longtime fans

13
00:01:04,110 --> 00:01:01,690

watching I'm super jazzed for this

14
00:01:05,460 --> 00:01:04,120
episode it's gonna be groovy we have dr.

15
00:01:07,350 --> 00:01:05,470
Eddie Spearman coming on we're going to

16
00:01:09,860 --> 00:01:07,360
talk about all kinds of things like

17
00:01:11,760 --> 00:01:09,870
exoplanets and bio signatures

18
00:01:14,190 --> 00:01:11,770
understanding earth through time and

19
00:01:16,200 --> 00:01:14,200
habitable zones and then more so it's

20
00:01:17,910 --> 00:01:16,210
gonna be super awesome but we do have

21
00:01:20,250 --> 00:01:17,920
some of our fun old housekeeping stuff

22
00:01:22,620 --> 00:01:20,260
to do first for instance we have our

23
00:01:25,020 --> 00:01:22,630
field site challenge that we do every

24
00:01:27,390 --> 00:01:25,030
month just before the episode we release

25
00:01:31,140 --> 00:01:27,400
a picture on the Twitter feed for Sagan

26
00:01:33,000 --> 00:01:31,150
net at Sagan org and we ask you where in

27
00:01:35,460 --> 00:01:33,010
the world or the universe is this

28
00:01:37,770 --> 00:01:35,470
location and maybe even tell us why it's

29
00:01:39,270 --> 00:01:37,780
important to ask for biology and so the

30
00:01:41,430 --> 00:01:39,280
image from this month is popping up

31
00:01:43,560 --> 00:01:41,440
right now it's this really weird

32
00:01:46,590 --> 00:01:43,570
strawberry milkshake of a lake

33
00:01:49,680 --> 00:01:46,600
this is Lake Hillier it's a hyper saline

34
00:01:51,930 --> 00:01:49,690
Lake and middle island off the south

35
00:01:55,770 --> 00:01:51,940
coast of Western Australia and that

36
00:01:58,380 --> 00:01:55,780
bubblegum pink coloration is caused by a

37
00:02:02,880 --> 00:01:58,390
little bit of life there's an organism

38
00:02:06,210 --> 00:02:02,890

called Denali ala Salina it's a green

39
00:02:08,399 --> 00:02:06,220
unicellular algae that produces a very

40
00:02:10,559 --> 00:02:08,409
large amount of pigments inside of its

41
00:02:12,210 --> 00:02:10,569
body or inside of its cell these

42
00:02:14,430 --> 00:02:12,220
organisms can survive very salty

43
00:02:16,880 --> 00:02:14,440
environments up to 35% salt

44
00:02:19,860 --> 00:02:16,890
concentrations like hyper saline lakes

45
00:02:22,229 --> 00:02:19,870
like this Lake Hillier and they also

46
00:02:24,930 --> 00:02:22,239
produce up to something around 10% of

47
00:02:26,789 --> 00:02:24,940
their dry mass and beta carotene and so

48
00:02:28,559 --> 00:02:26,799
we've actually used them in cosmetics

49
00:02:30,509 --> 00:02:28,569
and other places because they produce so

50
00:02:32,180 --> 00:02:30,519
much beta-carotene but it's also

51
00:02:35,729 --> 00:02:32,190
important for us understanding how life

52
00:02:38,610 --> 00:02:35,739
utilizes pigments not just for using

53
00:02:39,360 --> 00:02:38,620
metabolism for for taking energy from a

54
00:02:42,990 --> 00:02:39,370
star

55
00:02:45,869 --> 00:02:43,000
to grow but also to protect the cells

56
00:02:47,610 --> 00:02:45,879
from ionizing radiation from ultraviolet

57
00:02:49,080 --> 00:02:47,620
radiation and so this is a really

58
00:02:49,910 --> 00:02:49,090
important area of study for us in

59
00:02:52,830 --> 00:02:49,920
astrobiology

60
00:02:55,259 --> 00:02:52,840
now this month we have our winner was

61
00:02:58,589 --> 00:02:55,269
Andre on tunics who goes by at

62
00:03:00,180 --> 00:02:58,599
extremophiles UK on Twitter but we also

63
00:03:02,789 --> 00:03:00,190

want to give a special shout-out this

64
00:03:05,670 --> 00:03:02,799
month to Maryanne Denton and Victor

65
00:03:07,440 --> 00:03:05,680
Baron oov for creating a fun little play

66
00:03:10,860 --> 00:03:07,450
on words for the men at work song land

67
00:03:13,920 --> 00:03:10,870
down under now bear with me here it

68
00:03:17,220 --> 00:03:13,930
comes from a land down under where it

69
00:03:19,759 --> 00:03:17,230
licks glow and plankton blunder can't

70
00:03:23,699 --> 00:03:19,769
you hear can't you hear that thunder

71
00:03:25,559 --> 00:03:23,709
down to Lake Hillier so I know I'm not a

72
00:03:27,630 --> 00:03:25,569
great singer but you guys get the point

73
00:03:29,160 --> 00:03:27,640
there it's pretty awesome maybe in the

74
00:03:31,890 --> 00:03:29,170
future for asking astrobiologists we'll

75
00:03:35,099 --> 00:03:31,900
create our own soundtrack of song covers

76
00:03:36,960 --> 00:03:35,109
with astrobiology lyrics who knows we

77
00:03:39,210 --> 00:03:36,970
also have some awesome ambassadors of

78
00:03:41,369 --> 00:03:39,220
the month to share with you just like

79
00:03:43,440 --> 00:03:41,379
last month we decided to name four

80
00:03:45,930 --> 00:03:43,450
ambassadors this month and so many of

81
00:03:48,569 --> 00:03:45,940
you are sharing and retweeting and

82
00:03:50,220 --> 00:03:48,579
liking and commenting and engaging and

83
00:03:51,900 --> 00:03:50,230
and getting the word out about our show

84
00:03:53,729 --> 00:03:51,910
about the awesome work the

85
00:03:55,920 --> 00:03:53,739
astrobiologists do who come on the show

86
00:03:57,930 --> 00:03:55,930
with us so this month we want to

87
00:04:00,539 --> 00:03:57,940
celebrate four of you as our ambassadors

88
00:04:03,539 --> 00:04:00,549

of the month the four of you are MonaVie

89
00:04:04,589 --> 00:04:03,549
Kaukauna at MonaVie queque who I have to

90
00:04:06,780 --> 00:04:04,599
just started talking to through

91
00:04:08,520 --> 00:04:06,790
Instagram about her career in

92
00:04:11,069 --> 00:04:08,530
astrobiology and things that she's

93
00:04:15,479 --> 00:04:11,079
really into awesome Dallara

94
00:04:17,430 --> 00:04:15,489
kill Carson at Dobie dela Dallara is a

95
00:04:19,259 --> 00:04:17,440
graduate student in South Korea who's

96
00:04:21,360 --> 00:04:19,269
been working in the realm of

97
00:04:23,400 --> 00:04:21,370
astrobiology and is really interested in

98
00:04:26,129 --> 00:04:23,410
being involved in that career field we

99
00:04:29,610 --> 00:04:26,139
also have a zoo Lupino ba at as well

100
00:04:31,200 --> 00:04:29,620
Pino Bob as well as ESMA on Twitter at

101
00:04:34,080 --> 00:04:31,210
Astro as mala gist

102
00:04:35,790 --> 00:04:34,090
ESMA is actually just join me this

103
00:04:38,400 --> 00:04:35,800
summer in the blue marble space young

104
00:04:39,719 --> 00:04:38,410
scientist program she'll be working with

105
00:04:42,570 --> 00:04:39,729
me for the Center for life detection

106
00:04:45,240 --> 00:04:42,580
Sciences at NASA Ames on a project

107
00:04:46,800 --> 00:04:45,250
studying bio signatures and how we can

108
00:04:49,529 --> 00:04:46,810
use our knowledge of bio signatures to

109
00:04:51,910 --> 00:04:49,539
look for life beyond the earth so with

110
00:04:53,650 --> 00:04:51,920
all of that said I'm super excited

111
00:04:56,440 --> 00:04:53,660
this episode it's gonna be a lot of fun

112
00:04:59,170 --> 00:04:56,450
guys so please help me welcome to our

113
00:05:01,480 --> 00:04:59,180

show dr. Eddie sweet ermine hi Eddie

114
00:05:03,490 --> 00:05:01,490
hi Graham thank you so much for having

115
00:05:05,590 --> 00:05:03,500
me here and thank you to say Gannett and

116
00:05:07,540 --> 00:05:05,600
the NASA Astrobiology Institute

117
00:05:09,370 --> 00:05:07,550
I mean it's so great to have you on the

118
00:05:10,930 --> 00:05:09,380
show we wanted to have you on for a long

119
00:05:14,080 --> 00:05:10,940
time now talk about some of your work

120
00:05:17,730 --> 00:05:14,090
you've been prolific of like publishing

121
00:05:19,950 --> 00:05:17,740
so much awesome research in the realm is

122
00:05:22,900 --> 00:05:19,960
computational modeling to understand

123
00:05:24,840 --> 00:05:22,910
exoplanets to look for bio signatures

124
00:05:27,130 --> 00:05:24,850
what things might be false positives

125
00:05:29,260 --> 00:05:27,140
false negatives there's so much cool

126
00:05:31,450 --> 00:05:29,270
work you're doing and I definitely want

127
00:05:33,220 --> 00:05:31,460
to talk about a lot of that with you but

128
00:05:34,390 --> 00:05:33,230
before we get to that point since we do

129
00:05:36,700 --> 00:05:34,400
have a lot of folks who watch the show

130
00:05:38,920 --> 00:05:36,710
who are you know high school students or

131
00:05:40,510 --> 00:05:38,930
undergraduate collegiate students it's

132
00:05:43,480 --> 00:05:40,520
always nice for them to hear about the

133
00:05:45,220 --> 00:05:43,490
pathways that bring astrobiologists kind

134
00:05:46,780 --> 00:05:45,230
of forward in their careers and I'm

135
00:05:48,940 --> 00:05:46,790
curious if you could share with us kind

136
00:05:51,160 --> 00:05:48,950
of your your science origin story if you

137
00:05:52,170 --> 00:05:51,170
will what really got you kind of into

138
00:05:54,190 --> 00:05:52,180

this realm of wanting to become

139
00:05:56,500 --> 00:05:54,200
scientist and someone who works in this

140
00:05:57,670 --> 00:05:56,510
realm of exoplanets yeah that's that's a

141
00:05:59,050 --> 00:05:57,680
great question something I think about a

142
00:06:00,580 --> 00:05:59,060
lot you know my parents are really

143
00:06:02,740 --> 00:06:00,590
helpful in cultivating an interest in

144
00:06:03,850 --> 00:06:02,750
science with me like many kids I love

145
00:06:06,850 --> 00:06:03,860
dinosaurs

146
00:06:08,800 --> 00:06:06,860
I mean dinosaur books and I spent so

147
00:06:10,390 --> 00:06:08,810
much time with them even further than

148
00:06:12,850 --> 00:06:10,400
that my dad would take my sister and I

149
00:06:14,830 --> 00:06:12,860
out fossil hunting and so we drink dig

150
00:06:16,780 --> 00:06:14,840
up trilobite sand fossilized coral and

151
00:06:18,250 --> 00:06:16,790
I'd spend some time as the kid imagining

152
00:06:22,210 --> 00:06:18,260
what those places look like you know

153
00:06:25,510 --> 00:06:22,220
hundreds of years ago and and and

154
00:06:27,490 --> 00:06:25,520
somewhat you know naively well I had

155
00:06:28,990 --> 00:06:27,500
wanted to become a paleontologist I

156
00:06:31,570 --> 00:06:29,000
thought as a kid that by the time I got

157
00:06:33,520 --> 00:06:31,580
old enough that all the dinosaur bones

158
00:06:36,070 --> 00:06:33,530
would have been dug it dug up that all

159
00:06:38,080 --> 00:06:36,080
the fossils would have been gone which

160
00:06:40,030 --> 00:06:38,090
is not what not that that won't happen

161
00:06:43,150 --> 00:06:40,040
so if you want to be a paleontologist

162
00:06:44,710 --> 00:06:43,160
don't let that dissuade you but I also

163
00:06:47,140 --> 00:06:44,720

got interested in astronomy I bought my

164
00:06:49,390 --> 00:06:47,150
first telescope in high school I saw the

165
00:06:51,340 --> 00:06:49,400
transit of Venus in 2004 and I thought

166
00:06:55,800 --> 00:06:51,350
you know as that little disc of Venus

167
00:06:57,490 --> 00:06:55,810
went across the Sun you know what other

168
00:06:59,590 --> 00:06:57,500
civilizations are out there watching

169
00:07:01,870 --> 00:06:59,600
their planets watching our planet

170
00:07:03,310 --> 00:07:01,880
transit it's Sun you know and and that

171
00:07:04,580 --> 00:07:03,320
got me thinking about how vast the

172
00:07:06,290 --> 00:07:04,590
universe is and how there's

173
00:07:08,810 --> 00:07:06,300
much out there that no matter how many

174
00:07:10,730 --> 00:07:08,820
lifetimes you live you live there be so

175
00:07:12,770 --> 00:07:10,740
much more to explore and so much more to

176
00:07:15,980 --> 00:07:12,780
discover and so that's really what got

177
00:07:17,690 --> 00:07:15,990
me interested in in astronomy and then I

178
00:07:19,790 --> 00:07:17,700
went to the University of Washington in

179
00:07:21,740 --> 00:07:19,800
Seattle for graduate school we're with

180
00:07:23,510 --> 00:07:21,750
dr. Victoria Meadows who's head of the

181
00:07:25,880 --> 00:07:23,520
virtual planetary laboratory and that's

182
00:07:28,450 --> 00:07:25,890
really where I first started learning

183
00:07:32,120 --> 00:07:28,460
about every mod in planetary atmospheres

184
00:07:34,130 --> 00:07:32,130
professor next month at UC Riverside to

185
00:07:36,650 --> 00:07:34,140
continue this work on bio signatures and

186
00:07:38,210 --> 00:07:36,660
habitability that's awesome and I can

187
00:07:40,010 --> 00:07:38,220
Congrats and starting the new assistant

188
00:07:41,030 --> 00:07:40,020

professorship that's that's great I look

189
00:07:42,920 --> 00:07:41,040
forward to all the stuff you can be

190
00:07:44,240 --> 00:07:42,930
doing there it's really cool to start

191
00:07:47,600 --> 00:07:44,250
off the kind of that the dinosaur bone

192
00:07:49,700 --> 00:07:47,610
kind of I love that figure where you see

193
00:07:51,380 --> 00:07:49,710
it's like knowledge of dinosaurs through

194
00:07:52,880 --> 00:07:51,390
time of your life and like you're a kid

195
00:07:54,410 --> 00:07:52,890
you know everything about dinosaurs and

196
00:07:55,820 --> 00:07:54,420
then you lose it unless you become a

197
00:07:57,530 --> 00:07:55,830
paleontologist and then you get it back

198
00:08:00,050 --> 00:07:57,540
again I think for a lot of us it's a

199
00:08:02,810 --> 00:08:00,060
huge pathway is because dinosaurs are so

200
00:08:04,220 --> 00:08:02,820
cool but yeah so for everyone watching I

201
00:08:06,740 --> 00:08:04,230
mean there's lots of pathways to get

202
00:08:08,480 --> 00:08:06,750
into astrobiology dr. speedermen had a

203
00:08:10,460 --> 00:08:08,490
really incredible pathway as well and

204
00:08:11,840 --> 00:08:10,470
now he's gonna be a professor sharing

205
00:08:13,460 --> 00:08:11,850
his knowledge with other students who

206
00:08:15,080 --> 00:08:13,470
are coming up and learning about

207
00:08:19,250 --> 00:08:15,090
astrobiology and astronomy and

208
00:08:22,130 --> 00:08:19,260
astrophysics so it's very cool much like

209
00:08:24,490 --> 00:08:22,140
me you you were born at a time when we

210
00:08:27,830 --> 00:08:24,500
had no confirmations of any exoplanets

211
00:08:30,200 --> 00:08:27,840
so so for you as a scientist but also

212
00:08:31,940 --> 00:08:30,210
just as a person how what's it been like

213
00:08:34,520 --> 00:08:31,950

for you someone really interested with a

214
00:08:36,890 --> 00:08:34,530
lot of knowledge as we've been to more

215
00:08:39,110 --> 00:08:36,900
and more hundreds and thousands of

216
00:08:40,670 --> 00:08:39,120
exoplanets what's that experience been

217
00:08:43,250 --> 00:08:40,680
like for you since that's really what's

218
00:08:45,260 --> 00:08:43,260
intriguing you a lot yeah I mean I think

219
00:08:46,880 --> 00:08:45,270
I think you know you're absolutely right

220
00:08:49,880 --> 00:08:46,890
the first exoplanet around a sun-like

221
00:08:51,590 --> 00:08:49,890
star wasn't discovered in 1995 and

222
00:08:52,940 --> 00:08:51,600
before then you know it was somewhat

223
00:08:54,740 --> 00:08:52,950
speculative to think about planets

224
00:08:57,020 --> 00:08:54,750
around other stars but of course we knew

225
00:08:59,600 --> 00:08:57,030
that in our solar system we had you know

226
00:09:01,970 --> 00:08:59,610
at the time nine planets now we we say

227
00:09:03,860 --> 00:09:01,980
they're eight planets and we knew that

228
00:09:06,050 --> 00:09:03,870
the processes that happened in our own

229
00:09:08,660 --> 00:09:06,060
solar system probably happened elsewhere

230
00:09:10,550 --> 00:09:08,670
and I think this is often you know

231
00:09:12,620 --> 00:09:10,560
something that that astrobiologists rely

232
00:09:14,480 --> 00:09:12,630
on is this universality of physics and

233
00:09:17,280 --> 00:09:14,490
chemistry and then we hope that there's

234
00:09:18,660 --> 00:09:17,290
also a universality of biology that

235
00:09:21,030 --> 00:09:18,670
you know chem that biology is sort of

236
00:09:22,590 --> 00:09:21,040
derived chemistry and therefore if the

237
00:09:25,850 --> 00:09:22,600
same initial conditions happen somewhere

238
00:09:28,350 --> 00:09:25,860

else then we'd expect a similar result

239
00:09:30,210 --> 00:09:28,360
and so I think I think getting the

240
00:09:32,759 --> 00:09:30,220
confirmation that there are so many

241
00:09:34,800 --> 00:09:32,769
exoplanets out there you know is sort of

242
00:09:36,660 --> 00:09:34,810
a confirmation of this you know

243
00:09:38,970 --> 00:09:36,670
Copernican principle that you know the

244
00:09:43,620 --> 00:09:38,980
earth well it is a special place to us

245
00:09:45,660 --> 00:09:43,630
maybe isn't the only only example of a

246
00:09:47,790 --> 00:09:45,670
place that's potentially habitable and

247
00:09:49,710 --> 00:09:47,800
maybe inhabited and that our solar

248
00:09:51,809 --> 00:09:49,720
system is full of all these other

249
00:09:54,629 --> 00:09:51,819
planets but that there are similar

250
00:09:55,590 --> 00:09:54,639
planets else and in fact planets types

251
00:09:57,420 --> 00:09:55,600
of planets that we never would have

252
00:09:59,189 --> 00:09:57,430
imagined we're discovering you know the

253
00:10:00,809 --> 00:09:59,199
most common type of planet is actually a

254
00:10:01,829 --> 00:10:00,819
planet that's in between the size of the

255
00:10:04,079 --> 00:10:01,839
earth and the size of Neptune that

256
00:10:08,160 --> 00:10:04,089
wasn't expected and so we're learning a

257
00:10:09,930 --> 00:10:08,170
lot and we're also sort of discovering

258
00:10:12,449 --> 00:10:09,940
that you know what we thought might be

259
00:10:14,939 --> 00:10:12,459
rare isn't on the other hand we have to

260
00:10:16,920 --> 00:10:14,949
humble ourselves in knowing that just

261
00:10:19,139 --> 00:10:16,930
because we think that or hope that life

262
00:10:20,999 --> 00:10:19,149
is common doesn't necessarily mean it's

263
00:10:23,490 --> 00:10:21,009

true we've got to go and look hmm

264
00:10:25,290 --> 00:10:23,500
yeah no kidding so so could you for our

265
00:10:27,900 --> 00:10:25,300
audience maybe explain the process of

266
00:10:29,519 --> 00:10:27,910
looking at an exoplanet and specifically

267
00:10:31,559 --> 00:10:29,529
looking for bio signatures for signs of

268
00:10:33,269 --> 00:10:31,569
life in an exoplanet what does that

269
00:10:34,829 --> 00:10:33,279
require what are we actually looking for

270
00:10:36,540 --> 00:10:34,839
or looking at when we're doing that

271
00:10:38,730 --> 00:10:36,550
right it's important to remember that

272
00:10:40,920 --> 00:10:38,740
right now at this moment we're not

273
00:10:43,949 --> 00:10:40,930
analyzing exoplanet atmospheres for bio

274
00:10:46,949 --> 00:10:43,959
signatures we've detected molecules in

275
00:10:49,199 --> 00:10:46,959
large planets plans the size of Jupiter

276
00:10:51,840 --> 00:10:49,209
and the size of Neptune and individual

277
00:10:53,370 --> 00:10:51,850
gaseous molecules earth sized planets

278
00:10:55,650 --> 00:10:53,380
are smaller and they're harder to

279
00:10:58,019 --> 00:10:55,660
characterize and so we're really talking

280
00:11:00,720 --> 00:10:58,029
about future technology that's within

281
00:11:05,189 --> 00:11:00,730
many of our lifetimes but not right this

282
00:11:06,960 --> 00:11:05,199
second and what we look for is is signs

283
00:11:09,629 --> 00:11:06,970
that the environment has been changed by

284
00:11:12,030 --> 00:11:09,639
life and so one example that we often go

285
00:11:14,040 --> 00:11:12,040
to on earth that that represents huge

286
00:11:15,480 --> 00:11:14,050
monumental change in our planetary

287
00:11:17,220 --> 00:11:15,490
chemistry in our planetary atmosphere

288
00:11:18,960 --> 00:11:17,230

from life is the oxygen or atmosphere

289
00:11:22,139 --> 00:11:18,970
that we we breathe we need it to breathe

290
00:11:24,480 --> 00:11:22,149
and this oxygen came from in part

291
00:11:26,280 --> 00:11:24,490
photosynthetic life without the

292
00:11:28,230 --> 00:11:26,290
photosynthetic life taking carbon

293
00:11:30,680 --> 00:11:28,240
dioxide and water and energy from our

294
00:11:34,250 --> 00:11:30,690
Sun and creating oxygen

295
00:11:37,220 --> 00:11:34,260
and and an organic matter that oxygen

296
00:11:39,470 --> 00:11:37,230
atmosphere wouldn't exist and so oxygen

297
00:11:41,960 --> 00:11:39,480
is one signature potentially of life and

298
00:11:43,880 --> 00:11:41,970
the way that we can find it is the way

299
00:11:45,620 --> 00:11:43,890
that the oxygen molecule interacts with

300
00:11:47,420 --> 00:11:45,630
light so as light either passes through

301
00:11:49,790 --> 00:11:47,430
an atmosphere or scattered by the

302
00:11:51,980 --> 00:11:49,800
atmosphere certain wavelengths of light

303
00:11:54,860 --> 00:11:51,990
are absorbed by that oxygen molecule and

304
00:11:56,690 --> 00:11:54,870
certain ones are are scattered or

305
00:11:58,670 --> 00:11:56,700
transmitted through the atmosphere and

306
00:12:00,710 --> 00:11:58,680
by looking for that missing light we can

307
00:12:02,180 --> 00:12:00,720
infer the presence of say the oxygen

308
00:12:03,530 --> 00:12:02,190
molecule and there are other molecules

309
00:12:05,840 --> 00:12:03,540
that are like that we'd like to see

310
00:12:07,580 --> 00:12:05,850
oxygen perhaps methane because methane

311
00:12:08,900 --> 00:12:07,590
is also produced by life and together

312
00:12:10,820 --> 00:12:08,910
there in this what we call

313
00:12:13,160 --> 00:12:10,830

disequilibrium and that is if you left

314
00:12:15,740 --> 00:12:13,170
them alone they would react together and

315
00:12:17,960 --> 00:12:15,750
and the less abundant molecule would

316
00:12:19,670 --> 00:12:17,970
disappear but because both have active

317
00:12:21,740 --> 00:12:19,680
sources on earth due to life that

318
00:12:23,540 --> 00:12:21,750
creates a chemical district equilibrium

319
00:12:25,250 --> 00:12:23,550
in the atmosphere both interact with

320
00:12:27,440 --> 00:12:25,260
light in specific ways that could be

321
00:12:28,520 --> 00:12:27,450
inferred from by a remote observer so

322
00:12:30,830 --> 00:12:28,530
that's really what we're talking about

323
00:12:32,270 --> 00:12:30,840
when we talk about bio signatures that's

324
00:12:33,590 --> 00:12:32,280
incredible yeah and I think a lot of

325
00:12:35,450 --> 00:12:33,600
people that they talk a lot you know and

326
00:12:38,060 --> 00:12:35,460
I have just general conversations about

327
00:12:39,470 --> 00:12:38,070
looking at an exoplanet atmosphere for a

328
00:12:42,110 --> 00:12:39,480
sign of life a lot of people bring up

329
00:12:45,080 --> 00:12:42,120
oxygen right away but you've also done a

330
00:12:47,570 --> 00:12:45,090
lot of work in this issue of the false

331
00:12:48,920 --> 00:12:47,580
positives and even false negatives when

332
00:12:50,570 --> 00:12:48,930
we're when we start using some of these

333
00:12:52,760 --> 00:12:50,580
next-generation telescopes to look at

334
00:12:54,560 --> 00:12:52,770
these atmospheres could you speak for a

335
00:12:56,630 --> 00:12:54,570
bit to our audience about like what

336
00:12:58,910 --> 00:12:56,640
false positive signs would be what false

337
00:13:00,710 --> 00:12:58,920
negative signs would be and how we can

338
00:13:01,520 --> 00:13:00,720

best you know kind of muddle through

339
00:13:04,060 --> 00:13:01,530
figuring that out

340
00:13:07,280 --> 00:13:04,070
yeah that's that's a great question so

341
00:13:09,950 --> 00:13:07,290
so oxygen in our atmosphere is almost

342
00:13:13,700 --> 00:13:09,960
entirely created by plants and algae and

343
00:13:15,770 --> 00:13:13,710
cyanobacteria so life but we've got to

344
00:13:16,760 --> 00:13:15,780
be really quite sure that the oxygen we

345
00:13:18,440 --> 00:13:16,770
find in an exoplanet atmospheres

346
00:13:21,290 --> 00:13:18,450
actually due to that process not

347
00:13:23,150 --> 00:13:21,300
something else and so one possibility is

348
00:13:25,610 --> 00:13:23,160
that there are photochemical processes

349
00:13:27,290 --> 00:13:25,620
that generate the generate oxygen one

350
00:13:30,110 --> 00:13:27,300
example that sort of close to home is

351
00:13:31,910 --> 00:13:30,120
Mars Mars has a very thin co2 atmosphere

352
00:13:33,860 --> 00:13:31,920
it's cold it doesn't have a lot of water

353
00:13:36,290 --> 00:13:33,870
in it and those conditions mean that

354
00:13:38,780 --> 00:13:36,300
that that co2 in the atmosphere some of

355
00:13:41,160 --> 00:13:38,790
it gets broken apart into oxygen and

356
00:13:44,549 --> 00:13:41,170
carbon monoxide some of those ox

357
00:13:46,139 --> 00:13:44,559
atoms combine into oxygen molecules some

358
00:13:48,269 --> 00:13:46,149
of them form ozone and that's actually

359
00:13:50,789 --> 00:13:48,279
remotely detectable on earth we can see

360
00:13:53,249 --> 00:13:50,799
these small amounts of ozone and oxygen

361
00:13:55,559 --> 00:13:53,259
and Mars atmosphere and we wouldn't

362
00:13:57,479 --> 00:13:55,569
mistake that necessarily because of all

363
00:13:58,349 --> 00:13:57,489

the conditions I mentioned they're very

364
00:13:59,939 --> 00:13:58,359
different from Earth we necessarily

365
00:14:01,949 --> 00:13:59,949
mistake that for life but it does hop

366
00:14:03,539 --> 00:14:01,959
but the Dutch tell us that there are

367
00:14:05,789 --> 00:14:03,549
processes that can generate oxygen

368
00:14:08,249 --> 00:14:05,799
abiotic ly and they might be very

369
00:14:09,809 --> 00:14:08,259
different if the star that the planets

370
00:14:12,239 --> 00:14:09,819
orbiting is very different and the

371
00:14:14,340 --> 00:14:12,249
chemistry is driven in large part by the

372
00:14:16,139 --> 00:14:14,350
ultraviolet radiation from the star so

373
00:14:19,259 --> 00:14:16,149
you alter the ultraviolet radiation from

374
00:14:21,229 --> 00:14:19,269
the star then you can alter the the

375
00:14:24,389 --> 00:14:21,239
chemical pathways that can generate

376
00:14:26,489 --> 00:14:24,399
oxygen from carbon dioxide or ozone from

377
00:14:27,629 --> 00:14:26,499
that oxygen and carbon dioxide and so

378
00:14:29,970 --> 00:14:27,639
you have got to be very careful in

379
00:14:32,549 --> 00:14:29,980
teasing out those effects another

380
00:14:34,650 --> 00:14:32,559
example potentially is that you could

381
00:14:36,599 --> 00:14:34,660
lose a lot of water we know that for

382
00:14:38,369 --> 00:14:36,609
example Venus is an example of a planet

383
00:14:38,729 --> 00:14:38,379
close to home must have lost a lot of

384
00:14:41,039 --> 00:14:38,739
water

385
00:14:44,729 --> 00:14:41,049
dude it's DT reom to hydrogen ratio in

386
00:14:47,240 --> 00:14:44,739
the atmosphere and what happened what

387
00:14:49,670 --> 00:14:47,250
must have happened is the heavier

388
00:14:51,470 --> 00:14:49,680

like on Venus we don't have any free

389
00:14:55,270 --> 00:14:51,480
oxygen left except for a tiny amount

390
00:14:58,310 --> 00:14:55,280
like on Mars but but some speculated

391
00:15:00,800 --> 00:14:58,320
enough water and you have a robust

392
00:15:02,240 --> 00:15:00,810
runaway process where you're losing a

393
00:15:04,370 --> 00:15:02,250
lot of hydrogen and leaving oxygen

394
00:15:07,670 --> 00:15:04,380
behind that you could oxidize the planet

395
00:15:09,050 --> 00:15:07,680
so heavily that behind enough oxygen

396
00:15:10,310 --> 00:15:09,060
that it builds up in the atmosphere and

397
00:15:12,530 --> 00:15:10,320
that would represent another false

398
00:15:13,970 --> 00:15:12,540
positive for oxygen that's not due to

399
00:15:16,670 --> 00:15:13,980
biology but in fact doing an abiotic

400
00:15:18,770 --> 00:15:16,680
planetary process and so we don't know

401
00:15:20,990 --> 00:15:18,780
how common that is but again we have to

402
00:15:22,580 --> 00:15:21,000
look and our models show that it's

403
00:15:24,500 --> 00:15:22,590
plausible so it's something that we have

404
00:15:25,790 --> 00:15:24,510
to worry about and we think about ways

405
00:15:27,680 --> 00:15:25,800
to get around that one of the ways to

406
00:15:29,090 --> 00:15:27,690
get around that is to look for this

407
00:15:30,530 --> 00:15:29,100
disequilibrium signature that I

408
00:15:32,180 --> 00:15:30,540
mentioned so if you had an abiotic

409
00:15:35,360 --> 00:15:32,190
oxygen atmosphere you would not expect

410
00:15:37,940 --> 00:15:35,370
these pounds like methane to be present

411
00:15:40,430 --> 00:15:37,950
or nitrous oxide which is another

412
00:15:42,050 --> 00:15:40,440
potential gaseous bio signature so we

413
00:15:43,400 --> 00:15:42,060

want to look at a combination of things

414
00:15:46,460 --> 00:15:43,410
and we want to look at the context of

415
00:15:48,230 --> 00:15:46,470
the of the environment if we saw 20%

416
00:15:50,360 --> 00:15:48,240
oxygen on the one bar atmosphere around

417
00:15:53,120 --> 00:15:50,370
a sun-like star that would be a pretty

418
00:15:53,750 --> 00:15:53,130
pretty compelling indicator of life on

419
00:15:56,420 --> 00:15:53,760
that planet

420
00:15:58,940 --> 00:15:56,430
you also mentioned false negatives and

421
00:16:00,880 --> 00:15:58,950
so that would be for example the half of

422
00:16:03,829 --> 00:16:00,890
Earth history that had no oxygen at all

423
00:16:05,750 --> 00:16:03,839
and so we know that in in in the in the

424
00:16:07,130 --> 00:16:05,760
Archaean Eon which lasted from four

425
00:16:08,690 --> 00:16:07,140
billion years ago to two-and-a-half

426
00:16:10,070 --> 00:16:08,700
billion years ago there was very little

427
00:16:12,710 --> 00:16:10,080
free oxygen in our atmosphere yet there

428
00:16:16,280 --> 00:16:12,720
was microbial life it was generating

429
00:16:18,230 --> 00:16:16,290
methane but not oxygen and so some have

430
00:16:19,970 --> 00:16:18,240
speculated that if we look or and

431
00:16:22,130 --> 00:16:19,980
modeled that if we we look at the

432
00:16:23,960 --> 00:16:22,140
methane to carbon dioxide ratio in that

433
00:16:26,600 --> 00:16:23,970
atmosphere that would be indicative of a

434
00:16:29,240 --> 00:16:26,610
metabolic process that's taking co2 but

435
00:16:32,350 --> 00:16:29,250
hydrogen and methane which very

436
00:16:34,910 --> 00:16:32,360
primitive microbial metabolism hurts do

437
00:16:39,260 --> 00:16:34,920
we believe in the in the deep geologic

438
00:16:40,970 --> 00:16:39,270

past so that's kind of a flavor of this

439
00:16:43,010 --> 00:16:40,980
false negative and false positive issue

440
00:16:45,829 --> 00:16:43,020
it's looking looking at the context and

441
00:16:48,500 --> 00:16:45,839
we need not just astronomers and

442
00:16:50,630 --> 00:16:48,510
biologists but also chemists and

443
00:16:52,940 --> 00:16:50,640
geochemists and Atmospheric scientists

444
00:16:54,870 --> 00:16:52,950
to put all of this together to kind of

445
00:16:57,130 --> 00:16:54,880
give us our best shot of

446
00:17:00,550 --> 00:16:57,140
recognizing a habitable and inhabited

447
00:17:04,809 --> 00:17:00,560
planet so Eddie this user on Twitter

448
00:17:07,390 --> 00:17:04,819
Rick Ward at our Jay Ward 1775 had asked

449
00:17:08,860 --> 00:17:07,400
this really interesting question posting

450
00:17:11,770 --> 00:17:08,870
on the people of space Twitter account

451
00:17:14,049 --> 00:17:11,780
he wanted to know would it be safe to

452
00:17:15,939 --> 00:17:14,059
say that the earlier you go in the

453
00:17:17,679 --> 00:17:15,949
geological record here on earth that the

454
00:17:20,110 --> 00:17:17,689
less certain the less certainty you'd

455
00:17:23,049 --> 00:17:20,120
have if you were an extraterrestrial

456
00:17:25,500 --> 00:17:23,059
species watching us from afar that there

457
00:17:28,210 --> 00:17:25,510
actually is life on this little rock

458
00:17:30,280 --> 00:17:28,220
yeah that's a that's a great question

459
00:17:32,710 --> 00:17:30,290
one way to answer that is to think about

460
00:17:34,919 --> 00:17:32,720
how much biomass has existed on on earth

461
00:17:37,240 --> 00:17:34,929
you know through time we think the first

462
00:17:39,790 --> 00:17:37,250
metabolisms were chemosynthetic that is

463
00:17:42,310 --> 00:17:39,800

they took an existing energy gradient

464
00:17:45,669 --> 00:17:42,320
and then they utilize that energy

465
00:17:47,799 --> 00:17:45,679
gradient for for for for metabolic

466
00:17:49,780 --> 00:17:47,809
processes and that would be very hard to

467
00:17:51,880 --> 00:17:49,790
detect remotely and maybe impossible and

468
00:17:53,799 --> 00:17:51,890
then we had photosynthesis that didn't

469
00:17:55,240 --> 00:17:53,809
generate oxygen called anoxygenic

470
00:17:58,000 --> 00:17:55,250
photosynthesis and that may have

471
00:18:00,000 --> 00:17:58,010
generated a signature there's also

472
00:18:02,080 --> 00:18:00,010
managed an assist which does not require

473
00:18:04,650 --> 00:18:02,090
photosynthesis and so perhaps we could

474
00:18:08,410 --> 00:18:04,660
have seen those types of metabolisms on

475
00:18:11,230 --> 00:18:08,420
on early Earth but but it's absolutely

476
00:18:13,540 --> 00:18:11,240
true that that oxygen 'ok photosynthesis

477
00:18:16,060 --> 00:18:13,550
because it generates so much energy and

478
00:18:18,130 --> 00:18:16,070
therefore can support so much more

479
00:18:21,700 --> 00:18:18,140
biomass that would be an easier thing to

480
00:18:24,549 --> 00:18:21,710
see remotely than then the more

481
00:18:26,440 --> 00:18:24,559
primitive metabolisms but we don't know

482
00:18:29,310 --> 00:18:26,450
the extent to which that is true we

483
00:18:32,380 --> 00:18:29,320
think that there are potentially

484
00:18:34,780 --> 00:18:32,390
atmospheric indicators in the carbon

485
00:18:36,910 --> 00:18:34,790
bearing molecules so if we looked at

486
00:18:39,669 --> 00:18:36,920
carbon dioxide and methane and carbon

487
00:18:42,100 --> 00:18:39,679
monoxide that that a primitive

488
00:18:44,200 --> 00:18:42,110

metabolism that can do methanogenesis

489
00:18:47,410 --> 00:18:44,210
would change the ratios of those gases

490
00:18:49,540 --> 00:18:47,420
in such a way as to be inferable that

491
00:18:51,220 --> 00:18:49,550
that is a bio signature mm-hmm

492
00:18:52,750 --> 00:18:51,230
interesting yeah I mean so it's kind of

493
00:18:54,340 --> 00:18:52,760
cool to think about you know alien life

494
00:18:57,040 --> 00:18:54,350
watching us from afar and how they may

495
00:18:58,750 --> 00:18:57,050
or may not have detected us I often

496
00:19:00,370 --> 00:18:58,760
times have told people that you know

497
00:19:02,200 --> 00:19:00,380
we're never going to know specifically

498
00:19:04,360 --> 00:19:02,210
how life started on earth you know just

499
00:19:05,860 --> 00:19:04,370
too much unknown there but wouldn't it

500
00:19:07,500 --> 00:19:05,870
be cool if there were aliens out there

501
00:19:10,710 --> 00:19:07,510
watching us from afar who had

502
00:19:13,290 --> 00:19:10,720
some knowledge of what happened here and

503
00:19:16,650 --> 00:19:13,300
you have a paper titled a limited

504
00:19:19,320 --> 00:19:16,660
habitable zone for complex life and in

505
00:19:21,570 --> 00:19:19,330
this paper you discuss the issues with

506
00:19:23,550 --> 00:19:21,580
the idea of the habitable zone the

507
00:19:25,440 --> 00:19:23,560
Goldilocks zone in this region around a

508
00:19:28,500 --> 00:19:25,450
star where liquid water can exist in the

509
00:19:30,480 --> 00:19:28,510
surface of a planet based on the amount

510
00:19:32,490 --> 00:19:30,490
of star light as well that planet is

511
00:19:34,530 --> 00:19:32,500
receiving it turns out that some of

512
00:19:36,900 --> 00:19:34,540
these these habitable zone areas might

513
00:19:38,430 --> 00:19:36,910

actually not be habitable could you

514
00:19:40,320 --> 00:19:38,440
speak to that and tell us you know kind

515
00:19:42,420 --> 00:19:40,330
of what the interpretation was from the

516
00:19:44,130 --> 00:19:42,430
from those results yeah I mean I think I

517
00:19:46,500 --> 00:19:44,140
think so the habitable zone originally

518
00:19:48,770 --> 00:19:46,510
as a concept is is is focused on liquid

519
00:19:51,450 --> 00:19:48,780
water surface liquid water and a

520
00:19:55,050 --> 00:19:51,460
prerequisite for life and I think that

521
00:19:57,240 --> 00:19:55,060
you know that's a good paradigm for

522
00:20:01,080 --> 00:19:57,250
microbial life for simple for simple

523
00:20:02,580 --> 00:20:01,090
life and you have to think about the

524
00:20:05,310 --> 00:20:02,590
habitable zone is how it's that's how

525
00:20:07,620 --> 00:20:05,320
it's calculated often is to assume at

526
00:20:10,470 --> 00:20:07,630
the dominant greenhouse gas is co2 and

527
00:20:12,090 --> 00:20:10,480
so the closer you are to the star the

528
00:20:14,100 --> 00:20:12,100
less co2 you need and the further from

529
00:20:15,630 --> 00:20:14,110
the star the more co2 you need and we

530
00:20:16,980 --> 00:20:15,640
believe that the process that regulates

531
00:20:18,720 --> 00:20:16,990
how much co2 in the atmosphere are

532
00:20:20,310 --> 00:20:18,730
similar to that of the earth which is

533
00:20:22,500 --> 00:20:20,320
the carbonate silicates cycle and this

534
00:20:25,229 --> 00:20:22,510
is a process that's been posited for the

535
00:20:27,269 --> 00:20:25,239
last four

536
00:20:29,129 --> 00:20:27,279
Earth's habitability through time as the

537
00:20:32,489 --> 00:20:29,139
Sun has actually started off much dimmer

538
00:20:35,099 --> 00:20:32,499

and brighter in geologic time we believe

539
00:20:37,609 --> 00:20:35,109
the co2 in the in our atmosphere started

540
00:20:40,739 --> 00:20:37,619
off high and has been drawn down as

541
00:20:43,229 --> 00:20:40,749
weathering rates have became as the Sun

542
00:20:45,089 --> 00:20:43,239
got rubbed some got brighter well if you

543
00:20:46,919 --> 00:20:45,099
think about the habitable zone as it

544
00:20:49,259 --> 00:20:46,929
exists if you were to place an

545
00:20:50,879 --> 00:20:49,269
earth-like planet at the outer edge of

546
00:20:52,469 --> 00:20:50,889
the hapless honest it's currently

547
00:20:54,629 --> 00:20:52,479
calculated you would meet more than

548
00:20:57,239 --> 00:20:54,639
10,000 times the amount of co2 that's in

549
00:20:59,669 --> 00:20:57,249
our atmosphere today the co2 is not just

550
00:21:02,369 --> 00:20:59,679
a greenhouse gas it's also a chemically

551
00:21:04,409 --> 00:21:02,379
active gas and we know that from our

552
00:21:05,999 --> 00:21:04,419
answer per Jenica missions of the you

553
00:21:08,339 --> 00:21:06,009
know ocean has become acidified if

554
00:21:11,219 --> 00:21:08,349
you're in a room with too much co2 it

555
00:21:13,019 --> 00:21:11,229
can be deleterious to you can you could

556
00:21:16,049 --> 00:21:13,029
you you could get co2 poisoning it's

557
00:21:18,329 --> 00:21:16,059
called hypercapnia a blood acidosis and

558
00:21:20,639 --> 00:21:18,339
it turns out that if you were to place

559
00:21:23,070 --> 00:21:20,649
the earth in most of the habitable zone

560
00:21:25,200 --> 00:21:23,080
and let it equilibrate to the amount

561
00:21:27,930 --> 00:21:25,210
that you would need to maintain above

562
00:21:30,719 --> 00:21:27,940
freezing conditions for most of that

563
00:21:33,690 --> 00:21:30,729

zone humans and most animals on earth

564
00:21:37,139 --> 00:21:33,700
would not be able to survive and so this

565
00:21:39,029 --> 00:21:37,149
is a little bit of a wrinkle in in in

566
00:21:40,799 --> 00:21:39,039
another dimension to the hackls and i

567
00:21:42,869 --> 00:21:40,809
say i would say it doesn't necessarily

568
00:21:44,969 --> 00:21:42,879
exclude it doesn't exclude at all the

569
00:21:47,279 --> 00:21:44,979
existence of bio signatures or microbial

570
00:21:49,409 --> 00:21:47,289
life but it does make us question about

571
00:21:51,329 --> 00:21:49,419
whether the entire how durable zone is

572
00:21:52,799 --> 00:21:51,339
suitable for the kinds of bye it's gonna

573
00:21:53,969 --> 00:21:52,809
kind of biosphere we find on earth today

574
00:21:55,589 --> 00:21:53,979
mm-hmm

575
00:21:57,180 --> 00:21:55,599
that's a good point because meaning

576
00:21:58,589 --> 00:21:57,190
there could be could be organisms who

577
00:22:00,810 --> 00:21:58,599
survive and there's other environments

578
00:22:02,489 --> 00:22:00,820
quite well but just not the kind of the

579
00:22:04,919 --> 00:22:02,499
planet biosphere that we have here right

580
00:22:06,450 --> 00:22:04,929
now right well and absolutely and

581
00:22:08,549 --> 00:22:06,460
there's a time dimension too which is

582
00:22:10,379 --> 00:22:08,559
really fascinating because when you look

583
00:22:11,579 --> 00:22:10,389
at the habitable zone in most

584
00:22:13,859 --> 00:22:11,589
definitions of the habitable zone

585
00:22:15,180 --> 00:22:13,869
particularly the conservative one the

586
00:22:16,529 --> 00:22:15,190
earth is at the very inner edge of the

587
00:22:18,930 --> 00:22:16,539
habitable zone and you think that's kind

588
00:22:20,459 --> 00:22:18,940

of odd but if you think about you know

589
00:22:22,289 --> 00:22:20,469
the distribution of co2 and habits on

590
00:22:24,180 --> 00:22:22,299
you expect it to be low the inner edge

591
00:22:26,700 --> 00:22:24,190
and and high at the outer edge

592
00:22:28,619 --> 00:22:26,710
now these habitable zones are not static

593
00:22:30,450 --> 00:22:28,629
in geologic time they changed as the

594
00:22:32,099 --> 00:22:30,460
Stars bright and Brett Stars brightened

595
00:22:34,649 --> 00:22:32,109
with time just as our Sun has so you

596
00:22:36,180 --> 00:22:34,659
earth started more more or less in the

597
00:22:37,450 --> 00:22:36,190
middle of the habitable zone and it's

598
00:22:38,980 --> 00:22:37,460
moved inward with time

599
00:22:41,139 --> 00:22:38,990
and what do you know we find ourselves

600
00:22:44,200 --> 00:22:41,149
at the inner edge of the habitable zone

601
00:22:46,240 --> 00:22:44,210
today when the co2 problem wouldn't

602
00:22:48,269 --> 00:22:46,250
exist and so it's not necessarily

603
00:22:51,090 --> 00:22:48,279
definitive but it is suggestive that

604
00:22:54,310 --> 00:22:51,100
perhaps that isn't a coincidence Oh

605
00:22:56,139 --> 00:22:54,320
awesome yeah this is really cool

606
00:22:57,970 --> 00:22:56,149
research I do want to open it up soon to

607
00:23:00,610 --> 00:22:57,980
audience questions and so I think just

608
00:23:02,860 --> 00:23:00,620
before we get there if you could so so

609
00:23:05,889 --> 00:23:02,870
one I'd love if you could just tell us

610
00:23:07,029 --> 00:23:05,899
you know what what tools do you need for

611
00:23:09,779 --> 00:23:07,039
your work specifically to do

612
00:23:13,330 --> 00:23:09,789
computational modeling not to mention

613
00:23:14,740 --> 00:23:13,340

what tools in the near future from

614
00:23:16,330 --> 00:23:14,750
computational methods as well as the

615
00:23:19,029 --> 00:23:16,340
upcoming telescopes are you most excited

616
00:23:23,260 --> 00:23:19,039
about to really advance this work

617
00:23:25,060 --> 00:23:23,270
forward well well the tools III do a lot

618
00:23:26,830 --> 00:23:25,070
of models so I'm using photochemical

619
00:23:28,899 --> 00:23:26,840
models climate models and radio transfer

620
00:23:31,480 --> 00:23:28,909
models and that allows me to to

621
00:23:34,269 --> 00:23:31,490
stimulate planetary States you know

622
00:23:35,950 --> 00:23:34,279
climate States chemical States for

623
00:23:38,560 --> 00:23:35,960
planets if you say change the star

624
00:23:40,120 --> 00:23:38,570
change location in the hobble zone and

625
00:23:41,440 --> 00:23:40,130
things like that and then simulate the

626
00:23:42,700 --> 00:23:41,450
spectral appearance of that planet as

627
00:23:44,230 --> 00:23:42,710
they would be observed by future

628
00:23:46,570 --> 00:23:44,240
observatories what really excites me as

629
00:23:49,029 --> 00:23:46,580
a prospect of these future observatories

630
00:23:51,519 --> 00:23:49,039
so there are three competing

631
00:23:53,169 --> 00:23:51,529
observatories that can potentially

632
00:23:55,990 --> 00:23:53,179
characterize terrestrial planet

633
00:23:58,419 --> 00:23:56,000
atmospheres in the astrophysics 2020 to

634
00:24:01,389 --> 00:23:58,429
Keadle two of them would be able to

635
00:24:02,620 --> 00:24:01,399
image terrestrial temperate planets and

636
00:24:05,880 --> 00:24:02,630
hobbles none of their stars they're

637
00:24:08,550 --> 00:24:05,890
called hab have x2 have

638
00:24:11,460 --> 00:24:08,560

you know the large optical infrared

639
00:24:13,560 --> 00:24:11,470
surveyor and and then there's also the

640
00:24:14,730 --> 00:24:13,570
Origin Space Telescope which is similar

641
00:24:16,980 --> 00:24:14,740
to JD boost II but would be more

642
00:24:20,310 --> 00:24:16,990
sensitive and would be able to probe the

643
00:24:24,810 --> 00:24:20,320
atmospheres of transiting planets around

644
00:24:27,240 --> 00:24:24,820
em door stars and so these these would

645
00:24:30,090 --> 00:24:27,250
really be the workhorses in the future

646
00:24:31,770 --> 00:24:30,100
for determining the distribution of life

647
00:24:33,900 --> 00:24:31,780
in the universe this would be our chance

648
00:24:37,050 --> 00:24:33,910
to do a survey of multiple habitable

649
00:24:39,060 --> 00:24:37,060
zone planets and probe their atmospheres

650
00:24:41,880 --> 00:24:39,070
for gaseous bio signatures and perhaps

651
00:24:43,890 --> 00:24:41,890
their surfaces as well and really start

652
00:24:46,740 --> 00:24:43,900
to get some robust statistics about how

653
00:24:48,660 --> 00:24:46,750
common not just habitable planets are

654
00:24:50,760 --> 00:24:48,670
but maybe even an inhabited planets and

655
00:24:52,940 --> 00:24:50,770
they could tell us that life is common

656
00:24:54,840 --> 00:24:52,950
they could tell us that life is rare

657
00:24:55,860 --> 00:24:54,850
that's awesome you know I'm looking

658
00:24:58,290 --> 00:24:55,870
forward to a lot of these upcoming

659
00:24:59,670 --> 00:24:58,300
telescopes if there were you know some

660
00:25:01,980 --> 00:24:59,680
young students right now in high school

661
00:25:04,140 --> 00:25:01,990
or undergraduate level who might want to

662
00:25:05,630 --> 00:25:04,150
work on those missions in the future if

663
00:25:07,350 --> 00:25:05,640

they get funded if they go into space

664
00:25:09,690 --> 00:25:07,360
what would you recommend to those

665
00:25:12,540 --> 00:25:09,700
students so get started right now to get

666
00:25:15,060 --> 00:25:12,550
involved in that well I mean taking

667
00:25:17,010 --> 00:25:15,070
taking physics and math is important if

668
00:25:19,410 --> 00:25:17,020
you want to be a scientist or an

669
00:25:22,260 --> 00:25:19,420
engineer you can be an engineer and work

670
00:25:24,330 --> 00:25:22,270
on the this on the spacecraft themselves

671
00:25:25,530 --> 00:25:24,340
or you or you could be a scientist and

672
00:25:28,400 --> 00:25:25,540
think about how to interpret the

673
00:25:30,480 --> 00:25:28,410
observations plan the observations and

674
00:25:33,360 --> 00:25:30,490
in either way you're going to need a

675
00:25:36,450 --> 00:25:33,370
strong quantitative background so math

676
00:25:37,770 --> 00:25:36,460
and physics and but also expand your

677
00:25:39,960 --> 00:25:37,780
horizons and think about the meaning

678
00:25:42,330 --> 00:25:39,970
behind this so don't close yourself only

679
00:25:45,390 --> 00:25:42,340
in the stem classes take some art and

680
00:25:46,950 --> 00:25:45,400
and and philosophy and and and and

681
00:25:49,380 --> 00:25:46,960
writing classes communication is

682
00:25:50,670 --> 00:25:49,390
incredibly important for scientists it's

683
00:25:52,320 --> 00:25:50,680
one of the most important things we do

684
00:25:54,960 --> 00:25:52,330
we spend most of our time communicating

685
00:25:56,970 --> 00:25:54,970
just need scientists we need people who

686
00:25:59,820 --> 00:25:56,980
can help us tell the story of what the

687
00:26:01,800 --> 00:25:59,830
science is is saying we need people who

688
00:26:03,330 --> 00:26:01,810

are science communicators and so there's

689
00:26:05,790 --> 00:26:03,340
a whole ecosystem that's built around

690
00:26:08,790 --> 00:26:05,800
these things we interested in finding

691
00:26:11,790 --> 00:26:08,800
life beyond its a compelling question it

692
00:26:13,620 --> 00:26:11,800
motivates all of us and you don't need

693
00:26:16,950 --> 00:26:13,630
to necessarily be a scientist to be part

694
00:26:19,350 --> 00:26:16,960
of that yeah and as a communicator of

695
00:26:20,880 --> 00:26:19,360
science myself I love hear you say that

696
00:26:22,410 --> 00:26:20,890
um so just before I open it up now

697
00:26:24,480 --> 00:26:22,420
finally to the audience questions one

698
00:26:27,000 --> 00:26:24,490
more thing I want to ask I do just want

699
00:26:28,830 --> 00:26:27,010
to know in prepping for this episode we

700
00:26:31,650 --> 00:26:28,840
discovered that you actually enjoy a lot

701
00:26:33,180 --> 00:26:31,660
of gaming and so I'd like to know how

702
00:26:39,300 --> 00:26:33,190
you as an astrobiologist studying

703
00:26:41,340 --> 00:26:39,310
exoplanets how you relax yes so um so as

704
00:26:44,160 --> 00:26:41,350
many of us many of us interested in

705
00:26:46,080 --> 00:26:44,170
science started off in being interested

706
00:26:48,270 --> 00:26:46,090
in games I was interested in in

707
00:26:51,720 --> 00:26:48,280
civilization I played many hours as a

708
00:26:53,280 --> 00:26:51,730
teenager of civilization now I don't

709
00:26:55,320 --> 00:26:53,290
have a lot of time for gaming but when I

710
00:26:57,660 --> 00:26:55,330
do I play a game called stellaris which

711
00:27:00,540 --> 00:26:57,670
is about exploring a galaxy and making

712
00:27:03,750 --> 00:27:00,550
scientific discoveries and expanding

713
00:27:05,700 --> 00:27:03,760

it's a 4x game and what I like about is

714
00:27:09,210 --> 00:27:05,710
you can pause it and start it you know

715
00:27:12,090 --> 00:27:09,220
according to your own schedule so that's

716
00:27:14,460 --> 00:27:12,100
one of the games that I play to relax

717
00:27:20,640 --> 00:27:14,470
that like reading as a teenager a lot of

718
00:27:25,050 --> 00:27:20,650
the Asimov magazine analog I enjoy the

719
00:27:28,100 --> 00:27:25,060
novels by arthur c clarke and azimoff

720
00:27:30,900 --> 00:27:28,110
and david brin some of the authors

721
00:27:32,520 --> 00:27:30,910
that's awesome you know so you know all

722
00:27:34,200 --> 00:27:32,530
of us in the sciences and engineering

723
00:27:35,550 --> 00:27:34,210
and other rooms like this we also all

724
00:27:38,850 --> 00:27:35,560
have these other pursuits that kind of

725
00:27:39,750 --> 00:27:38,860
you know fill in our lives so I am going

726
00:27:41,730 --> 00:27:39,760
to open it now for the audience

727
00:27:43,800 --> 00:27:41,740
questions and thank you to our audience

728
00:27:46,590 --> 00:27:43,810
for bearing with us here technical

729
00:27:47,970 --> 00:27:46,600
glitches we've had along the way just

730
00:27:50,790 --> 00:27:47,980
remember you can ask your questions on

731
00:27:52,830 --> 00:27:50,800
twitter using hashtag ask aster bio into

732
00:27:55,140 --> 00:27:52,840
the second net chat or on the Facebook

733
00:27:57,720 --> 00:27:55,150
page for NASA Astrobiology if you're

734
00:28:00,410 --> 00:27:57,730
watching there as well so Eddie the very

735
00:28:03,030 --> 00:28:00,420
first question comes from dr. Jim pass

736
00:28:06,180 --> 00:28:03,040
of the Astro sociology Research

737
00:28:08,250 --> 00:28:06,190
Institute and dr. pass once this wants

738
00:28:11,250 --> 00:28:08,260

to know since he's a social scientist

739
00:28:12,990 --> 00:28:11,260
himself what your thoughts are about the

740
00:28:15,350 --> 00:28:13,000
types of techno signatures you would

741
00:28:18,420 --> 00:28:15,360
favor in the search for extraterrestrial

742
00:28:20,670 --> 00:28:18,430
societies and if you could maybe mention

743
00:28:23,040 --> 00:28:20,680
the relationship and differences between

744
00:28:25,320 --> 00:28:23,050
bio signatures and techno signatures as

745
00:28:28,320 --> 00:28:25,330
well and I use the word bio signature to

746
00:28:30,549 --> 00:28:28,330
mean on technological life so so

747
00:28:35,710 --> 00:28:30,559
evidence of

748
00:28:39,730 --> 00:28:35,720
analogues to bacteria or algae or or you

749
00:28:42,279 --> 00:28:39,740
know plants and and and they can affect

750
00:28:46,480 --> 00:28:42,289
their planet in in in drastic ways as we

751
00:28:47,919 --> 00:28:46,490
see on our on earth but a technical

752
00:28:49,990 --> 00:28:47,929
signature would be specifically an

753
00:28:51,940 --> 00:28:50,000
indication of a technologically advanced

754
00:28:54,039 --> 00:28:51,950
civilization and so you could think of a

755
00:28:56,409 --> 00:28:54,049
techno signature as present in a broad

756
00:29:00,130 --> 00:28:56,419
sense a radio wave that's generated by a

757
00:29:02,350 --> 00:29:00,140
transmitter by an laser flash by a

758
00:29:07,090 --> 00:29:02,360
structure perhaps that could only be

759
00:29:08,919 --> 00:29:07,100
made artificially by even a certain kind

760
00:29:10,269 --> 00:29:08,929
of molecule in an exoplanet atmosphere

761
00:29:12,760 --> 00:29:10,279
that can only be created through

762
00:29:14,169 --> 00:29:12,770
industrial processes so that would be

763
00:29:16,419 --> 00:29:14,179

those would be examples of techno

764
00:29:18,549 --> 00:29:16,429
signatures and so which ones do I favor

765
00:29:20,680 --> 00:29:18,559
well I think the advantage to bio

766
00:29:22,810 --> 00:29:20,690
signatures is that in the future we can

767
00:29:24,610 --> 00:29:22,820
we can do a volume limited survey we can

768
00:29:26,169 --> 00:29:24,620
look probe the atmospheres of planets

769
00:29:30,700 --> 00:29:26,179
that are in the solar neighborhood and

770
00:29:33,010 --> 00:29:30,710
we can look for for for for oxygen for

771
00:29:34,360 --> 00:29:33,020
methane for nitrous oxide and we can say

772
00:29:37,659 --> 00:29:34,370
yes or no those are present in

773
00:29:42,159 --> 00:29:37,669
detectable quantities for techno

774
00:29:44,019 --> 00:29:42,169
signatures I think we we have we have an

775
00:29:45,490 --> 00:29:44,029
advantage in the sense that potentially

776
00:29:47,560 --> 00:29:45,500
if you have a strong enough transmitter

777
00:29:49,539 --> 00:29:47,570
you could you could find a sign of

778
00:29:52,029 --> 00:29:49,549
intelligence from a much larger distance

779
00:29:53,740 --> 00:29:52,039
away so instead of tens of light-years

780
00:29:56,560 --> 00:29:53,750
maybe hundreds or thousands of

781
00:29:58,090 --> 00:29:56,570
light-years away if it exists and the

782
00:30:00,730 --> 00:29:58,100
problem of course is that you can't do a

783
00:30:02,529 --> 00:30:00,740
volume limited survey and so you can't

784
00:30:04,510 --> 00:30:02,539
necessarily you've set a lower limit on

785
00:30:07,750 --> 00:30:04,520
the prevalence of these techno

786
00:30:10,659 --> 00:30:07,760
signatures that are out there but I do

787
00:30:13,269 --> 00:30:10,669
favor the idea of of looking for them

788
00:30:16,299 --> 00:30:13,279

because we don't know until we look and

789
00:30:18,100 --> 00:30:16,309
and and there's a there's assumptions

790
00:30:20,080 --> 00:30:18,110
people have assumptions about whether

791
00:30:22,720 --> 00:30:20,090
life is rare or common and assumptions

792
00:30:25,090 --> 00:30:22,730
about whether civilizations are common

793
00:30:27,940 --> 00:30:25,100
or rare and the only way that we can be

794
00:30:29,740 --> 00:30:27,950
sure is to actually make the

795
00:30:33,010 --> 00:30:29,750
observations and to make the effort to

796
00:30:34,389 --> 00:30:33,020
find them and say that that bio

797
00:30:36,789 --> 00:30:34,399
signatures and techno signatures are

798
00:30:38,500 --> 00:30:36,799
complementary in this way that we can do

799
00:30:39,620 --> 00:30:38,510
this volume limited survey in the future

800
00:30:41,450 --> 00:30:39,630
for biosignature

801
00:30:44,990 --> 00:30:41,460
and we can kind of look at much larger

802
00:30:47,180 --> 00:30:45,000
distances for for techno signatures that

803
00:30:51,500 --> 00:30:47,190
may be more more detectable and more

804
00:30:53,720 --> 00:30:51,510
obvious mm-hmm yeah so our next question

805
00:30:56,180 --> 00:30:53,730
comes from autoroute mohanty at stray

806
00:30:56,900 --> 00:30:56,190
ologist on twitter autoroute wants to

807
00:30:58,640 --> 00:30:56,910
know

808
00:31:00,260 --> 00:30:58,650
so in this realm of talking about

809
00:31:02,030 --> 00:31:00,270
exoplanet atmospheres and we're talking

810
00:31:04,880 --> 00:31:02,040
a lot about you know that the Goldilocks

811
00:31:06,230 --> 00:31:04,890
zone the habitable zone and an honor

812
00:31:08,390 --> 00:31:06,240
wants to know if you think that we're

813
00:31:11,750 --> 00:31:08,400

missing out a lot of potentially

814
00:31:13,070 --> 00:31:11,760
habitable extrasolar bodies because of

815
00:31:14,450 --> 00:31:13,080
things like you know and in our solar

816
00:31:15,890 --> 00:31:14,460
system we have these icy worlds in the

817
00:31:19,610 --> 00:31:15,900
outer solar system that might have life

818
00:31:21,020 --> 00:31:19,620
and oceans are we missing out on on ways

819
00:31:23,480 --> 00:31:21,030
of looking for those kinds of life as

820
00:31:25,070 --> 00:31:23,490
well well I think this speaks to the

821
00:31:26,930 --> 00:31:25,080
complementarity of the search for life

822
00:31:28,820 --> 00:31:26,940
within the solar system and the search

823
00:31:31,039 --> 00:31:28,830
for life outside our solar system and so

824
00:31:33,620 --> 00:31:31,049
the reason why we're looking for planets

825
00:31:36,289 --> 00:31:33,630
in the habitable zone you know so-called

826
00:31:37,850 --> 00:31:36,299
habitable zone and exoplanets is the

827
00:31:40,820 --> 00:31:37,860
idea that you have this interface

828
00:31:43,130 --> 00:31:40,830
between the ocean or the land and the

829
00:31:45,350 --> 00:31:43,140
atmosphere so you have a way for bio

830
00:31:47,690 --> 00:31:45,360
signature gases for example to mix into

831
00:31:50,030 --> 00:31:47,700
the atmosphere and then create a signal

832
00:31:51,500 --> 00:31:50,040
that can be detected remotely and then

833
00:31:53,330 --> 00:31:51,510
that's robust enough to be detected over

834
00:31:54,980 --> 00:31:53,340
interstellar distances if the life is

835
00:31:57,049 --> 00:31:54,990
under an ice shell that's much more

836
00:31:59,150 --> 00:31:57,059
difficult if not impossible to detect

837
00:32:00,440 --> 00:31:59,160
remotely however we do have these

838
00:32:02,360 --> 00:32:00,450

examples of potentially habitable

839
00:32:06,680 --> 00:32:02,370
environments within our solar system and

840
00:32:10,400 --> 00:32:06,690
we could send in sissu probes to to

841
00:32:12,200 --> 00:32:10,410
sample those environments and so that

842
00:32:13,730 --> 00:32:12,210
could tell us if if we find life on

843
00:32:17,299 --> 00:32:13,740
Europa and Enceladus that icy moons are

844
00:32:20,090 --> 00:32:17,309
very common habitats and and in the in

845
00:32:22,850 --> 00:32:20,100
the universe in general but right now

846
00:32:24,950 --> 00:32:22,860
there's no way to look for them if

847
00:32:26,030 --> 00:32:24,960
they're in outside our solar system so

848
00:32:27,799 --> 00:32:26,040
it's really a matter of practicality

849
00:32:29,060 --> 00:32:27,809
we're not saying what the concept that

850
00:32:30,320 --> 00:32:29,070
the habitable zone that there are no

851
00:32:31,970 --> 00:32:30,330
habitable environments outside the

852
00:32:34,070 --> 00:32:31,980
Hamill's and we're saying is those are

853
00:32:36,560 --> 00:32:34,080
the places we have the best chance of

854
00:32:39,140 --> 00:32:36,570
detecting planetary biosphere remotely

855
00:32:40,280 --> 00:32:39,150
mm-hm that's awesome yeah so so on earth

856
00:32:43,669 --> 00:32:40,290
actually kind as a follow-up question

857
00:32:44,960 --> 00:32:43,679
then to kind of going on that so you

858
00:32:46,970 --> 00:32:44,970
know you're working a lot in

859
00:32:48,590 --> 00:32:46,980
computational modeling of the BIOS

860
00:32:50,240 --> 00:32:48,600
features that we're going to be looking

861
00:32:51,590 --> 00:32:50,250
for very soon at the next generation of

862
00:32:54,110 --> 00:32:51,600
telescopes

863
00:32:56,510 --> 00:32:54,120

and may potentially find honor Roop

864
00:32:58,510 --> 00:32:56,520
wants to know can we expect to see

865
00:33:01,220 --> 00:32:58,520
techniques being developed to analyze

866
00:33:03,140 --> 00:33:01,230
exoplanets sub surfaces in the near

867
00:33:05,810 --> 00:33:03,150
future

868
00:33:07,940 --> 00:33:05,820
III would say that that what we need is

869
00:33:10,100 --> 00:33:07,950
a way to translate what's happening in

870
00:33:12,440 --> 00:33:10,110
the subsurface to the atmosphere and so

871
00:33:13,910 --> 00:33:12,450
if there's an exchange of gases from the

872
00:33:15,410 --> 00:33:13,920
subsurface the atmosphere that creates a

873
00:33:17,510 --> 00:33:15,420
disequilibrium that's something that

874
00:33:20,299 --> 00:33:17,520
could potentially be looked for but what

875
00:33:22,130 --> 00:33:20,309
we need is the the the the composition

876
00:33:23,750 --> 00:33:22,140
of the atmosphere to have change in a

877
00:33:27,110 --> 00:33:23,760
way that's figured that that can

878
00:33:28,700 --> 00:33:27,120
fingerprint life for and for those gases

879
00:33:33,049 --> 00:33:28,710
to be abundant enough to be detected

880
00:33:34,760 --> 00:33:33,059
over interstellar distances mmm okay so

881
00:33:37,100 --> 00:33:34,770
we have another question here so a lot

882
00:33:39,620 --> 00:33:37,110
of folks might have noticed yesterday

883
00:33:41,090 --> 00:33:39,630
they might have heard some news that a

884
00:33:44,210 --> 00:33:41,100
new paper came out suggesting that

885
00:33:46,820 --> 00:33:44,220
there's some 30-ish planets in our Milky

886
00:33:49,640 --> 00:33:46,830
Way that likely have life we have a

887
00:33:52,490 --> 00:33:49,650
question from the rebel educator Doctor

888
00:33:53,230 --> 00:33:52,500

of Education on Twitter at dr. andrew

889
00:33:56,270 --> 00:33:53,240
kemp

890
00:33:58,580 --> 00:33:56,280
dr. Kempe wants to know with the news

891
00:34:00,830 --> 00:33:58,590
that there are potential 36 planets with

892
00:34:02,690 --> 00:34:00,840
life similar to ours would it make sense

893
00:34:04,850 --> 00:34:02,700
that some of these would be vastly more

894
00:34:07,180 --> 00:34:04,860
developed than we are if so is it

895
00:34:11,990 --> 00:34:07,190
logical that they know about us

896
00:34:14,180 --> 00:34:12,000
well so this this is a paper that I

897
00:34:16,460 --> 00:34:14,190
admittedly have not had a chance to read

898
00:34:18,889 --> 00:34:16,470
yet so I'll speak more generally about

899
00:34:20,720 --> 00:34:18,899
about the Drake Equation and about the

900
00:34:23,919 --> 00:34:20,730
search for extraterrestrial intelligence

901
00:34:26,180 --> 00:34:23,929
and so the Drake Equation is a way of

902
00:34:28,879 --> 00:34:26,190
kind of parameterizing our ignorance

903
00:34:31,070 --> 00:34:28,889
about how many civilizations are in our

904
00:34:32,780 --> 00:34:31,080
in the are in the galaxy and so you take

905
00:34:35,899 --> 00:34:32,790
the number of stars times the fraction

906
00:34:37,700 --> 00:34:35,909
of those that have planets times the

907
00:34:40,490 --> 00:34:37,710
fraction of those planets that could

908
00:34:42,320 --> 00:34:40,500
develop that are habitable times the

909
00:34:44,450 --> 00:34:42,330
fraction of those habitable environments

910
00:34:48,500 --> 00:34:44,460
that actually develop life and then so

911
00:34:51,230 --> 00:34:48,510
on and so forth the end is how long the

912
00:34:53,389 --> 00:34:51,240
civilization lasts on that planet and so

913
00:34:55,220 --> 00:34:53,399

that's a really key thing to consider is

914
00:34:57,139 --> 00:34:55,230
that I believe that many of these

915
00:35:00,670 --> 00:34:57,149
assumptions we assume that that last

916
00:35:03,590 --> 00:35:00,680
numbers is comparable to the to the

917
00:35:05,750 --> 00:35:03,600
current longevity of our technic

918
00:35:06,980 --> 00:35:05,760
civilization and so that's kind of a

919
00:35:09,830 --> 00:35:06,990
built-in assumption that they're similar

920
00:35:11,990 --> 00:35:09,840
to us but I do want to jump off of that

921
00:35:14,030 --> 00:35:12,000
because if you think about how old the

922
00:35:16,640 --> 00:35:14,040
universe is and and how old our galaxy

923
00:35:18,740 --> 00:35:16,650
is you can leverage something called the

924
00:35:21,770 --> 00:35:18,750
cosmic calendar which is collapsing the

925
00:35:25,280 --> 00:35:21,780
whole history of the universe down to

926
00:35:27,500 --> 00:35:25,290
one year and to illustrate that the Sun

927
00:35:30,170 --> 00:35:27,510
only formed four months ago in this

928
00:35:32,600 --> 00:35:30,180
timeline dinosaurs roam the earth on

929
00:35:34,460 --> 00:35:32,610
December 25th humanity developed

930
00:35:36,860 --> 00:35:34,470
developed eight minutes ago and the

931
00:35:40,040 --> 00:35:36,870
average human lifespan is 0.2 seconds in

932
00:35:42,920 --> 00:35:40,050
this cosmic year and so if you imagine a

933
00:35:47,660 --> 00:35:42,930
civilization that arose just a minute

934
00:35:51,230 --> 00:35:47,670
before ours ten minutes a day it would

935
00:35:53,270 --> 00:35:51,240
be incomprehensible beyond us when you

936
00:35:54,440 --> 00:35:53,280
consider the fact that the ten thousand

937
00:35:56,690 --> 00:35:54,450
years between the invention of

938
00:35:59,990 --> 00:35:56,700

agriculture and our current time is just

939
00:36:02,090 --> 00:36:00,000
this you know less than a less than a

940
00:36:04,130 --> 00:36:02,100
minute it's about it's about 25 seconds

941
00:36:05,900 --> 00:36:04,140
in this cosmic timeline so I would

942
00:36:07,310 --> 00:36:05,910
imagine that if we did find an

943
00:36:08,390 --> 00:36:07,320
extraterrestrial civilization the

944
00:36:10,730 --> 00:36:08,400
chances of us finding one that's

945
00:36:12,560 --> 00:36:10,740
comparable to us is is zero

946
00:36:14,600 --> 00:36:12,570
they're probably far ahead Oh

947
00:36:16,070 --> 00:36:14,610
interesting and and it's always

948
00:36:17,360 --> 00:36:16,080
compelling to think about you know time

949
00:36:19,910 --> 00:36:17,370
in that way that you know we really have

950
00:36:22,940 --> 00:36:19,920
been around for a very short time a blip

951
00:36:25,160 --> 00:36:22,950
in cosmic time and I also recommend for

952
00:36:26,720 --> 00:36:25,170
for our audience watching the website

953
00:36:30,080 --> 00:36:26,730
information is beautiful has a really

954
00:36:31,310 --> 00:36:30,090
cool Drake Equation interactive graphic

955
00:36:33,050 --> 00:36:31,320
that you can play with and change those

956
00:36:34,250 --> 00:36:33,060
numbers and kind of give yourself an

957
00:36:35,840 --> 00:36:34,260
idea of what happens when you start

958
00:36:39,410 --> 00:36:35,850
actually moving those numbers around so

959
00:36:41,450 --> 00:36:39,420
I highly recommend our next question for

960
00:36:45,500 --> 00:36:41,460
you Eddie comes from guara yaw table on

961
00:36:48,080 --> 00:36:45,510
Facebook Gaurav asks which instruments

962
00:36:50,840 --> 00:36:48,090
are used to detect and study these bio

963
00:36:52,580 --> 00:36:50,850

signatures and then kind of following on

964
00:36:54,980 --> 00:36:52,590
and this might be more specific to our

965
00:36:57,170 --> 00:36:54,990
solar system for now is there any way to

966
00:36:58,910 --> 00:36:57,180
miniaturize like mass spectroscopy that

967
00:37:01,490 --> 00:36:58,920
we could put on a spaceship and then and

968
00:37:04,250 --> 00:37:01,500
then detect bio signatures yeah okay so

969
00:37:06,080 --> 00:37:04,260
I'll do the first one so there there are

970
00:37:09,860 --> 00:37:06,090
many different technologies that have

971
00:37:11,810 --> 00:37:09,870
been proposed to detect the atmosphere

972
00:37:13,110 --> 00:37:11,820
and potentially probe the services of

973
00:37:16,650 --> 00:37:13,120
earth-sized exoplanet

974
00:37:20,160 --> 00:37:16,660
and so the challenge here is is multi

975
00:37:21,960 --> 00:37:20,170
flow multi fold so the earth is out out

976
00:37:23,940 --> 00:37:21,970
shown by the Sun by a factor of ten

977
00:37:26,910 --> 00:37:23,950
billion so that's ten to the ten

978
00:37:28,950 --> 00:37:26,920
and so you would you need the technology

979
00:37:31,110 --> 00:37:28,960
if you want to directly image the planet

980
00:37:33,000 --> 00:37:31,120
to null out the star light from That

981
00:37:34,950 --> 00:37:33,010
star revealed a star light of the planet

982
00:37:37,200 --> 00:37:34,960
or the the reflectance that reflected

983
00:37:38,550 --> 00:37:37,210
light from the planet and there are a

984
00:37:40,620 --> 00:37:38,560
couple of ways to do that one is called

985
00:37:42,630 --> 00:37:40,630
a coronagraph and the other is called a

986
00:37:45,810 --> 00:37:42,640
star shade the coronagraph is internal

987
00:37:48,630 --> 00:37:45,820
to the telescope and we have examples of

988
00:37:51,060 --> 00:37:48,640

these already the the challenge is

989
00:37:53,790 --> 00:37:51,070
getting to this level of one part in ten

990
00:37:55,980 --> 00:37:53,800
billion and so currently nasa stats

991
00:37:57,540 --> 00:37:55,990
studying both coronagraphs and starshade

992
00:37:59,610 --> 00:37:57,550
star shade is an external of culture

993
00:38:01,890 --> 00:37:59,620
that would be a separate spacecraft that

994
00:38:03,330 --> 00:38:01,900
would have petals that are shaped in

995
00:38:04,950 --> 00:38:03,340
just the right way to null out the light

996
00:38:07,470 --> 00:38:04,960
from the star and reveal the light of

997
00:38:09,210 --> 00:38:07,480
the planet and and there are current

998
00:38:10,710 --> 00:38:09,220
tests going on that are getting very

999
00:38:13,680 --> 00:38:10,720
close to this ten to the negative 10

1000
00:38:15,360 --> 00:38:13,690
star lights depression level and so they

1001
00:38:16,710 --> 00:38:15,370
open through a field a planet and then

1002
00:38:19,230 --> 00:38:16,720
it's just a matter of using a

1003
00:38:22,290 --> 00:38:19,240
spectrograph to to break up the light

1004
00:38:24,810 --> 00:38:22,300
from the planet and reveal the molecular

1005
00:38:26,760 --> 00:38:24,820
composition of the atmosphere that's one

1006
00:38:28,350 --> 00:38:26,770
way of doing it there's also the way of

1007
00:38:29,760 --> 00:38:28,360
doing it where you where you look at the

1008
00:38:31,860 --> 00:38:29,770
light filtered through the planet as

1009
00:38:33,240 --> 00:38:31,870
it's transiting and again what you have

1010
00:38:36,090 --> 00:38:33,250
to do is you have to subtract off the

1011
00:38:38,670 --> 00:38:36,100
light from the star and and reveal the

1012
00:38:40,530 --> 00:38:38,680
light from the planet and and the light

1013
00:38:42,120 --> 00:38:40,540

from and that light reveals the

1014
00:38:44,160 --> 00:38:42,130
molecular composition of the atmosphere

1015
00:38:48,210 --> 00:38:44,170
and so we have done that already for

1016
00:38:50,490 --> 00:38:48,220
large large planets gaseous planets it

1017
00:38:53,190 --> 00:38:50,500
whenever I think about I mean just the

1018
00:38:56,220 --> 00:38:53,200
very thought that we are capturing that

1019
00:38:59,760 --> 00:38:56,230
little itty bitty amount of star light

1020
00:39:01,770 --> 00:38:59,770
coming just through that small veneer of

1021
00:39:04,380 --> 00:39:01,780
atmosphere around a planet and then

1022
00:39:06,000 --> 00:39:04,390
we're able to actually subtract that

1023
00:39:08,070 --> 00:39:06,010
from the star light and actually do some

1024
00:39:10,080 --> 00:39:08,080
some chemical some chemistry with it and

1025
00:39:14,490 --> 00:39:10,090
actually understand it is just it's

1026
00:39:16,140 --> 00:39:14,500
almost so much shocking it's it's a it's

1027
00:39:18,690 --> 00:39:16,150
it's it's quite a fine measurement you

1028
00:39:21,270 --> 00:39:18,700
know so so the earth transiting the Sun

1029
00:39:23,010 --> 00:39:21,280
is one part in 10,000 and that's the

1030
00:39:24,690 --> 00:39:23,020
whole planet and then we talk about the

1031
00:39:26,250 --> 00:39:24,700
atmosphere you're talking about parts

1032
00:39:29,320 --> 00:39:26,260
parts per million

1033
00:39:30,940 --> 00:39:29,330
wowthat's it's so small and I hope

1034
00:39:32,860 --> 00:39:30,950
people spend some time just thinking

1035
00:39:35,020 --> 00:39:32,870
about we know how far we've come in

1036
00:39:37,420 --> 00:39:35,030
trying to understand this and how far we

1037
00:39:39,940 --> 00:39:37,430
can go yet in the future and doing more

1038
00:39:41,770 --> 00:39:39,950

there I actually want to jump out just

1039
00:39:46,020 --> 00:39:41,780
for a second and ask if you've heard of

1040
00:39:50,200 --> 00:39:46,030
this recent idea of sending a series of

1041
00:39:52,480 --> 00:39:50,210
telescopes far from our Sun and then

1042
00:39:55,570 --> 00:39:52,490
kind of looking back and using the Sun

1043
00:39:57,430 --> 00:39:55,580
as its own gravitational lens to

1044
00:40:00,040 --> 00:39:57,440
actually look at exoplanets from far

1045
00:40:01,150 --> 00:40:00,050
away so maybe you know and this wouldn't

1046
00:40:03,340 --> 00:40:01,160
have any time soon it would take a very

1047
00:40:05,770 --> 00:40:03,350
long time to build this but we could

1048
00:40:08,170 --> 00:40:05,780
build an array of gravitational lensing

1049
00:40:09,880 --> 00:40:08,180
telescopes to actually look at the

1050
00:40:11,350 --> 00:40:09,890
surface of an exoplanet I'm not sure if

1051
00:40:13,900 --> 00:40:11,360
you've heard of this this project or not

1052
00:40:17,140 --> 00:40:13,910
yet and if you could speak to it for a

1053
00:40:20,890 --> 00:40:17,150
moment yes so so the idea is that you'd

1054
00:40:22,840 --> 00:40:20,900
use the gravity gravitational the Sun as

1055
00:40:25,030 --> 00:40:22,850
a gravitational land's name amplify the

1056
00:40:27,490 --> 00:40:25,040
signal from a distant planet and you'd

1057
00:40:30,970 --> 00:40:27,500
have to go to the focus of the Sun which

1058
00:40:32,590 --> 00:40:30,980
is about a hundred au away 100

1059
00:40:34,000 --> 00:40:32,600
astronomical units a hundred times the

1060
00:40:35,500 --> 00:40:34,010
distance between Earth and the Sun and

1061
00:40:37,570 --> 00:40:35,510
it would be quite a challenging

1062
00:40:38,920 --> 00:40:37,580
proposition to put a telescope there but

1063
00:40:41,830 --> 00:40:38,930

it would be a lot less challenging than

1064
00:40:45,280 --> 00:40:41,840
actually trying to undertake

1065
00:40:47,200 --> 00:40:45,290
interstellar flight and and also be much

1066
00:40:49,450 --> 00:40:47,210
much much quicker and so this is

1067
00:40:50,860 --> 00:40:49,460
something probably probably in the far

1068
00:40:53,830 --> 00:40:50,870
what we think of as a far future but not

1069
00:40:56,140 --> 00:40:53,840
nearly as far as say sending sending an

1070
00:40:58,980 --> 00:40:56,150
interstellar spacecraft to a neighboring

1071
00:41:01,420 --> 00:40:58,990
star so I think it's a really fun idea

1072
00:41:04,660 --> 00:41:01,430
to pick apart and think about and I

1073
00:41:06,310 --> 00:41:04,670
think ultimately this is how the science

1074
00:41:09,010 --> 00:41:06,320
is going to progress is that we are

1075
00:41:12,070 --> 00:41:09,020
going to sort of start start a survey of

1076
00:41:16,150 --> 00:41:12,080
our solar neighborhood for planets that

1077
00:41:17,440 --> 00:41:16,160
we believe are potentially habitable and

1078
00:41:19,960 --> 00:41:17,450
we're going to learn more and more about

1079
00:41:21,580 --> 00:41:19,970
those worlds as time goes on and once we

1080
00:41:23,350 --> 00:41:21,590
find them and once we find the first

1081
00:41:24,640 --> 00:41:23,360
putative bio signature you know we're

1082
00:41:26,020 --> 00:41:24,650
never going to forget about those plants

1083
00:41:28,690 --> 00:41:26,030
there's always going to go back and

1084
00:41:31,840 --> 00:41:28,700
refine our understanding of those worlds

1085
00:41:34,420 --> 00:41:31,850
and it's going to last for for as long

1086
00:41:37,690 --> 00:41:34,430
as we last as a species

1087
00:41:39,730 --> 00:41:37,700
awesome so kind of in that realm then I

1088
00:41:42,220 --> 00:41:39,740

want to go to a question from auto group

1089
00:41:44,680 --> 00:41:42,230
as well from Twitter who wants to know

1090
00:41:46,210 --> 00:41:44,690
about the significance of having the

1091
00:41:49,089 --> 00:41:46,220
James Webb Space Telescope when that

1092
00:41:50,790 --> 00:41:49,099
launches go out to a position known as

1093
00:41:54,460 --> 00:41:50,800
El to go out go out just pass the moon

1094
00:41:55,839 --> 00:41:54,470
and orbit out there compared to

1095
00:41:58,599 --> 00:41:55,849
something like Hubble that orbits the

1096
00:42:00,099 --> 00:41:58,609
earth yeah I mean so the James Webb

1097
00:42:03,190 --> 00:42:00,109
Space Telescope is exciting it's gonna

1098
00:42:07,020 --> 00:42:03,200
do a lot of general astrophysics not

1099
00:42:10,150 --> 00:42:07,030
just exoplanets but it has the capacity

1100
00:42:12,640 --> 00:42:10,160
potentially to probe some rock EXO

1101
00:42:14,829 --> 00:42:12,650
planetary atmospheres maybe if we get

1102
00:42:17,049 --> 00:42:14,839
lucky will detect things like carbon

1103
00:42:19,089 --> 00:42:17,059
dioxide in an exoplanet area atmosphere

1104
00:42:23,140 --> 00:42:19,099
find the first secondary outgassed

1105
00:42:25,210 --> 00:42:23,150
atmospheres and and just begin with a

1106
00:42:29,589 --> 00:42:25,220
very small number of targets to perhaps

1107
00:42:32,799 --> 00:42:29,599
constrain habitability on some but it is

1108
00:42:34,839 --> 00:42:32,809
limited in some ways but the reason why

1109
00:42:38,410 --> 00:42:34,849
we why we want to put it out out at l2

1110
00:42:42,390 --> 00:42:38,420
is is in part to to make sure it's cold

1111
00:42:44,589 --> 00:42:42,400
in part to avoid the light from earth

1112
00:42:45,579 --> 00:42:44,599
interfering with the observations it

1113
00:42:48,460 --> 00:42:45,589

does mean that there are a lot of

1114
00:42:51,520 --> 00:42:48,470
consumables on on on spacecraft and

1115
00:42:53,430 --> 00:42:51,530
therefore its life time his problem is

1116
00:42:56,730 --> 00:42:53,440
much more limited than that of Hubble

1117
00:42:59,220 --> 00:42:56,740
okay with Hubble

1118
00:43:00,570 --> 00:42:59,230
I actually work on an orbit still

1119
00:43:03,750 --> 00:43:00,580
looking forward to judge a vestido

1120
00:43:04,700 --> 00:43:03,760
should be a very awesome mission another

1121
00:43:08,460 --> 00:43:04,710
question

1122
00:43:10,890 --> 00:43:08,470
Twitter from Avani hedge

1123
00:43:12,900 --> 00:43:10,900
Avani wants to know and this is

1124
00:43:15,870 --> 00:43:12,910
interesting is it an advantage or a

1125
00:43:18,390 --> 00:43:15,880
disadvantage for us to understand the

1126
00:43:20,730 --> 00:43:18,400
diversity of life on earth when we're in

1127
00:43:23,880 --> 00:43:20,740
this quest to understand or to find life

1128
00:43:26,850 --> 00:43:23,890
elsewhere I I have to think it's an

1129
00:43:29,910 --> 00:43:26,860
advantage you know if we we you know we

1130
00:43:31,980 --> 00:43:29,920
we are limited by the fact that we we

1131
00:43:33,690 --> 00:43:31,990
likely have one origin of life to work

1132
00:43:35,640 --> 00:43:33,700
with in our solar system as the origin

1133
00:43:38,460 --> 00:43:35,650
on on earth perhaps we have other

1134
00:43:39,840 --> 00:43:38,470
origins in the future when we probe the

1135
00:43:43,050 --> 00:43:39,850
subsurface of Mars with the subsurface

1136
00:43:45,240 --> 00:43:43,060
of Europa Enceladus but for now we have

1137
00:43:47,609 --> 00:43:45,250
one origin of life and we have all the

1138
00:43:49,380 --> 00:43:47,619

permutations that life has taken but

1139
00:43:52,440 --> 00:43:49,390
there is a concept called convergent

1140
00:43:54,390 --> 00:43:52,450
evolution that's existent it exists in

1141
00:43:55,830 --> 00:43:54,400
multiple clades that are relatively

1142
00:43:58,410 --> 00:43:55,840
unrelated on earth although they do

1143
00:44:00,450 --> 00:43:58,420
share a common origin they independently

1144
00:44:02,820 --> 00:44:00,460
evolved the same either metabolism or

1145
00:44:05,340 --> 00:44:02,830
the same adaptation the same morphology

1146
00:44:07,050 --> 00:44:05,350
to meet the same problem and so

1147
00:44:08,640 --> 00:44:07,060
understanding the diversity of life on

1148
00:44:10,620 --> 00:44:08,650
earth does give us a huge amount of

1149
00:44:12,140 --> 00:44:10,630
information about the possibilities for

1150
00:44:15,240 --> 00:44:12,150
life elsewhere because we do believe

1151
00:44:17,040 --> 00:44:15,250
physical chemical conditions that

1152
00:44:20,910 --> 00:44:17,050
existed on early Earth will exist

1153
00:44:21,900 --> 00:44:20,920
elsewhere in our universe yeah it seems

1154
00:44:24,960 --> 00:44:21,910
like you know convergent evolution

1155
00:44:27,270 --> 00:44:24,970
should lead to some similar things if

1156
00:44:28,590 --> 00:44:27,280
there is life out there but maybe not

1157
00:44:30,420 --> 00:44:28,600
exactly you know what we see in movies

1158
00:44:31,770 --> 00:44:30,430
right with with two arms two legs you

1159
00:44:35,040 --> 00:44:31,780
know two eyes that kind of thing but

1160
00:44:38,160 --> 00:44:35,050
maybe arms or fins or wings are common

1161
00:44:41,310 --> 00:44:38,170
for some work isms we have a question

1162
00:44:43,770 --> 00:44:41,320
from Austin Dieng on Facebook Austin

1163
00:44:45,480 --> 00:44:43,780

wants to know what methods do we do we

1164
00:44:50,820 --> 00:44:45,490
have to distinguish bio signatures that

1165
00:44:52,800 --> 00:44:50,830
are not a biotic Lea produced yeah so so

1166
00:44:56,460 --> 00:44:52,810
one is one is to fingerprint the abiotic

1167
00:44:57,720 --> 00:44:56,470
process so so if we think that it's from

1168
00:44:59,640 --> 00:44:57,730
this a photo chemistry there breaking

1169
00:45:01,590 --> 00:44:59,650
apart of say the co2 molecule into

1170
00:45:02,430 --> 00:45:01,600
oxygen and carbon monoxide we'd expect

1171
00:45:04,680 --> 00:45:02,440
there to be a lot of carbon monoxide

1172
00:45:06,930 --> 00:45:04,690
alongside that abiotic oxygen so that's

1173
00:45:09,030 --> 00:45:06,940
one idea that you could fingerprint the

1174
00:45:09,650 --> 00:45:09,040
abiotic process another idea is that if

1175
00:45:11,270 --> 00:45:09,660
you have a mass

1176
00:45:12,589 --> 00:45:11,280
the oxygen atmosphere from this runaway

1177
00:45:14,029 --> 00:45:12,599
process I mentioned earlier where the

1178
00:45:15,500 --> 00:45:14,039
hydrogen all escapes the oxygen is left

1179
00:45:17,809 --> 00:45:15,510
behind you probably would end up

1180
00:45:20,510 --> 00:45:17,819
actually with a lot more oxygen if you

1181
00:45:22,900 --> 00:45:20,520
were left with any then then exists on

1182
00:45:26,240 --> 00:45:22,910
earth today and and oxygen has these

1183
00:45:27,829 --> 00:45:26,250
molecular features that only are only

1184
00:45:29,299 --> 00:45:27,839
strong when when when the oxygen

1185
00:45:30,859 --> 00:45:29,309
abundance is very high because they're

1186
00:45:33,170 --> 00:45:30,869
due to collisions between oxygen

1187
00:45:34,970 --> 00:45:33,180
molecules so that's one way is to

1188
00:45:37,640 --> 00:45:34,980

fingerprint the abiotic process another

1189
00:45:40,339 --> 00:45:37,650
way is to look for the disequilibrium as

1190
00:45:41,990 --> 00:45:40,349
I mentioned so that you would not expect

1191
00:45:44,809 --> 00:45:42,000
the co-occurrence of certain gases

1192
00:45:47,150 --> 00:45:44,819
together the fact that Earth today has

1193
00:45:50,089 --> 00:45:47,160
oxygen ozone yes but also methane and

1194
00:45:52,670 --> 00:45:50,099
nitrous oxide is indicative of this

1195
00:45:54,440 --> 00:45:52,680
non-equilibrium process that's driving

1196
00:45:55,970 --> 00:45:54,450
that's life that's driving the

1197
00:45:57,559 --> 00:45:55,980
disability program between the gases

1198
00:45:59,630 --> 00:45:57,569
additionally we have something called

1199
00:46:02,510 --> 00:45:59,640
the vegetation red edge on on earth

1200
00:46:04,670 --> 00:46:02,520
which is this contrast between a

1201
00:46:07,180 --> 00:46:04,680
chlorophyll absorption at visible

1202
00:46:08,900 --> 00:46:07,190
wavelengths and very reflective

1203
00:46:11,240 --> 00:46:08,910
vegetation at near-infrared wavelengths

1204
00:46:13,700 --> 00:46:11,250
it's used this effect is used to map

1205
00:46:15,680 --> 00:46:13,710
vegetation on earth it exists in the

1206
00:46:18,200 --> 00:46:15,690
discourage of our planet to some extent

1207
00:46:19,849 --> 00:46:18,210
and it's another tool in the toolbox

1208
00:46:21,920 --> 00:46:19,859
potentially for fingerprinting

1209
00:46:24,109 --> 00:46:21,930
biospheres on other planets we don't

1210
00:46:26,779 --> 00:46:24,119
necessarily expect that to be the same

1211
00:46:29,990 --> 00:46:26,789
on on on other planets but it could be

1212
00:46:31,910 --> 00:46:30,000
there could be a similar signature where

1213
00:46:34,730 --> 00:46:31,920

you have this spectral break between

1214
00:46:37,400 --> 00:46:34,740
absorption and reflection that indicates

1215
00:46:38,900 --> 00:46:37,410
a biological pigment and so what we

1216
00:46:42,289 --> 00:46:38,910
really want to see is this multiple

1217
00:46:44,180 --> 00:46:42,299
lines of evidence that converge on the

1218
00:46:45,890 --> 00:46:44,190
bio signature interpretation so we rule

1219
00:46:47,510 --> 00:46:45,900
out the abiotic processes and then we

1220
00:46:51,589 --> 00:46:47,520
rule in the biology by looking for the

1221
00:46:54,289 --> 00:46:51,599
disk equilibrium on that so you know we

1222
00:46:56,180 --> 00:46:54,299
started off this episode with that image

1223
00:46:58,279 --> 00:46:56,190
of Lake Hillier being that bubblegum

1224
00:47:00,589 --> 00:46:58,289
pink coloration from this organism that

1225
00:47:02,990 --> 00:47:00,599
produces carotenoids you know these

1226
00:47:04,849 --> 00:47:03,000
these pigments I wonder you know just

1227
00:47:06,529 --> 00:47:04,859
for fun do you think we're going to

1228
00:47:09,109 --> 00:47:06,539
we're going to see out there in the

1229
00:47:11,930 --> 00:47:09,119
cosmos a bunch of planets that have like

1230
00:47:13,670 --> 00:47:11,940
weird colorations to them because of an

1231
00:47:15,799 --> 00:47:13,680
abundance of organisms producing

1232
00:47:17,900 --> 00:47:15,809
pigments like that yeah I mean that's

1233
00:47:20,180 --> 00:47:17,910
one one possibility is that there are

1234
00:47:21,680 --> 00:47:20,190
pigments that are that it's not just you

1235
00:47:24,350 --> 00:47:21,690
know green chlorophyll pigments

1236
00:47:26,480 --> 00:47:24,360
out there and so the there's there's a

1237
00:47:27,890 --> 00:47:26,490
den under Nellie Ella algae that

1238
00:47:30,350 --> 00:47:27,900

produced the carotenoid pigments and

1239
00:47:35,090 --> 00:47:30,360
then are also archaea that have pigments

1240
00:47:38,090 --> 00:47:35,100
like bacteria Ribera barren and and and

1241
00:47:41,990 --> 00:47:38,100
up since rhodopsins are kind of pigment

1242
00:47:45,380 --> 00:47:42,000
that generates energy from from the Sun

1243
00:47:47,990 --> 00:47:45,390
but is not a chlorophyll so it's driving

1244
00:47:50,450 --> 00:47:48,000
the production of energy by creating

1245
00:47:51,920 --> 00:47:50,460
this proton gradient that then drives

1246
00:47:54,020 --> 00:47:51,930
the production of ATP which is the

1247
00:47:55,280 --> 00:47:54,030
energy currency of a cell right now we

1248
00:47:57,380 --> 00:47:55,290
don't know of any organism that uses

1249
00:47:59,180 --> 00:47:57,390
this rhodopsin pigment to fix carbon but

1250
00:48:00,950 --> 00:47:59,190
it can make energy and so you might

1251
00:48:02,510 --> 00:48:00,960
imagine that there are other organisms

1252
00:48:04,310 --> 00:48:02,520
out there in the universe that are using

1253
00:48:06,080 --> 00:48:04,320
similar pigments to generate energy and

1254
00:48:08,750 --> 00:48:06,090
perhaps they'll have a spectral impact

1255
00:48:11,450 --> 00:48:08,760
on their planet be so cool to find a

1256
00:48:13,370 --> 00:48:11,460
pink world or a purple world or you know

1257
00:48:15,830 --> 00:48:13,380
other colorations besides our little

1258
00:48:18,830 --> 00:48:15,840
blue marble we have a question from

1259
00:48:20,090 --> 00:48:18,840
Satyam Tiwari on second net and this

1260
00:48:22,100 --> 00:48:20,100
kind of goes back to we were discussing

1261
00:48:23,540 --> 00:48:22,110
you know with conditions of life here on

1262
00:48:24,800 --> 00:48:23,550
earth and this idea of convergent

1263
00:48:26,860 --> 00:48:24,810

evolution leading to some things that

1264
00:48:29,690 --> 00:48:26,870
are similar but also being different

1265
00:48:32,030 --> 00:48:29,700
saaaam wants to know would life on

1266
00:48:36,160 --> 00:48:32,040
exoplanets evolve in similar conditions

1267
00:48:40,250 --> 00:48:36,170
or chemistry's as we find on earth today

1268
00:48:42,260 --> 00:48:40,260
well yes so so the earth today has a

1269
00:48:44,600 --> 00:48:42,270
wide variety of environments and so this

1270
00:48:46,190 --> 00:48:44,610
speaks speaks to one of the previous

1271
00:48:47,810 --> 00:48:46,200
questions that we have we have

1272
00:48:50,120 --> 00:48:47,820
environments that are low in pH that are

1273
00:48:51,740 --> 00:48:50,130
high in PSO acid and alkaline and high

1274
00:48:53,120 --> 00:48:51,750
in salt and low in salt and high in

1275
00:48:55,400 --> 00:48:53,130
temperature and low in temperature and

1276
00:48:56,570 --> 00:48:55,410
so we have this huge menu of

1277
00:48:58,700 --> 00:48:56,580
environments on earth that life is

1278
00:49:00,260 --> 00:48:58,710
adapted to and we believe that that

1279
00:49:02,450 --> 00:49:00,270
diversity is going to be recapitulated

1280
00:49:05,120 --> 00:49:02,460
on exoplanets that there will be a wide

1281
00:49:07,640 --> 00:49:05,130
diversity of environments and niches for

1282
00:49:09,530 --> 00:49:07,650
for life and so studying these

1283
00:49:11,360 --> 00:49:09,540
environments is really critical both to

1284
00:49:13,190 --> 00:49:11,370
understanding the history of life on

1285
00:49:14,600 --> 00:49:13,200
Earth where certain niche environments

1286
00:49:17,180 --> 00:49:14,610
today might have actually dominated in

1287
00:49:19,400 --> 00:49:17,190
the past to extrapolating those two to

1288
00:49:21,830 --> 00:49:19,410

other planets where where again the

1289
00:49:23,300 --> 00:49:21,840
conditions may be more similar to what

1290
00:49:25,430 --> 00:49:23,310
are in each conditions today or what are

1291
00:49:28,640 --> 00:49:25,440
more similar to ancient conditions in

1292
00:49:30,770 --> 00:49:28,650
the Earth's ancient past mmm that's

1293
00:49:32,150 --> 00:49:30,780
awesome I do want to so we are getting

1294
00:49:34,280 --> 00:49:32,160
close to the hour now

1295
00:49:36,290 --> 00:49:34,290
I think thank you to everyone who asked

1296
00:49:37,849 --> 00:49:36,300
questions I am gonna pick one of the

1297
00:49:39,830 --> 00:49:37,859
questions that remains yet as my

1298
00:49:40,640 --> 00:49:39,840
favorite one to ask this one comes from

1299
00:49:43,310 --> 00:49:40,650
my co-host

1300
00:49:46,130 --> 00:49:43,320
Sanjoy on sega nets and really wants to

1301
00:49:48,800 --> 00:49:46,140
know dr. speedermen how do you balance

1302
00:49:51,950 --> 00:49:48,810
the demands of science with raising a

1303
00:49:54,920 --> 00:49:51,960
young family right the great question

1304
00:49:57,380 --> 00:49:54,930
saundra yes I have I have two sons one

1305
00:50:00,349 --> 00:49:57,390
one was just born last month and one is

1306
00:50:03,349 --> 00:50:00,359
two and a half years old and and an

1307
00:50:05,630 --> 00:50:03,359
intelligent and lovely partner and so

1308
00:50:08,090 --> 00:50:05,640
and so yeah I think I think it's

1309
00:50:12,230 --> 00:50:08,100
incredibly important to prioritize your

1310
00:50:13,820 --> 00:50:12,240
family I love spending time with my kids

1311
00:50:17,150 --> 00:50:13,830
and playing with my kids and and they'll

1312
00:50:19,760 --> 00:50:17,160
always always come first for me but I

1313
00:50:21,920 --> 00:50:19,770

think I see I see is kind of my

1314
00:50:24,500 --> 00:50:21,930
responsibility to instill the Wonder in

1315
00:50:27,470 --> 00:50:24,510
my kids that I feel for my science and

1316
00:50:29,330 --> 00:50:27,480
that also my parents helped me with and

1317
00:50:32,270 --> 00:50:29,340
we are all kind of this continuation

1318
00:50:34,490 --> 00:50:32,280
we're all part of the same universe and

1319
00:50:36,140 --> 00:50:34,500
so understanding that and helping my

1320
00:50:38,750 --> 00:50:36,150
kids understand that in the future is

1321
00:50:40,310 --> 00:50:38,760
really important to me that we can all

1322
00:50:41,810 --> 00:50:40,320
share in this beautiful universe that we

1323
00:50:44,930 --> 00:50:41,820
live in where we can think about finding

1324
00:50:46,400 --> 00:50:44,940
life elsewhere and and I and and and and

1325
00:50:48,580 --> 00:50:46,410
this is all to say that everything is

1326
00:50:52,220 --> 00:50:48,590
related you know if you have to bring

1327
00:50:55,400 --> 00:50:52,230
compassion and love into your job and in

1328
00:50:57,890 --> 00:50:55,410
and into raising your family not

1329
00:50:59,510 --> 00:50:57,900
beautiful Eddie thank you so much for

1330
00:51:02,210 --> 00:50:59,520
joining us it's been great having you on

1331
00:51:04,849 --> 00:51:02,220
the show for everyone watching here's a

1332
00:51:06,530 --> 00:51:04,859
little call for action for all of you so

1333
00:51:09,170 --> 00:51:06,540
with upcoming missions now for looking

1334
00:51:10,010 --> 00:51:09,180
for signs of life in our solar system as

1335
00:51:12,230 --> 00:51:10,020
well as some of these upcoming

1336
00:51:14,349 --> 00:51:12,240
next-generation and telescopes that dr.

1337
00:51:16,880 --> 00:51:14,359
Street Irma mentioned during our episode

1338
00:51:19,580 --> 00:51:16,890

do you think we're most likely going to

1339
00:51:23,060 --> 00:51:19,590
find life on a world in our solar system

1340
00:51:24,349 --> 00:51:23,070
or from an exoplanet first and if you

1341
00:51:26,599 --> 00:51:24,359
have any thoughts on that feel free to

1342
00:51:31,960 --> 00:51:26,609
discuss amongst yourselves or you can

1343
00:51:36,890 --> 00:51:34,940
astrobiologist and use hashtag ask aster

1344
00:51:38,530 --> 00:51:36,900
bio on Twitter I get involved in the

1345
00:51:41,270 --> 00:51:38,540
conversation we'd love to have more

1346
00:51:42,540 --> 00:51:41,280
conversations with you Eddie thank you

1347
00:51:44,940 --> 00:51:42,550
so much for joining us thank

1348
00:51:47,220 --> 00:51:44,950
so much Graham it's great to be here and

1349
00:51:51,360 --> 00:51:47,230
for everyone watching right now Mike's

1350
00:51:53,940 --> 00:51:51,370
gonna bring up on to the display for you

1351
00:51:57,030 --> 00:51:53,950
to see how to subscribe to the email

1352
00:52:00,060 --> 00:51:57,040
list for NASA Astrobiology to loop into

1353
00:52:02,580 --> 00:52:00,070
upcoming episodes and more info and so

1354
00:52:03,690 --> 00:52:02,590
you can see that right now and then you

1355
00:52:08,210 --> 00:52:03,700
know to all of you thank you for joining

1356
00:52:48,810 --> 00:52:08,220
and as always remember stay curious