The Search for Life: Near & Far

Shawn Domagal-Goldman

Georgia Tech Astrobiology

1
00:00:12,830 --> 00:00:11,120
a lot of times kids ask me about like

2
00:00:14,270 --> 00:00:12,840
you know how do you how did I decide to

3
00:00:16,010 --> 00:00:14,280
be an astrobiologist you know I tell

4
00:00:17,689 --> 00:00:16,020
them like I really loved it and I went

5
00:00:18,950 --> 00:00:17,699
into it full bore because of that and

6
00:00:20,300 --> 00:00:18,960
it's important like to find something

7
00:00:22,130 --> 00:00:20,310
you love to do for your life and I think

8
00:00:23,689 --> 00:00:22,140
we've heard that kind of advice the

9
00:00:25,910 --> 00:00:23,699
second thing I like to tell kids is find

10
00:00:27,620 --> 00:00:25,920
something you can do where you love the

11
00:00:28,910 --> 00:00:27,630
people you work with and and you know

12
00:00:30,980 --> 00:00:28,920
Ken dimension we're colleagues and

13
00:00:32,659 --> 00:00:30,990

friends and it means so much to me to

14
00:00:33,650 --> 00:00:32,669
have people across the country and

15
00:00:35,569 --> 00:00:33,660
across the world that I've been working

16
00:00:37,130 --> 00:00:35,579
with that I really respect and admire as

17
00:00:38,569 --> 00:00:37,140
people and his friends as well as

18
00:00:40,880 --> 00:00:38,579
colleagues so thank you Kenda for that

19
00:00:42,229 --> 00:00:40,890
introduction Thank You Iron Monger for

20
00:00:45,319 --> 00:00:42,239
having us here and thank you and Lana

21
00:00:47,450 --> 00:00:45,329
science tavern for letting me speak a

22
00:00:48,500 --> 00:00:47,460
little bit tonight I am Sean Donald

23
00:00:51,290 --> 00:00:48,510
Goldman if you want to hit me up on

24
00:00:53,299 --> 00:00:51,300
Twitter I'm at Sean D Goldman and I'll

25
00:00:56,330 --> 00:00:53,309
be talking about the the search for life

26
00:00:58,340 --> 00:00:56,340
tonight and I'll be talking about this

27
00:01:00,319 --> 00:00:58,350
from the context of all the places that

28
00:01:03,380 --> 00:01:00,329
NASA is planning to search for signs of

29
00:01:05,270 --> 00:01:03,390
aliens you know life beyond Earth over

30
00:01:08,510 --> 00:01:05,280
the span of our lifetimes right over the

31
00:01:10,039 --> 00:01:08,520
next twenty to thirty years and I'll be

32
00:01:14,210 --> 00:01:10,049
doing that from like the standpoint of

33
00:01:15,200 --> 00:01:14,220
Mars Europa Titan exoplanets and the

34
00:01:16,910 --> 00:01:15,210
thing I just want to point out is like

35
00:01:19,130 --> 00:01:16,920
I'm one person standing up on this stage

36
00:01:21,289 --> 00:01:19,140
but you almost have to imagine like an

37
00:01:22,490 --> 00:01:21,299
army of people behind me because the

38
00:01:23,929 --> 00:01:22,500

thoughts I'm putting out are coming from

39
00:01:26,240 --> 00:01:23,939
the the virtual planet lab which is

40
00:01:28,399 --> 00:01:26,250
located in Seattle Washington this is

41
00:01:30,440 --> 00:01:28,409
the the big science team that I'm

42
00:01:31,940 --> 00:01:30,450
helping lead out of NASA Goddard the hab

43
00:01:33,910 --> 00:01:31,950
X and loop are teams which are

44
00:01:36,080 --> 00:01:33,920
telescopes I might talk about later

45
00:01:38,359 --> 00:01:36,090
Nexus which is an international science

46
00:01:40,160 --> 00:01:38,369
collaboration Mars Science Lab which is

47
00:01:41,390 --> 00:01:40,170
more popularly known as curiosity that's

48
00:01:43,429 --> 00:01:41,400
the rover on Mars right now and of

49
00:01:44,389 --> 00:01:43,439
course the agency because you know this

50
00:01:46,700 --> 00:01:44,399
is one of those things where the

51
00:01:48,980 --> 00:01:46,710
problems are actually really hard to do

52
00:01:51,080 --> 00:01:48,990
like I really believe the smartest

53
00:01:52,819 --> 00:01:51,090
person in the world I don't think if

54
00:01:54,679 --> 00:01:52,829
Albert Einstein were alive he could do

55
00:01:55,880 --> 00:01:54,689
this science all by himself I think it

56
00:01:57,620 --> 00:01:55,890
actually takes a community of people

57
00:02:00,380 --> 00:01:57,630
where there's expertise spread out

58
00:02:01,910 --> 00:02:00,390
across different disciplines so but I

59
00:02:03,109 --> 00:02:01,920
look before I even get into that because

60
00:02:04,429 --> 00:02:03,119
a lot of times I think there's some

61
00:02:07,760 --> 00:02:04,439
confusion about what we're talking about

62
00:02:09,260 --> 00:02:07,770
when we say aliens right so I like to

63
00:02:10,639 --> 00:02:09,270

start with like this little story right

64
00:02:11,960 --> 00:02:10,649
I used to walk into a bar and someone

65
00:02:13,240 --> 00:02:11,970
would ask me if I was just sitting at a

66
00:02:16,060 --> 00:02:13,250
bar stool like what do you do for

67
00:02:19,990 --> 00:02:16,070
living and I used to say like I look for

68
00:02:22,450 --> 00:02:20,000
aliens right so I would do that but

69
00:02:26,160 --> 00:02:22,460
inevitably what would happen is they get

70
00:02:29,710 --> 00:02:27,760
keep going Mike

71
00:02:31,840 --> 00:02:29,720
yeah we're that that person or that

72
00:02:33,100 --> 00:02:31,850
thing or you know if you're from my

73
00:02:35,590 --> 00:02:33,110
generation this is what you had in your

74
00:02:36,940 --> 00:02:35,600
mind CODIS or King or et if you're from

75
00:02:37,960 --> 00:02:36,950
my generation as well right and actually

76
00:02:39,760 --> 00:02:37,970
which alien you're thinking it was

77
00:02:41,260 --> 00:02:39,770
probably like dating you a little bit so

78
00:02:43,150 --> 00:02:41,270
now I say I'll look for ways to look for

79
00:02:44,260 --> 00:02:43,160
life on other planets next slide and

80
00:02:45,520 --> 00:02:44,270
then people start to get something like

81
00:02:48,070 --> 00:02:45,530
this in their head which is much closer

82
00:02:49,360 --> 00:02:48,080
to the truth right because I work for

83
00:02:51,190 --> 00:02:49,370
the most part on the spacecraft and at

84
00:02:54,280 --> 00:02:51,200
NASA what we do is we turn the question

85
00:02:55,840 --> 00:02:54,290
of are we alone into something that like

86
00:02:57,310 --> 00:02:55,850
we take it out of the barroom right out

87
00:02:59,110 --> 00:02:57,320
of it and that's fun like I actually

88
00:03:00,310 --> 00:02:59,120

like speculating and like there's a lot

89
00:03:01,900 --> 00:03:00,320
of good science that starts in a bar

90
00:03:04,270 --> 00:03:01,910
where we're just like kicking ideas

91
00:03:07,720 --> 00:03:04,280
around over a beer or glass of wine or a

92
00:03:08,979 --> 00:03:07,730
soda but but taking it from that space

93
00:03:10,630 --> 00:03:08,989
into a place where we can apply the

94
00:03:13,630 --> 00:03:10,640
scientific method where I can make a

95
00:03:15,490 --> 00:03:13,640
prediction of something that's happening

96
00:03:16,990 --> 00:03:15,500
beyond earth that we could then build

97
00:03:18,850 --> 00:03:17,000
the spacecraft to make a measurement to

98
00:03:20,110 --> 00:03:18,860
test that prediction and that because

99
00:03:21,610 --> 00:03:20,120
that's how science works right we make a

100
00:03:23,289 --> 00:03:21,620
prediction we tested with observation

101
00:03:24,729 --> 00:03:23,299
and if our predictions are wrong we

102
00:03:27,060 --> 00:03:24,739
refine our models and our theories to

103
00:03:30,460 --> 00:03:27,070
make a new prediction for somewhere else

104
00:03:32,050 --> 00:03:30,470
so this is this is this takes me back

105
00:03:33,550 --> 00:03:32,060
like about 20 years and this goes back

106
00:03:34,960 --> 00:03:33,560
to this story of like how I decided to

107
00:03:37,240 --> 00:03:34,970
be an astrobiologist in the first place

108
00:03:38,979 --> 00:03:37,250
I grew up in Chicago and so like here

109
00:03:40,210 --> 00:03:38,989
you know you can't necessarily do much

110
00:03:42,940 --> 00:03:40,220
astronomy right like there's too much

111
00:03:44,140 --> 00:03:42,950
light pollution and one night so we

112
00:03:45,160 --> 00:03:44,150
usually couldn't see the stars we

113
00:03:46,210 --> 00:03:45,170

couldn't we definitely couldn't see the

114
00:03:47,920 --> 00:03:46,220
Milky Way like you can see in this

115
00:03:49,720 --> 00:03:47,930
beautiful image but one night there was

116
00:03:51,789 --> 00:03:49,730
a lunar eclipse and I remember standing

117
00:03:53,140 --> 00:03:51,799
on the front yard with my with my little

118
00:03:54,550 --> 00:03:53,150
brother we I was in college at the time

119
00:03:55,870 --> 00:03:54,560
and I was you know figuring out what I

120
00:03:57,400 --> 00:03:55,880
wanted to do with the rest of my life I

121
00:03:58,900 --> 00:03:57,410
call that like the quarter life crisis

122
00:04:00,880 --> 00:03:58,910
when you're figuring out like what am I

123
00:04:02,199 --> 00:04:00,890
gonna do the rest of my life so I was I

124
00:04:03,610 --> 00:04:02,209
was sitting on the front yard during a

125
00:04:05,229 --> 00:04:03,620
lunar eclipse so we could actually see

126
00:04:07,750 --> 00:04:05,239
the stars for a change my brother turned

127
00:04:10,630 --> 00:04:07,760
to me and he said you think there's

128
00:04:13,030 --> 00:04:10,640
anybody out there and I like it like hit

129
00:04:14,680 --> 00:04:13,040
me cuz I was like yeah I don't know but

130
00:04:16,840 --> 00:04:14,690
that sounds like a pretty cool problem

131
00:04:18,460 --> 00:04:16,850
to address or look to tackle and so I

132
00:04:19,780 --> 00:04:18,470
started looking into like places I could

133
00:04:21,330 --> 00:04:19,790
do that for research or for grad school

134
00:04:25,400 --> 00:04:21,340
and that led me down a path to being an

135
00:04:27,080 --> 00:04:25,410
astrobiologist alright so

136
00:04:28,460 --> 00:04:27,090
I'm not the first astrobiologist I'm

137
00:04:30,080 --> 00:04:28,470
hopefully not the last astrobiologist

138
00:04:32,390 --> 00:04:30,090

we've actually been doing at NASA search

139
00:04:34,010 --> 00:04:32,400
a search for life around on planets

140
00:04:36,830 --> 00:04:34,020
beyond Earth for a long time actually

141
00:04:38,570 --> 00:04:36,840
the first explicit experiment in this in

142
00:04:40,190 --> 00:04:38,580
this space was done by the Viking rover

143
00:04:41,810 --> 00:04:40,200
decades ago rather Viking Lander I

144
00:04:43,760 --> 00:04:41,820
should say decades ago right so this is

145
00:04:47,630 --> 00:04:43,770
a paper if you can't see you from the

146
00:04:49,370 --> 00:04:47,640
back from 1976 and the this is from a

147
00:04:50,630 --> 00:04:49,380
specific measurement called the radiant

148
00:04:52,760 --> 00:04:50,640
and there's no data on here yet I'll

149
00:04:54,770 --> 00:04:52,770
show it in a second this is this is from

150
00:04:57,320 --> 00:04:54,780
and this is how we turn a theory that

151
00:04:59,360 --> 00:04:57,330
there's life on Mars into a testable

152
00:05:01,100 --> 00:04:59,370
observation the theory was like if

153
00:05:03,410 --> 00:05:01,110
there's life on Mars maybe it's it's

154
00:05:05,240 --> 00:05:03,420
starved for food so we're gonna do is

155
00:05:07,700 --> 00:05:05,250
we're gonna pick up some Martian soil

156
00:05:09,260 --> 00:05:07,710
we're gonna put it into the lander and

157
00:05:10,490 --> 00:05:09,270
then once it's in the lander we're gonna

158
00:05:11,840 --> 00:05:10,500
heat it up a little bit and we're gonna

159
00:05:13,400 --> 00:05:11,850
give it some food we're gonna give it

160
00:05:15,020 --> 00:05:13,410
some nutrients and stuff like that and

161
00:05:16,790 --> 00:05:15,030
we made those nutrients

162
00:05:18,980 --> 00:05:16,800
radioactively-labeled and the reason we

163
00:05:20,570 --> 00:05:18,990

did that is it would become very easy to

164
00:05:21,560 --> 00:05:20,580
detect the gases that the life would

165
00:05:23,030 --> 00:05:21,570
give off if they were radioactive

166
00:05:24,950 --> 00:05:23,040
because you can see radioactive stuff

167
00:05:26,300 --> 00:05:24,960
really easily with an instrument and

168
00:05:27,860 --> 00:05:26,310
this the the what I'm going to show you

169
00:05:29,360 --> 00:05:27,870
in a second is data from the instrument

170
00:05:31,610 --> 00:05:29,370
where if there's radioactivity you'll

171
00:05:33,880 --> 00:05:31,620
see it go up over time when we introduce

172
00:05:36,800 --> 00:05:33,890
the food with the radioactively-labeled

173
00:05:38,180 --> 00:05:36,810
food in there right alright so next

174
00:05:40,160 --> 00:05:38,190
slide let's see what the data look like

175
00:05:41,840 --> 00:05:40,170
the prediction it was exactly what

176
00:05:43,820 --> 00:05:41,850
happened you put the food and right here

177
00:05:46,040 --> 00:05:43,830
and all a sudden we saw this spike in

178
00:05:48,140 --> 00:05:46,050
radioactivity from the the presumably

179
00:05:49,850 --> 00:05:48,150
the microbes living in the soil munching

180
00:05:51,860 --> 00:05:49,860
on that food turning it into gas just

181
00:05:53,090 --> 00:05:51,870
like we're turning food into gas in our

182
00:05:55,190 --> 00:05:53,100
stomachs right now and releasing it as

183
00:05:58,010 --> 00:05:55,200
carbon dioxide they saw that spike in

184
00:05:59,600 --> 00:05:58,020
radioactivity and and the the person

185
00:06:02,060 --> 00:05:59,610
that led this experiment Gil Levin and

186
00:06:04,370 --> 00:06:02,070
his colleague Patricia strap to this day

187
00:06:05,900 --> 00:06:04,380
they will not just tell you they would

188
00:06:07,310 --> 00:06:05,910

get in a shouting match with me to say

189
00:06:09,320 --> 00:06:07,320
that they're the first person the first

190
00:06:12,650 --> 00:06:09,330
group to find evidence of life beyond

191
00:06:13,940 --> 00:06:12,660
Earth now for me that coming in

192
00:06:16,430 --> 00:06:13,950
astrobiology now this is actually a

193
00:06:17,840 --> 00:06:16,440
cautionary tale because not the majority

194
00:06:19,670 --> 00:06:17,850
of the astrobiology community does not

195
00:06:21,650 --> 00:06:19,680
accept this as definitive proof of life

196
00:06:23,330 --> 00:06:21,660
and the reason is it's not that this

197
00:06:25,700 --> 00:06:23,340
experiment in and of itself was a

198
00:06:26,990 --> 00:06:25,710
failure it's that the story is much more

199
00:06:28,340 --> 00:06:27,000
complicated than that

200
00:06:30,050 --> 00:06:28,350
there were three other experiments

201
00:06:32,090 --> 00:06:30,060
onboard that same lander at the same

202
00:06:33,529 --> 00:06:32,100
time and even though this had a positive

203
00:06:35,000 --> 00:06:33,539
result the others all had negative

204
00:06:36,980 --> 00:06:35,010
results and there was a fourth

205
00:06:38,840 --> 00:06:36,990
experiment and that was looking for

206
00:06:39,380 --> 00:06:38,850
carbon organic carbon in the Martian

207
00:06:40,940 --> 00:06:39,390
soil

208
00:06:42,380 --> 00:06:40,950
and it found there was no organic carbon

209
00:06:44,030 --> 00:06:42,390
in that soil to begin with which is the

210
00:06:45,230 --> 00:06:44,040
stuff that we're all made of so if you

211
00:06:46,670 --> 00:06:45,240
don't have the stuff life is made of it

212
00:06:49,220 --> 00:06:46,680
was really hard to argue that there was

213
00:06:50,420 --> 00:06:49,230

life there and now I know some people

214
00:06:51,680 --> 00:06:50,430
are quite thinking what about the weird

215
00:06:53,810 --> 00:06:51,690
stuff that's not made of organic carbon

216
00:06:55,790 --> 00:06:53,820
we'll get into that later but the main

217
00:06:56,930 --> 00:06:55,800
message here is like it's eat and

218
00:06:59,030 --> 00:06:56,940
actually go to the next slide because

219
00:07:00,560 --> 00:06:59,040
I've got a few examples of this we've

220
00:07:02,840 --> 00:07:00,570
declared that we've found life before

221
00:07:04,130 --> 00:07:02,850
and we've been wrong or at least the

222
00:07:05,840 --> 00:07:04,140
astrobiology community hasn't been

223
00:07:07,520 --> 00:07:05,850
convinced yet despite a safer way to say

224
00:07:09,080 --> 00:07:07,530
it so this is a picture of some

225
00:07:10,310 --> 00:07:09,090
scientists down in Antarctica what

226
00:07:12,080 --> 00:07:10,320
they're doing is they're there they're

227
00:07:14,510 --> 00:07:12,090
hunting for meteorites the reason they

228
00:07:16,340 --> 00:07:14,520
do this in in Antarctica is meteorites

229
00:07:17,840 --> 00:07:16,350
are dark rocks and Antarctica is like

230
00:07:19,550 --> 00:07:17,850
super bright because it's covered in ice

231
00:07:21,200 --> 00:07:19,560
and snow and so the rocks stand out

232
00:07:23,930 --> 00:07:21,210
really really easily and they can find

233
00:07:26,570 --> 00:07:23,940
them so next slide Mike so they're find

234
00:07:31,160 --> 00:07:26,580
these rocks also this is about 20 years

235
00:07:32,300 --> 00:07:31,170
ago in 1997 29 86 1997 David McKay and

236
00:07:34,070 --> 00:07:32,310
colleagues came out with this does

237
00:07:35,570 --> 00:07:34,080
anyone remember this picture from about

238
00:07:36,590 --> 00:07:35,580

20 years ago so this is the Allan Hills

239
00:07:39,140 --> 00:07:36,600
meteorite this is one of those

240
00:07:40,370 --> 00:07:39,150
meteorites they found in Antarctica they

241
00:07:42,470 --> 00:07:40,380
brought it back to the labs here in the

242
00:07:44,180 --> 00:07:42,480
United States and they analyzed them and

243
00:07:46,880 --> 00:07:44,190
they found multiple evidence of multiple

244
00:07:48,680 --> 00:07:46,890
lines of evidence that there was a life

245
00:07:50,840 --> 00:07:48,690
in this rock and the luck that that life

246
00:07:52,520 --> 00:07:50,850
was so ancient it actually took place

247
00:07:54,320 --> 00:07:52,530
when that rock was still on Mars because

248
00:07:56,300 --> 00:07:54,330
this particular meteorite originated on

249
00:07:58,370 --> 00:07:56,310
Mars and and they published a paper

250
00:08:00,260 --> 00:07:58,380
saying that we have evidence that life

251
00:08:01,880 --> 00:08:00,270
was there this rock was on the surface I

252
00:08:04,280 --> 00:08:01,890
got a check did buy to me a meteorite

253
00:08:05,870 --> 00:08:04,290
hurtled across space and then landed in

254
00:08:07,280 --> 00:08:05,880
Antarctica where we found it brought it

255
00:08:09,860 --> 00:08:07,290
to our labs and found found this

256
00:08:12,410 --> 00:08:09,870
evidence of life next slide and it

257
00:08:14,030 --> 00:08:12,420
included these these structures here and

258
00:08:15,890 --> 00:08:14,040
then what that kicked off was a lot of

259
00:08:17,570 --> 00:08:15,900
thinking about what you know could we

260
00:08:19,790 --> 00:08:17,580
make those structures those those things

261
00:08:21,200 --> 00:08:19,800
that look a lot like life right and back

262
00:08:22,370 --> 00:08:21,210
before the McKay it all work

263
00:08:24,890 --> 00:08:22,380

where they claimed to Alan Hills

264
00:08:26,660 --> 00:08:24,900
meteorite had life the the the story of

265
00:08:28,910 --> 00:08:26,670
whether or not something was alive like

266
00:08:30,770 --> 00:08:28,920
our proof as scientists was something

267
00:08:32,180 --> 00:08:30,780
like the Supreme Court's definition of

268
00:08:35,630 --> 00:08:32,190
pornography which is we'll know it when

269
00:08:37,130 --> 00:08:35,640
we see it right but it turns out like

270
00:08:39,260 --> 00:08:37,140
does that look like life that last slide

271
00:08:41,240 --> 00:08:39,270
this looks like life and this looks like

272
00:08:43,219 --> 00:08:41,250
life right if I saw this I'd be like

273
00:08:46,010 --> 00:08:43,229
yeah I know what that is not pornography

274
00:08:48,360 --> 00:08:46,020
say that selves right

275
00:08:51,210 --> 00:08:48,370
they are naked though so you know who

276
00:08:52,920 --> 00:08:51,220
knows but actually these aren't cells

277
00:08:55,020 --> 00:08:52,930
these are mineralogical features that

278
00:08:56,010 --> 00:08:55,030
were made explicitly to try to recreate

279
00:08:57,870 --> 00:08:56,020
some of the structures that look

280
00:09:01,620 --> 00:08:57,880
extremely creepy crawly and lifelike

281
00:09:02,730 --> 00:09:01,630
next slide all right and if you think

282
00:09:03,870 --> 00:09:02,740
I'm picking on the Martians because

283
00:09:05,940 --> 00:09:03,880
those for both Martian stories this

284
00:09:07,230 --> 00:09:05,950
actually also happens on earth right if

285
00:09:08,700 --> 00:09:07,240
you look in the in the literature if

286
00:09:11,370 --> 00:09:08,710
like the oldest evidence of life on

287
00:09:13,530 --> 00:09:11,380
Earth there is these these micro fossils

288
00:09:16,140 --> 00:09:13,540

or were argued to be micro fossils from

289
00:09:18,000 --> 00:09:16,150
like over 3 billion years ago and this

290
00:09:19,620 --> 00:09:18,010
if you ever have a scientist that's

291
00:09:21,630 --> 00:09:19,630
learning about like scientific debate

292
00:09:22,770 --> 00:09:21,640
like have them research like the the

293
00:09:24,780 --> 00:09:22,780
earliest evidence for life on Earth

294
00:09:29,820 --> 00:09:24,790
because it's like super contentious next

295
00:09:31,920 --> 00:09:29,830
slide and I'm highlighting this here

296
00:09:34,230 --> 00:09:31,930
mostly to get it one word if you can't

297
00:09:36,600 --> 00:09:34,240
read it in the back it's this one Dubiel

298
00:09:38,250 --> 00:09:36,610
fossils writes um this was a response to

299
00:09:40,380 --> 00:09:38,260
that lat to those those fossils I was

300
00:09:42,480 --> 00:09:40,390
showing another scientist is this is the

301
00:09:43,620 --> 00:09:42,490
equivalent of like scientist swearing at

302
00:09:45,420 --> 00:09:43,630
each other in the literature right

303
00:09:47,040 --> 00:09:45,430
because they won't they won't say you're

304
00:09:48,390 --> 00:09:47,050
like full of whatever right but they

305
00:09:52,080 --> 00:09:48,400
will say I think your fossils are

306
00:09:53,760 --> 00:09:52,090
actually do the apostles next slide all

307
00:09:57,870 --> 00:09:53,770
right so here's here's the main points

308
00:10:00,360 --> 00:09:57,880
from all that okay I can imagine a lot

309
00:10:01,920 --> 00:10:00,370
of things that life does and then I

310
00:10:03,540 --> 00:10:01,930
could set up an instrument to go and

311
00:10:05,070 --> 00:10:03,550
look for the stuff that life does right

312
00:10:08,370 --> 00:10:05,080
whether it's making a certain gas

313
00:10:10,370 --> 00:10:08,380

whether it's some microbial some in a

314
00:10:12,420 --> 00:10:10,380
shape feature that looks like a microbe

315
00:10:13,530 --> 00:10:12,430
there's a lot of stuff that life does

316
00:10:16,080 --> 00:10:13,540
that I could build an instrument say

317
00:10:18,090 --> 00:10:16,090
find that thing that looks like life and

318
00:10:20,490 --> 00:10:18,100
the hard part is eliminating what we

319
00:10:22,770 --> 00:10:20,500
call abiotic processes things that are

320
00:10:26,010 --> 00:10:22,780
not life but that do things that mimic

321
00:10:26,910 --> 00:10:26,020
life and and the hard thing like the

322
00:10:28,260 --> 00:10:26,920
like if you want to get in the

323
00:10:29,940 --> 00:10:28,270
philosophy of like what our real

324
00:10:31,980 --> 00:10:29,950
challenge is as scientists looking for

325
00:10:33,960 --> 00:10:31,990
life beyond Earth is there's a balance

326
00:10:35,610 --> 00:10:33,970
here because this issue would make you

327
00:10:37,530 --> 00:10:35,620
say well let's just be really strict in

328
00:10:39,120 --> 00:10:37,540
art and what we're looking for but if

329
00:10:41,010 --> 00:10:39,130
we're too limited and too strict will

330
00:10:42,540 --> 00:10:41,020
will will also miss some weird stuff

331
00:10:44,250 --> 00:10:42,550
right like one of the questions I get is

332
00:10:45,810 --> 00:10:44,260
like you're talking about aliens like

333
00:10:47,280 --> 00:10:45,820
shouldn't you be expecting something

334
00:10:49,500 --> 00:10:47,290
weird and not just like what we have on

335
00:10:51,480 --> 00:10:49,510
earth so that would that would cause us

336
00:10:52,890 --> 00:10:51,490
to like expand our horizons or our

337
00:10:54,600 --> 00:10:52,900
expectations and our measurements a

338
00:10:56,070 --> 00:10:54,610

little bit but on the other hand we also

339
00:10:57,750 --> 00:10:56,080
want to make sure that we when we

340
00:10:59,100 --> 00:10:57,760
actually call the President and have a

341
00:10:59,380 --> 00:10:59,110
press conference about like whether or

342
00:11:00,910 --> 00:10:59,390
not we

343
00:11:02,470 --> 00:11:00,920
life are not beyond earth that we're

344
00:11:06,850 --> 00:11:02,480
right okay we don't want to be fake news

345
00:11:08,350 --> 00:11:06,860
okay all right so now that that's kind

346
00:11:10,600 --> 00:11:08,360
of like a history of our field like in

347
00:11:11,650 --> 00:11:10,610
its canal OTT of its contentious right

348
00:11:13,210 --> 00:11:11,660
and that's part of the scientific

349
00:11:15,100 --> 00:11:13,220
process to write scientists will put out

350
00:11:16,720 --> 00:11:15,110
something really big in the headlines

351
00:11:18,610 --> 00:11:16,730
like we found life on Mars or ancient

352
00:11:20,320 --> 00:11:18,620
life on earth like the oldest evidence

353
00:11:25,150 --> 00:11:20,330
of life on Earth and other scientists

354
00:11:27,040 --> 00:11:25,160
will say okay I hear you but that sounds

355
00:11:29,470 --> 00:11:27,050
pretty like bold to claim that let me

356
00:11:30,700 --> 00:11:29,480
look in like excruciating detail about

357
00:11:32,800 --> 00:11:30,710
what you actually published in your

358
00:11:34,960 --> 00:11:32,810
paper and I'm gonna think of a way to

359
00:11:37,810 --> 00:11:34,970
you know reinterpret your data because

360
00:11:39,760 --> 00:11:37,820
of this rationale and and that is

361
00:11:41,710 --> 00:11:39,770
something really now are carrying

362
00:11:42,970 --> 00:11:41,720
forward to our future searches for life

363
00:11:44,950 --> 00:11:42,980

we're being actually thoughtful in

364
00:11:47,500 --> 00:11:44,960
advance about these ways that

365
00:11:48,820 --> 00:11:47,510
non-biological processes could mimic the

366
00:11:50,590 --> 00:11:48,830
signals we're planning to build

367
00:11:51,730 --> 00:11:50,600
instruments to go and look for and then

368
00:11:53,500 --> 00:11:51,740
we're thinking well how can we use those

369
00:11:55,780 --> 00:11:53,510
instruments to separate out the like

370
00:11:57,430 --> 00:11:55,790
true living planets and environments

371
00:11:58,750 --> 00:11:57,440
versus the ones that are like I call

372
00:12:00,340 --> 00:11:58,760
them like zombie planets right they're

373
00:12:01,900 --> 00:12:00,350
dead but they look alive right so I want

374
00:12:04,000 --> 00:12:01,910
to be able to separate those things out

375
00:12:05,410 --> 00:12:04,010
okay so dune Mars ever have life this is

376
00:12:07,210 --> 00:12:05,420
now I'm going to sort of do a tour of

377
00:12:08,980 --> 00:12:07,220
the the places we're gonna look for for

378
00:12:10,930 --> 00:12:08,990
life beyond Earth and when we're looking

379
00:12:12,160 --> 00:12:10,940
for life on Mars we're talking about

380
00:12:13,420 --> 00:12:12,170
like looking it's kind of like that

381
00:12:15,010 --> 00:12:13,430
Allen Hills meteorite we're looking at

382
00:12:16,870 --> 00:12:15,020
the minerals on Mars we're looking at

383
00:12:18,670 --> 00:12:16,880
fossil structures maybe we're looking

384
00:12:19,780 --> 00:12:18,680
for the geochemistry like the chemicals

385
00:12:21,790 --> 00:12:19,790
that are in that environment

386
00:12:23,230 --> 00:12:21,800
eventually next slide we're not just

387
00:12:24,880 --> 00:12:23,240
gonna do this Institute so that's the

388
00:12:27,070 --> 00:12:24,890

Curiosity rover that that's an awesome

389
00:12:28,480 --> 00:12:27,080
vehicle the next step in this is

390
00:12:30,220 --> 00:12:28,490
actually not just sending a Rover to

391
00:12:32,080 --> 00:12:30,230
Mars but sending a little bit of Mars

392
00:12:34,090 --> 00:12:32,090
back to us right so we got that Allen

393
00:12:36,580 --> 00:12:34,100
Hills meteorite and one of the issues

394
00:12:38,050 --> 00:12:36,590
with meteorites is we never get them

395
00:12:39,130 --> 00:12:38,060
purely fresh right they're crashing

396
00:12:41,110 --> 00:12:39,140
through the Earth's atmosphere of the

397
00:12:42,400 --> 00:12:41,120
landing in Antarctica and then humans

398
00:12:44,080 --> 00:12:42,410
are getting their grubby little hands on

399
00:12:46,360 --> 00:12:44,090
them and like like contaminating them

400
00:12:47,890 --> 00:12:46,370
potentially so it's better if we could

401
00:12:49,120 --> 00:12:47,900
actually send the samples back which is

402
00:12:50,950 --> 00:12:49,130
what that last slide was showing like

403
00:12:53,080 --> 00:12:50,960
we'll get a rover it's gonna take a

404
00:12:54,640 --> 00:12:53,090
sample like a geologist would and like

405
00:12:56,710 --> 00:12:54,650
kind of bag it up like a geologist would

406
00:12:58,720 --> 00:12:56,720
and then a second lander is gonna come

407
00:13:00,220 --> 00:12:58,730
down with a rocket the rover is going to

408
00:13:01,540 --> 00:13:00,230
send the sample to the rocket and the

409
00:13:04,030 --> 00:13:01,550
rocket is gonna actually launch the

410
00:13:06,280 --> 00:13:04,040
sample back to earth and that that has a

411
00:13:08,140 --> 00:13:06,290
lot of advantages the samples fresh but

412
00:13:10,330 --> 00:13:08,150
the other advantage is we have every

413
00:13:12,130 --> 00:13:10,340

single analytical tool on earth and all

414
00:13:13,369 --> 00:13:12,140
the expertise of scientists across earth

415
00:13:15,079 --> 00:13:13,379
to then apply to the

416
00:13:16,849 --> 00:13:15,089
fresh sample okay so that's why we're

417
00:13:19,099 --> 00:13:16,859
gonna send samples back from Mars and

418
00:13:20,719 --> 00:13:19,109
when we're asking the question of is

419
00:13:22,849 --> 00:13:20,729
there life on Mars or was there life on

420
00:13:24,349 --> 00:13:22,859
Mars especially we're also asking a more

421
00:13:25,849 --> 00:13:24,359
philosophical question because this

422
00:13:27,650 --> 00:13:25,859
search for life in different locations

423
00:13:29,899 --> 00:13:27,660
will tell us other things other than

424
00:13:31,609 --> 00:13:29,909
just whether or not we're alone on Mars

425
00:13:33,559 --> 00:13:31,619
the second question we'd be answering is

426
00:13:35,149 --> 00:13:33,569
how does it buy us for your end because

427
00:13:36,739 --> 00:13:35,159
we think that there's no life at least

428
00:13:38,899 --> 00:13:36,749
globally at the surface of Mars

429
00:13:40,399 --> 00:13:38,909
today but it's possible that there was

430
00:13:43,099 --> 00:13:40,409
lots of liquid water on the surface of

431
00:13:45,199 --> 00:13:43,109
Mars billions of years ago and if it had

432
00:13:46,759 --> 00:13:45,209
water at the surface and it had life at

433
00:13:49,069 --> 00:13:46,769
the surface in that timeframe and it

434
00:13:50,899 --> 00:13:49,079
lost it then the story of life on Mars

435
00:13:52,960 --> 00:13:50,909
is a story of how we lose the biosphere

436
00:13:54,889 --> 00:13:52,970
in the first place

437
00:13:56,809 --> 00:13:54,899
another place we're looking for evidence

438
00:13:58,159 --> 00:13:56,819

of life is on Europa and other icy

439
00:14:00,739 --> 00:13:58,169
worlds in the outer solar system like

440
00:14:02,210 --> 00:14:00,749
Enceladus the way we're doing it in this

441
00:14:03,619 --> 00:14:02,220
case is actually we've got a few steps

442
00:14:05,210 --> 00:14:03,629
in the process the first thing we're

443
00:14:07,009 --> 00:14:05,220
going to do probably in the next decade

444
00:14:08,960 --> 00:14:07,019
is and by the way the Marr stuff the

445
00:14:11,779 --> 00:14:08,970
Rovers there now we're setting another

446
00:14:13,549 --> 00:14:11,789
Rover they're in 2022 like collect and

447
00:14:15,379 --> 00:14:13,559
store the samples and then lay it around

448
00:14:16,639 --> 00:14:15,389
in the 2020s is when we'd send send that

449
00:14:19,069 --> 00:14:16,649
sample back home or maybe the early

450
00:14:21,229 --> 00:14:19,079
2030s for Europa we're gonna start with

451
00:14:23,689 --> 00:14:21,239
the Clipper in the 2020s what this is

452
00:14:25,759 --> 00:14:23,699
going to do is it's like gonna for my

453
00:14:27,349 --> 00:14:25,769
generation like Top Gun right like you

454
00:14:29,389 --> 00:14:27,359
had like them doing the flyby as the

455
00:14:31,340 --> 00:14:29,399
tower to like scare the pants off the

456
00:14:33,229 --> 00:14:31,350
air traffic controllers right so we're

457
00:14:34,909 --> 00:14:33,239
gonna be buzzing by you're by Europa

458
00:14:37,099 --> 00:14:34,919
with the Clipper in the same way it's

459
00:14:38,899 --> 00:14:37,109
gonna actually not be in orbit around

460
00:14:40,399 --> 00:14:38,909
Europa but actually around Jupiter and

461
00:14:41,539 --> 00:14:40,409
what it's going to do is its in its

462
00:14:42,799 --> 00:14:41,549
orbit around Jupiter it's gonna pass

463
00:14:45,379 --> 00:14:42,809

here we go

464
00:14:47,179 --> 00:14:45,389
really close to Europa every once in a

465
00:14:48,889 --> 00:14:47,189
while and when it gets close to Europa

466
00:14:49,249 --> 00:14:48,899
it's got a whole bunch of instruments on

467
00:14:51,109 --> 00:14:49,259
board

468
00:14:53,239 --> 00:14:51,119
first of all mapping out this sort of

469
00:14:55,069 --> 00:14:53,249
terrain on Europa and seeing where all

470
00:14:56,539 --> 00:14:55,079
those cracks are but it's also gonna

471
00:14:58,999 --> 00:14:56,549
have a radar that's gonna find out how

472
00:15:00,349 --> 00:14:59,009
deep that ice is and the reason we want

473
00:15:01,939 --> 00:15:00,359
to find out how deep the ice is is

474
00:15:03,799 --> 00:15:01,949
eventually we want to land on Europa

475
00:15:05,239 --> 00:15:03,809
just like we've landed on Mars and you

476
00:15:07,009 --> 00:15:05,249
want to land at a place where the ice is

477
00:15:08,329 --> 00:15:07,019
not quite so deep and you can get down

478
00:15:10,309 --> 00:15:08,339
to a sub because we think underneath

479
00:15:13,069 --> 00:15:10,319
that ice shell there's a huge liquid

480
00:15:14,809 --> 00:15:13,079
water ocean that's global in nature we

481
00:15:16,460 --> 00:15:14,819
want to get down in that water because

482
00:15:19,519 --> 00:15:16,470
water at least on earth is fundamental

483
00:15:21,369 --> 00:15:19,529
to life by the way that's why it's

484
00:15:23,689 --> 00:15:21,379
almost a joke within our community

485
00:15:25,460 --> 00:15:23,699
there's like a press release like every

486
00:15:27,250 --> 00:15:25,470
six months like hey we found water on

487
00:15:30,340 --> 00:15:27,260
Mars again

488
00:15:32,620 --> 00:15:30,350

and and it's it's become a bit of a joke

489
00:15:35,590 --> 00:15:32,630
because water is like it for us it's oil

490
00:15:38,380 --> 00:15:35,600
right like if you strike water anywhere

491
00:15:40,780 --> 00:15:38,390
you strike a location that could Harbor

492
00:15:42,130 --> 00:15:40,790
life everywhere we go on earth as long

493
00:15:43,450 --> 00:15:42,140
as there's enough liquid water in an

494
00:15:45,280 --> 00:15:43,460
environment you find life you could go

495
00:15:46,810 --> 00:15:45,290
to the driest place on earth if you find

496
00:15:49,870 --> 00:15:46,820
a little moist crevice in that like

497
00:15:51,910 --> 00:15:49,880
super dry desert or if it rains once in

498
00:15:54,310 --> 00:15:51,920
every 10 years you all of a sudden get

499
00:15:55,540 --> 00:15:54,320
blooms of life sometimes even huge plant

500
00:15:57,970 --> 00:15:55,550
blooms that are beautiful in the middle

501
00:15:59,710 --> 00:15:57,980
of a desert because that's all that's

502
00:16:01,330 --> 00:15:59,720
the one fundamental and consistent thing

503
00:16:02,830 --> 00:16:01,340
across our biosphere is where there's

504
00:16:03,940 --> 00:16:02,840
water there's life that's why we get

505
00:16:06,100 --> 00:16:03,950
super excited about it

506
00:16:08,140 --> 00:16:06,110
so for Europa we want to know how deep

507
00:16:09,880 --> 00:16:08,150
that ice shell is with the Clipper so we

508
00:16:11,830 --> 00:16:09,890
can send a lander that's close as close

509
00:16:13,690 --> 00:16:11,840
to the water as possible and hopefully

510
00:16:15,970 --> 00:16:13,700
get some water spewing up to the surface

511
00:16:18,550 --> 00:16:15,980
if not drilling down to it to go look

512
00:16:20,170 --> 00:16:18,560
for it for life there now for Europe

513
00:16:22,420 --> 00:16:20,180

we're asking a different philosophical

514
00:16:23,740 --> 00:16:22,430
question right when we think of life you

515
00:16:25,630 --> 00:16:23,750
know and this is sort of getting outside

516
00:16:26,980 --> 00:16:25,640
the box of what we're expecting when we

517
00:16:29,170 --> 00:16:26,990
think of life and trying to not just

518
00:16:32,230 --> 00:16:29,180
constrain ourselves to the kinds of life

519
00:16:33,850 --> 00:16:32,240
we have here on earth today on Europa

520
00:16:35,830 --> 00:16:33,860
there's a lot of water but there's no

521
00:16:37,240 --> 00:16:35,840
sunlight at the interacting with that

522
00:16:38,710 --> 00:16:37,250
water because there's this ice shell

523
00:16:41,320 --> 00:16:38,720
that's globally covering it right so

524
00:16:42,760 --> 00:16:41,330
this would be like the not just you like

525
00:16:44,410 --> 00:16:42,770
as an individual organism but like the

526
00:16:46,150 --> 00:16:44,420
whole biosphere being shut off from

527
00:16:47,950 --> 00:16:46,160
sunlight forever

528
00:16:49,390 --> 00:16:47,960
okay that's whether or not that works

529
00:16:51,010 --> 00:16:49,400
like there's a lot of theory we've

530
00:16:52,930 --> 00:16:51,020
written up that says it could and it

531
00:16:55,060 --> 00:16:52,940
should but whether or not it does is

532
00:16:56,560 --> 00:16:55,070
totally unanswered and this is where you

533
00:16:58,480 --> 00:16:56,570
know the science comes in right we've

534
00:16:59,800 --> 00:16:58,490
got a theory that if there's water and

535
00:17:00,880 --> 00:16:59,810
there's nutrients and there's energy and

536
00:17:02,800 --> 00:17:00,890
there should be some chemical energy

537
00:17:04,120 --> 00:17:02,810
under Europa's ice shell then that

538
00:17:06,370 --> 00:17:04,130

should be enough for life that's a

539
00:17:08,320 --> 00:17:06,380
that's a hypothesis we're gonna test

540
00:17:12,880 --> 00:17:08,330
with experiments these Clippers and

541
00:17:14,050 --> 00:17:12,890
these Landers all right now this is

542
00:17:15,040 --> 00:17:14,060
getting to the really weird stuff just

543
00:17:19,210 --> 00:17:15,050
tight and have life today

544
00:17:21,970 --> 00:17:19,220
all right next slide Mike so this is so

545
00:17:23,830 --> 00:17:21,980
cool this is okay most of the stuff I've

546
00:17:25,420 --> 00:17:23,840
talked about before is in some phase of

547
00:17:27,490 --> 00:17:25,430
like development or planning or funding

548
00:17:29,470 --> 00:17:27,500
I think the mission I'm about to talk

549
00:17:32,500 --> 00:17:29,480
about to tighten is up for consideration

550
00:17:33,970 --> 00:17:32,510
for a mission slot it hasn't been like

551
00:17:35,740 --> 00:17:33,980
formally selected yet but it's one of

552
00:17:37,180 --> 00:17:35,750
two finalists to be selected for an

553
00:17:39,160 --> 00:17:37,190
upcoming mission opportunity it's called

554
00:17:40,870 --> 00:17:39,170
the dragonfly and you can kind of see

555
00:17:44,380 --> 00:17:40,880
why this is actually

556
00:17:46,750 --> 00:17:44,390
a drone that we are gonna send a Titan

557
00:17:48,940 --> 00:17:46,760
to fly around Titan surface right so

558
00:17:49,990 --> 00:17:48,950
it's gonna be able to like land and this

559
00:17:51,250 --> 00:17:50,000
is why it's called a dragonfly it's

560
00:17:52,960 --> 00:17:51,260
gonna be able to land on these like

561
00:17:56,140 --> 00:17:52,970
methane ethane lakes that are on Titan

562
00:17:57,520 --> 00:17:56,150
so Titan has a has a hydrological cycle

563
00:18:00,790 --> 00:17:57,530

with like precipitation and evaporation

564
00:18:02,110 --> 00:18:00,800
and rivers and streams and lakes but

565
00:18:03,880 --> 00:18:02,120
it's not made of water it's made

566
00:18:05,920 --> 00:18:03,890
basically of like natural gas it's like

567
00:18:08,920 --> 00:18:05,930
methane ethane right it's wild

568
00:18:10,540 --> 00:18:08,930
well this dragonfly could land on that

569
00:18:12,040 --> 00:18:10,550
stuff like get a little bit of a test

570
00:18:13,810 --> 00:18:12,050
tube and like suck a little bit of it up

571
00:18:15,640 --> 00:18:13,820
and do all kinds of chemical analyses

572
00:18:17,740 --> 00:18:15,650
this actually has a lot of the same

573
00:18:20,620 --> 00:18:17,750
instruments we're sending to Mars if

574
00:18:22,870 --> 00:18:20,630
you've ever watched like CSI it says

575
00:18:25,150 --> 00:18:22,880
like a whole CSI lab like packaged into

576
00:18:26,230 --> 00:18:25,160
the size of like a Mini Cooper okay and

577
00:18:28,870 --> 00:18:26,240
that's the same thing that we send to

578
00:18:30,640 --> 00:18:28,880
Mars and elbow instead of wheels and

579
00:18:33,160 --> 00:18:30,650
it's gonna have these two little skis

580
00:18:35,230 --> 00:18:33,170
and what's called a dual layer quad

581
00:18:36,730 --> 00:18:35,240
copper copter arrangement so it can not

582
00:18:38,800 --> 00:18:36,740
just land in one place but actually land

583
00:18:40,930 --> 00:18:38,810
in multiple places in these lakes on the

584
00:18:44,710 --> 00:18:40,940
sand dunes maybe some other locales like

585
00:18:46,090 --> 00:18:44,720
and this is like the I don't know if

586
00:18:47,890 --> 00:18:46,100
you've ever won in here is like a sports

587
00:18:49,630 --> 00:18:47,900
fan but for me it's like I like watching

588
00:18:51,970 --> 00:18:49,640

things like the home run derby because

589
00:18:55,450 --> 00:18:51,980
you see like athletes like totally in

590
00:18:57,100 --> 00:18:55,460
awe of each other this that this is that

591
00:18:58,330 --> 00:18:57,110
for me right like I have nothing to do

592
00:18:59,950 --> 00:18:58,340
with this mission but when like my

593
00:19:01,210 --> 00:18:59,960
colleagues pitch it I was like oh my god

594
00:19:05,140 --> 00:19:01,220
it's like so cool

595
00:19:07,090 --> 00:19:05,150
so I yeah this thing is awesome but it's

596
00:19:08,710 --> 00:19:07,100
not funded yet like what we'll see the

597
00:19:10,750 --> 00:19:08,720
fingers cost and and the big thing here

598
00:19:11,980 --> 00:19:10,760
is like it's there's two things that go

599
00:19:14,020 --> 00:19:11,990
on when NASA is thinking about what

600
00:19:16,000 --> 00:19:14,030
mission to fly it's like how cool and

601
00:19:18,160 --> 00:19:16,010
exciting is the science and how

602
00:19:20,380 --> 00:19:18,170
difficult is it for you to pull off the

603
00:19:22,450 --> 00:19:20,390
like dragon fly drone you're sending to

604
00:19:23,620 --> 00:19:22,460
Titan and and that those are the two

605
00:19:25,090 --> 00:19:23,630
things that this team is gonna have to

606
00:19:27,430 --> 00:19:25,100
worry about the next couple years

607
00:19:28,690 --> 00:19:27,440
improve the NASA and in this ongoing

608
00:19:30,940 --> 00:19:28,700
competition that it's the one that we're

609
00:19:33,850 --> 00:19:30,950
going to send send somewhere else next

610
00:19:35,500 --> 00:19:33,860
time so a Titan we're asking a different

611
00:19:36,970 --> 00:19:35,510
question in terms of the search for life

612
00:19:39,010 --> 00:19:36,980
now I should say that the Dragonfly

613
00:19:41,260 --> 00:19:39,020

mission isn't being designed from the

614
00:19:42,820 --> 00:19:41,270
ground up to search for life but it is

615
00:19:45,400 --> 00:19:42,830
making measurements that could in theory

616
00:19:46,810 --> 00:19:45,410
detect life if it were there you know if

617
00:19:48,280 --> 00:19:46,820
we're if we're looking for life on Titan

618
00:19:50,080 --> 00:19:48,290
we're asking a different philosophical

619
00:19:52,090 --> 00:19:50,090
question we're asking like is weird life

620
00:19:53,380 --> 00:19:52,100
and thing every time I give a public

621
00:19:54,370 --> 00:19:53,390
talk about this every time you give a

622
00:19:56,650 --> 00:19:54,380
science talk

623
00:19:59,169 --> 00:19:56,660
if it's to a non astrobiology audience

624
00:20:01,240 --> 00:19:59,179
if I'm talking to my mother-in-law about

625
00:20:02,830 --> 00:20:01,250
what I do like I get the same question

626
00:20:04,240 --> 00:20:02,840
over and over again which is like are

627
00:20:06,039 --> 00:20:04,250
you thinking outside the box are you

628
00:20:09,100 --> 00:20:06,049
thinking about like not water based life

629
00:20:10,570 --> 00:20:09,110
non carbon-based life any life on Titan

630
00:20:12,610 --> 00:20:10,580
is not going to be water based because

631
00:20:14,140 --> 00:20:12,620
water is locked up as like in mountains

632
00:20:16,900 --> 00:20:14,150
basically there's like ice mountains on

633
00:20:18,310 --> 00:20:16,910
Titan another like crazy thing so the

634
00:20:20,080 --> 00:20:18,320
water life there would actually be

635
00:20:23,169 --> 00:20:20,090
existing in these methane methane

636
00:20:24,669 --> 00:20:23,179
natural gas like lakes and and not solve

637
00:20:26,110 --> 00:20:24,679
it you actually probably would not want

638
00:20:27,730 --> 00:20:26,120

to be carbon-based you probably want

639
00:20:29,680 --> 00:20:27,740
some other biochemistry at least not the

640
00:20:31,180 --> 00:20:29,690
same biochemistry we have on earth so

641
00:20:33,220 --> 00:20:31,190
like for Titan the question we're asking

642
00:20:36,220 --> 00:20:33,230
philosophically is this weird life of

643
00:20:37,570 --> 00:20:36,230
thing okay so now the last place we're

644
00:20:40,360 --> 00:20:37,580
gonna look and there's other places we

645
00:20:42,760 --> 00:20:40,370
could look you know Enceladus Venus but

646
00:20:44,529 --> 00:20:42,770
but for the most part what the plans we

647
00:20:46,419 --> 00:20:44,539
have on the table are the ones I just

648
00:20:47,500 --> 00:20:46,429
mentioned with one more and this is the

649
00:20:49,750 --> 00:20:47,510
place that I probably have the most

650
00:20:50,830 --> 00:20:49,760
familiarity and expertise and this is

651
00:20:52,270 --> 00:20:50,840
the missions that I've been working on

652
00:20:56,260 --> 00:20:52,280
the most so that the last question is do

653
00:20:57,789 --> 00:20:56,270
exoplanets have light and and this

654
00:20:58,870 --> 00:20:57,799
really start this story for me starts in

655
00:21:00,490 --> 00:20:58,880
our solar system because their

656
00:21:03,700 --> 00:21:00,500
expectations start here with our nine

657
00:21:06,460 --> 00:21:03,710
planets I know like we're supposed to

658
00:21:13,090 --> 00:21:06,470
say eight now but to me include Ocilla

659
00:21:14,680 --> 00:21:13,100
planet all right so like and and that's

660
00:21:17,010 --> 00:21:14,690
not just me being like an old curmudgeon

661
00:21:18,970 --> 00:21:17,020
that learned that in grade school like

662
00:21:20,289 --> 00:21:18,980
actually I think the best the best

663
00:21:22,120 --> 00:21:20,299

version of this is someone says like

664
00:21:23,710 --> 00:21:22,130
this thing passes the Captain Kirk test

665
00:21:25,840 --> 00:21:23,720
right like if Captain Kirk we're looking

666
00:21:27,190 --> 00:21:25,850
at this thing he wouldn't say like I'm

667
00:21:29,470 --> 00:21:27,200
looking at a dwarf object he'd say

668
00:21:31,600 --> 00:21:29,480
there's a planet here right and and

669
00:21:33,310 --> 00:21:31,610
beyond that like the the differences in

670
00:21:35,380 --> 00:21:33,320
like morphology and the different kinds

671
00:21:37,450 --> 00:21:35,390
of features here like this thing is

672
00:21:39,669 --> 00:21:37,460
geologically active it's not just some

673
00:21:43,060 --> 00:21:39,679
like dumb ball of rock hurtling through

674
00:21:46,149 --> 00:21:43,070
space so at any rate that's my little

675
00:21:47,770 --> 00:21:46,159
rant so nine planets there's a whole lot

676
00:21:49,930 --> 00:21:47,780
of diversity here like in terms of the

677
00:21:51,610 --> 00:21:49,940
environments that they have but one

678
00:21:52,840 --> 00:21:51,620
thing that we thought before we started

679
00:21:55,029 --> 00:21:52,850
looking for planets beyond the solar

680
00:21:57,880 --> 00:21:55,039
system is you had small rocky things

681
00:21:59,710 --> 00:21:57,890
Mercury Venus Earth and Mars close into

682
00:22:02,470 --> 00:21:59,720
the star and we had Jupiter Saturn

683
00:22:04,240 --> 00:22:02,480
Uranus Neptune and Pluto further outlets

684
00:22:06,070 --> 00:22:04,250
let's step floow2 aside for a second

685
00:22:07,840 --> 00:22:06,080
these these were these are all gas

686
00:22:10,000 --> 00:22:07,850
giants these are all small rocky thing

687
00:22:11,380 --> 00:22:10,010
this wasn't separating peas and carrots

688
00:22:13,810 --> 00:22:11,390

in our mind this was like separating

689
00:22:15,190 --> 00:22:13,820
like peas and grapefruits okay like the

690
00:22:16,779 --> 00:22:15,200
peas were closed in and the grapefruits

691
00:22:19,240 --> 00:22:16,789
were far away now let's sort of our

692
00:22:21,460 --> 00:22:19,250
model for how planets formed in all

693
00:22:23,529 --> 00:22:21,470
solar systems because every model we we

694
00:22:25,870 --> 00:22:23,539
wrote was basically designed to give us

695
00:22:27,610 --> 00:22:25,880
the solar system because so here's what

696
00:22:28,900 --> 00:22:27,620
we have now right even if you think we

697
00:22:30,549 --> 00:22:28,910
lost Pluto that's alright because we've

698
00:22:32,799 --> 00:22:30,559
got thousands of planets we found in the

699
00:22:34,210 --> 00:22:32,809
last 20 years these are all planets

700
00:22:35,919 --> 00:22:34,220
around other stars they're not this

701
00:22:37,270 --> 00:22:35,929
close to each other they're packed as

702
00:22:40,630 --> 00:22:37,280
close to each other so we can show them

703
00:22:42,490 --> 00:22:40,640
all so every single dot here is a planet

704
00:22:44,350 --> 00:22:42,500
we've found beyond our solar system

705
00:22:47,080 --> 00:22:44,360
that's orbiting another Sun another star

706
00:22:49,330 --> 00:22:47,090
the size of the dot is basically scaling

707
00:22:51,430 --> 00:22:49,340
how big the planet is how fast it's

708
00:22:53,890 --> 00:22:51,440
moving is how fast its orbit is compared

709
00:22:55,690 --> 00:22:53,900
to like one year on earth and the color

710
00:22:57,399 --> 00:22:55,700
is basically how hot the planet would be

711
00:23:00,039 --> 00:22:57,409
based on how close it is to the host

712
00:23:01,720 --> 00:23:00,049
star there's a tremendous diversity here

713
00:23:04,180 --> 00:23:01,730

so there's two things that could have

714
00:23:06,580 --> 00:23:04,190
come out of this the first is like when

715
00:23:08,110 --> 00:23:06,590
I've told this story before I literally

716
00:23:11,560 --> 00:23:08,120
look at the night sky differently now

717
00:23:13,120 --> 00:23:11,570
because of these discoveries if you ask

718
00:23:14,649 --> 00:23:13,130
scientists 20 years ago like how many

719
00:23:15,520 --> 00:23:14,659
planets are out there we'd be like I

720
00:23:17,049 --> 00:23:15,530
don't know there should be like

721
00:23:20,110 --> 00:23:17,059
something out there but like you know

722
00:23:23,110 --> 00:23:20,120
now we have an estimate there is at

723
00:23:26,169 --> 00:23:23,120
least one planet for every star in the

724
00:23:27,820 --> 00:23:26,179
sky so if you go out tonight and you

725
00:23:29,529 --> 00:23:27,830
count stars you can even do this in the

726
00:23:31,750 --> 00:23:29,539
bright lights of Atlanta if you count

727
00:23:32,980 --> 00:23:31,760
stars you're counting planets too right

728
00:23:35,020 --> 00:23:32,990
there should be at least one planet for

729
00:23:36,430 --> 00:23:35,030
every star you see and some of those

730
00:23:37,720 --> 00:23:36,440
bright stars and those stars might

731
00:23:39,850 --> 00:23:37,730
actually be galaxies which I could would

732
00:23:42,669 --> 00:23:39,860
have billions of planets in them the

733
00:23:44,169 --> 00:23:42,679
other thing that's changed is if I 20

734
00:23:45,549 --> 00:23:44,179
years ago try to say not just how many

735
00:23:47,020 --> 00:23:45,559
planets were out there but how many

736
00:23:48,190 --> 00:23:47,030
planets that could potentially be like

737
00:23:50,110 --> 00:23:48,200
earth that were of the right size and

738
00:23:51,789 --> 00:23:50,120

the right distance from their star to

739
00:23:53,440 --> 00:23:51,799
have global oceans like we do at the

740
00:23:55,570 --> 00:23:53,450
surface that could have global surface

741
00:23:56,590 --> 00:23:55,580
biospheres like we do if I put out any

742
00:23:58,210 --> 00:23:56,600
number it doesn't matter what that

743
00:23:59,710 --> 00:23:58,220
number was scientists would tell me I

744
00:24:01,630 --> 00:23:59,720
was like crazy and I shouldn't be saying

745
00:24:05,020 --> 00:24:01,640
stuff like that but I can say it now and

746
00:24:07,690 --> 00:24:05,030
I'm not crazy okay so if if you go out

747
00:24:09,700 --> 00:24:07,700
and you count stars for every 10 stars

748
00:24:11,799 --> 00:24:09,710
you count not only you counting at least

749
00:24:13,990 --> 00:24:11,809
10 planets we've probably counted at

750
00:24:16,240 --> 00:24:14,000
least one planet that's of the right

751
00:24:18,430 --> 00:24:16,250
size and the right energy so the right

752
00:24:20,620 --> 00:24:18,440
distance from the host star to harbor

753
00:24:21,139 --> 00:24:20,630
global biospheres similar to the one we

754
00:24:24,469 --> 00:24:21,149
have

755
00:24:25,969 --> 00:24:24,479
on earth today that's that's that's an

756
00:24:26,629 --> 00:24:25,979
amazing statement and we couldn't make

757
00:24:28,279 --> 00:24:26,639
it 10 years ago

758
00:24:30,169 --> 00:24:28,289
okay next line now the other thing

759
00:24:31,849 --> 00:24:30,179
that's happened in addition is sort of

760
00:24:34,489 --> 00:24:31,859
those counting statistics is we've just

761
00:24:36,349 --> 00:24:34,499
been like surprise over and over again I

762
00:24:38,149 --> 00:24:36,359
was talking about like separating out

763
00:24:39,950 --> 00:24:38,159

like peas and grapefruits like what

764
00:24:41,239 --> 00:24:39,960
exoplanet science has done is it's like

765
00:24:42,799 --> 00:24:41,249
put the peas and the grapefruits and

766
00:24:45,379 --> 00:24:42,809
made it into like some disgusting

767
00:24:47,149 --> 00:24:45,389
toddler smoothie thing because like

768
00:24:49,039 --> 00:24:47,159
nothing is separated anymore

769
00:24:50,930 --> 00:24:49,049
the very first exoplanets we found were

770
00:24:52,430 --> 00:24:50,940
hot Jupiters user that the planets

771
00:24:54,589 --> 00:24:52,440
bigger than Jupiter the biggest thing we

772
00:24:56,869 --> 00:24:54,599
have in our solar system but closer to

773
00:24:58,729 --> 00:24:56,879
the Sun than mercury to its star than

774
00:25:01,159 --> 00:24:58,739
mercury is to our Sun right this is the

775
00:25:02,690 --> 00:25:01,169
exact opposite of what our models were

776
00:25:04,729 --> 00:25:02,700
predicting because our models were

777
00:25:07,969 --> 00:25:04,739
designed to recreate the solar system in

778
00:25:09,169 --> 00:25:07,979
which we live the next surprise or the

779
00:25:10,609 --> 00:25:09,179
next prize I'll talk about at least were

780
00:25:12,099 --> 00:25:10,619
these super Earths so these are planets

781
00:25:14,060 --> 00:25:12,109
that are like bigger they're not like

782
00:25:15,079 --> 00:25:14,070
they're not like earth with superpowers

783
00:25:17,239 --> 00:25:15,089
okay

784
00:25:19,999 --> 00:25:17,249
there are the things that are like kind

785
00:25:21,259 --> 00:25:20,009
of earth ish but like bigger in size and

786
00:25:22,820 --> 00:25:21,269
they're smaller than Neptune now we

787
00:25:25,070 --> 00:25:22,830
don't have anything like that in our

788
00:25:26,239 --> 00:25:25,080

solar system and so our models which

789
00:25:27,889 --> 00:25:26,249
were designed to recreate the solar

790
00:25:30,529 --> 00:25:27,899
system we're predicting that these

791
00:25:32,479 --> 00:25:30,539
things would not exist turns out they're

792
00:25:34,159 --> 00:25:32,489
the most common thing that we found and

793
00:25:35,509 --> 00:25:34,169
are like local neighborhood right so

794
00:25:37,879 --> 00:25:35,519
again the models really not not just

795
00:25:39,739 --> 00:25:37,889
wrong they were like the opposite of

796
00:25:42,440 --> 00:25:39,749
like the opposite of our predictions was

797
00:25:45,469 --> 00:25:42,450
what reality gave us and then lastly

798
00:25:47,119 --> 00:25:45,479
there's planets like Kepler 16b so and

799
00:25:48,859 --> 00:25:47,129
by the way that every planet has like a

800
00:25:50,570 --> 00:25:48,869
boring catalog name like this just

801
00:25:52,849 --> 00:25:50,580
that's how we like keep track of them so

802
00:25:55,129 --> 00:25:52,859
a couple are 16b this is a planet

803
00:25:56,599 --> 00:25:55,139
orbiting a double star system so like I

804
00:25:57,529 --> 00:25:56,609
like using the beer as an example

805
00:26:00,079 --> 00:25:57,539
because I can have some of this nice

806
00:26:01,489 --> 00:26:00,089
ironmonger beer so imagine you have two

807
00:26:03,320 --> 00:26:01,499
stars sort of orbiting each other at the

808
00:26:05,629 --> 00:26:03,330
center of a system and you have a planet

809
00:26:07,489 --> 00:26:05,639
orbiting like way outside of it that's

810
00:26:09,889 --> 00:26:07,499
that's called a binary star where the

811
00:26:10,969 --> 00:26:09,899
binaries interior if you were standing

812
00:26:12,680 --> 00:26:10,979
on the surface of that planet you would

813
00:26:14,089 --> 00:26:12,690

see a double sunset as that planets

814
00:26:16,369 --> 00:26:14,099
rotating because both the stars would

815
00:26:18,349 --> 00:26:16,379
sort of set at the same time now that's

816
00:26:21,499 --> 00:26:18,359
awesome but our models said that those

817
00:26:23,139 --> 00:26:21,509
were impossible and so nobody nobody

818
00:26:25,339 --> 00:26:23,149
thought that these things could exist

819
00:26:28,830 --> 00:26:25,349
except maybe they were looking at the

820
00:26:37,430 --> 00:26:32,740
[Applause]

821
00:26:39,080 --> 00:26:37,440
knowing when Star Wars came out the

822
00:26:40,610 --> 00:26:39,090
astrophysicists said well that that's

823
00:26:41,480 --> 00:26:40,620
poetic George Lucas but like that's

824
00:26:42,950 --> 00:26:41,490
impossible

825
00:26:45,230 --> 00:26:42,960
turns out he might not have been right

826
00:26:47,540 --> 00:26:45,240
about whether or not hunch hovers but he

827
00:26:51,950 --> 00:26:47,550
was right about this okay he was right

828
00:26:53,540 --> 00:26:51,960
about this alright so how are we gonna

829
00:26:54,770 --> 00:26:53,550
look for life on these things because

830
00:26:56,360 --> 00:26:54,780
all we know so far is like they're

831
00:26:58,220 --> 00:26:56,370
Astrophysical properties we know how big

832
00:26:59,840 --> 00:26:58,230
these planets are we know how far they

833
00:27:01,490 --> 00:26:59,850
are from their host star we can make

834
00:27:02,960 --> 00:27:01,500
some estimates to say like you know

835
00:27:04,460 --> 00:27:02,970
where oceans are and are not possible

836
00:27:07,280 --> 00:27:04,470
but we aren't looking for life yet

837
00:27:08,720 --> 00:27:07,290
that's about a change so this is a

838
00:27:10,160 --> 00:27:08,730

telescope that's being built at the

839
00:27:12,260 --> 00:27:10,170
institution I work at the Goddard Space

840
00:27:13,580 --> 00:27:12,270
Flight Center this is the James Webb

841
00:27:14,900 --> 00:27:13,590
Space Telescope it's been in the news

842
00:27:17,210 --> 00:27:14,910
this week because it's delayed we can

843
00:27:19,010 --> 00:27:17,220
get into that into Q&A if you want it's

844
00:27:21,080 --> 00:27:19,020
awesome like this thing is plated in

845
00:27:22,850 --> 00:27:21,090
gold at 6 and 1/2 meters across Hubble

846
00:27:25,190 --> 00:27:22,860
is about this big across right about my

847
00:27:27,050 --> 00:27:25,200
wingspan maybe a little bit bigger Webb

848
00:27:29,540 --> 00:27:27,060
is like the width of this stage across

849
00:27:31,010 --> 00:27:29,550
so like six and a half meters so it's

850
00:27:33,670 --> 00:27:31,020
it's kind of hard to show but like a

851
00:27:35,780 --> 00:27:33,680
telescope the size of this stage

852
00:27:37,460 --> 00:27:35,790
compared to the like something that's a

853
00:27:39,470 --> 00:27:37,470
little bit taller than me that's a

854
00:27:41,660 --> 00:27:39,480
tremendous amount of collecting area you

855
00:27:42,980 --> 00:27:41,670
get a lot more photons with this what

856
00:27:44,510 --> 00:27:42,990
that means the scientist is we can

857
00:27:47,150 --> 00:27:44,520
actually start to not just see these

858
00:27:48,890 --> 00:27:47,160
planets but take the data the light

859
00:27:51,230 --> 00:27:48,900
we're getting from the planet and split

860
00:27:53,360 --> 00:27:51,240
it up into little tiny color buckets now

861
00:27:55,400 --> 00:27:53,370
that's important because color is how

862
00:27:57,920 --> 00:27:55,410
astronomers and astrophysicists and

863
00:28:00,800 --> 00:27:57,930

earth scientists look for chemical

864
00:28:02,690 --> 00:28:00,810
composition because certain gases in the

865
00:28:05,330 --> 00:28:02,700
atmosphere absorbs absorb certain

866
00:28:06,950 --> 00:28:05,340
wavelengths of light so we see a dip or

867
00:28:08,600 --> 00:28:06,960
a peak in certain in the in sort of the

868
00:28:10,820 --> 00:28:08,610
color distribution coming from a planet

869
00:28:13,280 --> 00:28:10,830
that'll tell us if it has water it'll

870
00:28:14,720 --> 00:28:13,290
tell us it has carbon dioxide and in

871
00:28:16,640 --> 00:28:14,730
some cases it might tell us if the

872
00:28:18,500 --> 00:28:16,650
planet has oxygen or ozone the gases

873
00:28:20,840 --> 00:28:18,510
that on earth are made exclusively by

874
00:28:24,410 --> 00:28:20,850
algae and plants ok the gas we're all

875
00:28:25,910 --> 00:28:24,420
breathing right now so James Webb is not

876
00:28:27,710 --> 00:28:25,920
designed to do this but because it's

877
00:28:30,050 --> 00:28:27,720
such an awesome thing it's going to be

878
00:28:31,790 --> 00:28:30,060
able to do this for some stars there are

879
00:28:33,380 --> 00:28:31,800
some planets that that we're about to

880
00:28:35,000 --> 00:28:33,390
discover with the test satellite that's

881
00:28:37,100 --> 00:28:35,010
going to launch later this year these

882
00:28:38,870 --> 00:28:37,110
are planets run n-type stars so next

883
00:28:40,010 --> 00:28:38,880
slide jay WSU is going to be able to

884
00:28:42,140 --> 00:28:40,020
probe their chemical

885
00:28:44,420 --> 00:28:42,150
position of the planets and look for

886
00:28:45,560 --> 00:28:44,430
signs of life on them the problem is I'm

887
00:28:48,710 --> 00:28:45,570
not optimistic we're going to find

888
00:28:51,110 --> 00:28:48,720

anything there and the reason is this

889
00:28:52,850 --> 00:28:51,120
awesome cartoon so this is this is

890
00:28:54,080 --> 00:28:52,860
actually Mars this is data from Mars

891
00:28:56,510 --> 00:28:54,090
that's being recreated with this awesome

892
00:28:57,530 --> 00:28:56,520
visualization this is B from

893
00:28:59,990 --> 00:28:57,540
measurements made by the MAVEN

894
00:29:02,510 --> 00:29:00,000
spacecraft with the MAVEN spacecraft is

895
00:29:04,070 --> 00:29:02,520
doing is it's exploring basically how an

896
00:29:06,560 --> 00:29:04,080
atmosphere can be sort of blown away

897
00:29:08,090 --> 00:29:06,570
from a planet right and and if you don't

898
00:29:09,320 --> 00:29:08,100
have an atmosphere there there's a bunch

899
00:29:12,260 --> 00:29:09,330
of problems first of all you can't

900
00:29:13,400 --> 00:29:12,270
breathe kind of an issue secondly you if

901
00:29:15,650 --> 00:29:13,410
you don't have an atmosphere you can't

902
00:29:17,990 --> 00:29:15,660
hold liquid water in at the surface it's

903
00:29:19,520 --> 00:29:18,000
you just it goes straight into steam and

904
00:29:21,680 --> 00:29:19,530
it and and you lose it immediately

905
00:29:23,000 --> 00:29:21,690
there's no liquid water phase and this

906
00:29:25,670 --> 00:29:23,010
is not the end this is that

907
00:29:27,230 --> 00:29:25,680
high-resolution simulation now mapped to

908
00:29:28,790 --> 00:29:27,240
the Maven data and this is the

909
00:29:31,250 --> 00:29:28,800
high-resolution simulation comes from a

910
00:29:32,540 --> 00:29:31,260
model this in this case our models are

911
00:29:34,370 --> 00:29:32,550
actually matching the measurements

912
00:29:36,500 --> 00:29:34,380
really really really well

913
00:29:37,940 --> 00:29:36,510

what mavens teaching us is that you can

914
00:29:39,320 --> 00:29:37,950
actually lose an atmosphere fairly

915
00:29:41,660 --> 00:29:39,330
easily if you've got a lot of high

916
00:29:43,640 --> 00:29:41,670
energy radiation from the host star the

917
00:29:46,910 --> 00:29:43,650
problem with the JWST the James Webb

918
00:29:48,650 --> 00:29:46,920
Space Telescope's exploration of life on

919
00:29:52,040 --> 00:29:48,660
planets around other stars it's gonna

920
00:29:53,090 --> 00:29:52,050
try but the planet star combinations

921
00:29:55,130 --> 00:29:53,100
it's going to be looking at are

922
00:29:57,800 --> 00:29:55,140
especially prone to atmospheric loss

923
00:30:00,050 --> 00:29:57,810
okay so if all the details of what I

924
00:30:01,850 --> 00:30:00,060
just said like like kind of like it was

925
00:30:03,470 --> 00:30:01,860
just too much like basically Webb's

926
00:30:05,450 --> 00:30:03,480
gonna be able to look for life on

927
00:30:07,100 --> 00:30:05,460
planets that are like warm enough like

928
00:30:09,410 --> 00:30:07,110
they've got enough energy from the host

929
00:30:10,850 --> 00:30:09,420
star in total to keep ocean stable but

930
00:30:12,620 --> 00:30:10,860
it's getting too much of the high-energy

931
00:30:15,050 --> 00:30:12,630
radiation in my blow atmospheres away

932
00:30:17,660 --> 00:30:15,060
and the planets might be dead like as a

933
00:30:19,610 --> 00:30:17,670
modeler what I'm expecting is that

934
00:30:21,080 --> 00:30:19,620
Webb's gonna see like a bunch of bare

935
00:30:25,010 --> 00:30:21,090
rocks without atmospheres and without

936
00:30:26,270 --> 00:30:25,020
life like that's just my expectation but

937
00:30:27,650 --> 00:30:26,280
that's why we do the measurement right

938
00:30:29,540 --> 00:30:27,660

because you shouldn't just like trust me

939
00:30:31,280 --> 00:30:29,550
if we if I if I know with 100%

940
00:30:31,610 --> 00:30:31,290
confidence that what I just said was

941
00:30:33,200 --> 00:30:31,620
true

942
00:30:34,460 --> 00:30:33,210
there wouldn't be a point to doing the

943
00:30:36,080 --> 00:30:34,470
measurement but that's that's what

944
00:30:38,270 --> 00:30:36,090
science is about I'm making a prediction

945
00:30:40,220 --> 00:30:38,280
we're gonna test it with observation

946
00:30:42,020 --> 00:30:40,230
when Webb launches so Webb will look for

947
00:30:44,000 --> 00:30:42,030
life but in places that are skeptical

948
00:30:46,370 --> 00:30:44,010
life could exist next time

949
00:30:48,410 --> 00:30:46,380
now if you want to looking for life in

950
00:30:49,640 --> 00:30:48,420
places that are more like our earths on

951
00:30:52,190 --> 00:30:49,650
combination and by the way the problem

952
00:30:53,450 --> 00:30:52,200
with Webb is this this the host stars

953
00:30:55,130 --> 00:30:53,460
it's looking at

954
00:30:56,960 --> 00:30:55,140
like rambunctious teenagers that are

955
00:30:58,370 --> 00:30:56,970
like like kicking things all around the

956
00:31:00,019 --> 00:30:58,380
room and that like that's just to high

957
00:31:01,760 --> 00:31:00,029
energy so if you want to look for

958
00:31:03,350 --> 00:31:01,770
planets around more sun-like stars and

959
00:31:05,090 --> 00:31:03,360
probe their chemical composition and

960
00:31:07,100 --> 00:31:05,100
look for bio signatures on those worlds

961
00:31:08,539 --> 00:31:07,110
you need a bigger telescope and that's

962
00:31:10,340 --> 00:31:08,549
something called noir this is also

963
00:31:12,350 --> 00:31:10,350

something like the Dragonfly mission

964
00:31:13,669 --> 00:31:12,360
that's in the concept phase it's

965
00:31:15,590 --> 00:31:13,679
something we're studying and basically

966
00:31:16,789 --> 00:31:15,600
pitching to the science community to see

967
00:31:19,070 --> 00:31:16,799
if this is what they want to be their

968
00:31:21,320 --> 00:31:19,080
priority going forward I'll tell you I'm

969
00:31:23,240 --> 00:31:21,330
biased I'm the deputy study scientist on

970
00:31:24,830 --> 00:31:23,250
this mission I love it and I plan to

971
00:31:26,810 --> 00:31:24,840
spend the rest of my life working on it

972
00:31:28,610 --> 00:31:26,820
if it gets you know selected going

973
00:31:29,779 --> 00:31:28,620
forward so I'm biased towards this one

974
00:31:32,029 --> 00:31:29,789
and it's like near and dear to my heart

975
00:31:33,529 --> 00:31:32,039
next slide but if we built it we'd be

976
00:31:35,180 --> 00:31:33,539
able to look not just for signs of life

977
00:31:37,279 --> 00:31:35,190
but we'd be able to look for signs of

978
00:31:39,110 --> 00:31:37,289
life on planets that are pretty much

979
00:31:41,120 --> 00:31:39,120
like the earth around stars that are

980
00:31:42,830 --> 00:31:41,130
pretty much like the Sun and not only

981
00:31:44,360 --> 00:31:42,840
would we be able to do that once or

982
00:31:46,490 --> 00:31:44,370
twice we think we could do that for

983
00:31:48,470 --> 00:31:46,500
about 30 to 60 planets depending on

984
00:31:50,720 --> 00:31:48,480
which version of leVoir we're talking

985
00:31:54,019 --> 00:31:50,730
about so at that point we're starting to

986
00:31:55,820 --> 00:31:54,029
ask different questions and the bill

987
00:31:57,409 --> 00:31:55,830
topical question here isn't just are we

988
00:31:59,240 --> 00:31:57,419

alone or is there life on like Louvois

989
00:32:01,970 --> 00:31:59,250
r5 C or whatever the planets going to be

990
00:32:04,250 --> 00:32:01,980
called we're asking to global biospheres

991
00:32:05,960 --> 00:32:04,260
exist beyond Earth we're also going to

992
00:32:07,789 --> 00:32:05,970
be able to ask other questions like why

993
00:32:09,889 --> 00:32:07,799
is planted on why is there life on these

994
00:32:12,350 --> 00:32:09,899
planets and not on those planets and

995
00:32:14,120 --> 00:32:12,360
when we do that just as I said like you

996
00:32:16,370 --> 00:32:14,130
know our models were all wrong about the

997
00:32:17,539 --> 00:32:16,380
solar system well guess what when our

998
00:32:20,060 --> 00:32:17,549
models were wrong we didn't just like

999
00:32:22,100 --> 00:32:20,070
give up we went back and changed our

1000
00:32:23,779 --> 00:32:22,110
models and they're better now and not

1001
00:32:25,010 --> 00:32:23,789
only can they recreate all the surprises

1002
00:32:27,049 --> 00:32:25,020
that we found when we look for those

1003
00:32:28,610 --> 00:32:27,059
those exoplanets and found things that

1004
00:32:31,490 --> 00:32:28,620
didn't fit our models our models

1005
00:32:33,350 --> 00:32:31,500
reproduce that stuff now they also now

1006
00:32:35,990 --> 00:32:33,360
tell us to tell a better more accurate

1007
00:32:37,460 --> 00:32:36,000
story of our own solar system 20 years

1008
00:32:39,799 --> 00:32:37,470
ago before all those extra planets were

1009
00:32:41,539 --> 00:32:39,809
found we couldn't really predict why we

1010
00:32:44,240 --> 00:32:41,549
didn't understand why Mars has the size

1011
00:32:46,279 --> 00:32:44,250
it does in the orbit it does and we do

1012
00:32:47,990 --> 00:32:46,289
now and the reason our models can

1013
00:32:50,210 --> 00:32:48,000

predict Mars today and it couldn't

1014
00:32:53,210 --> 00:32:50,220
before is because our models got better

1015
00:32:54,889 --> 00:32:53,220
by being wrong and fixing them to fix

1016
00:32:57,919 --> 00:32:54,899
the mistakes that they had in them okay

1017
00:33:00,289 --> 00:32:57,929
what I want the future I like can't wait

1018
00:33:02,060 --> 00:33:00,299
to see like 30 years from now or when

1019
00:33:04,370 --> 00:33:02,070
our models are a little bit off from the

1020
00:33:06,170 --> 00:33:04,380
loop our data about how a biosphere

1021
00:33:07,430 --> 00:33:06,180
interacts with its host planet

1022
00:33:08,990 --> 00:33:07,440
when those are wrong and we improved

1023
00:33:10,580 --> 00:33:09,000
those models we'll have a better

1024
00:33:12,110 --> 00:33:10,590
understanding how life and a planet

1025
00:33:13,370 --> 00:33:12,120
interact and that's going to be better

1026
00:33:18,590 --> 00:33:13,380
for all of us whether or not you care

1027
00:33:20,570 --> 00:33:18,600
about the search for life okay so and I

1028
00:33:22,070 --> 00:33:20,580
earth is really important to me for a

1029
00:33:25,310 --> 00:33:22,080
number of reasons not just because like

1030
00:33:26,900 --> 00:33:25,320
I depend on it to live it's also like

1031
00:33:28,430 --> 00:33:26,910
academically where I got my start like I

1032
00:33:30,140 --> 00:33:28,440
was a physics major in undergrad but I

1033
00:33:32,240 --> 00:33:30,150
went to grad school in geology and the

1034
00:33:34,010 --> 00:33:32,250
reason I did was because if you want to

1035
00:33:35,630 --> 00:33:34,020
understand life as a planetary

1036
00:33:37,880 --> 00:33:35,640
phenomenon you have to think about life

1037
00:33:39,530 --> 00:33:37,890
in a planetary context so everything I

1038
00:33:41,030 --> 00:33:39,540

do everything I take to the job of

1039
00:33:43,880 --> 00:33:41,040
looking for life whether it's on Mars or

1040
00:33:45,620 --> 00:33:43,890
Europa or these exoplanets it comes from

1041
00:33:47,930 --> 00:33:45,630
a framework of thinking about how

1042
00:33:49,880 --> 00:33:47,940
complicated earth is about how many

1043
00:33:53,060 --> 00:33:49,890
different systems we have interacting on

1044
00:33:55,640 --> 00:33:53,070
earth right and NASA has acknowledged

1045
00:33:56,960 --> 00:33:55,650
this complexity we've this is an awesome

1046
00:33:59,120 --> 00:33:56,970
video of like all the things that we've

1047
00:34:01,070 --> 00:33:59,130
got out there observing our host planet

1048
00:34:02,180 --> 00:34:01,080
and now as you zoom out you actually see

1049
00:34:03,320 --> 00:34:02,190
things that are observing the Sun

1050
00:34:05,600 --> 00:34:03,330
because part of what drives our

1051
00:34:10,490 --> 00:34:05,610
environment is energy coming from our

1052
00:34:12,860 --> 00:34:10,500
host star we look constantly from above

1053
00:34:14,450 --> 00:34:12,870
down on earth at its cryosphere how the

1054
00:34:16,159 --> 00:34:14,460
ice sheets are changing we're looking at

1055
00:34:17,090 --> 00:34:16,169
the atmosphere and the carbon dioxide in

1056
00:34:18,919 --> 00:34:17,100
the atmosphere we're looking at the

1057
00:34:20,899 --> 00:34:18,929
biosphere and where life is and how that

1058
00:34:22,880 --> 00:34:20,909
changes over the seasons we're looking

1059
00:34:25,399 --> 00:34:22,890
at it land-use changes we're doing all

1060
00:34:27,440 --> 00:34:25,409
kinds of detailed investigations of our

1061
00:34:29,180 --> 00:34:27,450
host planet and we're tying that back to

1062
00:34:32,290 --> 00:34:29,190
our host star which is giving us the

1063
00:34:36,200 --> 00:34:32,300

energy for life and for a lot of our

1064
00:34:37,730 --> 00:34:36,210
civilization when we do that that

1065
00:34:39,950 --> 00:34:37,740
doesn't happen in a vacuum because

1066
00:34:42,919 --> 00:34:39,960
there's astrobiologists like me that are

1067
00:34:44,450 --> 00:34:42,929
like leveraging all that because when we

1068
00:34:46,130 --> 00:34:44,460
do that like we're developing new

1069
00:34:47,570 --> 00:34:46,140
theories new models new science all the

1070
00:34:48,860 --> 00:34:47,580
time based on the data that's coming

1071
00:34:50,389 --> 00:34:48,870
back on earth and then they're

1072
00:34:52,550 --> 00:34:50,399
scientists like me saying like I want

1073
00:34:54,440 --> 00:34:52,560
those awesome models so I can apply them

1074
00:34:56,240 --> 00:34:54,450
to the search for life on planets around

1075
00:34:58,220 --> 00:34:56,250
other stars or even to other planets in

1076
00:34:59,720 --> 00:34:58,230
our solar system I literally wouldn't

1077
00:35:01,370 --> 00:34:59,730
know how to approach the problem to

1078
00:35:03,170 --> 00:35:01,380
begin with if it weren't for the

1079
00:35:05,390 --> 00:35:03,180
foundation that's been laid laid for me

1080
00:35:08,420 --> 00:35:05,400
by all these amazing earth scientists

1081
00:35:10,160 --> 00:35:08,430
over the last 30 to 40 years to give an

1082
00:35:11,390 --> 00:35:10,170
example of this you know I talked about

1083
00:35:13,430 --> 00:35:11,400
the search for life as being like an

1084
00:35:16,400 --> 00:35:13,440
assessment of chemistry if you want to

1085
00:35:18,020 --> 00:35:16,410
know how we can like see life from space

1086
00:35:20,060 --> 00:35:18,030
like or like across the interstellar

1087
00:35:20,420 --> 00:35:20,070
space the best way for me to describe

1088
00:35:22,730 --> 00:35:20,430

this

1089
00:35:25,010 --> 00:35:22,740
like to show you a map of how we can map

1090
00:35:26,750 --> 00:35:25,020
light on earth today this these are

1091
00:35:29,049 --> 00:35:26,760
these are satellite observations that

1092
00:35:31,970 --> 00:35:29,059
NASA has made with the seawifs mission

1093
00:35:34,370 --> 00:35:31,980
and seawifs instrument which is tracking

1094
00:35:35,660 --> 00:35:34,380
life on the surface you can see forests

1095
00:35:37,309 --> 00:35:35,670
grow and shrink in the northern

1096
00:35:39,680 --> 00:35:37,319
hemisphere alternating with the southern

1097
00:35:41,839 --> 00:35:39,690
hemisphere seasonally you can also see

1098
00:35:45,020 --> 00:35:41,849
blooms of chlorophyll of algae growing

1099
00:35:47,299 --> 00:35:45,030
in the ocean periodically so in other

1100
00:35:49,099 --> 00:35:47,309
words we can detect life remotely you

1101
00:35:51,109 --> 00:35:49,109
don't have to be there scooping up sand

1102
00:35:52,940 --> 00:35:51,119
to know that life is there because we

1103
00:35:54,799 --> 00:35:52,950
can see the specific colors associated

1104
00:35:57,109 --> 00:35:54,809
with chlorophyll on the oceans or with

1105
00:35:58,670 --> 00:35:57,119
forests on land and not just the stuff

1106
00:36:00,500 --> 00:35:58,680
that life has in it that not just the

1107
00:36:01,790 --> 00:36:00,510
chlorophyll in the leaf structures we

1108
00:36:03,500 --> 00:36:01,800
can also see the gases that life

1109
00:36:06,980 --> 00:36:03,510
produces in this in this case this is a

1110
00:36:08,450 --> 00:36:06,990
beautiful map of data from the oshio

1111
00:36:10,520 --> 00:36:08,460
mission which is looking at the carbon

1112
00:36:12,620 --> 00:36:10,530
dioxide in our atmosphere another NASA

1113
00:36:14,720 --> 00:36:12,630

mission and you can see gases in our

1114
00:36:16,430 --> 00:36:14,730
atmosphere remotely what we plan to do

1115
00:36:19,640 --> 00:36:16,440
for these exoplanets is take these same

1116
00:36:21,349 --> 00:36:19,650
techniques that look for co2 or o2 or

1117
00:36:23,089 --> 00:36:21,359
methane or in the case of the prior

1118
00:36:24,829 --> 00:36:23,099
slide the chlorophyll in the forests and

1119
00:36:26,599 --> 00:36:24,839
we're going to apply it to a telescope

1120
00:36:27,920 --> 00:36:26,609
looking at a planet around another star

1121
00:36:29,329 --> 00:36:27,930
and that's how we're gonna look for like

1122
00:36:32,559 --> 00:36:29,339
that but it leverages all the stuff

1123
00:36:34,579 --> 00:36:32,569
we've learned from doing it here at home

1124
00:36:35,660 --> 00:36:34,589
now when we're looking at our the

1125
00:36:37,130 --> 00:36:35,670
fundamental question we're asking

1126
00:36:38,329 --> 00:36:37,140
because it's like it's not a mystery

1127
00:36:39,980 --> 00:36:38,339
whether or not there's life on Earth we

1128
00:36:41,210 --> 00:36:39,990
know if there's life on Earth but we're

1129
00:36:42,410 --> 00:36:41,220
trying to figure out what its limits are

1130
00:36:44,870 --> 00:36:42,420
we're trying to figure out how far can

1131
00:36:46,339 --> 00:36:44,880
we push life before in the most extreme

1132
00:36:48,200 --> 00:36:46,349
environments before there's there's not

1133
00:36:49,520 --> 00:36:48,210
life anymore and we also want to know

1134
00:36:52,549 --> 00:36:49,530
how does life interact with the tost

1135
00:36:54,349 --> 00:36:52,559
planet what is light do that impacts the

1136
00:36:56,240 --> 00:36:54,359
host planet and what is the host planet

1137
00:36:57,740 --> 00:36:56,250
through that impacts life and how how

1138
00:36:59,480 --> 00:36:57,750

does that relationship play out over the

1139
00:37:05,240 --> 00:36:59,490
billions of years of Earth history that

1140
00:37:07,430 --> 00:37:05,250
we have access to here at home oh that's

1141
00:37:08,599 --> 00:37:07,440
it all right so I guess what I'd like to

1142
00:37:10,910 --> 00:37:08,609
do now is just say thank you for

1143
00:37:12,200 --> 00:37:10,920
attention I'm gonna stay up here and

1144
00:37:17,360 --> 00:37:12,210
take questions from the audience

1145
00:37:25,350 --> 00:37:21,110
read the catch box alright alright

1146
00:37:28,020 --> 00:37:25,360
alright so this this awesome thing is

1147
00:37:30,090 --> 00:37:28,030
called a catch box it's a microphone you

1148
00:37:32,130 --> 00:37:30,100
can throw alright it's like a microphone

1149
00:37:33,900 --> 00:37:32,140
in an earth box so raise your hand and

1150
00:37:38,660 --> 00:37:33,910
we'll try to toss you the the mic for a

1151
00:37:41,070 --> 00:37:38,670
question alright

1152
00:37:42,390 --> 00:37:41,080
hello thank you for the presentation

1153
00:37:46,560 --> 00:37:42,400
thank you just wanted to ask a question

1154
00:37:50,730 --> 00:37:46,570
about landing on Europa many people have

1155
00:37:54,540 --> 00:37:50,740
brought a concern that when would the

1156
00:37:56,490 --> 00:37:54,550
ocean full I would actually detecting

1157
00:37:58,980 --> 00:37:56,500
large brought with the probe is very

1158
00:38:02,280 --> 00:37:58,990
difficult to clean the probe yeah to

1159
00:38:04,800 --> 00:38:02,290
destroy all the signs of life from Earth

1160
00:38:06,720 --> 00:38:04,810
right so the question because your

1161
00:38:08,130 --> 00:38:06,730
little feedback is like when we when we

1162
00:38:09,510 --> 00:38:08,140
look for life on Europa some people are

1163
00:38:11,280 --> 00:38:09,520

worried that we're gonna basically bring

1164
00:38:13,470 --> 00:38:11,290
like with us and just detect ourselves

1165
00:38:15,780 --> 00:38:13,480
that's a huge problem there's actually I

1166
00:38:17,520 --> 00:38:15,790
think actually like the coolest title

1167
00:38:19,500 --> 00:38:17,530
and the federal government is planetary

1168
00:38:22,320 --> 00:38:19,510
protection officer the United States of

1169
00:38:24,330 --> 00:38:22,330
America right and literally their motto

1170
00:38:26,250 --> 00:38:24,340
the model that office is all of the

1171
00:38:27,390 --> 00:38:26,260
planets all of the time right like it's

1172
00:38:30,270 --> 00:38:27,400
the one office I feel like should come

1173
00:38:32,040 --> 00:38:30,280
with like a super cape and tights the

1174
00:38:34,860 --> 00:38:32,050
job at that office is actually to worry

1175
00:38:36,780 --> 00:38:34,870
about that exact problem to make sure

1176
00:38:38,040 --> 00:38:36,790
that when we send spacecraft to a place

1177
00:38:39,870 --> 00:38:38,050
we're gonna look for life that we don't

1178
00:38:41,670 --> 00:38:39,880
contaminate it with the life we have on

1179
00:38:43,020 --> 00:38:41,680
earth and that's both for moral reasons

1180
00:38:44,790 --> 00:38:43,030
because we don't want to like

1181
00:38:46,710 --> 00:38:44,800
contaminate other planets with our life

1182
00:38:47,940 --> 00:38:46,720
here because we should decide whether or

1183
00:38:50,010 --> 00:38:47,950
not that's a good thing to do as a

1184
00:38:52,020 --> 00:38:50,020
society not just some scientists like

1185
00:38:54,150 --> 00:38:52,030
messing up in the lab but it's also

1186
00:38:55,320 --> 00:38:54,160
important scientifically for the reasons

1187
00:38:56,190 --> 00:38:55,330
the questioner just put out there we

1188
00:38:57,330 --> 00:38:56,200

want to make sure that we're not

1189
00:38:59,430 --> 00:38:57,340
bringing life with us so we've got a

1190
00:39:01,890 --> 00:38:59,440
whole range of measurements and

1191
00:39:03,090 --> 00:39:01,900
standards that we utilize to make sure

1192
00:39:04,860 --> 00:39:03,100
we're not going to do just that

1193
00:39:06,630 --> 00:39:04,870
now the other aspect of that office is

1194
00:39:07,980 --> 00:39:06,640
if we bring samples back from Europa or

1195
00:39:10,140 --> 00:39:07,990
from Mars like we're planning to do

1196
00:39:12,270 --> 00:39:10,150
they're also making sure that like the

1197
00:39:13,560 --> 00:39:12,280
science fiction horror movie version of

1198
00:39:15,480 --> 00:39:13,570
bringing samples back doesn't end up

1199
00:39:17,160 --> 00:39:15,490
happening and that we're all safe from

1200
00:39:22,050 --> 00:39:17,170
contamination from those other planets

1201
00:39:25,110 --> 00:39:22,060
as well yeah so you had mentioned I

1202
00:39:26,160 --> 00:39:25,120
think was Titan that you had the weather

1203
00:39:28,620 --> 00:39:26,170
dragonfly mission

1204
00:39:31,140 --> 00:39:28,630
that you were looking at what drone for

1205
00:39:34,320 --> 00:39:31,150
a drone to work it has to have a pretty

1206
00:39:36,060 --> 00:39:34,330
substantial atmosphere and so I was sort

1207
00:39:38,280 --> 00:39:36,070
of surprised that it had that much of an

1208
00:39:41,160 --> 00:39:38,290
atmosphere that that a drone could

1209
00:39:42,870 --> 00:39:41,170
actually fly yeah so Titan is special in

1210
00:39:44,670 --> 00:39:42,880
that way it actually has it's one of the

1211
00:39:46,290 --> 00:39:44,680
few planets that has like this

1212
00:39:48,840 --> 00:39:46,300
hydrological cycle but also has a pretty

1213
00:39:50,580 --> 00:39:48,850

dense atmosphere in it and the molecules

1214
00:39:52,290 --> 00:39:50,590
that the Titan Titan atmosphere are made

1215
00:39:54,660 --> 00:39:52,300
of are actually more massive than Earth

1216
00:39:56,370 --> 00:39:54,670
and so the mean molecular weight of the

1217
00:39:57,780 --> 00:39:56,380
atmosphere is higher and that gives you

1218
00:39:59,550 --> 00:39:57,790
actually it's actually good for all

1219
00:40:01,770 --> 00:39:59,560
kinds of aerial stuff people have also

1220
00:40:03,630 --> 00:40:01,780
pitched balloons and airplanes basically

1221
00:40:05,970 --> 00:40:03,640
anything airborne works pretty well on

1222
00:40:07,830 --> 00:40:05,980
Titan the drones is something we're

1223
00:40:09,570 --> 00:40:07,840
looking at right now because the

1224
00:40:12,420 --> 00:40:09,580
technology for Jones has it been so

1225
00:40:14,310 --> 00:40:12,430
rapidly the last decade or so that we

1226
00:40:16,230 --> 00:40:14,320
think that that's relatively mature in

1227
00:40:18,390 --> 00:40:16,240
terms of doing airborne stuff on another

1228
00:40:19,980 --> 00:40:18,400
planet I should say that people are also

1229
00:40:21,750 --> 00:40:19,990
talking about putting a helicopter on

1230
00:40:24,540 --> 00:40:21,760
Mars as part of the next Mars rover

1231
00:40:26,160 --> 00:40:24,550
payload for Mars what you just mentioned

1232
00:40:28,140 --> 00:40:26,170
like the lack of an atmosphere because

1233
00:40:29,670 --> 00:40:28,150
the atmosphere is thinner on Mars that

1234
00:40:33,230 --> 00:40:29,680
becomes a pretty big problem but on

1235
00:40:38,970 --> 00:40:36,780
how did they know that a meteorite came

1236
00:40:42,060 --> 00:40:38,980
from Mars oh that's a good question so

1237
00:40:43,590 --> 00:40:42,070
the way we get at the source of where a

1238
00:40:45,960 --> 00:40:43,600

meteorite came from is actually looking

1239
00:40:47,250 --> 00:40:45,970
at its chemistry both the gases that are

1240
00:40:49,260 --> 00:40:47,260
contained in it and if you know what

1241
00:40:51,510 --> 00:40:49,270
isotopes are it's basically like the

1242
00:40:53,400 --> 00:40:51,520
same molecule or atom but like a

1243
00:40:56,130 --> 00:40:53,410
different mass for that atom both the

1244
00:40:58,350 --> 00:40:56,140
isotopic composition of the meteorite

1245
00:41:00,330 --> 00:40:58,360
and the gas composition match Marge's

1246
00:41:02,190 --> 00:41:00,340
atmosphere really well and there's some

1247
00:41:03,480 --> 00:41:02,200
gases that kind of stay constant over

1248
00:41:06,060 --> 00:41:03,490
time and we're using those as sort of

1249
00:41:07,380 --> 00:41:06,070
the tracer we didn't like see it

1250
00:41:09,330 --> 00:41:07,390
launched off Mars because that happened

1251
00:41:10,620 --> 00:41:09,340
a long long time ago but it's basically

1252
00:41:16,470 --> 00:41:10,630
matching the composition of the

1253
00:41:18,390 --> 00:41:16,480
meteorite to that of Mars it could have

1254
00:41:20,010 --> 00:41:18,400
come from somewhere else except most of

1255
00:41:22,320 --> 00:41:20,020
the places it could come from we've also

1256
00:41:24,420 --> 00:41:22,330
mapped out those compositions and they

1257
00:41:25,800 --> 00:41:24,430
also don't match and like I mean I'm

1258
00:41:28,740 --> 00:41:25,810
kind of glossing over a lot of detail

1259
00:41:30,660 --> 00:41:28,750
here but like the this the when I say

1260
00:41:32,370 --> 00:41:30,670
composition it's it's not something that

1261
00:41:34,200 --> 00:41:32,380
would vary between like here and

1262
00:41:35,100 --> 00:41:34,210
Maryland where I flew in from like the

1263
00:41:36,780 --> 00:41:35,110

other day and where I'm flying home

1264
00:41:37,480 --> 00:41:36,790
tomorrow like it's something that's kind

1265
00:41:41,340 --> 00:41:37,490
of constant

1266
00:41:42,580 --> 00:41:41,350
over the the whole planets environments

1267
00:41:45,220 --> 00:41:42,590
yep

1268
00:41:46,870 --> 00:41:45,230
so as an undergrad student you were

1269
00:41:49,270 --> 00:41:46,880
studying physics and as a grad student

1270
00:41:53,260 --> 00:41:49,280
you were a geologist how do you turn

1271
00:41:56,020 --> 00:41:53,270
that into astrobiology okay so a couple

1272
00:41:57,640 --> 00:41:56,030
things one I sought out specific places

1273
00:41:59,650 --> 00:41:57,650
that were good at astrobiology research

1274
00:42:03,040 --> 00:41:59,660
so where were you at like are you well

1275
00:42:06,790 --> 00:42:03,050
you're a student in what level high

1276
00:42:08,770 --> 00:42:06,800
school junior okay so a few things you

1277
00:42:11,200 --> 00:42:08,780
don't I I don't recommend anyone follow

1278
00:42:12,460 --> 00:42:11,210
like the exact path I followed like

1279
00:42:14,830 --> 00:42:12,470
unless that's like the thing that you

1280
00:42:16,420 --> 00:42:14,840
think is like super awesome to be good

1281
00:42:19,359 --> 00:42:16,430
at Mastro's biology you have to be good

1282
00:42:21,010 --> 00:42:19,369
at a few things you don't have to know

1283
00:42:22,200 --> 00:42:21,020
everything like that's the trap like

1284
00:42:23,980 --> 00:42:22,210
some people say like oh like

1285
00:42:25,840 --> 00:42:23,990
astrobiology is like astronomy and

1286
00:42:27,100 --> 00:42:25,850
biology and geology and physics and

1287
00:42:28,720 --> 00:42:27,110
chemistry and like all like mixed

1288
00:42:30,340 --> 00:42:28,730

together so I'm gonna like take a little

1289
00:42:32,410 --> 00:42:30,350
bit of all those things I actually think

1290
00:42:33,820 --> 00:42:32,420
that's a bit of a trap like a turbo

1291
00:42:36,700 --> 00:42:33,830
admiral ackbar would tell you it's a

1292
00:42:38,170 --> 00:42:36,710
traffic what you would instead what you

1293
00:42:40,030 --> 00:42:38,180
want to do is you want to get really

1294
00:42:41,710 --> 00:42:40,040
good at that like one discipline that

1295
00:42:43,450 --> 00:42:41,720
like you can be an expert in eventually

1296
00:42:45,370 --> 00:42:43,460
get a graduate degree and be like the

1297
00:42:48,430 --> 00:42:45,380
world's expert in one tiny corner of

1298
00:42:50,230 --> 00:42:48,440
knowledge but have those things be

1299
00:42:52,240 --> 00:42:50,240
related to astrobiology like you can be

1300
00:42:53,200 --> 00:42:52,250
an astral by out everybody is there's no

1301
00:42:54,760 --> 00:42:53,210
one I know that's just an

1302
00:42:56,770 --> 00:42:54,770
astrobiologists like I'm literally one

1303
00:42:58,780 --> 00:42:56,780
of the oldest people alive that has a

1304
00:43:00,730 --> 00:42:58,790
degree in astrobiology but I have a

1305
00:43:02,770 --> 00:43:00,740
degree in astrobiology and Geosciences

1306
00:43:04,330 --> 00:43:02,780
okay other people have a degrees in

1307
00:43:05,859 --> 00:43:04,340
astrobiology and chemistry or

1308
00:43:09,580 --> 00:43:05,869
astrobiology and astronomy or

1309
00:43:11,200 --> 00:43:09,590
astrobiology and whatever you have to

1310
00:43:13,090 --> 00:43:11,210
have a home discipline you're good at

1311
00:43:15,730 --> 00:43:13,100
and you're bringing that expertise to

1312
00:43:17,740 --> 00:43:15,740
the question of are we alone and and if

1313
00:43:19,300 --> 00:43:17,750

you want like I'm not gonna come

1314
00:43:20,220 --> 00:43:19,310
especially cuz I'm online I'm not going

1315
00:43:22,630 --> 00:43:20,230
to give you advice on specific

1316
00:43:23,859 --> 00:43:22,640
institutions like on a live stream but

1317
00:43:25,660 --> 00:43:23,869
if you come up afterwards I'll tell you

1318
00:43:29,830 --> 00:43:25,670
some really cool places to go to college

1319
00:43:31,990 --> 00:43:29,840
that are doing amazing things okay yep I

1320
00:43:33,460 --> 00:43:32,000
just had a curious question about the

1321
00:43:34,660 --> 00:43:33,470
private and public sector do you guys

1322
00:43:37,120 --> 00:43:34,670
are you guys gonna eventually have to

1323
00:43:39,400 --> 00:43:37,130
are you partnering with like the the

1324
00:43:41,560 --> 00:43:39,410
current private sector that's up and

1325
00:43:43,240 --> 00:43:41,570
coming all right so this is this is an

1326
00:43:44,680 --> 00:43:43,250
interesting question because like a the

1327
00:43:46,359 --> 00:43:44,690
first thing I think that we need that

1328
00:43:48,280 --> 00:43:46,369
like people like me up on stage need to

1329
00:43:50,080 --> 00:43:48,290
do is actually clarify something in

1330
00:43:50,609 --> 00:43:50,090
public private partnerships a lot of

1331
00:43:52,440 --> 00:43:50,619
NASA

1332
00:43:54,960 --> 00:43:52,450
actually already is a public-private

1333
00:43:56,849 --> 00:43:54,970
partnership right like if we build a

1334
00:43:58,739 --> 00:43:56,859
rover to send to Mars or if we build a

1335
00:44:01,170 --> 00:43:58,749
telescope to send a space like a

1336
00:44:03,180 --> 00:44:01,180
tremendous amount of the work that we do

1337
00:44:04,799 --> 00:44:03,190
is actually done by private aerospace

1338
00:44:06,329 --> 00:44:04,809

companies right and we're partnering

1339
00:44:08,279 --> 00:44:06,339
with them all the time like when I go to

1340
00:44:10,289 --> 00:44:08,289
astronomy meetings now probably about a

1341
00:44:11,609 --> 00:44:10,299
quarter of my meetings are with are with

1342
00:44:13,529 --> 00:44:11,619
companies not with other astronomers

1343
00:44:15,269 --> 00:44:13,539
because those companies have the

1344
00:44:17,220 --> 00:44:15,279
engineering expertise and know-how to do

1345
00:44:19,499 --> 00:44:17,230
a lot of stuff that we really need to

1346
00:44:21,150 --> 00:44:19,509
make these things work so there's a

1347
00:44:22,980 --> 00:44:21,160
there's sort of this deep history of

1348
00:44:24,779 --> 00:44:22,990
public/private partnerships that we have

1349
00:44:26,549 --> 00:44:24,789
had at NASA to just make all this stuff

1350
00:44:27,900 --> 00:44:26,559
possible now that all said like if I

1351
00:44:30,599 --> 00:44:27,910
just ended there'd be a bit of a dodge

1352
00:44:32,549 --> 00:44:30,609
right because like there there is talk

1353
00:44:34,349 --> 00:44:32,559
about actually doing like like like

1354
00:44:36,450 --> 00:44:34,359
private spaceflight being a new player

1355
00:44:38,009 --> 00:44:36,460
now like like I'm sure people have seen

1356
00:44:40,049 --> 00:44:38,019
SpaceX in the news right and like one

1357
00:44:41,190 --> 00:44:40,059
question I get a lot is like can you

1358
00:44:44,519 --> 00:44:41,200
work at NASA like are you worried about

1359
00:44:46,559 --> 00:44:44,529
SpaceX right the part of NASA I work in

1360
00:44:49,170 --> 00:44:46,569
which is like this science wing like

1361
00:44:51,390 --> 00:44:49,180
when SpaceX launches a new rocket we're

1362
00:44:53,309 --> 00:44:51,400
like cheering like literally like I was

1363
00:44:55,559 --> 00:44:53,319

at my computer like what cheering with

1364
00:44:57,390 --> 00:44:55,569
everybody else and it was from two

1365
00:45:00,359 --> 00:44:57,400
things one I mean it was cool like it

1366
00:45:02,549 --> 00:45:00,369
was awesome but - if SpaceX builds a new

1367
00:45:05,009 --> 00:45:02,559
really capable less expensive rocket

1368
00:45:06,660 --> 00:45:05,019
that's great for me because I can put a

1369
00:45:10,200 --> 00:45:06,670
rover or a telescope in that thing and

1370
00:45:11,819 --> 00:45:10,210
launch it up to space now what the third

1371
00:45:13,799 --> 00:45:11,829
aspect to this is like there are people

1372
00:45:16,499 --> 00:45:13,809
talking about doing like basically

1373
00:45:18,900 --> 00:45:16,509
private spaceflight science missions

1374
00:45:21,299 --> 00:45:18,910
like a privately funded like a GoFundMe

1375
00:45:23,370 --> 00:45:21,309
campaign for a telescope or a rover or

1376
00:45:24,809 --> 00:45:23,380
something like that that hasn't happened

1377
00:45:27,569 --> 00:45:24,819
yet but people are seriously talking

1378
00:45:29,249 --> 00:45:27,579
about it like and if it happened I would

1379
00:45:30,749 --> 00:45:29,259
be happy that it was happening because

1380
00:45:32,519 --> 00:45:30,759
I'm a scientist and I love the data I

1381
00:45:35,130 --> 00:45:32,529
think the most important thing there is

1382
00:45:36,749 --> 00:45:35,140
that when that stuff starts to become I

1383
00:45:38,009 --> 00:45:36,759
don't want to say reality but when it

1384
00:45:39,630 --> 00:45:38,019
starts to get funded to the point where

1385
00:45:41,309 --> 00:45:39,640
they're actually gonna do it

1386
00:45:42,779 --> 00:45:41,319
we need to have conversations between

1387
00:45:44,519 --> 00:45:42,789
the public and private space to make

1388
00:45:45,960 --> 00:45:44,529

sure we're not competing with each other

1389
00:45:47,940 --> 00:45:45,970
but we're looking at different targets

1390
00:45:50,670 --> 00:45:47,950
or different investigations on the same

1391
00:45:52,769 --> 00:45:50,680
target okay Sean yeah Sean Sean right

1392
00:45:54,809 --> 00:45:52,779
here right up here buddy right here I

1393
00:45:56,519 --> 00:45:54,819
know you can't see me here I'm gonna

1394
00:45:57,960 --> 00:45:56,529
come up front no I I was actually gonna

1395
00:45:59,039 --> 00:45:57,970
say it from the Mars perspective I can

1396
00:46:00,329 --> 00:45:59,049
already kind of talked about this for

1397
00:46:02,489 --> 00:46:00,339
you yes so

1398
00:46:04,170 --> 00:46:02,499
what you know so Sean's an expert

1399
00:46:07,200 --> 00:46:04,180
exoplanets my planet of focus is

1400
00:46:09,599 --> 00:46:07,210
actually Mars and I said I said on the I

1401
00:46:11,999 --> 00:46:09,609
said on a committee called the Mars

1402
00:46:13,380 --> 00:46:12,009
program Mars exploration program

1403
00:46:16,680 --> 00:46:13,390
analysis group and this is an analysis

1404
00:46:17,910 --> 00:46:16,690
group that is part of the entire Mars

1405
00:46:20,009 --> 00:46:17,920
committee and what we do is we kind of

1406
00:46:21,089 --> 00:46:20,019
assess the state of the Mars exploration

1407
00:46:23,039 --> 00:46:21,099
program not only NASA but

1408
00:46:24,359 --> 00:46:23,049
internationally and we kind of start we

1409
00:46:26,219 --> 00:46:24,369
all talk to each other about upcoming

1410
00:46:27,120 --> 00:46:26,229
missions what are the major science

1411
00:46:29,069 --> 00:46:27,130
questions and things like that

1412
00:46:31,019 --> 00:46:29,079
so in the last couple of meetings

1413
00:46:32,819 --> 00:46:31,029

meetings we it's called me pag for short

1414
00:46:35,569 --> 00:46:32,829
well on the last virtual meeting we had

1415
00:46:38,459 --> 00:46:35,579
we actually had representatives from

1416
00:46:41,039 --> 00:46:38,469
SpaceX talking about their most recent

1417
00:46:42,599 --> 00:46:41,049
launch to Mars and what their plans are

1418
00:46:44,400 --> 00:46:42,609
for human exploration so the

1419
00:46:46,769 --> 00:46:44,410
conversation at least for Mars

1420
00:46:48,539 --> 00:46:46,779
exploration has already started where we

1421
00:46:50,009 --> 00:46:48,549
have invited SpaceX and private

1422
00:46:52,289 --> 00:46:50,019
Nasheed's to come in and communicate

1423
00:46:54,479 --> 00:46:52,299
with the science community as part of

1424
00:46:56,219 --> 00:46:54,489
the community with regard to what are

1425
00:46:57,870 --> 00:46:56,229
our plans for Mars exploration and the

1426
00:47:00,209 --> 00:46:57,880
next steps as we kind of move towards

1427
00:47:01,650 --> 00:47:00,219
planetary exploration and having this

1428
00:47:02,880 --> 00:47:01,660
private partnership because they're

1429
00:47:05,039 --> 00:47:02,890
planning to send a human mission to Mars

1430
00:47:06,239 --> 00:47:05,049
and we want to be talking to each other

1431
00:47:08,940 --> 00:47:06,249
because we're learning a set of human

1432
00:47:10,680 --> 00:47:08,950
emissions Mars so that's already kind of

1433
00:47:11,910 --> 00:47:10,690
happening at least for Mars but it would

1434
00:47:13,739 --> 00:47:11,920
be great we could see it happening

1435
00:47:15,120 --> 00:47:13,749
across the entire program just like Sean

1436
00:47:16,380 --> 00:47:15,130
said but I just wanted to give you that

1437
00:47:18,029 --> 00:47:16,390
update cuz I'm pretty sure you don't do

1438
00:47:26,489 --> 00:47:18,039

me peg meetings I don't do me a packet

1439
00:47:27,779 --> 00:47:26,499
thank you by the way one of the

1440
00:47:29,130 --> 00:47:27,789
challenges in science is work-life

1441
00:47:33,680 --> 00:47:29,140
balance which gavin is giving us a great

1442
00:47:47,549 --> 00:47:46,380
where we and in addition to writing our

1443
00:47:50,279 --> 00:47:47,559
congressmen to give you guys more

1444
00:47:53,609 --> 00:47:50,289
funding is there anything else that the

1445
00:47:57,599 --> 00:47:53,619
private sector you and I can do to help

1446
00:47:59,670 --> 00:47:57,609
you get things funded I think like share

1447
00:48:01,739 --> 00:47:59,680
your enthusiasm in general for the stuff

1448
00:48:03,779 --> 00:48:01,749
we're doing which I mean this is why I'm

1449
00:48:07,289 --> 00:48:03,789
like really happy to be here tonight I I

1450
00:48:09,209 --> 00:48:07,299
am legally prohibited from lobbying

1451
00:48:10,829 --> 00:48:09,219
Congress and I can't even tell you to

1452
00:48:11,969 --> 00:48:10,839
lobby Congress right like that's that's

1453
00:48:13,240 --> 00:48:11,979
something like recording of the Hatch

1454
00:48:16,270 --> 00:48:13,250
Act like I can't do

1455
00:48:18,400 --> 00:48:16,280
but what I can do is I can I can share

1456
00:48:20,590 --> 00:48:18,410
my love for like the science and the

1457
00:48:22,630 --> 00:48:20,600
cool stuff that we've got on like in the

1458
00:48:24,730 --> 00:48:22,640
pipeline to maybe do in the future

1459
00:48:26,380 --> 00:48:24,740
and and do everything I can to promote

1460
00:48:28,090 --> 00:48:26,390
the next generation of scientists coming

1461
00:48:29,440 --> 00:48:28,100
up behind me and that's the other thing

1462
00:48:31,510 --> 00:48:29,450
I think everyone can do right like if

1463
00:48:33,310 --> 00:48:31,520

you've got students or you've got kids

1464
00:48:34,930 --> 00:48:33,320
or you've got friends or neighbors that

1465
00:48:36,850 --> 00:48:34,940
are thinking about doing this stuff like

1466
00:48:39,070 --> 00:48:36,860
encourage them because there's actually

1467
00:48:39,490 --> 00:48:39,080
a huge future here if we reach out and

1468
00:48:41,260 --> 00:48:39,500
grab it

1469
00:48:43,000 --> 00:48:41,270
and the stuff I'm talking about it's not

1470
00:48:45,460 --> 00:48:43,010
happening tomorrow it's happening five

1471
00:48:47,260 --> 00:48:45,470
ten twenty thirty years from now which

1472
00:48:48,640 --> 00:48:47,270
means if you're an undergrad student if

1473
00:48:50,980 --> 00:48:48,650
you're a high school student like you

1474
00:48:52,510 --> 00:48:50,990
could write your PhD thesis on the data

1475
00:48:54,610 --> 00:48:52,520
from the levar telescope I'm trying to

1476
00:48:56,170 --> 00:48:54,620
make happen right like and you could be

1477
00:48:57,580 --> 00:48:56,180
at your stage in your career that I'm at

1478
00:48:59,230 --> 00:48:57,590
in my career right now right like that

1479
00:49:00,490 --> 00:48:59,240
it's not happening tomorrow so though

1480
00:49:02,640 --> 00:49:00,500
the other thing is just support young

1481
00:49:09,670 --> 00:49:02,650
people that are trying to get involved

1482
00:49:11,490 --> 00:49:09,680
like Gavin I've got the mic now I'm

1483
00:49:16,840 --> 00:49:11,500
originally from Flagstaff Arizona

1484
00:49:18,400 --> 00:49:16,850
Territory it's found in that neighbor

1485
00:49:22,000 --> 00:49:18,410
has a planet yeah

1486
00:49:23,950 --> 00:49:22,010
my question is discovering and releasing

1487
00:49:24,970 --> 00:49:23,960
information about our own planet I'm how

1488
00:49:27,670 --> 00:49:24,980

involved is NASA

1489
00:49:30,040 --> 00:49:27,680
I mean we've got so many oceans that are

1490
00:49:31,150 --> 00:49:30,050
unexplored the deep history of our

1491
00:49:35,350 --> 00:49:31,160
planet that we still have yet to

1492
00:49:36,750 --> 00:49:35,360
discover how involved is NASA in well so

1493
00:49:39,430 --> 00:49:36,760
NASA is involved in a number of ways

1494
00:49:41,350 --> 00:49:39,440
there's the the thing that NASA's most

1495
00:49:42,880 --> 00:49:41,360
involved in is is earth observations

1496
00:49:44,830 --> 00:49:42,890
which I was talking about a little bit

1497
00:49:47,110 --> 00:49:44,840
today like if you if you see like a

1498
00:49:49,210 --> 00:49:47,120
weather weather radar satellite like

1499
00:49:51,610 --> 00:49:49,220
like that was probably launched by NASA

1500
00:49:52,990 --> 00:49:51,620
NOAA partnership so we're we're involved

1501
00:49:54,160 --> 00:49:53,000
in almost all of the stuff that's

1502
00:49:56,260 --> 00:49:54,170
looking back down at Earth but it

1503
00:49:57,730 --> 00:49:56,270
actually goes further than that we work

1504
00:49:59,430 --> 00:49:57,740
with NOAA a lot partially to get to

1505
00:50:02,140 --> 00:49:59,440
Antarctica and do exploration of

1506
00:50:03,550 --> 00:50:02,150
environments down there and the Atacama

1507
00:50:05,020 --> 00:50:03,560
Desert we do a lot of work on Earth

1508
00:50:06,940 --> 00:50:05,030
today looking at extreme environments

1509
00:50:08,950 --> 00:50:06,950
that are cold or try a really deep or

1510
00:50:10,900 --> 00:50:08,960
really dark to see the limits of life

1511
00:50:12,880 --> 00:50:10,910
now the other thing that NASA is doing

1512
00:50:15,520 --> 00:50:12,890
is its funding Earth history research

1513
00:50:17,020 --> 00:50:15,530

right because as someone said at this

1514
00:50:19,150 --> 00:50:17,030
great Georgia Tech astrobiology

1515
00:50:20,530 --> 00:50:19,160
conference that I was at yesterday we

1516
00:50:22,900 --> 00:50:20,540
actually have four different versions of

1517
00:50:24,820 --> 00:50:22,910
Earth spread out in time through its

1518
00:50:25,580 --> 00:50:24,830
geological record not necessarily spread

1519
00:50:27,410 --> 00:50:25,590
out like for Earth

1520
00:50:29,390 --> 00:50:27,420
we found around other stars like if I

1521
00:50:31,940 --> 00:50:29,400
went in a time machine like a DeLorean

1522
00:50:34,880 --> 00:50:31,950
or like a TARDIS or like a hot tub or

1523
00:50:36,170 --> 00:50:34,890
something I know but I went back three

1524
00:50:37,850 --> 00:50:36,180
billion years I'd be in a heap of

1525
00:50:39,320 --> 00:50:37,860
trouble unless I also brought a gas mask

1526
00:50:41,480 --> 00:50:39,330
because there would have been no oxygen

1527
00:50:43,280 --> 00:50:41,490
there but there was life present at the

1528
00:50:44,420 --> 00:50:43,290
time so like and actually this I'm kind

1529
00:50:45,500 --> 00:50:44,430
of geeking out a little bit because this

1530
00:50:48,170 --> 00:50:45,510
is like what my dissertation research

1531
00:50:49,880 --> 00:50:48,180
was on but like the there was like a

1532
00:50:52,490 --> 00:50:49,890
billion years at least where there was

1533
00:50:54,620 --> 00:50:52,500
life on Earth but no oxygen for animals

1534
00:50:56,000 --> 00:50:54,630
like us to breathe and oxygens the main

1535
00:50:58,790 --> 00:50:56,010
bio signature we'd be looking for on

1536
00:51:00,470 --> 00:50:58,800
exoplanets so NASA's investing has been

1537
00:51:03,170 --> 00:51:00,480
investing in decades including like my

1538
00:51:04,520 --> 00:51:03,180

PhD research into those questions so we

1539
00:51:06,230 --> 00:51:04,530
can better understand not just how to

1540
00:51:09,590 --> 00:51:06,240
find modern-day earth life but like

1541
00:51:11,120 --> 00:51:09,600
ancient like earth life so there is

1542
00:51:12,740 --> 00:51:11,130
there's the thing there MSF is also a

1543
00:51:18,890 --> 00:51:12,750
big player in that space and we

1544
00:51:21,680 --> 00:51:18,900
collaborate with them a lot okay you're

1545
00:51:25,490 --> 00:51:21,690
talking about Europa how has a sort you

1546
00:51:27,970 --> 00:51:25,500
speculate that it has a melted liquid

1547
00:51:30,380 --> 00:51:27,980
water underneath the ice surface yeah

1548
00:51:31,640 --> 00:51:30,390
why would that water not be frozen there

1549
00:51:36,830 --> 00:51:31,650
is there some sort of internal heat

1550
00:51:39,050 --> 00:51:36,840
source yes got it so there's there's a

1551
00:51:40,580 --> 00:51:39,060
few internal heat sources for Europa one

1552
00:51:42,650 --> 00:51:40,590
is just like the remnant stuff like a

1553
00:51:43,850 --> 00:51:42,660
batch in like all this stuff when the

1554
00:51:45,650 --> 00:51:43,860
planets form smashing together

1555
00:51:47,390 --> 00:51:45,660
everything gets really hot and then

1556
00:51:48,860 --> 00:51:47,400
cools down it actually takes a long time

1557
00:51:51,560 --> 00:51:48,870
for it to cool down especially because

1558
00:51:52,820 --> 00:51:51,570
there's radioactive materials inside the

1559
00:51:54,950 --> 00:51:52,830
center of planets that are still

1560
00:51:56,360 --> 00:51:54,960
generating heat but that's that's not

1561
00:51:57,680 --> 00:51:56,370
the real reason you rope it still has a

1562
00:52:00,680 --> 00:51:57,690
nice shell the real reason is it's

1563
00:52:01,940 --> 00:52:00,690

getting like slung around Jupiter all

1564
00:52:04,700 --> 00:52:01,950
the time and when it's getting slung

1565
00:52:07,040 --> 00:52:04,710
around it's it's gravitationally

1566
00:52:08,960 --> 00:52:07,050
interacting with other moons as they

1567
00:52:10,160 --> 00:52:08,970
pass by each other and when they

1568
00:52:11,900 --> 00:52:10,170
gravitationally interact

1569
00:52:14,450 --> 00:52:11,910
there's tidal forcings the same way that

1570
00:52:16,490 --> 00:52:14,460
like the moon around our earth is like

1571
00:52:18,470 --> 00:52:16,500
causing the oceans to slosh around and

1572
00:52:20,390 --> 00:52:18,480
like we have high tide and low tide same

1573
00:52:22,460 --> 00:52:20,400
things happening on Europa with the ice

1574
00:52:24,080 --> 00:52:22,470
shell but there's no water to slosh

1575
00:52:25,850 --> 00:52:24,090
around and because there's no water to

1576
00:52:27,770 --> 00:52:25,860
slosh around all that tidal energy is

1577
00:52:29,240 --> 00:52:27,780
going into the ice shell and it's kind

1578
00:52:31,550 --> 00:52:29,250
of like flexing it back and forth like

1579
00:52:33,890 --> 00:52:31,560
this and that flexing just the like

1580
00:52:35,300 --> 00:52:33,900
mechanical motion of that is generating

1581
00:52:36,920 --> 00:52:35,310
heat like I don't know if you've ever

1582
00:52:38,300 --> 00:52:36,930
done like any like woodworking or

1583
00:52:39,830 --> 00:52:38,310
anything like that at home but if like

1584
00:52:41,570 --> 00:52:39,840
you saw on something or drilling

1585
00:52:43,340 --> 00:52:41,580
something and it gets hot from that

1586
00:52:45,410 --> 00:52:43,350
friction that's what's happening on

1587
00:52:47,980 --> 00:52:45,420
Europa and it's generating just enough

1588
00:52:54,760 --> 00:52:47,990

heat to keep some of the ice melted a

1589
00:53:03,680 --> 00:52:59,930
where we got it oh I've heard that the

1590
00:53:06,680 --> 00:53:03,690
next telescope is might be able to

1591
00:53:09,980 --> 00:53:06,690
examine the atmospheres of exoplanets

1592
00:53:12,980 --> 00:53:09,990
Josh might give an indication of there

1593
00:53:16,310 --> 00:53:12,990
was life do you know how they could tell

1594
00:53:19,130 --> 00:53:16,320
women on a an exoplanet has life or

1595
00:53:20,840 --> 00:53:19,140
probably has life so the the

1596
00:53:22,670 --> 00:53:20,850
observations you're talking about were

1597
00:53:23,780 --> 00:53:22,680
from that that like awesome gold

1598
00:53:25,040 --> 00:53:23,790
telescope I was showing earlier the

1599
00:53:27,560 --> 00:53:25,050
James Webb Space Telescope

1600
00:53:29,570 --> 00:53:27,570
what's gonna happen there is planets are

1601
00:53:31,580 --> 00:53:29,580
gonna pass in front of the star we're

1602
00:53:32,810 --> 00:53:31,590
only gonna look at stars where we know

1603
00:53:34,820 --> 00:53:32,820
there's gonna be a planet passing in

1604
00:53:37,070 --> 00:53:34,830
front of the star when the planet passes

1605
00:53:39,380 --> 00:53:37,080
in front of the star it's the atmosphere

1606
00:53:41,600 --> 00:53:39,390
of the planet is going to sort of serve

1607
00:53:42,920 --> 00:53:41,610
as like a color filter like if you were

1608
00:53:44,840 --> 00:53:42,930
up here on stage with me you'd see some

1609
00:53:46,370 --> 00:53:44,850
blue lights to the side or if you ever

1610
00:53:48,560 --> 00:53:46,380
work on it as a stagehand you'll have

1611
00:53:50,840 --> 00:53:48,570
like red and blue gels or like if you

1612
00:53:53,960 --> 00:53:50,850
ever remember like an over school school

1613
00:53:55,280 --> 00:53:53,970

or an old school overhead projector at a

1614
00:53:57,080 --> 00:53:55,290
school we're like you put this sheet

1615
00:53:59,210 --> 00:53:57,090
down and the light pass through it and

1616
00:54:00,920 --> 00:53:59,220
it put colors up on the screen well the

1617
00:54:02,480 --> 00:54:00,930
same way this works is there's a little

1618
00:54:04,280 --> 00:54:02,490
thing in here that's actually generating

1619
00:54:06,140 --> 00:54:04,290
specific colors that fly up onto the

1620
00:54:07,400 --> 00:54:06,150
onto the screen all of those things work

1621
00:54:09,500 --> 00:54:07,410
because you're filtering out certain

1622
00:54:10,580 --> 00:54:09,510
colors of light and the same thing is

1623
00:54:12,470 --> 00:54:10,590
gonna happen with these planets they're

1624
00:54:14,180 --> 00:54:12,480
gonna pass in front of the star and it's

1625
00:54:15,920 --> 00:54:14,190
gonna filter out certain colors of light

1626
00:54:17,720 --> 00:54:15,930
in this case the filter is gonna be

1627
00:54:19,790 --> 00:54:17,730
based on what gases are in that planet's

1628
00:54:22,190 --> 00:54:19,800
atmosphere if there's a lot of carbon

1629
00:54:23,930 --> 00:54:22,200
dioxide it's gonna block the wavelengths

1630
00:54:25,520 --> 00:54:23,940
of light that carbon dioxide absorbs

1631
00:54:27,440 --> 00:54:25,530
that there's oxygen in that atmosphere

1632
00:54:30,350 --> 00:54:27,450
there's certain wavelengths of light a

1633
00:54:32,090 --> 00:54:30,360
little bit redder than the the reddest

1634
00:54:33,830 --> 00:54:32,100
things we can see you'll see a little

1635
00:54:35,180 --> 00:54:33,840
bit of a dip in the spectrum from that

1636
00:54:36,380 --> 00:54:35,190
and that's how James Webb's gonna look

1637
00:54:39,140 --> 00:54:36,390
for for life

1638
00:54:40,400 --> 00:54:39,150

now I I'm honestly not counting on it

1639
00:54:42,530 --> 00:54:40,410
working because it's going to be looking

1640
00:54:44,540 --> 00:54:42,540
at these planets around these like like

1641
00:54:46,280 --> 00:54:44,550
wild teenage stars that like are like

1642
00:54:47,360 --> 00:54:46,290
way too active and wild and are going to

1643
00:54:49,250 --> 00:54:47,370
cause all kinds of havoc for the

1644
00:54:51,620 --> 00:54:49,260
planetary atmosphere but we're gonna

1645
00:54:56,329 --> 00:54:54,589
got one right here where's here to your

1646
00:54:58,939 --> 00:54:56,339
left all right finally we got over here

1647
00:54:59,390 --> 00:54:58,949
yeah oh yeah oh yeah sorry I know where

1648
00:55:03,349 --> 00:54:59,400
he's gotcha

1649
00:55:05,299 --> 00:55:03,359
so uh Earth has a electromagnetic core

1650
00:55:07,339 --> 00:55:05,309
that provides protection for the

1651
00:55:09,529 --> 00:55:07,349
atmosphere and it would seem that that

1652
00:55:11,239 --> 00:55:09,539
might be something that we could look

1653
00:55:13,719 --> 00:55:11,249
for elsewhere to repeat a faulty model

1654
00:55:17,539 --> 00:55:13,729
of relying on what's happened here yes

1655
00:55:19,670 --> 00:55:17,549
so are there sensing capabilities to

1656
00:55:21,949 --> 00:55:19,680
detect electromagnetic subsurface

1657
00:55:23,029 --> 00:55:21,959
activity to gather whether or not

1658
00:55:26,829 --> 00:55:23,039
there's an atmosphere or other means

1659
00:55:29,349 --> 00:55:26,839
doing that and then jumping ahead do our

1660
00:55:32,329 --> 00:55:29,359
electromagnetic signatures as

1661
00:55:33,789 --> 00:55:32,339
intelligent light become apparent with

1662
00:55:36,620 --> 00:55:33,799
the same sensing apparatus

1663
00:55:39,559 --> 00:55:36,630

okay let me break that into let me play

1664
00:55:41,539 --> 00:55:39,569
only do the two so let me do the first

1665
00:55:42,680 --> 00:55:41,549
one so yeah I might have to ask you a

1666
00:55:43,849 --> 00:55:42,690
question about the second one so I make

1667
00:55:44,269 --> 00:55:43,859
sure I understand right for the first

1668
00:55:52,189 --> 00:55:44,279
one

1669
00:55:53,329 --> 00:55:52,199
the challenges with all this stuff is we

1670
00:55:56,150 --> 00:55:53,339
have to make sure that we're including

1671
00:55:58,549 --> 00:55:56,160
as many brains as possible into the

1672
00:56:02,660 --> 00:55:58,559
conversation historically the people

1673
00:56:05,359 --> 00:56:02,670
that do space physics and and like space

1674
00:56:06,890 --> 00:56:05,369
weather and and like geomagnetic studies

1675
00:56:08,689 --> 00:56:06,900
like they haven't been involved in the

1676
00:56:10,729 --> 00:56:08,699
study of habitability and bio signatures

1677
00:56:12,019 --> 00:56:10,739
and stuff like that and so we're aware

1678
00:56:14,209 --> 00:56:12,029
of that science and we've thought about

1679
00:56:15,949 --> 00:56:14,219
it at a very top level to the extent

1680
00:56:17,150 --> 00:56:15,959
that someone it's not an expert in it so

1681
00:56:19,009 --> 00:56:17,160
I'm not an expert in that stuff but I've

1682
00:56:20,509 --> 00:56:19,019
thought about it a lot we really need to

1683
00:56:22,069 --> 00:56:20,519
do is engage that community more and

1684
00:56:24,229 --> 00:56:22,079
bring them into the fold NASA actually

1685
00:56:26,180 --> 00:56:24,239
has so there's four science divisions at

1686
00:56:27,799 --> 00:56:26,190
NASA they get like like geeky about like

1687
00:56:29,089 --> 00:56:27,809
our organizational structure we got

1688
00:56:30,289 --> 00:56:29,099

Earth Sciences which I was talking about

1689
00:56:32,329 --> 00:56:30,299
an astrophysics

1690
00:56:33,739 --> 00:56:32,339
we got planetary sciences and we've got

1691
00:56:35,809 --> 00:56:33,749
Helio physics which is the science you

1692
00:56:37,160 --> 00:56:35,819
were talking about historically Helio

1693
00:56:39,380 --> 00:56:37,170
physics has been the one that's had the

1694
00:56:40,789 --> 00:56:39,390
least amount of interaction but like

1695
00:56:42,769 --> 00:56:40,799
there's stuff we've got going on with

1696
00:56:44,630 --> 00:56:42,779
grants and and new research programs

1697
00:56:45,920 --> 00:56:44,640
that are trying to change that I mean if

1698
00:56:47,329 --> 00:56:45,930
that's if you like are particularly

1699
00:56:48,739 --> 00:56:47,339
active in that like that might be a

1700
00:56:51,140 --> 00:56:48,749
funding source for you in the future or

1701
00:56:52,969 --> 00:56:51,150
if you have friends that are the second

1702
00:56:54,859 --> 00:56:52,979
question about like like could could

1703
00:56:55,849 --> 00:56:54,869
aliens detect us basically are you

1704
00:56:57,499 --> 00:56:55,859
talking about like they're talking like

1705
00:56:59,630 --> 00:56:57,509
radio communications and stuff like that

1706
00:57:01,880 --> 00:56:59,640
so in theory asks like we know how to

1707
00:57:03,420 --> 00:57:01,890
search for signs of intelligent life

1708
00:57:04,950 --> 00:57:03,430
which I was by the way I wasn't talking

1709
00:57:06,839 --> 00:57:04,960
about study at all and it's not that I

1710
00:57:08,819 --> 00:57:06,849
hate study it's just like that's not the

1711
00:57:11,849 --> 00:57:08,829
kind of astrobiology that like NASA does

1712
00:57:12,870 --> 00:57:11,859
and funds like and part of it is that's

1713
00:57:14,520 --> 00:57:12,880

not what you build a space flight

1714
00:57:16,079 --> 00:57:14,530
mission to do right you would do SETI

1715
00:57:17,700 --> 00:57:16,089
you'd search for those radio wave stuff

1716
00:57:19,470 --> 00:57:17,710
with ground-based observatories and I'm

1717
00:57:20,700 --> 00:57:19,480
really glad that folks in with

1718
00:57:22,079 --> 00:57:20,710
ground-based observatories are doing

1719
00:57:25,079 --> 00:57:22,089
doing that stuff and I think it's cool

1720
00:57:26,640 --> 00:57:25,089
and worthwhile one of the there's some

1721
00:57:29,040 --> 00:57:26,650
interesting stuff about that one thing

1722
00:57:30,329 --> 00:57:29,050
that that I didn't appreciate till I

1723
00:57:32,910 --> 00:57:30,339
started talking to some folks is we're

1724
00:57:35,309 --> 00:57:32,920
actually getting quieter over time and

1725
00:57:38,160 --> 00:57:35,319
part of the reason like so who now has

1726
00:57:39,690 --> 00:57:38,170
digital television in some form right or

1727
00:57:41,940 --> 00:57:39,700
like television like television that

1728
00:57:44,370 --> 00:57:41,950
they get over the internet or digital

1729
00:57:47,160 --> 00:57:44,380
antenna digital transmissions are much

1730
00:57:49,079 --> 00:57:47,170
more energy efficient than the than what

1731
00:57:51,359 --> 00:57:49,089
they're replacing and as a result we're

1732
00:57:53,579 --> 00:57:51,369
actually leaking less of a signal than

1733
00:57:55,470 --> 00:57:53,589
we were 10 years ago right so digital

1734
00:57:57,210 --> 00:57:55,480
TVs brought us like awesome sporting

1735
00:58:00,890 --> 00:57:57,220
events in high-definition they're also

1736
00:58:03,030 --> 00:58:00,900
making us harder to see from far away in

1737
00:58:05,069 --> 00:58:03,040
general you might expect that trend to

1738
00:58:06,990 --> 00:58:05,079

continue in theory right like because we

1739
00:58:09,210 --> 00:58:07,000
as our technology improves just stuff

1740
00:58:10,770 --> 00:58:09,220
should get more efficient overall and

1741
00:58:12,180 --> 00:58:10,780
then you'd look for other things right

1742
00:58:13,890 --> 00:58:12,190
so you then you have to think about what

1743
00:58:15,569 --> 00:58:13,900
other things is our civilization doing

1744
00:58:17,339 --> 00:58:15,579
that could be detectable remotely and

1745
00:58:24,270 --> 00:58:17,349
there's like that's a whole nother talk

1746
00:58:26,549 --> 00:58:24,280
I know you're talking about Europa being

1747
00:58:29,250 --> 00:58:26,559
opaque to sunlight what about condition

1748
00:58:31,470 --> 00:58:29,260
to drilling through the surface use of

1749
00:58:34,710 --> 00:58:31,480
remotely operated submarines to look for

1750
00:58:36,359 --> 00:58:34,720
geothermal vents on Europa yeah so that

1751
00:58:39,299 --> 00:58:36,369
that's a that's a great question and I

1752
00:58:40,380 --> 00:58:39,309
got I said briefly that like Europa has

1753
00:58:42,150 --> 00:58:40,390
energy but I didn't say where it came

1754
00:58:43,380 --> 00:58:42,160
from so I was talking about Europa

1755
00:58:45,920 --> 00:58:43,390
having this ice shell that kind of

1756
00:58:48,030 --> 00:58:45,930
isolates the water from from sunlight

1757
00:58:50,190 --> 00:58:48,040
and that's not to say that your hope is

1758
00:58:51,210 --> 00:58:50,200
totally devoid of energy as the previous

1759
00:58:53,250 --> 00:58:51,220
or question was getting if there's sort

1760
00:58:54,450 --> 00:58:53,260
of these tidal energies but the other

1761
00:58:55,799 --> 00:58:54,460
thing that's happening is at the very

1762
00:58:57,210 --> 00:58:55,809
very bottom of that ocean there's

1763
00:58:59,549 --> 00:58:57,220

there's we think there's these this

1764
00:59:01,680 --> 00:58:59,559
geothermal activity much like exists at

1765
00:59:03,510 --> 00:59:01,690
the bottom of our ocean and that's not

1766
00:59:05,190 --> 00:59:03,520
only important for thinking about the

1767
00:59:07,170 --> 00:59:05,200
water existing it's probably even more

1768
00:59:09,450 --> 00:59:07,180
important from thinking about the energy

1769
00:59:11,520 --> 00:59:09,460
that life could use to make a living on

1770
00:59:14,430 --> 00:59:11,530
Europa all life needs energy we get our

1771
00:59:15,650 --> 00:59:14,440
energy by eating food or drinking beer

1772
00:59:18,049 --> 00:59:15,660
that has organic carbon in

1773
00:59:19,190 --> 00:59:18,059
and burning it with oxygen on Europa

1774
00:59:20,900 --> 00:59:19,200
what you'd probably do if you're a

1775
00:59:23,390 --> 00:59:20,910
microbe is you actually use a set of

1776
00:59:25,700 --> 00:59:23,400
chemical reactions taking the oxidized

1777
00:59:27,380 --> 00:59:25,710
space environment and and comparing it

1778
00:59:28,880 --> 00:59:27,390
to the reduced environment chemically

1779
00:59:30,349 --> 00:59:28,890
reduced environment of the interior and

1780
00:59:32,150 --> 00:59:30,359
basically taking a chemical

1781
00:59:34,910 --> 00:59:32,160
disequilibrium almost like a battery and

1782
00:59:36,980 --> 00:59:34,920
using that energy to build cells of

1783
00:59:39,440 --> 00:59:36,990
maintained cellular structure and that's

1784
00:59:40,670 --> 00:59:39,450
if that isn't happening on Europa which

1785
00:59:42,470 --> 00:59:40,680
we think it is it would be a major

1786
00:59:43,940 --> 00:59:42,480
problem but because that geothermal

1787
00:59:48,170 --> 00:59:43,950
activities there we think that life

1788
00:59:49,630 --> 00:59:48,180

could potentially exist hi

1789
00:59:53,120 --> 00:59:49,640
you had mentioned in your presentation

1790
00:59:56,329 --> 00:59:53,130
that they had discovered some life and

1791
00:59:58,370 --> 00:59:56,339
on on Antarctica and it was discounted

1792
01:00:01,460 --> 00:59:58,380
what was the reasoning that they said

1793
01:00:05,299 --> 01:00:01,470
that it was you know just thrown out a

1794
01:00:07,430 --> 01:00:05,309
number of reasons number one if I say I

1795
01:00:11,210 --> 01:00:07,440
found evidence of life on another planet

1796
01:00:14,120 --> 01:00:11,220
that's a super hot like it's so bold the

1797
01:00:16,520 --> 01:00:14,130
standard that I have to live up to by my

1798
01:00:19,299 --> 01:00:16,530
scientific peers is tremendously high

1799
01:00:21,470 --> 01:00:19,309
it's about as high as anything else

1800
01:00:23,150 --> 01:00:21,480
number two there were three other

1801
01:00:24,380 --> 01:00:23,160
experiments on that Rover that did not

1802
01:00:26,779 --> 01:00:24,390
find signs of life there were also

1803
01:00:27,950 --> 01:00:26,789
designed to look for it right so there

1804
01:00:29,809 --> 01:00:27,960
were like there I think there were a

1805
01:00:31,279 --> 01:00:29,819
total of four experiments three of them

1806
01:00:33,130 --> 01:00:31,289
were negative and said there was no life

1807
01:00:36,589 --> 01:00:33,140
here and that was the one that did and

1808
01:00:38,120 --> 01:00:36,599
then lastly there was a complete absence

1809
01:00:40,430 --> 01:00:38,130
of organic carbon like the stuff that

1810
01:00:42,710 --> 01:00:40,440
life is made of also assessed at that

1811
01:00:44,329 --> 01:00:42,720
time now as a result the astrobiology

1812
01:00:48,319 --> 01:00:44,339
community over time has not been

1813
01:00:50,269 --> 01:00:48,329

convinced by that I think here's this is

1814
01:00:51,589 --> 01:00:50,279
what I would say as an independent

1815
01:00:53,000 --> 01:00:51,599
science is that like I don't really have

1816
01:00:56,089 --> 01:00:53,010
a stake in this game I'm not convinced

1817
01:00:57,650 --> 01:00:56,099
by the data right now okay if we did

1818
01:00:59,960 --> 01:00:57,660
more detailed experiments in the future

1819
01:01:00,589 --> 01:00:59,970
that showed that life is present on the

1820
01:01:02,690 --> 01:01:00,599
Martian surface

1821
01:01:03,890 --> 01:01:02,700
today I think it would only be fair of

1822
01:01:05,329 --> 01:01:03,900
Gil Levin the person that did that

1823
01:01:07,579 --> 01:01:05,339
experiment got credit for being the

1824
01:01:08,690 --> 01:01:07,589
first one to find it even if he didn't

1825
01:01:10,309 --> 01:01:08,700
convince the science community at the

1826
01:01:11,690 --> 01:01:10,319
time and there's actually a dispute over

1827
01:01:13,819 --> 01:01:11,700
who found the first exoplanet because

1828
01:01:15,769 --> 01:01:13,829
the first exoplanet discovered wasn't

1829
01:01:17,420 --> 01:01:15,779
believed until like the second exoplanet

1830
01:01:18,740 --> 01:01:17,430
was discovered and then they believed

1831
01:01:20,000 --> 01:01:18,750
the first exoplanet but it's actually

1832
01:01:23,420 --> 01:01:20,010
the second discovery that gets a lot of

1833
01:01:25,069 --> 01:01:23,430
the credit right so if we ever convince

1834
01:01:26,809 --> 01:01:25,079
ourselves that there is life on Mars I

1835
01:01:28,039 --> 01:01:26,819
think Gil Levin and his team should get

1836
01:01:29,120 --> 01:01:28,049
the credit for being the first ones to

1837
01:01:30,260 --> 01:01:29,130
discover it

1838
01:01:31,910 --> 01:01:30,270

this level because of those other

1839
01:01:34,130 --> 01:01:31,920
negative results and because of the lack

1840
01:01:36,100 --> 01:01:34,140
of organic carbon on the surface that's

1841
01:01:42,170 --> 01:01:36,110
that's why most people doubt the claim

1842
01:01:44,180 --> 01:01:42,180
Shawn I think I think the other question

1843
01:01:45,980 --> 01:01:44,190
was also yeah it kind of would be afraid

1844
01:01:47,900 --> 01:01:45,990
of things yeah well I especially since I

1845
01:01:48,620 --> 01:01:47,910
used to work for David Mackay yeah yeah

1846
01:01:51,830 --> 01:01:48,630
that's right

1847
01:01:53,450 --> 01:01:51,840
because I was like yeah so I used to

1848
01:01:57,890 --> 01:01:53,460
work in that group because you're asking

1849
01:01:59,780 --> 01:01:57,900
about the Mars meteorite okay oh sorry

1850
01:02:03,080 --> 01:01:59,790
yeah I was talking about the Viking

1851
01:02:09,770 --> 01:02:03,090
Lander totally but it wasn't a Mars

1852
01:02:12,200 --> 01:02:09,780
meteorite it was the meteorite I know so

1853
01:02:13,790 --> 01:02:12,210
what happened is is that they felt like

1854
01:02:14,840 --> 01:02:13,800
Sean showed you they found these

1855
01:02:16,940 --> 01:02:14,850
structures that they're like oh these

1856
01:02:18,410 --> 01:02:16,950
are absolutely biological only

1857
01:02:19,430 --> 01:02:18,420
biological forms can make these so what

1858
01:02:21,920 --> 01:02:19,440
they found are these things called

1859
01:02:23,150 --> 01:02:21,930
magnetite crystals and we have this

1860
01:02:25,070 --> 01:02:23,160
thing on earth called magnetotactic

1861
01:02:27,020 --> 01:02:25,080
bacteria these these bacteria to swim in

1862
01:02:28,550 --> 01:02:27,030
the ocean and they have a make these

1863
01:02:30,740 --> 01:02:28,560

crystals they literally make minerals

1864
01:02:32,930 --> 01:02:30,750
inside their bodies that allow that

1865
01:02:34,790 --> 01:02:32,940
align up and allow them to detect

1866
01:02:36,590 --> 01:02:34,800
Earth's magnetic field and so that they

1867
01:02:39,230 --> 01:02:36,600
can swim along and then move along

1868
01:02:41,440 --> 01:02:39,240
Earth's magnetic field lines so they

1869
01:02:44,350 --> 01:02:41,450
found these crystals inside an actual

1870
01:02:46,070 --> 01:02:44,360
kind of this this actual kind of

1871
01:02:47,030 --> 01:02:46,080
carbon-carbon structure that we found in

1872
01:02:48,380 --> 01:02:47,040
the meteorite we actually found these

1873
01:02:50,900 --> 01:02:48,390
kind of weird carbon structures in the

1874
01:02:53,930 --> 01:02:50,910
meteorite and they were they were and

1875
01:02:55,820 --> 01:02:53,940
and they're they are fairly unique to

1876
01:02:57,740 --> 01:02:55,830
magnetotactic bacteria so that's kind of

1877
01:02:58,850 --> 01:02:57,750
the thing that made them say oh it's how

1878
01:03:00,260 --> 01:02:58,860
do we made my life and it was deep

1879
01:03:02,090 --> 01:03:00,270
enough in the meteorite that they were

1880
01:03:03,800 --> 01:03:02,100
convinced that it wasn't contamination

1881
01:03:05,900 --> 01:03:03,810
or anything like that but the problem is

1882
01:03:08,810 --> 01:03:05,910
that these magnetite crystals another

1883
01:03:11,330 --> 01:03:08,820
team showed can be made in a purely

1884
01:03:14,030 --> 01:03:11,340
chemical process so the big argument

1885
01:03:16,100 --> 01:03:14,040
that cast huge doubt on the Mars

1886
01:03:18,560 --> 01:03:16,110
meteorite discovery is well where the

1887
01:03:23,960 --> 01:03:18,570
magnetite crystals made by biology or

1888
01:03:26,150 --> 01:03:23,970

they made by by chemistry and to make it

1889
01:03:28,610 --> 01:03:26,160
clear the process that this really

1890
01:03:29,930 --> 01:03:28,620
brilliant chemist at Johnson space or

1891
01:03:32,210 --> 01:03:29,940
came up with to figure out how to make

1892
01:03:34,430 --> 01:03:32,220
these things by natural by chemistry

1893
01:03:36,350 --> 01:03:34,440
came up with is a really complex process

1894
01:03:37,700 --> 01:03:36,360
but it's it's a process that could have

1895
01:03:39,470 --> 01:03:37,710
could have happened on Mars so it is a

1896
01:03:41,690 --> 01:03:39,480
process that could have made these

1897
01:03:42,589 --> 01:03:41,700
magnetite crystals so that's why we're

1898
01:03:43,999 --> 01:03:42,599
just not convinced

1899
01:03:45,529 --> 01:03:44,009
not enough data to tell us that these

1900
01:03:47,089 --> 01:03:45,539
magnetite crystals were definitely made

1901
01:03:49,519 --> 01:03:47,099
by biology inside this Mars meteorite

1902
01:03:51,529 --> 01:03:49,529
okay nobody's convinced and that

1903
01:03:54,309 --> 01:03:51,539
chemical process we didn't know how to

1904
01:03:56,890 --> 01:03:54,319
do it yeah before we found their

1905
01:04:00,529 --> 01:03:56,900
brilliant geochemistry name DC golden

1906
01:04:03,170 --> 01:04:00,539
that that he spent like a year figuring

1907
01:04:05,089 --> 01:04:03,180
out how to do this chemically and MIT he

1908
01:04:06,979 --> 01:04:05,099
did it and this story has motivated a

1909
01:04:08,569 --> 01:04:06,989
lot of research in the field since then

1910
01:04:10,999 --> 01:04:08,579
because now we're because what happened

1911
01:04:13,099 --> 01:04:11,009
there right is like that team found

1912
01:04:15,049 --> 01:04:13,109
signatures that we knew of no

1913
01:04:16,969 --> 01:04:15,059

non-biological process to make those

1914
01:04:19,190 --> 01:04:16,979
things exactly and then and then a bunch

1915
01:04:21,829 --> 01:04:19,200
of other smart people said well I maybe

1916
01:04:22,999 --> 01:04:21,839
I can make those things team where

1917
01:04:24,559 --> 01:04:23,009
they're like right we think it's this

1918
01:04:25,999 --> 01:04:24,569
you guys go and figure out if you can do

1919
01:04:28,819 --> 01:04:26,009
it chemically and they're like yep we

1920
01:04:31,069 --> 01:04:28,829
did it chemically your stuff to see

1921
01:04:32,390 --> 01:04:31,079
inclusive so the hard thing is and this

1922
01:04:35,089 --> 01:04:32,400
is what astrobiologists are trying to do

1923
01:04:36,799 --> 01:04:35,099
now we're trying to game out here's what

1924
01:04:38,390 --> 01:04:36,809
we think our data are going to be for a

1925
01:04:40,279 --> 01:04:38,400
future mission that would find life and

1926
01:04:41,930 --> 01:04:40,289
we're actually spinning up those those

1927
01:04:44,210 --> 01:04:41,940
sorts of like red team blue team's now

1928
01:04:46,460 --> 01:04:44,220
to find other ways to make those signals

1929
01:04:48,349 --> 01:04:46,470
before we launch the mission before we

1930
01:04:49,999 --> 01:04:48,359
build the spacecraft so that mission of

1931
01:04:51,109 --> 01:04:50,009
that spacecraft could also have the

1932
01:04:53,120 --> 01:04:51,119
stuff that would differentiate between

1933
01:04:55,940 --> 01:04:53,130
the like chemistry the pure chemistry

1934
01:04:57,049 --> 01:04:55,950
versus the biology that's that's one of

1935
01:04:58,279 --> 01:04:57,059
the things we're doing differently now

1936
01:04:59,660 --> 01:04:58,289
than we did before the Ellen Hills

1937
01:05:01,819 --> 01:04:59,670
meteorite because we're thinking about

1938
01:05:03,079 --> 01:05:01,829

that stuff in advance and we have a lot

1939
01:05:09,709 --> 01:05:03,089
yet we a lot of people doing this in lab

1940
01:05:11,059 --> 01:05:09,719
everyday so I got to give it back to

1941
01:05:12,529 --> 01:05:11,069
this young lady who again let me have

1942
01:05:15,499 --> 01:05:12,539
the cash box there you go sweetheart ask

1943
01:05:19,359 --> 01:05:15,509
your question how do we know that all

1944
01:05:26,269 --> 01:05:19,369
life has to be made up of carbon oh nice

1945
01:05:27,529 --> 01:05:26,279
that's that so so I'll be honest we

1946
01:05:29,059 --> 01:05:27,539
don't know that it has to be made up of

1947
01:05:30,829 --> 01:05:29,069
carbon and actually there's chemists

1948
01:05:32,779 --> 01:05:30,839
much better than myself that that would

1949
01:05:34,940 --> 01:05:32,789
have like come up with ways to make life

1950
01:05:37,609 --> 01:05:34,950
out of things other than carbon now that

1951
01:05:39,079 --> 01:05:37,619
that I'm gonna give you two answers to

1952
01:05:41,059 --> 01:05:39,089
this question okay I'm gonna give you

1953
01:05:43,279 --> 01:05:41,069
the answer I would have given five years

1954
01:05:45,469 --> 01:05:43,289
ago and then the answer I'll give that

1955
01:05:47,509 --> 01:05:45,479
that I give today okay five years ago I

1956
01:05:49,609 --> 01:05:47,519
would have said you know you know

1957
01:05:51,650 --> 01:05:49,619
organic carbon like not organic carbon

1958
01:05:53,779 --> 01:05:51,660
based life could happen but as a

1959
01:05:56,390 --> 01:05:53,789
scientist I need a test to figure out

1960
01:05:58,250 --> 01:05:56,400
what life that wasn't based on carbon

1961
01:06:00,350 --> 01:05:58,260
what do I have to understand not

1962
01:06:01,790 --> 01:06:00,360
carbon-based life well enough to make a

1963
01:06:03,620 --> 01:06:01,800

prediction of what it would produce that

1964
01:06:05,420 --> 01:06:03,630
I could go look for and I'm not a good

1965
01:06:06,590 --> 01:06:05,430
enough chemist to do that but maybe

1966
01:06:08,420 --> 01:06:06,600
there's a good enough chemist out there

1967
01:06:11,060 --> 01:06:08,430
okay that was my five years ago answer

1968
01:06:12,440 --> 01:06:11,070
my answer today is there's some awesome

1969
01:06:14,120 --> 01:06:12,450
chemists out there and they figured out

1970
01:06:15,890 --> 01:06:14,130
how to look for the signs of life that

1971
01:06:17,480 --> 01:06:15,900
that isn't based on carbon might make

1972
01:06:19,520 --> 01:06:17,490
and actually one of them came through

1973
01:06:20,690 --> 01:06:19,530
Georgia for a time Sarah Walker who used

1974
01:06:22,580 --> 01:06:20,700
to be a postdoc here at Georgia Tech

1975
01:06:24,830 --> 01:06:22,590
she's now a faculty member at Arizona

1976
01:06:26,330 --> 01:06:24,840
State she's working with Lee Cronin

1977
01:06:28,280 --> 01:06:26,340
who's across the pond in England I think

1978
01:06:30,460 --> 01:06:28,290
and some other scientists and what

1979
01:06:32,480 --> 01:06:30,470
they're coming out with now is like

1980
01:06:35,090 --> 01:06:32,490
instead of looking for the specific

1981
01:06:36,950 --> 01:06:35,100
things that a particular organism that

1982
01:06:38,480 --> 01:06:36,960
might be organic carbon-based makes

1983
01:06:41,780 --> 01:06:38,490
right like so organic carbon-based

1984
01:06:43,490 --> 01:06:41,790
organisms on our planet the the thing we

1985
01:06:45,110 --> 01:06:43,500
look for a lot is like oxygen or like

1986
01:06:46,640 --> 01:06:45,120
we're breathing out carbon dioxide we're

1987
01:06:48,440 --> 01:06:46,650
looking for specific things that come

1988
01:06:50,450 --> 01:06:48,450

from that specific biochemistry that's

1989
01:06:51,740 --> 01:06:50,460
ultimately carbon-based what Sarah

1990
01:06:53,810 --> 01:06:51,750
Walker and her colleagues are saying is

1991
01:06:55,490 --> 01:06:53,820
like throw that out the window what you

1992
01:06:58,040 --> 01:06:55,500
really want to look for is look at is

1993
01:07:00,260 --> 01:06:58,050
sort of the complexity just a basically

1994
01:07:02,930 --> 01:07:00,270
like a mathematical analysis of the

1995
01:07:05,240 --> 01:07:02,940
overall complexity of the chemistry the

1996
01:07:07,130 --> 01:07:05,250
chemical Network that is created by life

1997
01:07:09,020 --> 01:07:07,140
because whether or not it's carbon-based

1998
01:07:11,120 --> 01:07:09,030
or silicon based or something else based

1999
01:07:12,890 --> 01:07:11,130
if life is in the environment it's going

2000
01:07:14,600 --> 01:07:12,900
to be enriching and developing the

2001
01:07:16,610 --> 01:07:14,610
complexity of the chemistry around it

2002
01:07:18,830 --> 01:07:16,620
way more than non-biological processes

2003
01:07:20,630 --> 01:07:18,840
can do it and it's like orders of

2004
01:07:23,470 --> 01:07:20,640
magnitude like hundreds of thousands of

2005
01:07:26,300 --> 01:07:23,480
times more complex because of life and

2006
01:07:28,010 --> 01:07:26,310
that becomes our bio signature now that

2007
01:07:30,020 --> 01:07:28,020
bio signature the complexity of

2008
01:07:31,040 --> 01:07:30,030
chemistry that life creates it doesn't

2009
01:07:33,290 --> 01:07:31,050
have to be because it's organic

2010
01:07:35,270 --> 01:07:33,300
carbon-based life or silicon-based life

2011
01:07:37,400 --> 01:07:35,280
or water-based life or anything base

2012
01:07:38,840 --> 01:07:37,410
life as long as you agree with the

2013
01:07:40,280 --> 01:07:38,850

fundamental principle that life is

2014
01:07:42,950 --> 01:07:40,290
making caught the chemistry and its

2015
01:07:45,140 --> 01:07:42,960
environment more complicated which does

2016
01:07:46,700 --> 01:07:45,150
seem to be ubiquitous even for our

2017
01:07:48,710 --> 01:07:46,710
models of not organic based chemistry

2018
01:07:56,190 --> 01:07:48,720
now you've got a bio signature that

2019
01:08:02,730 --> 01:08:01,319
oh yeah you so back here and then we got

2020
01:08:05,520 --> 01:08:02,740
a question over here if we need to do

2021
01:08:07,650 --> 01:08:05,530
that one naturally when you talk to

2022
01:08:09,000 --> 01:08:07,660
other scientists in other countries how

2023
01:08:11,430 --> 01:08:09,010
forthcoming are there with their

2024
01:08:16,760 --> 01:08:11,440
research and data or is it like more

2025
01:08:27,419 --> 01:08:20,400
ask me after I'll give you a story that

2026
01:08:31,590 --> 01:08:27,429
I don't want to tell on stage in general

2027
01:08:33,450 --> 01:08:31,600
people are awesome right like and and I

2028
01:08:35,640 --> 01:08:33,460
actually believe as a scientist it pays

2029
01:08:37,829 --> 01:08:35,650
to be really generous with your data

2030
01:08:39,180 --> 01:08:37,839
with your models because like so on the

2031
01:08:40,410 --> 01:08:39,190
model or like most of what I do I didn't

2032
01:08:41,550 --> 01:08:40,420
really go into this today like most of

2033
01:08:43,019 --> 01:08:41,560
what I do is I build models with

2034
01:08:43,979 --> 01:08:43,029
planetary atmospheres to figure out what

2035
01:08:45,990 --> 01:08:43,989
their chemistry was like what their

2036
01:08:47,370 --> 01:08:46,000
climates like what biology would do that

2037
01:08:48,870 --> 01:08:47,380
would impact like the chemistry not the

2038
01:08:50,669 --> 01:08:48,880

chemical network of an atmosphere stuff

2039
01:08:52,530 --> 01:08:50,679
like that everything I do like and

2040
01:08:53,970 --> 01:08:52,540
there's some per part like there's a an

2041
01:08:56,430 --> 01:08:53,980
instinct to be like really proprietary

2042
01:08:58,200 --> 01:08:56,440
with my model and keep it like locked in

2043
01:08:59,340 --> 01:08:58,210
and close to me so only I have access to

2044
01:09:01,320 --> 01:08:59,350
it and write papers with it

2045
01:09:03,630 --> 01:09:01,330
but actually I think the opposite

2046
01:09:04,890 --> 01:09:03,640
instinct is a much healthier one because

2047
01:09:06,689 --> 01:09:04,900
when I let my model out there to the

2048
01:09:08,939 --> 01:09:06,699
community two things happen one other

2049
01:09:10,979 --> 01:09:08,949
scientists that have not developed a

2050
01:09:12,689 --> 01:09:10,989
model like mine they don't want to just

2051
01:09:14,130 --> 01:09:12,699
like steal it and use it for their own

2052
01:09:15,269 --> 01:09:14,140
purposes they'll email me and they'll

2053
01:09:16,349 --> 01:09:15,279
want to collaborate and maybe it'll

2054
01:09:17,760 --> 01:09:16,359
write a grant that gets me or my

2055
01:09:20,430 --> 01:09:17,770
students some funding and that that's

2056
01:09:22,169 --> 01:09:20,440
awesome also like I might talk to them

2057
01:09:24,090 --> 01:09:22,179
because they found a bug in my model

2058
01:09:26,700 --> 01:09:24,100
that I really should fix before I write

2059
01:09:29,370 --> 01:09:26,710
my next paper and that's also awesome so

2060
01:09:31,019 --> 01:09:29,380
I think and I think most scientists

2061
01:09:32,610 --> 01:09:31,029
especially younger scientists like that

2062
01:09:35,249 --> 01:09:32,620
are my age like around 40 or younger

2063
01:09:37,979 --> 01:09:35,259

really buy into that model that said

2064
01:09:40,110 --> 01:09:37,989
when you do you are exposing yourself a

2065
01:09:41,999 --> 01:09:40,120
little bit like I'm really open like

2066
01:09:43,950 --> 01:09:42,009
with my like crazy like fun ideas for

2067
01:09:46,829 --> 01:09:43,960
like my next research grant and I at one

2068
01:09:49,140 --> 01:09:46,839
point in a very stressful intending as

2069
01:09:50,880 --> 01:09:49,150
part of my career had researched I was

2070
01:09:52,829 --> 01:09:50,890
working with um with a colleague that

2071
01:09:55,020 --> 01:09:52,839
when basically published that research

2072
01:09:57,180 --> 01:09:55,030
without me on the paper and that was

2073
01:09:58,380 --> 01:09:57,190
like look like I'm normally really calm

2074
01:09:59,790 --> 01:09:58,390
and I can sleep well like I know I'm

2075
01:10:01,439 --> 01:09:59,800
like really excited when I want to stage

2076
01:10:02,640 --> 01:10:01,449
but like I usually don't stress out too

2077
01:10:04,970 --> 01:10:02,650
much about stuff like I was loosing

2078
01:10:07,050 --> 01:10:04,980
sleep over it was horrible it was awful

2079
01:10:08,729 --> 01:10:07,060
but I got through it because eventually

2080
01:10:09,550 --> 01:10:08,739
I got my paper out they got their paper

2081
01:10:11,830 --> 01:10:09,560
out and we was

2082
01:10:13,570 --> 01:10:11,840
some of the science disputes in the

2083
01:10:15,760 --> 01:10:13,580
literature right and in the end like I

2084
01:10:18,430 --> 01:10:15,770
can say five years later like looking

2085
01:10:19,750 --> 01:10:18,440
back on it not in the moment like it

2086
01:10:21,280 --> 01:10:19,760
ended up being really healthy because we

2087
01:10:22,570 --> 01:10:21,290
figured out some cool science from the

2088
01:10:24,700 --> 01:10:22,580

differences in our results that that

2089
01:10:26,230 --> 01:10:24,710
happened and when we kind of split I'm

2090
01:10:27,700 --> 01:10:26,240
kind of like venting a little bit now

2091
01:10:29,350 --> 01:10:27,710
but like the moral of story is like if

2092
01:10:32,140 --> 01:10:29,360
you are a scientist be open with your

2093
01:10:34,030 --> 01:10:32,150
data be open with your methods someone

2094
01:10:36,340 --> 01:10:34,040
might steal it someday but that's on

2095
01:10:41,440 --> 01:10:36,350
them and not on you and you should just

2096
01:10:43,300 --> 01:10:41,450
like go hi so but overall people are

2097
01:10:44,680 --> 01:10:43,310
awesome and I actually haven't noticed a

2098
01:10:46,060 --> 01:10:44,690
huge difference in like their country of

2099
01:11:01,480 --> 01:10:46,070
origin in terms of whether or not they

2100
01:11:03,370 --> 01:11:01,490
steal data thank you thinking about

2101
01:11:04,900 --> 01:11:03,380
you're talking about modeling yeah I'm

2102
01:11:07,930 --> 01:11:04,910
interested well you were talking about

2103
01:11:11,920 --> 01:11:07,940
the peas and the grapefruits yeah and

2104
01:11:15,070 --> 01:11:11,930
that everybody expected class-m planets

2105
01:11:17,010 --> 01:11:15,080
to be small and close to their Suns but

2106
01:11:19,630 --> 01:11:17,020
now you know that we're the weird ones

2107
01:11:22,080 --> 01:11:19,640
so the solar systems what is it for make

2108
01:11:31,360 --> 01:11:22,090
those makes us so weird why why are we

2109
01:11:32,950 --> 01:11:31,370
why are we Portland yes yeah so it the

2110
01:11:34,660 --> 01:11:32,960
thing that we're probably missing the

2111
01:11:36,280 --> 01:11:34,670
most are those super Earths that's the

2112
01:11:38,620 --> 01:11:36,290
thing that seems to be super common that

2113
01:11:40,420 --> 01:11:38,630

we don't have and this goes back to like

2114
01:11:43,540 --> 01:11:40,430
the fixing the models thing so to make

2115
01:11:44,920 --> 01:11:43,550
those hot Jupiters by the way it's easy

2116
01:11:46,630 --> 01:11:44,930
for us to as scientists to like

2117
01:11:48,520 --> 01:11:46,640
misrepresent this those hot Jupiters

2118
01:11:50,110 --> 01:11:48,530
were the first things we found but it

2119
01:11:52,150 --> 01:11:50,120
wasn't because those hot Jupiters are

2120
01:11:53,770 --> 01:11:52,160
really really common it's just that

2121
01:11:55,480 --> 01:11:53,780
those are the planets that gave off the

2122
01:11:57,010 --> 01:11:55,490
biggest signals so when we were first

2123
01:11:59,140 --> 01:11:57,020
developing these instruments they

2124
01:12:00,550 --> 01:11:59,150
weren't like super sensitive and the

2125
01:12:02,410 --> 01:12:00,560
biggest signals were the first things we

2126
01:12:04,150 --> 01:12:02,420
saw so the hot Jupiters there was like

2127
01:12:04,990 --> 01:12:04,160
an observational bias right like the

2128
01:12:06,550 --> 01:12:05,000
only thing we could see what the hot

2129
01:12:09,690 --> 01:12:06,560
Jupiters I'm like oh my god saw hot

2130
01:12:11,680 --> 01:12:09,700
Jupiters right like would it guess

2131
01:12:13,420 --> 01:12:11,690
finding the hot Jupiters finding the

2132
01:12:15,790 --> 01:12:13,430
super Earths has caused us to rewrite

2133
01:12:17,710 --> 01:12:15,800
the models on how planets interact with

2134
01:12:19,960 --> 01:12:17,720
each other gravitationally and how they

2135
01:12:22,510 --> 01:12:19,970
interact with like the gas and dust in

2136
01:12:23,390 --> 01:12:22,520
in a planetary system and what we now

2137
01:12:25,220 --> 01:12:23,400
know too

2138
01:12:27,590 --> 01:12:25,230

explain a hot Jupiter what we now know

2139
01:12:30,050 --> 01:12:27,600
is that planets can migrate over time

2140
01:12:31,910 --> 01:12:30,060
you can form a gas giant out here where

2141
01:12:33,590 --> 01:12:31,920
we think ass Giants could form and then

2142
01:12:35,240 --> 01:12:33,600
as it interacts with gas and dust in the

2143
01:12:37,189 --> 01:12:35,250
disk it can actually move over time

2144
01:12:39,590 --> 01:12:37,199
closer to the host star which is how we

2145
01:12:40,820 --> 01:12:39,600
think these hot Jupiters exist they they

2146
01:12:42,290 --> 01:12:40,830
didn't form close to the star they

2147
01:12:45,740 --> 01:12:42,300
formed out where Jupiter formed and then

2148
01:12:48,530 --> 01:12:45,750
moved in but because we put the physics

2149
01:12:49,939 --> 01:12:48,540
of that into our models we now know that

2150
01:12:51,830 --> 01:12:49,949
this probably happened in our own solar

2151
01:12:52,970 --> 01:12:51,840
system and it actually explains a whole

2152
01:12:54,890 --> 01:12:52,980
bunch of stuff we couldn't explain

2153
01:12:56,510 --> 01:12:54,900
before for one we think the plant

2154
01:12:58,160 --> 01:12:56,520
Jupiter and Saturn probably moved in a

2155
01:12:59,930 --> 01:12:58,170
little bit at one point in solar system

2156
01:13:01,930 --> 01:12:59,940
history and they moved back out again

2157
01:13:04,520 --> 01:13:01,940
and that had two massive consequences

2158
01:13:06,860 --> 01:13:04,530
one is it kind of cleared out a lot of

2159
01:13:08,720 --> 01:13:06,870
debris and around the region of the

2160
01:13:11,390 --> 01:13:08,730
solar system where Mars exists and it

2161
01:13:13,310 --> 01:13:11,400
kind of like sucked all that mass out so

2162
01:13:15,709 --> 01:13:13,320
that is why Mars ended up being as small

2163
01:13:17,750 --> 01:13:15,719

as it is at least that's the way the

2164
01:13:19,580 --> 01:13:17,760
models are explaining it now the second

2165
01:13:22,370 --> 01:13:19,590
thing is when it when those planets

2166
01:13:26,720 --> 01:13:22,380
moved you know gosh I'm trying to think

2167
01:13:30,380 --> 01:13:26,730
of like a good analogy like it was kind

2168
01:13:31,790 --> 01:13:30,390
of like like like the system was full of

2169
01:13:33,709 --> 01:13:31,800
dust and like these small rocks

2170
01:13:35,479 --> 01:13:33,719
scattered all over the solar system and

2171
01:13:37,220 --> 01:13:35,489
as soon as those gas giants started to

2172
01:13:39,169 --> 01:13:37,230
move they started to gravitationally

2173
01:13:41,060 --> 01:13:39,179
like like move some of that dust in the

2174
01:13:42,080 --> 01:13:41,070
small rocks around but as soon as they

2175
01:13:43,280 --> 01:13:42,090
started moving around they started

2176
01:13:45,320 --> 01:13:43,290
moving the other things around it was

2177
01:13:47,360 --> 01:13:45,330
almost like a set of dominoes or like

2178
01:13:48,800 --> 01:13:47,370
like taking like a house of cards and

2179
01:13:51,080 --> 01:13:48,810
knocking one car down and everything

2180
01:13:53,180 --> 01:13:51,090
just collapsed in this case the collapse

2181
01:13:55,040 --> 01:13:53,190
was like all these small rocks all over

2182
01:13:57,050 --> 01:13:55,050
the solar system as soon as Jupiter and

2183
01:13:58,430 --> 01:13:57,060
Saturn move basically getting slung all

2184
01:14:00,830 --> 01:13:58,440
around this the solar system and

2185
01:14:02,209 --> 01:14:00,840
crashing into planets and that's one of

2186
01:14:04,250 --> 01:14:02,219
the reasons we think that the moon has

2187
01:14:06,229 --> 01:14:04,260
the craters it does is from that motion

2188
01:14:07,850 --> 01:14:06,239

of Saturn and Saturn and Jupiter and

2189
01:14:09,470 --> 01:14:07,860
actually the dating of those craters is

2190
01:14:12,260 --> 01:14:09,480
really well explained if you had a

2191
01:14:14,810 --> 01:14:12,270
one-time event like that this is one of

2192
01:14:16,010 --> 01:14:14,820
the places that that looking at these

2193
01:14:18,080 --> 01:14:16,020
surprises we've seen in these other

2194
01:14:19,550 --> 01:14:18,090
planets like the hot Jupiters has helped

2195
01:14:23,030 --> 01:14:19,560
us understand why the solar system has

2196
01:14:25,070 --> 01:14:23,040
its properties today I don't know if we

2197
01:14:26,419 --> 01:14:25,080
have a good explanation as to why we

2198
01:14:28,640 --> 01:14:26,429
don't have super Earths which is the

2199
01:14:31,850 --> 01:14:28,650
weirdest most Portland like thing about

2200
01:14:36,210 --> 01:14:31,860
our solar system someone does but it's

2201
01:14:36,220 --> 01:14:45,400
where's Mike

2202
01:14:54,890 --> 01:14:52,070
so can you comment on how this latest

2203
01:14:57,440 --> 01:14:54,900
research is affecting the result of the

2204
01:14:59,860 --> 01:14:57,450
Drake Equation oh yeah I love that so

2205
01:15:03,200 --> 01:14:59,870
who knows what the Drake Equation is

2206
01:15:05,000 --> 01:15:03,210
alright so maybe like a fifth of people

2207
01:15:08,660 --> 01:15:05,010
so the Drake equation is an equation

2208
01:15:11,510 --> 01:15:08,670
that that was written oh like 40 years

2209
01:15:12,980 --> 01:15:11,520
ago and the purpose of it was actually

2210
01:15:14,510 --> 01:15:12,990
to organize a conference about this very

2211
01:15:16,160 --> 01:15:14,520
topic I'm talking about tonight which

2212
01:15:17,990 --> 01:15:16,170
was like is there life beyond Earth and

2213
01:15:19,400 --> 01:15:18,000

how many in this case like Drake was

2214
01:15:22,190 --> 01:15:19,410
like involved in study in the search for

2215
01:15:23,690 --> 01:15:22,200
intelligent life on other planets he

2216
01:15:25,490 --> 01:15:23,700
wanted to just get a ballpark estimate

2217
01:15:28,120 --> 01:15:25,500
for how much intelligent life is there

2218
01:15:30,230 --> 01:15:28,130
in our in the universe or in our galaxy

2219
01:15:31,520 --> 01:15:30,240
and the way he broke that up because

2220
01:15:33,200 --> 01:15:31,530
that's like a hard question to answer as

2221
01:15:34,790 --> 01:15:33,210
he broke it up into like basically a

2222
01:15:36,650 --> 01:15:34,800
number of factors that get multiplied

2223
01:15:38,450 --> 01:15:36,660
together so he said it's like depending

2224
01:15:39,980 --> 01:15:38,460
on how you write the equation you could

2225
01:15:42,200 --> 01:15:39,990
say like it's the number of stars in our

2226
01:15:44,030 --> 01:15:42,210
galaxy or in the universe or the rate at

2227
01:15:45,080 --> 01:15:44,040
which those stars form times the

2228
01:15:47,150 --> 01:15:45,090
fraction of stars that have planets

2229
01:15:48,470 --> 01:15:47,160
times the fraction of those planets that

2230
01:15:50,510 --> 01:15:48,480
could have conditions that are right for

2231
01:15:52,610 --> 01:15:50,520
life times the fraction of those planets

2232
01:15:54,470 --> 01:15:52,620
that could have life that actually do

2233
01:15:56,540 --> 01:15:54,480
have life turns a fraction that have

2234
01:15:57,320 --> 01:15:56,550
intelligent life times a lifetime of a

2235
01:15:59,240 --> 01:15:57,330
civilization

2236
01:16:00,410 --> 01:15:59,250
okay what's interesting is since Drake

2237
01:16:02,990 --> 01:16:00,420
wrote down that equation we've actually

2238
01:16:04,100 --> 01:16:03,000

been marching down that set of terms

2239
01:16:05,780 --> 01:16:04,110
actually should walk the other way from

2240
01:16:07,940 --> 01:16:05,790
your perspective right so like when

2241
01:16:09,710 --> 01:16:07,950
Drake wrote the equation we had a pretty

2242
01:16:11,330 --> 01:16:09,720
good handle on how many stars were out

2243
01:16:13,400 --> 01:16:11,340
there but we didn't really have any

2244
01:16:15,140 --> 01:16:13,410
information on anything else now we

2245
01:16:16,460 --> 01:16:15,150
first of all we have a better tighter

2246
01:16:18,410 --> 01:16:16,470
constraint on how many stars are out

2247
01:16:20,090 --> 01:16:18,420
there but more importantly we now know

2248
01:16:22,340 --> 01:16:20,100
how many planets are around those stars

2249
01:16:23,840 --> 01:16:22,350
on average and we even have a handle

2250
01:16:25,880 --> 01:16:23,850
although there's a bit of air bar around

2251
01:16:27,170 --> 01:16:25,890
them about how many planets are around

2252
01:16:29,060 --> 01:16:27,180
those stars or what fraction of those

2253
01:16:31,250 --> 01:16:29,070
planets have conditions that could allow

2254
01:16:33,200 --> 01:16:31,260
for life and the next step in the Drake

2255
01:16:34,400 --> 01:16:33,210
Equation is to figure out of that subset

2256
01:16:36,290 --> 01:16:34,410
of planets that could have global

2257
01:16:37,970 --> 01:16:36,300
biospheres like earth how many actually

2258
01:16:39,590 --> 01:16:37,980
do have life and that's what the loop

2259
01:16:41,000 --> 01:16:39,600
our telescope is it's actually being

2260
01:16:42,710 --> 01:16:41,010
designed you could think of as being

2261
01:16:44,450 --> 01:16:42,720
designed to measure the next term in the

2262
01:16:45,530 --> 01:16:44,460
Drake Equation and the next mission

2263
01:16:46,940 --> 01:16:45,540

after that would actually go back to

2264
01:16:49,430 --> 01:16:46,950
like looking for intelligent life and

2265
01:16:51,380 --> 01:16:49,440
signals of intelligence or civilization

2266
01:16:53,390 --> 01:16:51,390
on those worlds so from like that the

2267
01:16:54,530 --> 01:16:53,400
scientific method and I don't think this

2268
01:16:56,360 --> 01:16:54,540
was intentional because we don't like

2269
01:16:57,740 --> 01:16:56,370
sit around and like plan our stuff

2270
01:16:59,300 --> 01:16:57,750
around the Drake Equation

2271
01:17:00,800 --> 01:16:59,310
it's just so happened that like each

2272
01:17:13,250 --> 01:17:00,810
term is more difficult than the one

2273
01:17:25,850 --> 01:17:13,260
before right right up here yeah I'll

2274
01:17:30,350 --> 01:17:25,860
play shortstop hello so if there were

2275
01:17:34,670 --> 01:17:30,360
life on Europa you know maybe it might

2276
01:17:37,040 --> 01:17:34,680
be really cold yeah eutectic slush of

2277
01:17:38,330 --> 01:17:37,050
water and ammonia and methanol or

2278
01:17:42,440 --> 01:17:38,340
something yeah well though I'm from

2279
01:17:42,890 --> 01:17:42,450
Chicago so cold is relative so am i all

2280
01:17:46,450 --> 01:17:42,900
right

2281
01:17:51,590 --> 01:17:46,460
Lane Tech High School nice comfort north

2282
01:17:56,090 --> 01:17:51,600
so if life existed it really cold

2283
01:17:58,400 --> 01:17:56,100
temperatures would it would it do

2284
01:18:00,230 --> 01:17:58,410
anything you know like yeah you have a

2285
01:18:02,810 --> 01:18:00,240
fish that could swim

2286
01:18:06,530 --> 01:18:02,820
would it have enough energy or would it

2287
01:18:10,100 --> 01:18:06,540
just like maybe divide over the course

2288
01:18:11,480 --> 01:18:10,110

of a thousand years and be so such low

2289
01:18:14,210 --> 01:18:11,490
energy that you wouldn't be able to

2290
01:18:17,930 --> 01:18:14,220
detect any metabolic byproducts or

2291
01:18:20,510 --> 01:18:17,940
anything like that so that's an

2292
01:18:22,550 --> 01:18:20,520
excellent question I don't know the map

2293
01:18:24,680 --> 01:18:22,560
of the energetics of Europa compared to

2294
01:18:28,190 --> 01:18:24,690
the volume of ocean to give you a solid

2295
01:18:30,260 --> 01:18:28,200
answer I will tell you my my intuition

2296
01:18:32,180 --> 01:18:30,270
is that you're probably on to something

2297
01:18:33,890 --> 01:18:32,190
there however the people that are

2298
01:18:35,090 --> 01:18:33,900
actually experts on this stuff like that

2299
01:18:37,870 --> 01:18:35,100
that come from the background of like

2300
01:18:40,160 --> 01:18:37,880
looking at Europa and by the way all

2301
01:18:41,870 --> 01:18:40,170
folks in the Atlanta area I hope I hope

2302
01:18:44,000 --> 01:18:41,880
you recognize it like first of all there

2303
01:18:45,620 --> 01:18:44,010
is some amazing astrobiology going on at

2304
01:18:46,970 --> 01:18:45,630
Georgia Tech and at Emory like I was at

2305
01:18:49,250 --> 01:18:46,980
this conference yesterday with with

2306
01:18:50,690 --> 01:18:49,260
local researchers and on Europa in

2307
01:18:52,550 --> 01:18:50,700
particular like one of the best

2308
01:18:54,020 --> 01:18:52,560
scientists in the world on Europa is

2309
01:18:56,660 --> 01:18:54,030
Brittany Schmidt is a faculty member

2310
01:18:57,830 --> 01:18:56,670
down at Georgia Tech if you ever see

2311
01:18:59,390 --> 01:18:57,840
Brittany Schmidt at one of these things

2312
01:19:01,100 --> 01:18:59,400
you should ask her that question because

2313
01:19:04,730 --> 01:19:01,110

whatever she says you should trust over

2314
01:19:06,380 --> 01:19:04,740
what I'm saying right now I what you're

2315
01:19:07,550 --> 01:19:06,390
saying concerns me with regards to your

2316
01:19:09,290 --> 01:19:07,560
open in terms of the amount of energy

2317
01:19:11,000 --> 01:19:09,300
that is input into the system the

2318
01:19:11,850 --> 01:19:11,010
temperature of the system and whether or

2319
01:19:14,400 --> 01:19:11,860
not life would be

2320
01:19:17,430 --> 01:19:14,410
slow to reproduce in that context in

2321
01:19:19,710 --> 01:19:17,440
that environmental context but let's

2322
01:19:21,840 --> 01:19:19,720
assume that our Theory really has that

2323
01:19:24,000 --> 01:19:21,850
as an expectation I still think the

2324
01:19:26,370 --> 01:19:24,010
right thing to do is to develop a test

2325
01:19:28,950 --> 01:19:26,380
of that hypothesis right you still I

2326
01:19:30,720 --> 01:19:28,960
think go into Europa and say like you

2327
01:19:33,840 --> 01:19:30,730
would make a prediction of like what the

2328
01:19:36,750 --> 01:19:33,850
the standing biomass size would be per

2329
01:19:38,460 --> 01:19:36,760
mole of water per liter of water in in

2330
01:19:39,690 --> 01:19:38,470
the Europan ocean and then and then make

2331
01:19:41,550 --> 01:19:39,700
a measurement and do a cell count and

2332
01:19:44,750 --> 01:19:41,560
see if your prediction of the biomass

2333
01:19:47,850 --> 01:19:44,760
size matches what's actually in there

2334
01:19:51,810 --> 01:19:47,860
it's a concern the your opens that know

2335
01:19:52,890 --> 01:19:51,820
more about me are too concerned all

2336
01:20:09,540 --> 01:19:52,900
right we got a couple questions back

2337
01:20:12,870 --> 01:20:09,550
here trillion planets in the galaxy

2338
01:20:15,900 --> 01:20:12,880

how come et is a contact with us Fermi

2339
01:20:17,490 --> 01:20:15,910
paradox okay so why if there's all this

2340
01:20:19,470 --> 01:20:17,500
all these planets out there why I've

2341
01:20:21,390 --> 01:20:19,480
been like we've been contacted by by

2342
01:20:25,470 --> 01:20:21,400
ancient civilization or by alien

2343
01:20:27,330 --> 01:20:25,480
civilizations so for astrobiologists the

2344
01:20:28,950 --> 01:20:27,340
question of like why and actually if you

2345
01:20:31,740 --> 01:20:28,960
look historically the question of like

2346
01:20:34,500 --> 01:20:31,750
if all these potential abodes for life

2347
01:20:36,390 --> 01:20:34,510
exists beyond our solar system like as

2348
01:20:37,620 --> 01:20:36,400
Carl Sagan put it like you know look up

2349
01:20:38,880 --> 01:20:37,630
in the stars like if there's nothing out

2350
01:20:41,280 --> 01:20:38,890
there I'd be a horrible waste of space

2351
01:20:42,840 --> 01:20:41,290
right and why haven't we been contacted

2352
01:20:45,450 --> 01:20:42,850
yet if like if the universe is teeming

2353
01:20:47,220 --> 01:20:45,460
with all this light what I think is

2354
01:20:49,380 --> 01:20:47,230
interesting is if you look back at the

2355
01:20:51,090 --> 01:20:49,390
history of the scientific responses to

2356
01:20:52,710 --> 01:20:51,100
those questions that that that specific

2357
01:20:55,530 --> 01:20:52,720
question it's a bit of a Rorschach test

2358
01:20:56,850 --> 01:20:55,540
right if you ask Carl Sagan that he

2359
01:20:58,200 --> 01:20:56,860
would have said because he was living at

2360
01:21:00,960 --> 01:20:58,210
a time when the biggest threat to our

2361
01:21:03,210 --> 01:21:00,970
civilization was nuclear winter right he

2362
01:21:05,430 --> 01:21:03,220
was worried about a Ria's living in the

2363
01:21:07,140 --> 01:21:05,440

Cold War he was worried that we'd really

2364
01:21:09,720 --> 01:21:07,150
damage our environment for decades if

2365
01:21:11,460 --> 01:21:09,730
not centuries with the the clouds that

2366
01:21:15,720 --> 01:21:11,470
would exist in the wake of a nuclear war

2367
01:21:18,900 --> 01:21:15,730
in which there is no winner so his

2368
01:21:21,420 --> 01:21:18,910
answer was civilizations blow themselves

2369
01:21:23,430 --> 01:21:21,430
up because that's what he was worried

2370
01:21:25,410 --> 01:21:23,440
about as a scientist if you look at the

2371
01:21:25,739 --> 01:21:25,420
literature today on that very question

2372
01:21:27,719 --> 01:21:25,749
of like

2373
01:21:30,119 --> 01:21:27,729
why haven't we been contacted the most

2374
01:21:31,799 --> 01:21:30,129
kind of popular answer today like like

2375
01:21:34,589 --> 01:21:31,809
the flavor of the month for that bet the

2376
01:21:36,299 --> 01:21:34,599
answer right now is like well you know

2377
01:21:37,649 --> 01:21:36,309
if you assume exponential growth because

2378
01:21:38,939 --> 01:21:37,659
that's part of this right you would suit

2379
01:21:40,259 --> 01:21:38,949
assume like you know if you move to

2380
01:21:41,339 --> 01:21:40,269
another planet in like two thousand

2381
01:21:42,989 --> 01:21:41,349
years then after that each of those

2382
01:21:44,459 --> 01:21:42,999
moved to two more planets and then a

2383
01:21:46,259 --> 01:21:44,469
four more planets Nate you keep doubling

2384
01:21:48,239 --> 01:21:46,269
the the number of planets you're

2385
01:21:50,249 --> 01:21:48,249
inhabiting on the time scale of

2386
01:21:53,699 --> 01:21:50,259
astronomy and geology like that you fill

2387
01:21:56,399 --> 01:21:53,709
up the whole galaxy that equation

2388
01:21:57,929 --> 01:21:56,409

presumes exponential growth and every

2389
01:22:00,439 --> 01:21:57,939
ecological system we've looked at

2390
01:22:02,999 --> 01:22:00,449
whether it's a microbe in a test tube to

2391
01:22:05,819 --> 01:22:03,009
something existing like in a riverine or

2392
01:22:08,009 --> 01:22:05,829
a land-based system to our own society

2393
01:22:09,569 --> 01:22:08,019
when it's been placed on islands to

2394
01:22:12,689 --> 01:22:09,579
concerns we have today about ourselves

2395
01:22:14,759 --> 01:22:12,699
as a global species every single scale

2396
01:22:17,249 --> 01:22:14,769
you ever look at exponential growth is

2397
01:22:19,409 --> 01:22:17,259
inherently unstable over long time

2398
01:22:22,049 --> 01:22:19,419
periods and so the most popular answer

2399
01:22:23,489 --> 01:22:22,059
today is like exponential growth is

2400
01:22:25,439 --> 01:22:23,499
unsustainable and that's part of the

2401
01:22:26,909 --> 01:22:25,449
assumptions to the Fermi paradox of a

2402
01:22:28,799 --> 01:22:26,919
lot like that that as soon as we should

2403
01:22:30,419 --> 01:22:28,809
have been contacted by now and what's

2404
01:22:31,559 --> 01:22:30,429
interesting is the scientists that are

2405
01:22:32,879 --> 01:22:31,569
talking about that what are they

2406
01:22:34,019 --> 01:22:32,889
actually worried about on the side

2407
01:22:35,879 --> 01:22:34,029
they're thinking about climate change

2408
01:22:38,489 --> 01:22:35,889
and then exponential growth and our

2409
01:22:42,449 --> 01:22:38,499
energy usage as a society is problematic

2410
01:22:43,709 --> 01:22:42,459
so that seems like a good answer to me

2411
01:22:45,329 --> 01:22:43,719
today but maybe that's just because of

2412
01:22:47,489 --> 01:22:45,339
like some bias I've got in my head right

2413
01:22:49,169 --> 01:22:47,499

now just like Sagan twenty years ago had

2414
01:22:52,829 --> 01:22:49,179
like concerns about nuclear winter in

2415
01:22:54,239 --> 01:22:52,839
his head and I hope that twenty years

2416
01:22:55,919 --> 01:22:54,249
from now we're over the climate change

2417
01:22:57,959 --> 01:22:55,929
problem and we figured out a way to

2418
01:22:59,039 --> 01:22:57,969
address that and some scientists in the

2419
01:23:06,209 --> 01:22:59,049
future is giving you a different answer

2420
01:23:09,569 --> 01:23:06,219
to that question yeah the last question

2421
01:23:12,029 --> 01:23:09,579
is that on many occasions

2422
01:23:15,209 --> 01:23:12,039
you mentioned carbon but you have a

2423
01:23:18,359 --> 01:23:15,219
tendency to put the word organic in

2424
01:23:19,979 --> 01:23:18,369
front of the carpet oh yeah why why do

2425
01:23:21,569 --> 01:23:19,989
you put the word organic in front of

2426
01:23:25,799 --> 01:23:21,579
carbon why don't you just say carbon

2427
01:23:30,870 --> 01:23:25,809
well it's not because I'm like a hippie

2428
01:23:35,410 --> 01:23:33,399
although do support local farmers that's

2429
01:23:37,060 --> 01:23:35,420
like a good thing to do in general when

2430
01:23:38,410 --> 01:23:37,070
I say organic carbon yeah thank you

2431
01:23:39,879 --> 01:23:38,420
because that's that's jargon and it's

2432
01:23:42,189 --> 01:23:39,889
confusing jargon oh that's not the kind

2433
01:23:43,600 --> 01:23:42,199
of organic I'm talking about when

2434
01:23:45,490 --> 01:23:43,610
biologists talk about organic carbon

2435
01:23:47,319 --> 01:23:45,500
they're taught like any element or many

2436
01:23:48,640 --> 01:23:47,329
elements can have like different states

2437
01:23:50,500 --> 01:23:48,650
they exist in with regards to their

2438
01:23:52,979 --> 01:23:50,510

environment organic carbon is like the

2439
01:23:55,810 --> 01:23:52,989
carbon that exists in the form that life

2440
01:23:57,459 --> 01:23:55,820
uses it in if you're a chemist we say

2441
01:24:00,220 --> 01:23:57,469
it's reduced carbon or it's fixed carbon

2442
01:24:02,529 --> 01:24:00,230
but it's the carbon that's not in this

2443
01:24:04,149 --> 01:24:02,539
it like it is in carbon dioxide which is

2444
01:24:06,459 --> 01:24:04,159
inorganic carbon that's not part of

2445
01:24:08,259 --> 01:24:06,469
biological organisms organic carbon is

2446
01:24:10,479 --> 01:24:08,269
the stuff that like forms hydrocarbon

2447
01:24:12,129 --> 01:24:10,489
chains that are like the basic basis of

2448
01:24:14,830 --> 01:24:12,139
the chemistry of at least all earth

2449
01:24:16,000 --> 01:24:14,840
based life and that when we say organic

2450
01:24:17,290 --> 01:24:16,010
carbon we're not talking about like

2451
01:24:19,390 --> 01:24:17,300
farmer's market car that we're talking

2452
01:24:21,549 --> 01:24:19,400
about the difference between the kind of

2453
01:24:24,009 --> 01:24:21,559
carbon that's in biology versus the kind

2454
01:24:25,779 --> 01:24:24,019
that's not and biology can actually turn

2455
01:24:28,000 --> 01:24:25,789
the inorganic carbon like in the

2456
01:24:29,890 --> 01:24:28,010
atmosphere into organic carbon but that

2457
01:24:31,660 --> 01:24:29,900
takes energy and actually that is the

2458
01:24:33,250 --> 01:24:31,670
demand another one of our questioners

2459
01:24:34,720 --> 01:24:33,260
was getting at like if you actually have

2460
01:24:36,040 --> 01:24:34,730
to expend energy to do that you need an

2461
01:24:38,200 --> 01:24:36,050
energy source and it has to be big

2462
01:24:40,299 --> 01:24:38,210
enough to make that happen we do that

2463
01:24:42,939 --> 01:24:40,309

like the way we get or our organic

2464
01:24:44,890 --> 01:24:42,949
carbon is whether the like bananas

2465
01:24:47,830 --> 01:24:44,900
coming from Trader Joe's or like a big

2466
01:24:49,299 --> 01:24:47,840
like mega Mars or whatever we're getting

2467
01:24:52,000 --> 01:24:49,309
it from some other organism that's

2468
01:24:53,830 --> 01:24:52,010
already turned that inorganic co2 into

2469
01:24:55,720 --> 01:24:53,840
organic carbon some plant has done that

2470
01:25:02,790 --> 01:24:55,730
for us already and that's where we get

2471
01:25:14,910 --> 01:25:02,800
or our organic carbon from okay okay

2472
01:25:19,450 --> 01:25:17,410
we're just we're just we're just gonna

2473
01:25:20,770 --> 01:25:19,460
give a minute for Dave to get up here

2474
01:25:24,070 --> 01:25:20,780
thanks Dave

2475
01:25:25,870 --> 01:25:24,080
so um again we want to thank you all for

2476
01:25:27,880 --> 01:25:25,880
being here I have another special guest

2477
01:25:38,170 --> 01:25:27,890
for us this is Dave Sheets he is the

2478
01:25:40,750 --> 01:25:38,180
owner of the brewery I'll keep the

2479
01:25:42,340 --> 01:25:40,760
commercial very quick so anyway just

2480
01:25:44,020 --> 01:25:42,350
thank you guys so much for coming out

2481
01:25:45,730 --> 01:25:44,030
and Sean thank you I mean I just can't

2482
01:25:48,970 --> 01:25:45,740
thank you enough for yeah yeah

2483
01:25:52,210 --> 01:25:48,980
and giving us some wisdom thanks for

2484
01:25:55,510 --> 01:25:52,220
giving me some beer that's a good trade

2485
01:25:58,240 --> 01:25:55,520
yeah awesome really so anyway Tap Room's

2486
01:26:00,730 --> 01:25:58,250
open till 11:00 we do lots of fun stuff

2487
01:26:02,320 --> 01:26:00,740
in this room like comedy nights and my

2488
01:26:04,690 --> 01:26:02,330

music and all that kind of stuff so it's

2489
01:26:06,370 --> 01:26:04,700
if it's your first time here go onto the

2490
01:26:08,770 --> 01:26:06,380
website sign up for the noisy list come

2491
01:26:09,350 --> 01:26:08,780
say hi okay great thank you very much