BECKY FERREIRA

LIFE ON JUPITER'S EUROPA?

1
00:00:25,349 --> 00:00:23,590
[Music]

2
00:00:27,189 --> 00:00:25,359
hello everyone and welcome to the

3
00:00:28,950 --> 00:00:27,199
everything else show i call it that

4
00:00:31,269 --> 00:00:28,960
because it's everything else besides

5
00:00:33,590 --> 00:00:31,279
what you usually see me on and it's

6
00:00:37,030 --> 00:00:33,600
things that interest me i was contacted

7
00:00:38,470 --> 00:00:37,040
by um i believe a publicist for vice

8
00:00:41,590 --> 00:00:38,480
that connected me

9
00:00:42,869 --> 00:00:41,600
to our guest tonight becky ferreira and

10
00:00:46,069 --> 00:00:42,879
she is going to be talking about the

11
00:00:47,830 --> 00:00:46,079
possibilities of life on europa i'm

12
00:00:50,229 --> 00:00:47,840
excited to have her on and

13
00:00:53,430 --> 00:00:50,239

helping me out co-hosting tonight is

14
00:00:56,310 --> 00:00:53,440
mark d'antonio an astronomer and a

15
00:00:58,470 --> 00:00:56,320
frequent guest of the show so becky

16
00:00:59,830 --> 00:00:58,480
welcome to the show thank you so much

17
00:01:01,990 --> 00:00:59,840
for having me

18
00:01:04,549 --> 00:01:02,000
thank you for being here and here is

19
00:01:06,710 --> 00:01:04,559
mark d'antonio

20
00:01:07,590 --> 00:01:06,720
hello there thanks martin hi becky how

21
00:01:13,750 --> 00:01:07,600
are you

22
00:01:16,710 --> 00:01:13,760
so how'd and how did you get interested

23
00:01:17,749 --> 00:01:16,720
in this topic to begin with i mean in

24
00:01:19,429 --> 00:01:17,759
general

25
00:01:21,429 --> 00:01:19,439
how did you become a science writer and

26
00:01:24,550 --> 00:01:21,439
and was it your

27
00:01:26,390 --> 00:01:24,560
lifelong search of uh science and would

28
00:01:29,429 --> 00:01:26,400
that always interest you

29
00:01:31,590 --> 00:01:29,439
yeah sort of i mean uh like probably a

30
00:01:34,230 --> 00:01:31,600
lot of people like i watched the

31
00:01:36,870 --> 00:01:34,240
original cosmos uh with carl sagan and i

32
00:01:38,789 --> 00:01:36,880
kind of get started percolating then i

33
00:01:41,910 --> 00:01:38,799
really enjoyed just the presentation of

34
00:01:43,510 --> 00:01:41,920
the science in that and um i you know i

35
00:01:44,870 --> 00:01:43,520
when i went to college i tried doing a

36
00:01:47,270 --> 00:01:44,880
couple scientific fields but i kind of

37
00:01:48,870 --> 00:01:47,280
was like i i can't decide on this and it

38
00:01:50,469 --> 00:01:48,880

was much easier to just be a writer

39
00:01:53,350 --> 00:01:50,479
where you can kind of just

40
00:01:55,190 --> 00:01:53,360
hop into the scientific worlds of uh

41
00:01:57,670 --> 00:01:55,200
people who are doing often like

42
00:02:00,310 --> 00:01:57,680
extremely niche research and then just

43
00:02:02,950 --> 00:02:00,320
hop out of it you know so i just really

44
00:02:03,990 --> 00:02:02,960
enjoyed being able to kind of

45
00:02:06,230 --> 00:02:04,000
um

46
00:02:08,949 --> 00:02:06,240
you know just phone up or

47
00:02:11,589 --> 00:02:08,959
talk over email with people and um and

48
00:02:13,270 --> 00:02:11,599
share their stories and uh meant that i

49
00:02:15,510 --> 00:02:13,280
didn't have to decide if i wanted to be

50
00:02:17,670 --> 00:02:15,520
an astronomer or a paleontologist or a

51
00:02:18,949 --> 00:02:17,680
geophysicist or whatever you could kind

52
00:02:21,510 --> 00:02:18,959
of be everything when you're a science

53
00:02:24,390 --> 00:02:21,520
writer oh i bet i bet and

54
00:02:25,830 --> 00:02:24,400
how do you uh how do you back up like

55
00:02:27,350 --> 00:02:25,840
sources and things like that i mean do

56
00:02:28,550 --> 00:02:27,360
you have to do a lot of research when

57
00:02:30,150 --> 00:02:28,560
you're doing this type of thing i'm

58
00:02:33,190 --> 00:02:30,160
going to pull up your article

59
00:02:34,550 --> 00:02:33,200
uh also here as we are talking

60
00:02:36,229 --> 00:02:34,560
well i find that's one of the nice

61
00:02:37,910 --> 00:02:36,239
things about being a science writer i

62
00:02:39,670 --> 00:02:37,920
mean with this for this article for

63
00:02:42,869 --> 00:02:39,680

instance i think i only spoke to the

64
00:02:44,390 --> 00:02:42,879
lead author often it would you know with

65
00:02:45,990 --> 00:02:44,400
it's it's fun to you know talk to a lot

66
00:02:47,910 --> 00:02:46,000
of people in the field but that you know

67
00:02:50,790 --> 00:02:47,920
that can take a lot more time so

68
00:02:51,830 --> 00:02:50,800
um but one of one of this nice things

69
00:02:54,309 --> 00:02:51,840
about this is that it's kind of

70
00:02:55,350 --> 00:02:54,319
pre-vetted a lot of time right that

71
00:02:56,550 --> 00:02:55,360
um

72
00:02:58,470 --> 00:02:56,560
this was published in nature

73
00:03:00,390 --> 00:02:58,480
communication so it was peer-reviewed

74
00:03:03,350 --> 00:03:00,400
and so um

75
00:03:05,750 --> 00:03:03,360
so a lot of the kind of vetting is done

76
00:03:07,670 --> 00:03:05,760
already uh if you want to get really

77
00:03:09,430 --> 00:03:07,680
deep into a topic talk to a bunch of

78
00:03:11,509 --> 00:03:09,440
sources that can be really great because

79
00:03:13,030 --> 00:03:11,519
you often i mean practically always get

80
00:03:14,309 --> 00:03:13,040
some lovely debates between the

81
00:03:16,830 --> 00:03:14,319
scientists about

82
00:03:21,830 --> 00:03:16,840
either nuances or just like the main

83
00:03:23,670 --> 00:03:21,840
story um but uh but yeah mainly i just i

84
00:03:25,350 --> 00:03:23,680
will always talk to the lead ask what

85
00:03:26,789 --> 00:03:25,360
they think and honestly like one of the

86
00:03:28,229 --> 00:03:26,799
nice things again about being a science

87
00:03:29,750 --> 00:03:28,239
writer is that they'll like volunteer

88
00:03:31,110 --> 00:03:29,760

the limitations of their study that's

89
00:03:33,030 --> 00:03:31,120
something you don't get with like

90
00:03:34,550 --> 00:03:33,040
politics or entertainment or anything

91
00:03:37,270 --> 00:03:34,560
like that so

92
00:03:39,190 --> 00:03:37,280
um yeah yeah that's great well you know

93
00:03:41,509 --> 00:03:39,200
this is this has always fascinated me i

94
00:03:43,750 --> 00:03:41,519
heard something about the possibility

95
00:03:46,789 --> 00:03:43,760
of life on europa this particular

96
00:03:49,030 --> 00:03:46,799
article that you wrote and um you know i

97
00:03:50,149 --> 00:03:49,040
mean just uh we talked a little bit off

98
00:03:53,509 --> 00:03:50,159
here and just

99
00:03:55,830 --> 00:03:53,519
the pure the gravity of jupiter just

100
00:03:58,309 --> 00:03:55,840
causes the moons the what we know is the

101
00:04:00,149 --> 00:03:58,319
galilean moon sir i know they started

102
00:04:02,390 --> 00:04:00,159
out as the medici stars or something

103
00:04:03,910 --> 00:04:02,400
like that um you know way back their

104
00:04:05,509 --> 00:04:03,920
first name something like that but the

105
00:04:09,110 --> 00:04:05,519
four moons that we see

106
00:04:10,949 --> 00:04:09,120
going around jupiter are and this one

107
00:04:13,750 --> 00:04:10,959
appears to be

108
00:04:17,670 --> 00:04:13,760
um ice ice covered up to i believe was

109
00:04:19,189 --> 00:04:17,680
it 15 miles or something like that uh um

110
00:04:21,110 --> 00:04:19,199
i don't know the details i know it's

111
00:04:22,069 --> 00:04:21,120
something like 600 million miles away

112
00:04:24,150 --> 00:04:22,079
and

113
00:04:26,950 --> 00:04:24,160

you know so it's not going to get solar

114
00:04:29,189 --> 00:04:26,960
energy from from the sun as far as life

115
00:04:31,830 --> 00:04:29,199
goes

116
00:04:33,590 --> 00:04:31,840
yeah no it's a it's a fascinating moon

117
00:04:36,070 --> 00:04:33,600
and you mentioned like it's got it's got

118
00:04:38,310 --> 00:04:36,080
interesting history too um observed by

119
00:04:40,870 --> 00:04:38,320
galileo and is like very much a part of

120
00:04:42,469 --> 00:04:40,880
kind of discovering our own solar system

121
00:04:45,110 --> 00:04:42,479
watching these you know moons orbit

122
00:04:46,870 --> 00:04:45,120
jupiter was kind of a tip off that

123
00:04:49,270 --> 00:04:46,880
um we might be orbiting the sun for

124
00:04:51,030 --> 00:04:49,280
instance and then voyager took these

125
00:04:52,870 --> 00:04:51,040
amazing uh the voyager mission in the

126
00:04:55,830 --> 00:04:52,880
80s took these amazing shots of it and

127
00:04:58,790 --> 00:04:55,840
it's very clearly a nice moon

128
00:05:00,870 --> 00:04:58,800
there's a range of estimates for how

129
00:05:02,070 --> 00:05:00,880
thick the shell is going up to like 100

130
00:05:02,870 --> 00:05:02,080
kilometers

131
00:05:05,029 --> 00:05:02,880
but

132
00:05:07,270 --> 00:05:05,039
it's the smoothest body major body in

133
00:05:09,590 --> 00:05:07,280
the solar system it's very looks like

134
00:05:12,629 --> 00:05:09,600
it's being replenished

135
00:05:13,990 --> 00:05:12,639
by this and possible geological cycling

136
00:05:15,590 --> 00:05:14,000
with the with the ocean that's

137
00:05:16,790 --> 00:05:15,600
underneath it and one thing that i think

138
00:05:18,230 --> 00:05:16,800

is great about it even though it's just

139
00:05:20,870 --> 00:05:18,240
the size of the moon more or less just a

140
00:05:24,070 --> 00:05:20,880
little bit smaller um the estimates the

141
00:05:25,749 --> 00:05:24,080
models for this subsurface ocean uh it

142
00:05:27,590 --> 00:05:25,759
could be two to three times as much

143
00:05:28,629 --> 00:05:27,600
water in there as all the oceans on

144
00:05:31,749 --> 00:05:28,639
earth so

145
00:05:34,070 --> 00:05:31,759
small but mighty i think um in terms of

146
00:05:35,990 --> 00:05:34,080
that and then you know uh i know mark

147
00:05:37,990 --> 00:05:36,000
knows quite a lot about the

148
00:05:39,830 --> 00:05:38,000
the title flexing issue on that and the

149
00:05:41,510 --> 00:05:39,840
kind of interesting sources of energy

150
00:05:42,870 --> 00:05:41,520
that could be in there so i

151
00:05:44,629 --> 00:05:42,880
definitely would love to hear his

152
00:05:46,550 --> 00:05:44,639
thoughts on that as well

153
00:05:47,590 --> 00:05:46,560
yeah go ahead mark this is an image from

154
00:05:51,590 --> 00:05:47,600
the

155
00:05:54,950 --> 00:05:51,600
those

156
00:05:57,110 --> 00:05:54,960
fissures

157
00:05:59,189 --> 00:05:57,120
uh and when the ice cracks and

158
00:06:02,230 --> 00:05:59,199
re-freezes which happens rather quickly

159
00:06:04,070 --> 00:06:02,240
because it's it's of course very cold

160
00:06:06,230 --> 00:06:04,080
at the surface

161
00:06:08,870 --> 00:06:06,240
the brown color is actually that stuff

162
00:06:11,110 --> 00:06:08,880
welling up from those cracks

163
00:06:13,270 --> 00:06:11,120

and uh europa has this particular

164
00:06:15,749 --> 00:06:13,280
interesting uh particularly interesting

165
00:06:17,830 --> 00:06:15,759
uh feature on it that's called freckles

166
00:06:20,710 --> 00:06:17,840
um and there are these brown spots that

167
00:06:22,390 --> 00:06:20,720
appear they look like age spots okay

168
00:06:24,629 --> 00:06:22,400
but they're actually these brown

169
00:06:27,749 --> 00:06:24,639
upwellings from the interior and that

170
00:06:29,990 --> 00:06:27,759
that stuff inside europa is really the

171
00:06:31,749 --> 00:06:30,000
most important thing to study and we

172
00:06:32,870 --> 00:06:31,759
have to get a lot closer we have to

173
00:06:34,550 --> 00:06:32,880
actually

174
00:06:35,590 --> 00:06:34,560
get that europa clipper mission out

175
00:06:37,830 --> 00:06:35,600
there

176
00:06:39,670 --> 00:06:37,840
because we need to get to this moon and

177
00:06:42,390 --> 00:06:39,680
figure out what's going on in the

178
00:06:43,830 --> 00:06:42,400
interior we can guess right becky knows

179
00:06:46,150 --> 00:06:43,840
this i'm sure

180
00:06:48,550 --> 00:06:46,160
we can guess what's inside europa we can

181
00:06:49,909 --> 00:06:48,560
guess at the thickness of the ice mantle

182
00:06:52,550 --> 00:06:49,919
we can guess at the internal

183
00:06:55,029 --> 00:06:52,560
temperatures we kind of have an idea

184
00:06:57,430 --> 00:06:55,039
but everything is a model and there's no

185
00:06:58,550 --> 00:06:57,440
specific data other than what we see

186
00:07:01,110 --> 00:06:58,560
visually

187
00:07:02,790 --> 00:07:01,120
in the imagery and in some of the the

188
00:07:03,589 --> 00:07:02,800

upwellings that have made its way into

189
00:07:12,070 --> 00:07:03,599
the

190
00:07:12,950 --> 00:07:12,080
exceedingly thin it's just a

191
00:07:15,189 --> 00:07:12,960
few

192
00:07:17,589 --> 00:07:15,199
particles per million of

193
00:07:19,990 --> 00:07:17,599
of uh material that we would like to see

194
00:07:22,550 --> 00:07:20,000
right i mean we know that there's water

195
00:07:25,189 --> 00:07:22,560
uh there and we know that europa like

196
00:07:27,510 --> 00:07:25,199
enceladus that saturn is spewing some

197
00:07:29,510 --> 00:07:27,520
water from time to time and that's very

198
00:07:31,029 --> 00:07:29,520
promising right i mean you know

199
00:07:32,550 --> 00:07:31,039
i think i think you wrote about that

200
00:07:35,430 --> 00:07:32,560
becky i'm not sure

201
00:07:38,469 --> 00:07:35,440
um but it's just a a moon i think that

202
00:07:42,070 --> 00:07:38,479
really uh takes the cake for me it's

203
00:07:47,430 --> 00:07:45,830
um so so becky have you

204
00:07:49,670 --> 00:07:47,440
uh thought about

205
00:07:50,790 --> 00:07:49,680
what a mission would look like to find

206
00:07:52,790 --> 00:07:50,800
the life

207
00:07:54,710 --> 00:07:52,800
on europa i mean they'd have to drill

208
00:07:57,189 --> 00:07:54,720
down i mean isn't there a movie about

209
00:07:59,110 --> 00:07:57,199
that i think there's a europa report

210
00:08:01,270 --> 00:07:59,120
yeah great movie

211
00:08:05,110 --> 00:08:01,280
it was fun um

212
00:08:07,670 --> 00:08:05,120
yeah no and and um it's a challenging uh

213
00:08:09,909 --> 00:08:07,680

moon to explore as as you as you uh

214
00:08:11,670 --> 00:08:09,919
referenced already the radiation

215
00:08:13,189 --> 00:08:11,680
at jupiter is really intense so that

216
00:08:15,350 --> 00:08:13,199
makes it really hard to have a

217
00:08:17,029 --> 00:08:15,360
spacecraft survive there for very long

218
00:08:19,029 --> 00:08:17,039
and there's you know and as mark

219
00:08:21,189 --> 00:08:19,039
mentioned like basically don't know much

220
00:08:23,749 --> 00:08:21,199
about how the surface is so planning a

221
00:08:25,749 --> 00:08:23,759
lander that's gonna be on going on this

222
00:08:28,150 --> 00:08:25,759
terrain it's you know it's it's a

223
00:08:30,710 --> 00:08:28,160
difficult um thing to do so nasa already

224
00:08:33,269 --> 00:08:30,720
has a mission um the europa clipper

225
00:08:35,269 --> 00:08:33,279
that's supposed to launch i think 2025

226
00:08:37,110 --> 00:08:35,279
that we'll just be doing flybys to kind

227
00:08:39,190 --> 00:08:37,120
of you know it will be trying to assess

228
00:08:40,550 --> 00:08:39,200
habitability but i think a lot of it is

229
00:08:44,389 --> 00:08:40,560
trying to assess

230
00:08:46,150 --> 00:08:44,399
how you would actually land on it and um

231
00:08:47,509 --> 00:08:46,160
then you mentioned this of course huge

232
00:08:50,630 --> 00:08:47,519
challenge of actually getting into that

233
00:08:52,710 --> 00:08:50,640
subsurface ocean that's probably i would

234
00:08:55,509 --> 00:08:52,720
say decades in the future because you

235
00:08:57,430 --> 00:08:55,519
need i think a lander to go there first

236
00:09:00,550 --> 00:08:57,440
and kind of assess the scene and then

237
00:09:01,910 --> 00:09:00,560
maybe get some kind of heat driven probe

238
00:09:03,590 --> 00:09:01,920

that can get into the ocean there's

239
00:09:05,190 --> 00:09:03,600
definitely like concepts like submarines

240
00:09:07,350 --> 00:09:05,200
and things like that that are really

241
00:09:08,949 --> 00:09:07,360
fun to look at but it it does pose this

242
00:09:10,070 --> 00:09:08,959
immense challenge but that's one of the

243
00:09:11,750 --> 00:09:10,080
things that was exciting about that

244
00:09:13,269 --> 00:09:11,760
study that i covered in that article is

245
00:09:16,389 --> 00:09:13,279
that they um

246
00:09:18,150 --> 00:09:16,399
they're speculating that perhaps there

247
00:09:21,430 --> 00:09:18,160
is um

248
00:09:24,470 --> 00:09:21,440
shallow water pools possibly even just

249
00:09:27,190 --> 00:09:24,480
within a mile of the surface of europa

250
00:09:29,670 --> 00:09:27,200
that um could uh would be protected from

251
00:09:32,070 --> 00:09:29,680
the radiation of jupiter and

252
00:09:33,670 --> 00:09:32,080
um and that could potentially host like

253
00:09:35,030 --> 00:09:33,680
little

254
00:09:36,470 --> 00:09:35,040
i don't know microbes or something like

255
00:09:38,389 --> 00:09:36,480
that probably not the kind of space

256
00:09:40,550 --> 00:09:38,399
whales or anything that you

257
00:09:41,750 --> 00:09:40,560
like to see in science fiction but um

258
00:09:44,070 --> 00:09:41,760
but that's what's so exciting is that

259
00:09:45,670 --> 00:09:44,080
not only would that be uh something that

260
00:09:47,269 --> 00:09:45,680
would kind of if these sills these

261
00:09:49,670 --> 00:09:47,279
little pools of water existed that would

262
00:09:51,509 --> 00:09:49,680
kind of hint more that it's habitable it

263
00:09:53,110 --> 00:09:51,519

would also just make it way simpler if

264
00:09:55,509 --> 00:09:53,120
you know a lander could then

265
00:09:57,269 --> 00:09:55,519
go and and possibly drill just a little

266
00:09:59,110 --> 00:09:57,279
bit down and maybe they wouldn't find

267
00:09:59,910 --> 00:09:59,120
like intact microbes so it may be like

268
00:10:02,949 --> 00:09:59,920
some

269
00:10:05,269 --> 00:10:02,959
dna sequence sequenceable stuff like

270
00:10:08,310 --> 00:10:05,279
some some fragments um

271
00:10:09,110 --> 00:10:08,320
and that would be uh obviously like

272
00:10:10,710 --> 00:10:09,120
that

273
00:10:12,550 --> 00:10:10,720
would change everything to be able to

274
00:10:15,750 --> 00:10:12,560
discover something like that

275
00:10:17,910 --> 00:10:15,760
yeah i needed to go ahead oh sorry one

276
00:10:19,670 --> 00:10:17,920
of the things too becky which i think is

277
00:10:20,470 --> 00:10:19,680
is important and you probably know this

278
00:10:21,750 --> 00:10:20,480
too

279
00:10:22,949 --> 00:10:21,760
um

280
00:10:25,350 --> 00:10:22,959
is that

281
00:10:26,870 --> 00:10:25,360
when you have an isolated ecosystem like

282
00:10:28,630 --> 00:10:26,880
that they have to set up their own

283
00:10:31,509 --> 00:10:28,640
carbon cycles and

284
00:10:32,710 --> 00:10:31,519
other cycles that that work to sustain

285
00:10:34,470 --> 00:10:32,720
themselves

286
00:10:36,550 --> 00:10:34,480
what brings us the reason that i think

287
00:10:38,310 --> 00:10:36,560
life could exist on europa is is two

288
00:10:40,550 --> 00:10:38,320

reasons number one

289
00:10:44,470 --> 00:10:40,560
uh our hydrothermal vents

290
00:10:47,030 --> 00:10:44,480
have these microcosmic microcosms okay

291
00:10:49,910 --> 00:10:47,040
of ecosystems that uh die out as soon as

292
00:10:52,470 --> 00:10:49,920
that hot spot migrates away under the

293
00:10:53,670 --> 00:10:52,480
under the plate the second one is lake

294
00:10:55,030 --> 00:10:53,680
vostok

295
00:10:57,990 --> 00:10:55,040
say no more wars lake father lake

296
00:10:59,990 --> 00:10:58,000
vostok's antarctica and it's over 11 000

297
00:11:04,310 --> 00:11:00,000
feet under the ice of antarctica yet it

298
00:11:05,110 --> 00:11:04,320
has over 3 500 species of microbial life

299
00:11:06,550 --> 00:11:05,120
and

300
00:11:09,030 --> 00:11:06,560
most importantly

301
00:11:10,389 --> 00:11:09,040
that lake again which you already know

302
00:11:12,550 --> 00:11:10,399
sorry for repeating what you already

303
00:11:14,389 --> 00:11:12,560
know uh that lake and i'll say it

304
00:11:17,190 --> 00:11:14,399
tomorrow you know that lake has its own

305
00:11:19,509 --> 00:11:17,200
cycles that it's set up to process

306
00:11:20,949 --> 00:11:19,519
carbon and other uh

307
00:11:22,790 --> 00:11:20,959
chemistry that goes on there and it's

308
00:11:25,110 --> 00:11:22,800
all chemosynthetic life like we're

309
00:11:27,269 --> 00:11:25,120
looking for i think that's great okay so

310
00:11:29,350 --> 00:11:27,279
let's explain to the average listener

311
00:11:30,470 --> 00:11:29,360
out there what chemocentric

312
00:11:33,350 --> 00:11:30,480
centrifug

313
00:11:36,310 --> 00:11:33,360

life is i mean we're it's it's on

314
00:11:37,190 --> 00:11:36,320
chemicals not sun-based energy is that

315
00:11:39,430 --> 00:11:37,200
correct

316
00:11:41,670 --> 00:11:39,440
yeah you know what it is right chemical

317
00:11:43,990 --> 00:11:41,680
reaction or chemical something

318
00:11:45,990 --> 00:11:44,000
yeah and one well in in particular the

319
00:11:47,590 --> 00:11:46,000
hydrothermal vent systems is kind of

320
00:11:49,269 --> 00:11:47,600
interesting as well because it's a big

321
00:11:50,550 --> 00:11:49,279
theory about how life got started on

322
00:11:52,230 --> 00:11:50,560
earth um

323
00:11:54,629 --> 00:11:52,240
obviously life was not as habitable or

324
00:11:58,470 --> 00:11:54,639
the planet wasn't as habitable 4 billion

325
00:12:00,310 --> 00:11:58,480
years ago odd um years ago so uh

326
00:12:02,150 --> 00:12:00,320
one possibility is that hydrothermal

327
00:12:04,230 --> 00:12:02,160
vents in the ocean could have been

328
00:12:06,389 --> 00:12:04,240
a way for life to emerge and that would

329
00:12:08,710 --> 00:12:06,399
be exciting um

330
00:12:11,269 --> 00:12:08,720
because that would extend the habitable

331
00:12:13,910 --> 00:12:11,279
zones and other systems we're discussing

332
00:12:15,829 --> 00:12:13,920
that uh you know like it's

333
00:12:17,670 --> 00:12:15,839
habitable zones are usually

334
00:12:19,829 --> 00:12:17,680
calculated by the

335
00:12:21,910 --> 00:12:19,839
the sun's energy but if you have these

336
00:12:23,190 --> 00:12:21,920
kinds of systems that are isolated in

337
00:12:26,069 --> 00:12:23,200
deep oceans

338
00:12:28,629 --> 00:12:26,079

which we still do on earth um

339
00:12:30,230 --> 00:12:28,639
then you know it's really

340
00:12:32,470 --> 00:12:30,240
maybe there's there's been speculation

341
00:12:34,069 --> 00:12:32,480
that rogue planets without a star could

342
00:12:35,829 --> 00:12:34,079
potentially have

343
00:12:37,750 --> 00:12:35,839
uh life in their course because of that

344
00:12:38,629 --> 00:12:37,760
or close to

345
00:12:40,550 --> 00:12:38,639
yeah i

346
00:12:42,150 --> 00:12:40,560
agree with that i agree with that yeah

347
00:12:44,389 --> 00:12:42,160
there's a lot of really interesting

348
00:12:46,790 --> 00:12:44,399
theories there you know and

349
00:12:49,110 --> 00:12:46,800
i see the nice thing this is why

350
00:12:50,069 --> 00:12:49,120
this is why i love astronomy okay

351
00:12:53,509 --> 00:12:50,079
because

352
00:12:55,509 --> 00:12:53,519
there's so many unknowns

353
00:12:57,110 --> 00:12:55,519
all right becky knows she's having a

354
00:12:59,829 --> 00:12:57,120
good time writing about it i'm sorry

355
00:13:03,430 --> 00:12:59,839
martin go ahead yeah it's your show

356
00:13:05,990 --> 00:13:03,440
yeah yeah it's uh you know uh

357
00:13:09,430 --> 00:13:06,000
you grabbed my attention mark so i lost

358
00:13:13,190 --> 00:13:12,230
but um let's see okay i know what it was

359
00:13:15,990 --> 00:13:13,200
that is

360
00:13:17,750 --> 00:13:16,000
uh doesn't all life though i mean isn't

361
00:13:21,030 --> 00:13:17,760
it the energy

362
00:13:23,910 --> 00:13:21,040
of say the big i've heard this and and

363
00:13:26,550 --> 00:13:23,920

mark or becky either one of you uh can

364
00:13:28,949 --> 00:13:26,560
comment on this that

365
00:13:31,350 --> 00:13:28,959
they speculate that when the big bang or

366
00:13:33,430 --> 00:13:31,360
whatever it was that actually happened

367
00:13:37,190 --> 00:13:33,440
that all the energy

368
00:13:39,910 --> 00:13:37,200
that ever will be was created then and

369
00:13:40,790 --> 00:13:39,920
energy just changes form it doesn't go

370
00:13:42,310 --> 00:13:40,800
away

371
00:13:44,389 --> 00:13:42,320
or or something like that am i getting

372
00:13:46,550 --> 00:13:44,399
that totally wrong

373
00:13:47,590 --> 00:13:46,560
uh that's that's conservation of energy

374
00:13:50,949 --> 00:13:47,600
and

375
00:13:53,590 --> 00:13:50,959
okay

376
00:13:55,990 --> 00:13:53,600
we can apply it to that as well but

377
00:13:58,550 --> 00:13:56,000
um you got to remember that when a star

378
00:14:00,069 --> 00:13:58,560
is formed out of hydrogen gas

379
00:14:01,990 --> 00:14:00,079
that's the first thing we get right it's

380
00:14:03,350 --> 00:14:02,000
the most dominant element in the whole

381
00:14:05,430 --> 00:14:03,360
universe right

382
00:14:07,350 --> 00:14:05,440
well when that happens the star makes

383
00:14:09,829 --> 00:14:07,360
its own energy right

384
00:14:11,990 --> 00:14:09,839
so we actually have a lot of other

385
00:14:12,790 --> 00:14:12,000
energy sources in the universe

386
00:14:15,189 --> 00:14:12,800
now

387
00:14:17,189 --> 00:14:15,199
clearly there was some beginning energy

388
00:14:17,990 --> 00:14:17,199

that it all started from

389
00:14:20,069 --> 00:14:18,000
right

390
00:14:22,470 --> 00:14:20,079
and it's unclear to me

391
00:14:24,470 --> 00:14:22,480
uh how the very beginning operated

392
00:14:27,430 --> 00:14:24,480
versus where we are now

393
00:14:29,509 --> 00:14:27,440
uh in fact cosmologists can't give you a

394
00:14:31,750 --> 00:14:29,519
proper answer to that either

395
00:14:33,590 --> 00:14:31,760
so that's sort of a question that

396
00:14:36,150 --> 00:14:33,600
for me has to remain open i don't know

397
00:14:38,710 --> 00:14:36,160
if uh anybody has any ideas go for it

398
00:14:40,710 --> 00:14:38,720
i'm willing to listen

399
00:14:42,069 --> 00:14:40,720
but okay and here's

400
00:14:43,590 --> 00:14:42,079
so does

401
00:14:49,189 --> 00:14:43,600
life

402
00:14:52,150 --> 00:14:49,199
without any initial source of

403
00:14:53,829 --> 00:14:52,160
energy from a sun is that is that

404
00:14:55,189 --> 00:14:53,839
correct

405
00:14:57,269 --> 00:14:55,199
that is that uh mark that's

406
00:14:59,189 --> 00:14:57,279
chemosynthetic synthesis there yeah

407
00:15:01,350 --> 00:14:59,199
that's that's the chemosynthetic process

408
00:15:03,670 --> 00:15:01,360
that right and the chemothen the

409
00:15:05,829 --> 00:15:03,680
chemosynthetic process had nothing to do

410
00:15:08,550 --> 00:15:05,839
with energy from any sun at any given

411
00:15:12,470 --> 00:15:08,560
point historically

412
00:15:14,470 --> 00:15:12,480
correct it's it's life based on a eco

413
00:15:16,710 --> 00:15:14,480

where a place where there was no life

414
00:15:19,509 --> 00:15:16,720
okay fostered the growth of bacteria

415
00:15:21,189 --> 00:15:19,519
that ate the hydrogen sulfide minerals

416
00:15:23,670 --> 00:15:21,199
that are welling up from these black

417
00:15:25,189 --> 00:15:23,680
smokers these hydrothermal vents okay

418
00:15:26,629 --> 00:15:25,199
whatever you want to call them they have

419
00:15:29,829 --> 00:15:26,639
a bunch of names

420
00:15:32,310 --> 00:15:29,839
okay chimneys sulfite chimneys

421
00:15:33,430 --> 00:15:32,320
and those bacteria

422
00:15:35,509 --> 00:15:33,440
fostered

423
00:15:38,069 --> 00:15:35,519
more animals that wanted to eat the

424
00:15:41,030 --> 00:15:38,079
bacteria filter feeders like big giant

425
00:15:43,670 --> 00:15:41,040
clams the size of your head okay

426
00:15:44,870 --> 00:15:43,680
and beyond and tube worms that have this

427
00:15:46,790 --> 00:15:44,880
this uh

428
00:15:49,189 --> 00:15:46,800
this amazing five foot length you ever

429
00:15:51,030 --> 00:15:49,199
see a worm five feet long

430
00:15:53,189 --> 00:15:51,040
i've seen that i've seen those two berms

431
00:15:55,030 --> 00:15:53,199
on you know some documentary they're

432
00:15:57,269 --> 00:15:55,040
bizarre yeah they are

433
00:15:59,030 --> 00:15:57,279
yeah so they foster different kinds of

434
00:15:59,990 --> 00:15:59,040
life and different types of crustaceans

435
00:16:02,710 --> 00:16:00,000
that have been down there i actually

436
00:16:04,870 --> 00:16:02,720
have a black smoker section over in the

437
00:16:06,470 --> 00:16:04,880
other end of my office here that i got

438
00:16:08,710 --> 00:16:06,480

from woods hole osteographic institution

439
00:16:10,710 --> 00:16:08,720
because i used to be up there all a lot

440
00:16:12,150 --> 00:16:10,720
because i

441
00:16:14,230 --> 00:16:12,160
i've been in the album but not in it

442
00:16:15,509 --> 00:16:14,240
when it was diving okay so i was in the

443
00:16:16,629 --> 00:16:15,519
surface with it and got to know the

444
00:16:19,269 --> 00:16:16,639
scientists and so forth did

445
00:16:21,509 --> 00:16:19,279
presentations up there but this these

446
00:16:22,470 --> 00:16:21,519
these concepts are just

447
00:16:24,310 --> 00:16:22,480
fundamental

448
00:16:26,550 --> 00:16:24,320
as becky said to the formation of life

449
00:16:28,310 --> 00:16:26,560
on our planet i i'm with that 100

450
00:16:32,389 --> 00:16:28,320
percent

451
00:16:33,910 --> 00:16:32,399
oh so becky what what about enceladus um

452
00:16:35,509 --> 00:16:33,920
saturn's moon what is the difference

453
00:16:37,030 --> 00:16:35,519
between europa

454
00:16:37,990 --> 00:16:37,040
and enceladus i know there's size

455
00:16:41,189 --> 00:16:38,000
difference

456
00:16:43,430 --> 00:16:41,199
there yeah enceladus is very small um

457
00:16:45,189 --> 00:16:43,440
but uh one of the nice differences is

458
00:16:46,790 --> 00:16:45,199
that until this would be potentially a

459
00:16:49,110 --> 00:16:46,800
lot easier to study

460
00:16:51,350 --> 00:16:49,120
um because it does have these plumes

461
00:16:53,829 --> 00:16:51,360
that it shoots out uh into

462
00:16:55,910 --> 00:16:53,839
space and um though europa does that

463
00:16:57,509 --> 00:16:55,920

that does have those as well it would be

464
00:16:59,670 --> 00:16:57,519
a lot easier to just

465
00:17:02,069 --> 00:16:59,680
send a spacecraft plunging through in

466
00:17:04,870 --> 00:17:02,079
fact i think the cassini orbiter already

467
00:17:07,429 --> 00:17:04,880
did that um it just wasn't equipped to

468
00:17:10,710 --> 00:17:07,439
actually look for life in those plumes

469
00:17:13,029 --> 00:17:10,720
so if there is life uh inside enceladus

470
00:17:14,789 --> 00:17:13,039
which has a very similar you know uh

471
00:17:16,470 --> 00:17:14,799
makeup in terms of what they think is

472
00:17:19,429 --> 00:17:16,480
inside there compared to europa it's

473
00:17:20,949 --> 00:17:19,439
just on a very very much smaller scale

474
00:17:22,710 --> 00:17:20,959
then you know it could be blowing that

475
00:17:24,470 --> 00:17:22,720
life out into space which would be a

476
00:17:27,029 --> 00:17:24,480
really easy way to get it don't have to

477
00:17:28,950 --> 00:17:27,039
land at all so hopefully i'm based in

478
00:17:29,990 --> 00:17:28,960
ithaca and at cornell there is a there's

479
00:17:36,390 --> 00:17:30,000
a

480
00:17:39,029 --> 00:17:36,400
life finder

481
00:17:40,390 --> 00:17:39,039
um out to out there and it's one of my

482
00:17:42,310 --> 00:17:40,400
just like favorite kind of mission

483
00:17:43,909 --> 00:17:42,320
concepts because it just seems like it

484
00:17:45,669 --> 00:17:43,919
would be one of those things that would

485
00:17:46,390 --> 00:17:45,679
be fascinating to check and

486
00:17:47,909 --> 00:17:46,400
you know

487
00:17:49,830 --> 00:17:47,919
we already have the proof of concept

488
00:17:51,750 --> 00:17:49,840

that you can go through those plumes and

489
00:17:54,470 --> 00:17:51,760
um yeah why not

490
00:17:56,950 --> 00:17:54,480
now the plumes on europa are are smaller

491
00:17:58,710 --> 00:17:56,960
and possibly not from the depth of

492
00:18:01,270 --> 00:17:58,720
through the ice is that what's the

493
00:18:02,630 --> 00:18:01,280
difference i actually don't know um i've

494
00:18:04,549 --> 00:18:02,640
read a little bit of controversy on

495
00:18:05,430 --> 00:18:04,559
those on the plumes and like so mark do

496
00:18:06,630 --> 00:18:05,440
you want to take that one because i

497
00:18:09,350 --> 00:18:06,640
think you know a little bit more about

498
00:18:11,590 --> 00:18:09,360
them i i saw the hubble imagery of the

499
00:18:13,669 --> 00:18:11,600
plumes taken with novel space telescope

500
00:18:15,909 --> 00:18:13,679
looking at europa

501
00:18:18,870 --> 00:18:15,919
and there was definitely hydrogen and

502
00:18:20,470 --> 00:18:18,880
oxygen in these plumes so

503
00:18:22,230 --> 00:18:20,480
that was part of the reason that they

504
00:18:24,070 --> 00:18:22,240
were so dead set on thinking that

505
00:18:25,430 --> 00:18:24,080
there's probably an ocean underneath the

506
00:18:27,750 --> 00:18:25,440
icy crust

507
00:18:30,230 --> 00:18:27,760
but you got to understand

508
00:18:32,710 --> 00:18:30,240
one of the land satellites

509
00:18:36,230 --> 00:18:32,720
except for io all right we have io we

510
00:18:39,510 --> 00:18:36,240
have europa ganymede and kalisto well

511
00:18:42,150 --> 00:18:39,520
ganymede and kalisto are also ice moons

512
00:18:44,230 --> 00:18:42,160
and these can also have potential oceans

513
00:18:46,310 --> 00:18:44,240

beneath i just don't think that

514
00:18:48,549 --> 00:18:46,320
uh that we've studied those as much as

515
00:18:50,870 --> 00:18:48,559
we have europa and ganymede is the

516
00:18:53,350 --> 00:18:50,880
biggest moon in the entire solar system

517
00:18:56,549 --> 00:18:53,360
yeah bigger than mercury right yeah it's

518
00:18:59,029 --> 00:18:56,559
a huge huge moon there is a really

519
00:19:01,110 --> 00:18:59,039
interesting mission uh

520
00:19:02,710 --> 00:19:01,120
which the acronym is juice i can't

521
00:19:04,230 --> 00:19:02,720
remember what the

522
00:19:06,789 --> 00:19:04,240
what it stands for but it's from the

523
00:19:08,470 --> 00:19:06,799
europe european space agency that is

524
00:19:10,390 --> 00:19:08,480
going specifically to see ganymede it

525
00:19:12,310 --> 00:19:10,400
will do some um

526
00:19:13,510 --> 00:19:12,320
it will do some fly-bys of europa too so

527
00:19:15,190 --> 00:19:13,520
it might be able to characterize that

528
00:19:17,029 --> 00:19:15,200
but i i think getting made is like one

529
00:19:18,789 --> 00:19:17,039
of the most underestimated bodies in the

530
00:19:19,909 --> 00:19:18,799
solar system for that reason because i

531
00:19:21,909 --> 00:19:19,919
agree

532
00:19:24,310 --> 00:19:21,919
yeah it's it's the largest

533
00:19:26,710 --> 00:19:24,320
moon and it certainly has um the

534
00:19:28,150 --> 00:19:26,720
potential for habitability as well

535
00:19:30,470 --> 00:19:28,160
um it will be a really interesting

536
00:19:32,710 --> 00:19:30,480
mission i think i think that's supposed

537
00:19:35,110 --> 00:19:32,720
to arrive sometime this decade or yeah

538
00:19:39,029 --> 00:19:35,120

anyway that's that stands for jupiter

539
00:19:41,350 --> 00:19:39,039
icy moons explorer okay i'm not a genius

540
00:19:42,630 --> 00:19:41,360
i looked it up oh i thought i didn't

541
00:19:43,909 --> 00:19:42,640
know if you were joking he has a sense

542
00:19:46,470 --> 00:19:43,919
of humor so i didn't know if that was a

543
00:19:48,710 --> 00:19:46,480
joker it is it's jupiter icy moons

544
00:19:49,510 --> 00:19:48,720
explorer there you go so that's pretty

545
00:19:51,430 --> 00:19:49,520
cool

546
00:19:52,870 --> 00:19:51,440
and until until you mentioned it becky i

547
00:19:55,909 --> 00:19:52,880
didn't know that they were doing this i

548
00:19:57,190 --> 00:19:55,919
i i knew about the europa clipper i know

549
00:19:59,830 --> 00:19:57,200
that europa clipper was actually a

550
00:20:02,230 --> 00:19:59,840
two-phase mission one's a flyby and then

551
00:20:04,070 --> 00:20:02,240
one deposits a lander now the juno

552
00:20:05,590 --> 00:20:04,080
mission currently at jupiter right going

553
00:20:07,190 --> 00:20:05,600
over the south north poles right

554
00:20:08,070 --> 00:20:07,200
unprecedented views

555
00:20:09,750 --> 00:20:08,080
well

556
00:20:11,510 --> 00:20:09,760
they're going to crash it into jupiter's

557
00:20:13,750 --> 00:20:11,520
atmosphere at the conclusion

558
00:20:15,350 --> 00:20:13,760
and you know this but martin may not but

559
00:20:17,909 --> 00:20:15,360
it's it's to actually prevent

560
00:20:19,669 --> 00:20:17,919
contamination on europa should something

561
00:20:21,669 --> 00:20:19,679
ever happen and it ends up crashing at

562
00:20:24,310 --> 00:20:21,679
the europa so you see we're thinking

563
00:20:26,350 --> 00:20:24,320

about this star trek non-directive in

564
00:20:28,870 --> 00:20:26,360
the star trek directive right of

565
00:20:30,950 --> 00:20:28,880
non-interference i mean it's almost like

566
00:20:32,789 --> 00:20:30,960
that but we're actually you know art

567
00:20:34,390 --> 00:20:32,799
imitates life sometimes right

568
00:20:37,110 --> 00:20:34,400
i think actually there are plans for the

569
00:20:40,149 --> 00:20:37,120
europa lander should it ever come to

570
00:20:42,070 --> 00:20:40,159
pass to like self-destruct as well

571
00:20:44,070 --> 00:20:42,080
to try to because i mean it's a huge

572
00:20:45,110 --> 00:20:44,080
problem that planetary protection kind

573
00:20:45,990 --> 00:20:45,120
of um

574
00:20:47,350 --> 00:20:46,000
issue

575
00:20:48,789 --> 00:20:47,360
um and it's something that they're doing

576
00:20:50,230 --> 00:20:48,799
with mars right now because obviously

577
00:20:51,830 --> 00:20:50,240
like there's all these really exciting

578
00:20:53,909 --> 00:20:51,840
places on mars that you want to go to

579
00:20:55,750 --> 00:20:53,919
but you don't want to land your craft

580
00:20:57,830 --> 00:20:55,760
there that might have earth life on it

581
00:20:59,430 --> 00:20:57,840
contaminate it or of course backward

582
00:21:01,110 --> 00:20:59,440
contamination bring mars life back to

583
00:21:03,190 --> 00:21:01,120
earth which

584
00:21:05,590 --> 00:21:03,200
but yeah so uh i think that there's

585
00:21:07,510 --> 00:21:05,600
there's been like some loosening of of

586
00:21:08,870 --> 00:21:07,520
just like the rules on that because

587
00:21:10,230 --> 00:21:08,880
eventually we're gonna have to explore

588
00:21:11,110 --> 00:21:10,240

those places

589
00:21:13,669 --> 00:21:11,120
um

590
00:21:16,470 --> 00:21:13,679
and but if for the most part like

591
00:21:18,310 --> 00:21:16,480
it has been kind of this uh you know i

592
00:21:19,990 --> 00:21:18,320
think we're kind of dipping our toe in

593
00:21:21,510 --> 00:21:20,000
so to speak of these uh these

594
00:21:23,270 --> 00:21:21,520
environments where

595
00:21:25,270 --> 00:21:23,280
there are real planetary protection

596
00:21:26,950 --> 00:21:25,280
concerns because we're you know

597
00:21:28,950 --> 00:21:26,960
life on earth as you mentioned with lake

598
00:21:31,590 --> 00:21:28,960
bostock and things like that life on

599
00:21:33,190 --> 00:21:31,600
earth is really good at surviving where

600
00:21:35,029 --> 00:21:33,200
we've got some

601
00:21:36,149 --> 00:21:35,039
stream of files so they're gonna you

602
00:21:38,070 --> 00:21:36,159
know it's hard to kill them on the

603
00:21:39,190 --> 00:21:38,080
spacecraft and yeah

604
00:21:40,870 --> 00:21:39,200
that's right

605
00:21:42,870 --> 00:21:40,880
and

606
00:21:44,470 --> 00:21:42,880
in addition right i mean we have to

607
00:21:47,190 --> 00:21:44,480
really be careful with europa because uh

608
00:21:49,110 --> 00:21:47,200
arthur's clark uh warned us away from it

609
00:21:51,110 --> 00:21:49,120
all these worlds are yours except europa

610
00:21:52,789 --> 00:21:51,120
attempt no landing there use the others

611
00:21:55,669 --> 00:21:52,799
together use them in peace remember that

612
00:22:00,549 --> 00:21:55,679
final message from what's that from 2010

613
00:22:04,390 --> 00:22:02,149

yeah yeah look it up it's really cool

614
00:22:06,310 --> 00:22:04,400
you know um but see what i'm getting at

615
00:22:08,070 --> 00:22:06,320
though is back then even people

616
00:22:10,710 --> 00:22:08,080
recognized there might be life on europa

617
00:22:11,590 --> 00:22:10,720
back when that movie when he wrote that

618
00:22:16,070 --> 00:22:11,600
okay

619
00:22:19,029 --> 00:22:17,110
totally

620
00:22:20,950 --> 00:22:19,039
two possibilities exist either we are

621
00:22:23,110 --> 00:22:20,960
alone in the universe or not both are

622
00:22:26,310 --> 00:22:23,120
equally terrifying yeah and then that's

623
00:22:27,510 --> 00:22:26,320
like seth joshtek saying you know um if

624
00:22:29,190 --> 00:22:27,520
uh

625
00:22:30,789 --> 00:22:29,200
if they're if we're

626
00:22:33,430 --> 00:22:30,799
how do you say it if we're alone in the

627
00:22:35,270 --> 00:22:33,440
universe that'd be a miracle okay but

628
00:22:36,710 --> 00:22:35,280
there was another corollary to that too

629
00:22:38,789 --> 00:22:36,720
which i can't remember

630
00:22:40,390 --> 00:22:38,799
i use it in my book actually it's really

631
00:22:42,149 --> 00:22:40,400
um true

632
00:22:44,549 --> 00:22:42,159
you know if there is no life that's a

633
00:22:47,110 --> 00:22:44,559
miracle that's what it was yeah yeah

634
00:22:48,710 --> 00:22:47,120
yeah here's a question uh i'm not aware

635
00:22:50,070 --> 00:22:48,720
of this uh

636
00:22:52,549 --> 00:22:50,080
what are your thoughts this is becky

637
00:22:53,430 --> 00:22:52,559
ormark opinion on nasa finding

638
00:22:59,830 --> 00:22:53,440

life

639
00:23:01,510 --> 00:22:59,840
there is a mission

640
00:23:03,990 --> 00:23:01,520
that works right now i think it's called

641
00:23:06,630 --> 00:23:04,000
dragonfly that they're going to

642
00:23:07,669 --> 00:23:06,640
send to titan i think titan if

643
00:23:08,950 --> 00:23:07,679
i mean

644
00:23:10,630 --> 00:23:08,960
i don't know

645
00:23:12,310 --> 00:23:10,640
it's one of the most exciting worlds in

646
00:23:15,510 --> 00:23:12,320
that in this way because it is so

647
00:23:18,070 --> 00:23:15,520
strange it's so it's you know the the

648
00:23:19,990 --> 00:23:18,080
the liquid oceans are made of methane

649
00:23:22,070 --> 00:23:20,000
and hydrocarbons and things like that so

650
00:23:24,390 --> 00:23:22,080
if we were to find signs of life on on

651
00:23:26,710 --> 00:23:24,400
that world i mean it would have to be

652
00:23:29,510 --> 00:23:26,720
such a different type of of

653
00:23:30,870 --> 00:23:29,520
like system it would be so fascinating i

654
00:23:33,110 --> 00:23:30,880
don't even know how you would recognize

655
00:23:34,950 --> 00:23:33,120
it but it is it is very much like i

656
00:23:38,549 --> 00:23:34,960
believe it has the densest atmosphere of

657
00:23:42,070 --> 00:23:38,559
any anything except for earth in in the

658
00:23:44,310 --> 00:23:42,080
at any any rocky world anyway and so i

659
00:23:46,470 --> 00:23:44,320
think it's really like an uh exciting

660
00:23:47,269 --> 00:23:46,480
mission to go out there and and one of

661
00:23:54,789 --> 00:23:47,279
the

662
00:23:56,310 --> 00:23:54,799
horizons probe landed on titan but it's

663
00:23:59,029 --> 00:23:56,320

almost like kind of forgotten i feel

664
00:24:00,870 --> 00:23:59,039
like that we did this amazing landing on

665
00:24:02,149 --> 00:24:00,880
titan and we have these incredible

666
00:24:04,630 --> 00:24:02,159
pictures

667
00:24:06,870 --> 00:24:04,640
of what is the whole descent camera

668
00:24:09,590 --> 00:24:06,880
yeah exactly and it was just you know it

669
00:24:11,750 --> 00:24:09,600
was i think uh it's the only outer solar

670
00:24:14,230 --> 00:24:11,760
system landing that we've done yet so

671
00:24:16,070 --> 00:24:14,240
it's a really big pathfinder um i'm i'm

672
00:24:17,750 --> 00:24:16,080
personally a big neptune fan i hope we'd

673
00:24:19,590 --> 00:24:17,760
get a triton lander out there at some

674
00:24:20,710 --> 00:24:19,600
point too speaking of weirdly

675
00:24:22,470 --> 00:24:20,720
inhabitable

676
00:24:23,669 --> 00:24:22,480
places but um yeah what are your

677
00:24:25,350 --> 00:24:23,679
thoughts mark

678
00:24:27,110 --> 00:24:25,360
all right my feeling is that first of

679
00:24:28,310 --> 00:24:27,120
all uh the dragonfly land the reason

680
00:24:31,029 --> 00:24:28,320
they're calling it dragonfly i think is

681
00:24:33,029 --> 00:24:31,039
because it has propellers it's gonna fly

682
00:24:34,470 --> 00:24:33,039
uh and i think that i think i'm right

683
00:24:35,669 --> 00:24:34,480
about i may may not be right about that

684
00:24:38,870 --> 00:24:35,679
but we have to see

685
00:24:41,269 --> 00:24:38,880
um uh but you know with there is that's

686
00:24:43,430 --> 00:24:41,279
the uh is that the tightening that's

687
00:24:44,230 --> 00:24:43,440
pictures of titan yes yeah on the way

688
00:24:45,750 --> 00:24:44,240

down

689
00:24:47,830 --> 00:24:45,760
yeah but the the thick atmosphere on

690
00:24:50,789 --> 00:24:47,840
titan it seems like it's also

691
00:24:53,110 --> 00:24:50,799
has some weather but it probably is a

692
00:24:55,430 --> 00:24:53,120
pretty stagnant weather system but these

693
00:24:57,110 --> 00:24:55,440
liquid ethane lakes are just

694
00:24:58,870 --> 00:24:57,120
uh you know you think well nothing can

695
00:25:00,470 --> 00:24:58,880
survive it does temperatures you know

696
00:25:03,029 --> 00:25:00,480
way below zero

697
00:25:05,110 --> 00:25:03,039
uh i beg to differ uh it sure then

698
00:25:07,190 --> 00:25:05,120
you're not gonna find fish okay flying

699
00:25:08,630 --> 00:25:07,200
around in there okay or swimming around

700
00:25:10,710 --> 00:25:08,640
but you're definitely gonna find some

701
00:25:13,110 --> 00:25:10,720
potential microbes

702
00:25:14,549 --> 00:25:13,120
you know and i think that that's a i

703
00:25:16,070 --> 00:25:14,559
think it's a wonderful idea for a

704
00:25:17,669 --> 00:25:16,080
mission i don't know if i'll ever get

705
00:25:19,350 --> 00:25:17,679
off the ground because you know how nasa

706
00:25:21,750 --> 00:25:19,360
is with funding sometimes the funding is

707
00:25:23,830 --> 00:25:21,760
there next year it's not you know

708
00:25:26,390 --> 00:25:23,840
yeah is that one of the lakes so-called

709
00:25:28,310 --> 00:25:26,400
lakes right there mark in this image

710
00:25:30,950 --> 00:25:28,320
if that's an actual photo that looks

711
00:25:32,630 --> 00:25:30,960
like uh it could be a artist rendering

712
00:25:34,230 --> 00:25:32,640
but maybe it's not i mean it does it

713
00:25:36,870 --> 00:25:34,240

does look like a rendering but it would

714
00:25:39,909 --> 00:25:36,880
be an ethane lake yeah which is a very

715
00:25:41,590 --> 00:25:39,919
you know uh fancy hydrocarbon

716
00:25:43,269 --> 00:25:41,600
and then i think um there's also

717
00:25:45,430 --> 00:25:43,279
theories that titan itself might also

718
00:25:48,070 --> 00:25:45,440
have a liquid water subsurface ocean so

719
00:25:50,149 --> 00:25:48,080
there's like multiple layers of

720
00:25:51,590 --> 00:25:50,159
potential habitability there that's

721
00:25:53,830 --> 00:25:51,600
right that's right

722
00:25:55,909 --> 00:25:53,840
oh it's like even if it's totally

723
00:25:57,830 --> 00:25:55,919
inhospitable what a what a cool little

724
00:25:59,029 --> 00:25:57,840
world that is just not like anything in

725
00:26:00,470 --> 00:25:59,039
this world i know

726
00:26:02,149 --> 00:26:00,480
you know and and you ran back you

727
00:26:03,830 --> 00:26:02,159
remember that when the huygens probe

728
00:26:05,430 --> 00:26:03,840
actually sent back that first photograph

729
00:26:07,269 --> 00:26:05,440
that long strip and i'm like

730
00:26:08,630 --> 00:26:07,279
wow and i just couldn't get the scale

731
00:26:10,310 --> 00:26:08,640
and then they told me that they're all

732
00:26:11,510 --> 00:26:10,320
pebbles because this camera was right

733
00:26:12,789 --> 00:26:11,520
down low and you're only looking at

734
00:26:15,430 --> 00:26:12,799
little pebbles

735
00:26:17,029 --> 00:26:15,440
so it's like a very that's so funny yeah

736
00:26:19,510 --> 00:26:17,039
because i know

737
00:26:21,350 --> 00:26:19,520
yeah this very like vertical frame

738
00:26:23,510 --> 00:26:21,360

picture yeah yeah i thought they were

739
00:26:25,750 --> 00:26:23,520
big rocks and no they're pebbles that's

740
00:26:27,590 --> 00:26:25,760
a cow you know i wanted rocks you know

741
00:26:28,630 --> 00:26:27,600
that's okay i thought it was pretty cool

742
00:26:30,789 --> 00:26:28,640
i just like

743
00:26:34,070 --> 00:26:30,799
freaking photos on that kind of hazy

744
00:26:35,510 --> 00:26:34,080
like smog world like it's it's yeah it

745
00:26:36,870 --> 00:26:35,520
would be really interesting to see what

746
00:26:40,549 --> 00:26:36,880
they do with the next mission yeah i

747
00:26:42,630 --> 00:26:40,559
hope it does me too me too so we always

748
00:26:45,269 --> 00:26:42,640
go ahead no i'll show you my head yeah

749
00:26:47,430 --> 00:26:45,279
no we always uh often we think of you

750
00:26:48,870 --> 00:26:47,440
know we're looking at planets

751
00:26:50,549 --> 00:26:48,880
out there that are in the habitable

752
00:26:54,950 --> 00:26:50,559
zones and stuff like that

753
00:26:57,110 --> 00:26:54,960
but but there could be moons as well out

754
00:26:59,029 --> 00:26:57,120
there in these solar systems

755
00:27:00,310 --> 00:26:59,039
that there that could be habitable

756
00:27:03,350 --> 00:27:00,320
matter of fact

757
00:27:06,710 --> 00:27:03,360
there's no way to tell whether there

758
00:27:08,630 --> 00:27:06,720
could be um intelligent life that

759
00:27:11,269 --> 00:27:08,640
evolved on a moon i mean that sounds

760
00:27:13,190 --> 00:27:11,279
bizarre but it's it's a it's it's a

761
00:27:14,789 --> 00:27:13,200
planet in a type of way you know i mean

762
00:27:17,269 --> 00:27:14,799
it just depends on

763
00:27:18,870 --> 00:27:17,279

you know what happens to happen there

764
00:27:20,310 --> 00:27:18,880
but does it

765
00:27:23,029 --> 00:27:20,320
mark maybe i don't know if you know this

766
00:27:24,310 --> 00:27:23,039
any uh if you know this in particular

767
00:27:26,710 --> 00:27:24,320
but does

768
00:27:28,549 --> 00:27:26,720
like any type of planetary

769
00:27:30,389 --> 00:27:28,559
body have to have

770
00:27:31,669 --> 00:27:30,399
certain things to make it work you've

771
00:27:32,470 --> 00:27:31,679
got to think about

772
00:27:34,630 --> 00:27:32,480
um

773
00:27:37,269 --> 00:27:34,640
it's got to have a magnetosphere right

774
00:27:39,990 --> 00:27:37,279
to keep the radiation out or it'll kill

775
00:27:41,029 --> 00:27:40,000
life as we know it yeah

776
00:27:43,430 --> 00:27:41,039
yeah

777
00:27:45,190 --> 00:27:43,440
i mean

778
00:27:47,990 --> 00:27:45,200
the magnetosphere the magnetic field

779
00:27:50,470 --> 00:27:48,000
around the planet traps the solar wind

780
00:27:52,870 --> 00:27:50,480
the solar wind then gets trapped in the

781
00:27:54,630 --> 00:27:52,880
magnetosphere spirals around

782
00:27:55,909 --> 00:27:54,640
that's the source of you know the van

783
00:27:59,350 --> 00:27:55,919
allen radiation belts here that's

784
00:28:01,430 --> 00:27:59,360
actually just our solar particle trapped

785
00:28:03,750 --> 00:28:01,440
you know uh magnetosphere

786
00:28:06,149 --> 00:28:03,760
so that's what the van allen belts are

787
00:28:09,350 --> 00:28:06,159
and mars used to have one but it sort of

788
00:28:11,190 --> 00:28:09,360

died away which means that mars ended up

789
00:28:13,430 --> 00:28:11,200
still exuding a lot of water molecules

790
00:28:15,669 --> 00:28:13,440
which got broken apart the oxygen went

791
00:28:17,750 --> 00:28:15,679
into the surface where it bonded with

792
00:28:19,190 --> 00:28:17,760
iron compounds and rusted mars which is

793
00:28:21,750 --> 00:28:19,200
why it's red

794
00:28:23,590 --> 00:28:21,760
okay and then the the hydrogen got lost

795
00:28:25,350 --> 00:28:23,600
to space right well that was a

796
00:28:26,950 --> 00:28:25,360
significant amount of that planet's

797
00:28:29,909 --> 00:28:26,960
atmosphere right

798
00:28:32,470 --> 00:28:29,919
so uh we gotta we have to look at what

799
00:28:34,070 --> 00:28:32,480
goes into making a planet habitable you

800
00:28:36,470 --> 00:28:34,080
know and i'm sure becky knows this as

801
00:28:37,990 --> 00:28:36,480
well and it when you look at a planet it

802
00:28:40,230 --> 00:28:38,000
has to be in the habitable zone where we

803
00:28:45,029 --> 00:28:40,240
can have liquid water why because we

804
00:28:47,510 --> 00:28:45,039
survive we are genesis of liquid water

805
00:28:49,190 --> 00:28:47,520
so we say well maybe liquid water is a

806
00:28:51,590 --> 00:28:49,200
good place to start and since we know

807
00:28:53,510 --> 00:28:51,600
that life originated in the oceans we

808
00:28:55,830 --> 00:28:53,520
figured that if water exists potentially

809
00:28:57,830 --> 00:28:55,840
life exists you know the planet makes

810
00:28:58,870 --> 00:28:57,840
amino acids they were delivered the

811
00:29:00,630 --> 00:28:58,880
building blocks of life they were

812
00:29:02,630 --> 00:29:00,640
delivered by meteors and comets and

813
00:29:06,149 --> 00:29:02,640

everything throughout history

814
00:29:08,070 --> 00:29:06,159
so over time our planet built these

815
00:29:10,789 --> 00:29:08,080
these building blocks of life all by

816
00:29:12,870 --> 00:29:10,799
itself and from visitors from afar and

817
00:29:15,430 --> 00:29:12,880
this led to life here right

818
00:29:17,269 --> 00:29:15,440
and it gives becky and i lots of things

819
00:29:19,830 --> 00:29:17,279
to talk about

820
00:29:21,110 --> 00:29:19,840
indeed it does yes yeah just like the

821
00:29:23,669 --> 00:29:21,120
fact that you were mentioning these

822
00:29:25,190 --> 00:29:23,679
chemosynthetic organisms earlier

823
00:29:26,710 --> 00:29:25,200
maybe they don't need the sun but they

824
00:29:29,029 --> 00:29:26,720
certainly need water

825
00:29:31,430 --> 00:29:29,039
you know water

826
00:29:32,870 --> 00:29:31,440
yeah the magic ingredient for sure so

827
00:29:35,110 --> 00:29:32,880
but but water does not have to be in the

828
00:29:36,789 --> 00:29:35,120
habitable zone necessarily uh liquid

829
00:29:39,269 --> 00:29:36,799
water on the surface maybe but as we've

830
00:29:41,110 --> 00:29:39,279
been talking with europa enceladus titan

831
00:29:43,990 --> 00:29:41,120
all these worlds uh potentially have

832
00:29:45,990 --> 00:29:44,000
subsurface water yeah yeah and again

833
00:29:47,909 --> 00:29:46,000
like when you were talking about uh with

834
00:29:49,909 --> 00:29:47,919
your article especially when you talked

835
00:29:53,510 --> 00:29:49,919
about enceladus a little earlier

836
00:29:55,669 --> 00:29:53,520
you know uh saturn's moon deoni

837
00:29:57,029 --> 00:29:55,679
is doing a tug of war with enceladus so

838
00:30:00,310 --> 00:29:57,039

enceladus is doing this i actually

839
00:30:02,870 --> 00:30:00,320
demonstrated that for uh one on earth

840
00:30:05,990 --> 00:30:02,880
on uh i think it was tlc for once a

841
00:30:08,950 --> 00:30:06,000
while and actually i covered a balloon

842
00:30:11,590 --> 00:30:08,960
with this this plastery material and i

843
00:30:13,350 --> 00:30:11,600
started squeezing it to show house

844
00:30:14,950 --> 00:30:13,360
enceladus flexes

845
00:30:16,870 --> 00:30:14,960
and then it generated the fissures at

846
00:30:18,789 --> 00:30:16,880
the south pole that you could see the

847
00:30:20,310 --> 00:30:18,799
the you know potential stuff coming out

848
00:30:22,470 --> 00:30:20,320
of those those vents

849
00:30:23,990 --> 00:30:22,480
and so when you have that that squishing

850
00:30:26,630 --> 00:30:24,000
going on by that constant tugging

851
00:30:28,630 --> 00:30:26,640
between saturn and diony i mean this

852
00:30:31,029 --> 00:30:28,640
this almost looks oddly satisfying

853
00:30:32,950 --> 00:30:31,039
doesn't it does you can just feel it

854
00:30:35,110 --> 00:30:32,960
it's you can almost see the kneading

855
00:30:38,389 --> 00:30:35,120
process right going on you know in the

856
00:30:40,230 --> 00:30:38,399
moon and that kept the interior warm

857
00:30:41,909 --> 00:30:40,240
okay even more than it's it's it's

858
00:30:43,669 --> 00:30:41,919
nuclear particles it might be in the

859
00:30:44,950 --> 00:30:43,679
center keeping it warm from its original

860
00:30:48,710 --> 00:30:44,960
formation right

861
00:30:51,190 --> 00:30:48,720
so that kneading process is what made uh

862
00:30:53,750 --> 00:30:51,200
makes enceladus a potential target and

863
00:30:56,070 --> 00:30:53,760

gave it those hydrothermal vents

864
00:30:58,870 --> 00:30:56,080
so the same type of thing could go on in

865
00:31:00,310 --> 00:30:58,880
europa and i i'm i'm sure that you know

866
00:31:03,750 --> 00:31:00,320
becky's got an awful lot of writing to

867
00:31:05,509 --> 00:31:03,760
do if she hasn't talked about this yet

868
00:31:07,509 --> 00:31:05,519
no it's true there's never there's never

869
00:31:08,950 --> 00:31:07,519
uh any kind of pause in the in the

870
00:31:10,470 --> 00:31:08,960
habitability stuff because we're talking

871
00:31:12,789 --> 00:31:10,480
of course about these wonderful exciting

872
00:31:14,389 --> 00:31:12,799
worlds in our in our own solar system

873
00:31:15,909 --> 00:31:14,399
but you know scientists are getting

874
00:31:17,830 --> 00:31:15,919
obviously a lot better at looking at

875
00:31:20,710 --> 00:31:17,840
life you know and exoplanets and other

876
00:31:21,750 --> 00:31:20,720
systems and so oh yeah just uh you know

877
00:31:23,430 --> 00:31:21,760
we're still

878
00:31:25,350 --> 00:31:23,440
trying to figure out what's going on in

879
00:31:26,630 --> 00:31:25,360
the deep subsurface of our planet like

880
00:31:28,950 --> 00:31:26,640
this is just

881
00:31:29,669 --> 00:31:28,960
life uh is definitely very tenacious out

882
00:31:31,110 --> 00:31:29,679
there

883
00:31:32,870 --> 00:31:31,120
yeah theoretically i mean we only got

884
00:31:35,110 --> 00:31:32,880
down to lake vostok in the last few

885
00:31:36,549 --> 00:31:35,120
years you know relatively compared to

886
00:31:39,430 --> 00:31:36,559
the existence of the human race and the

887
00:31:41,029 --> 00:31:39,440
planet uh it's been like the last

888
00:31:43,509 --> 00:31:41,039

snap at a finger that we actually found

889
00:31:45,509 --> 00:31:43,519
lake vostok yeah didn't really get there

890
00:31:47,110 --> 00:31:45,519
to see this all this life right well you

891
00:31:49,029 --> 00:31:47,120
know i i mean

892
00:31:51,909 --> 00:31:49,039
i think and i like you you're that

893
00:31:53,590 --> 00:31:51,919
you're a neptune fan too by the way

894
00:31:55,909 --> 00:31:53,600
yeah i like that oh that's that picture

895
00:31:59,830 --> 00:31:55,919
in the background yes

896
00:32:03,430 --> 00:32:01,350
but just in a different time of our own

897
00:32:05,350 --> 00:32:03,440
planet i always like to think of it as

898
00:32:08,149 --> 00:32:05,360
sort of think i've gone to land there

899
00:32:13,909 --> 00:32:10,070
so is that when you're talking about

900
00:32:16,470 --> 00:32:13,919
like chemical energy for for life um

901
00:32:18,070 --> 00:32:16,480
when you say like okay everything needs

902
00:32:19,590 --> 00:32:18,080
to eat right

903
00:32:21,029 --> 00:32:19,600
and so

904
00:32:24,549 --> 00:32:21,039
the eating

905
00:32:26,789 --> 00:32:24,559
in some term would be that chemical

906
00:32:28,389 --> 00:32:26,799
reaction or energy

907
00:32:29,909 --> 00:32:28,399
is that i mean

908
00:32:35,430 --> 00:32:29,919
it wouldn't be

909
00:32:38,070 --> 00:32:35,440
eating something right or would it

910
00:32:39,830 --> 00:32:38,080
it could create an ecosystem i think as

911
00:32:42,950 --> 00:32:39,840
you were mentioning mark with the the

912
00:32:44,630 --> 00:32:42,960
tube worms and stuff i i um

913
00:32:46,710 --> 00:32:44,640

yeah i mean you seem to be much more

914
00:32:48,630 --> 00:32:46,720
well-versed in the actual chemical

915
00:32:50,070 --> 00:32:48,640
process uh that's going on in these

916
00:32:51,509 --> 00:32:50,080
hydrothermal vents but they seem to be

917
00:32:53,830 --> 00:32:51,519
metabolizing

918
00:32:56,389 --> 00:32:53,840
minerals right yeah and the thing to

919
00:32:57,830 --> 00:32:56,399
keep in mind is that

920
00:32:59,669 --> 00:32:57,840
for anything to survive it has to

921
00:33:01,830 --> 00:32:59,679
generate energy to generate energy it

922
00:33:04,070 --> 00:33:01,840
has to consume something that something

923
00:33:04,950 --> 00:33:04,080
may be living it may not be

924
00:33:06,870 --> 00:33:04,960
okay

925
00:33:09,509 --> 00:33:06,880
and generally

926
00:33:12,230 --> 00:33:09,519
living things that have dna

927
00:33:14,149 --> 00:33:12,240
consume some type of material to produce

928
00:33:16,230 --> 00:33:14,159
sugars and to

929
00:33:18,789 --> 00:33:16,240
you know continue their lives right

930
00:33:21,350 --> 00:33:18,799
and they ingest oxygen in many cases in

931
00:33:25,110 --> 00:33:21,360
order to help further that process keep

932
00:33:27,830 --> 00:33:25,120
it going generate energy etc um and like

933
00:33:29,350 --> 00:33:27,840
with the dna process that that you know

934
00:33:31,350 --> 00:33:29,360
becky's referring to

935
00:33:33,990 --> 00:33:31,360
uh you know we're talking about carbon

936
00:33:34,950 --> 00:33:34,000
hydrogen nitrogen oxygen phosphorus and

937
00:33:37,750 --> 00:33:34,960
sulfur

938
00:33:40,230 --> 00:33:37,760

chomps okay that's an acronym

939
00:33:42,230 --> 00:33:40,240
and that's really the basis of dna

940
00:33:44,870 --> 00:33:42,240
uh you have sulfur in your bones and all

941
00:33:47,669 --> 00:33:44,880
so i mean we we have these basic

942
00:33:49,750 --> 00:33:47,679
elements here that were generated by our

943
00:33:52,389 --> 00:33:49,760
planet right and so

944
00:33:53,830 --> 00:33:52,399
we know that they exist elsewhere and

945
00:33:55,190 --> 00:33:53,840
the huge

946
00:33:58,549 --> 00:33:55,200
question for me is

947
00:34:00,310 --> 00:33:58,559
can we find a similar process at europa

948
00:34:03,909 --> 00:34:00,320
you know

949
00:34:05,909 --> 00:34:03,919
i think that's why martin invited me to

950
00:34:08,470 --> 00:34:05,919
talk with you tonight becky because he

951
00:34:09,990 --> 00:34:08,480
knows i'm a big fan of europa

952
00:34:10,869 --> 00:34:10,000
so i i

953
00:34:12,310 --> 00:34:10,879
yeah

954
00:34:14,389 --> 00:34:12,320
no it's really it's really interesting

955
00:34:15,909 --> 00:34:14,399
to hear your insights on on that as well

956
00:34:17,349 --> 00:34:15,919
and um

957
00:34:19,510 --> 00:34:17,359
yeah um

958
00:34:21,510 --> 00:34:19,520
it i mean it's it's a world that is just

959
00:34:23,270 --> 00:34:21,520
like it's really been

960
00:34:25,669 --> 00:34:23,280
so exciting for really hundreds of years

961
00:34:27,829 --> 00:34:25,679
you know yeah i i agree yeah

962
00:34:30,869 --> 00:34:27,839
closer to getting there that's right

963
00:34:32,950 --> 00:34:30,879

ever since galileo saw these moons

964
00:34:34,470 --> 00:34:32,960
okay uh that's just started the ball

965
00:34:36,149 --> 00:34:34,480
rolling to all these additional

966
00:34:37,669 --> 00:34:36,159
discoveries right over time it just got

967
00:34:40,550 --> 00:34:37,679
better and better and better and you

968
00:34:43,909 --> 00:34:40,560
know the time will come when we'll have

969
00:34:46,149 --> 00:34:43,919
a presence on europa of some type

970
00:34:47,909 --> 00:34:46,159
okay uh just like we have the presence

971
00:34:49,829 --> 00:34:47,919
on mars incidentally i just want to say

972
00:34:51,669 --> 00:34:49,839
this just and and you could repeat this

973
00:34:53,349 --> 00:34:51,679
if you want to becky

974
00:34:57,510 --> 00:34:53,359
mars is the only planet in our solar

975
00:35:00,230 --> 00:34:58,550
it's true

976
00:35:02,470 --> 00:35:00,240
as far as we know as far as we know far

977
00:35:04,470 --> 00:35:02,480
as we know yeah maybe some tiny earth

978
00:35:05,430 --> 00:35:04,480
microbes as well got them that's right

979
00:35:07,589 --> 00:35:05,440
well

980
00:35:09,750 --> 00:35:07,599
yeah i i did want to quickly just ask

981
00:35:11,349 --> 00:35:09,760
though for for both of you you know one

982
00:35:12,790 --> 00:35:11,359
of the questions i think about alien

983
00:35:15,190 --> 00:35:12,800
life is really

984
00:35:17,910 --> 00:35:15,200
i would like to have answered is

985
00:35:20,230 --> 00:35:17,920
is dna kind of if there were if if alien

986
00:35:22,950 --> 00:35:20,240
life does exist does it rely on dna is

987
00:35:24,870 --> 00:35:22,960
dna something that every one every life

988
00:35:26,230 --> 00:35:24,880

form needs you know i would i think it'd

989
00:35:27,670 --> 00:35:26,240
be so interesting to find something that

990
00:35:29,270 --> 00:35:27,680
was different from that

991
00:35:31,109 --> 00:35:29,280
totally agree with that becky in fact

992
00:35:33,990 --> 00:35:31,119
that's one of the main questions i offer

993
00:35:36,470 --> 00:35:34,000
proffer up in the book is you know we

994
00:35:38,550 --> 00:35:36,480
look at our bilateral symmetry right and

995
00:35:40,230 --> 00:35:38,560
we look at the symmetry of all living

996
00:35:43,430 --> 00:35:40,240
things in this planet whether radial

997
00:35:45,750 --> 00:35:43,440
symmetry like a tulip a pentamerism like

998
00:35:48,069 --> 00:35:45,760
a starfish five-sided symmetry or our

999
00:35:49,829 --> 00:35:48,079
bilateral symmetry uh incidentally

1000
00:35:51,349 --> 00:35:49,839
starfish are bilaterally symmetric is

1001
00:35:53,670 --> 00:35:51,359
larvae just for the record then they go

1002
00:35:56,230 --> 00:35:53,680
into this pentameron state so that's you

1003
00:35:58,150 --> 00:35:56,240
know so bilateral symmetry is

1004
00:35:59,829 --> 00:35:58,160
interesting and you know i always ask

1005
00:36:00,950 --> 00:35:59,839
the question you look at all the life

1006
00:36:02,550 --> 00:36:00,960
forms

1007
00:36:04,310 --> 00:36:02,560
why all the symmetry why don't we have

1008
00:36:06,150 --> 00:36:04,320
pogo stick cows

1009
00:36:07,430 --> 00:36:06,160
you know they only have like one leg

1010
00:36:09,750 --> 00:36:07,440
right why

1011
00:36:11,670 --> 00:36:09,760
well i think the answer lies in how dna

1012
00:36:14,310 --> 00:36:11,680
replicates

1013
00:36:17,030 --> 00:36:14,320

i'm i'm just a thought okay it unzips

1014
00:36:19,349 --> 00:36:17,040
and replicates a complementary strand

1015
00:36:21,109 --> 00:36:19,359
at the macro level that same thing could

1016
00:36:23,430 --> 00:36:21,119
be responsible for how the human

1017
00:36:26,069 --> 00:36:23,440
organism interacts we interact through

1018
00:36:27,510 --> 00:36:26,079
bilateral symmetry with our environment

1019
00:36:29,109 --> 00:36:27,520
and i think that that's something

1020
00:36:31,270 --> 00:36:29,119
there's something to be said there we

1021
00:36:32,550 --> 00:36:31,280
only have one heart but it is it has its

1022
00:36:35,349 --> 00:36:32,560
own symmetries

1023
00:36:37,750 --> 00:36:35,359
right we have one spleen but it has its

1024
00:36:39,589 --> 00:36:37,760
own symmetries we have one liver but it

1025
00:36:40,790 --> 00:36:39,599
has its own symmetries

1026
00:36:42,790 --> 00:36:40,800
and it's but

1027
00:36:44,790 --> 00:36:42,800
you know on the at the outside we're

1028
00:36:46,390 --> 00:36:44,800
bilaterally symmetric you know right

1029
00:36:47,990 --> 00:36:46,400
down the middle you can say you know you

1030
00:36:49,750 --> 00:36:48,000
do a mirror image and you'll probably

1031
00:36:51,829 --> 00:36:49,760
look nearly the same

1032
00:36:53,430 --> 00:36:51,839
you know uh except if you look like this

1033
00:36:54,550 --> 00:36:53,440
like when i go so if i do that i might

1034
00:36:56,790 --> 00:36:54,560
look very different when you look in the

1035
00:36:58,710 --> 00:36:56,800
mirror right but the point being that

1036
00:37:00,470 --> 00:36:58,720
that bilateral symmetric

1037
00:37:02,230 --> 00:37:00,480
uh design is something that i think

1038
00:37:04,630 --> 00:37:02,240

because it's prevalent on all life forms

1039
00:37:05,829 --> 00:37:04,640
because dna is present in all life forms

1040
00:37:07,109 --> 00:37:05,839
on the planet

1041
00:37:08,790 --> 00:37:07,119
okay

1042
00:37:10,710 --> 00:37:08,800
i think that that's a template that's

1043
00:37:12,630 --> 00:37:10,720
the universe creates

1044
00:37:15,109 --> 00:37:12,640
it's some sort of a template

1045
00:37:17,109 --> 00:37:15,119
and it comes from the basic hydrocarbon

1046
00:37:19,190 --> 00:37:17,119
amino acids and the building blocks of

1047
00:37:22,950 --> 00:37:19,200
life that are delivered in a way that

1048
00:37:27,270 --> 00:37:25,030
that's my thought anyway i mean i

1049
00:37:28,950 --> 00:37:27,280
i think that it's i think it's along the

1050
00:37:31,109 --> 00:37:28,960
right track but you know what we need

1051
00:37:32,150 --> 00:37:31,119
more research to show

1052
00:37:33,910 --> 00:37:32,160
for sure

1053
00:37:36,470 --> 00:37:33,920
and there's also isn't there also a

1054
00:37:40,790 --> 00:37:36,480
thought out there that there could be

1055
00:37:44,470 --> 00:37:43,109
okay okay

1056
00:37:46,310 --> 00:37:44,480
remember the periodic table that

1057
00:37:52,870 --> 00:37:46,320
everybody hates in high school

1058
00:37:57,109 --> 00:37:54,550
i used to sing that table by the way

1059
00:37:58,630 --> 00:37:57,119
there's hydrogen and helium

1060
00:37:59,670 --> 00:37:58,640
i can do it i'm not going to do it i

1061
00:38:00,550 --> 00:37:59,680
promise

1062
00:38:01,510 --> 00:38:00,560
okay

1063
00:38:03,430 --> 00:38:01,520

but

1064
00:38:05,030 --> 00:38:03,440
when we go to carbon okay and we look at

1065
00:38:07,109 --> 00:38:05,040
the carbon atom

1066
00:38:09,589 --> 00:38:07,119
you have to keep in mind that that

1067
00:38:11,589 --> 00:38:09,599
carbon atom number six

1068
00:38:14,710 --> 00:38:11,599
right is right above silicon and the

1069
00:38:17,109 --> 00:38:14,720
columns represent the most likely

1070
00:38:19,349 --> 00:38:17,119
elements that are familial to each other

1071
00:38:21,670 --> 00:38:19,359
right so underneath carbon is silicon

1072
00:38:24,069 --> 00:38:21,680
right next row down but that that's that

1073
00:38:26,630 --> 00:38:24,079
row that column i mean means more than

1074
00:38:28,710 --> 00:38:26,640
the row in this particular case so

1075
00:38:30,710 --> 00:38:28,720
silicon is the next likely element that

1076
00:38:32,630 --> 00:38:30,720
could do what carbon does carbon is the

1077
00:38:33,910 --> 00:38:32,640
granddaddy of all elements it bonds with

1078
00:38:35,270 --> 00:38:33,920
more things than anything else in the

1079
00:38:37,510 --> 00:38:35,280
periodic table

1080
00:38:40,150 --> 00:38:37,520
and more importantly it can break those

1081
00:38:41,589 --> 00:38:40,160
bonds relatively easily and those bonds

1082
00:38:43,109 --> 00:38:41,599
can be changed look at that look at that

1083
00:38:43,990 --> 00:38:43,119
look what he's got there

1084
00:38:46,390 --> 00:38:44,000
okay

1085
00:38:48,310 --> 00:38:46,400
yes you're right um and the thing about

1086
00:38:50,470 --> 00:38:48,320
carbon is because it has those four

1087
00:38:52,790 --> 00:38:50,480
electrons in the outer shell there that

1088
00:38:55,349 --> 00:38:52,800

can link with four other things

1089
00:38:58,550 --> 00:38:55,359
it immediately gives us the ability to

1090
00:39:00,310 --> 00:38:58,560
link with hundreds of thousands of other

1091
00:39:01,829 --> 00:39:00,320
compounds make up hundreds of thousands

1092
00:39:03,349 --> 00:39:01,839
of other compounds

1093
00:39:05,430 --> 00:39:03,359
the things that require that are

1094
00:39:07,109 --> 00:39:05,440
required by life now silicon

1095
00:39:08,150 --> 00:39:07,119
on the other hand

1096
00:39:10,790 --> 00:39:08,160
silicon

1097
00:39:13,190 --> 00:39:10,800
is it has more electron to say oh wow

1098
00:39:15,190 --> 00:39:13,200
silicon might be good except silicon is

1099
00:39:18,550 --> 00:39:15,200
tenacious and it makes bonds that tend

1100
00:39:21,510 --> 00:39:18,560
to go into crystals

1101
00:39:24,630 --> 00:39:21,520
and crystals are harder to break apart

1102
00:39:27,190 --> 00:39:24,640
and so silicon being so tenacious is not

1103
00:39:28,630 --> 00:39:27,200
so likely in fact i think it is highly

1104
00:39:29,510 --> 00:39:28,640
unlikely

1105
00:39:30,950 --> 00:39:29,520
you know

1106
00:39:32,230 --> 00:39:30,960
a but interesting little bit of trivia

1107
00:39:33,750 --> 00:39:32,240
for you is when you walk in a beach

1108
00:39:36,390 --> 00:39:33,760
martin

1109
00:39:38,950 --> 00:39:36,400
you're walking on mostly gas

1110
00:39:41,750 --> 00:39:38,960
silicon dioxide silicon and two oxygen

1111
00:39:44,310 --> 00:39:41,760
so the majority of the the atoms in a

1112
00:39:46,630 --> 00:39:44,320
grain of sand are oxygen

1113
00:39:47,829 --> 00:39:46,640

not by mass but just by count so i think

1114
00:39:49,510 --> 00:39:47,839
that's kind of an interesting little bit

1115
00:39:50,390 --> 00:39:49,520
of trivia

1116
00:39:52,950 --> 00:39:50,400
yeah

1117
00:39:55,750 --> 00:39:52,960
and as far as as far as now this may be

1118
00:39:57,349 --> 00:39:55,760
a real layperson's question

1119
00:40:00,630 --> 00:39:57,359
but that's what i am

1120
00:40:01,910 --> 00:40:00,640
and that is as far as you know does life

1121
00:40:09,510 --> 00:40:01,920
need

1122
00:40:13,190 --> 00:40:10,710
i mean

1123
00:40:14,310 --> 00:40:13,200
with water um being kind of the magic

1124
00:40:15,510 --> 00:40:14,320
ingredient um

1125
00:40:18,390 --> 00:40:15,520
[Music]

1126
00:40:19,510 --> 00:40:18,400
yeah i like oxygen being part of of that

1127
00:40:21,750 --> 00:40:19,520
uh

1128
00:40:22,710 --> 00:40:21,760
as far as we know oh as far as the

1129
00:40:25,589 --> 00:40:22,720
oxygen

1130
00:40:29,109 --> 00:40:25,599
in the water h2o right yeah

1131
00:40:30,550 --> 00:40:29,119
um metabolizing that um but

1132
00:40:32,710 --> 00:40:30,560
uh

1133
00:40:35,589 --> 00:40:32,720
yeah what are the extract yeah what are

1134
00:40:38,069 --> 00:40:35,599
the chemical advantages of oxygen mark

1135
00:40:41,190 --> 00:40:38,079
for life there well i mean too much

1136
00:40:43,190 --> 00:40:41,200
oxygen is an issue of course and

1137
00:40:44,710 --> 00:40:43,200
uh one of the problems they would europe

1138
00:40:46,309 --> 00:40:44,720

let's go back to europa for a second if

1139
00:40:47,589 --> 00:40:46,319
you have too much oxygen in the waters

1140
00:40:49,910 --> 00:40:47,599
of the europa

1141
00:40:53,270 --> 00:40:49,920
then that could cause some other

1142
00:40:54,710 --> 00:40:53,280
problems now there's sort of a

1143
00:40:56,309 --> 00:40:54,720
mythos about the fact that if you have

1144
00:40:57,990 --> 00:40:56,319
too much oxygen then the water might be

1145
00:41:00,069 --> 00:40:58,000
too acidic well there is really no

1146
00:41:01,109 --> 00:41:00,079
direct link between oxygen and acidity

1147
00:41:03,030 --> 00:41:01,119
in the water

1148
00:41:06,390 --> 00:41:03,040
but there is a link between

1149
00:41:07,270 --> 00:41:06,400
carbonate and and and bicarbonate ions

1150
00:41:10,150 --> 00:41:07,280
okay

1151
00:41:11,990 --> 00:41:10,160
carbon dioxide is more of a measure of

1152
00:41:14,150 --> 00:41:12,000
that ph than the

1153
00:41:15,829 --> 00:41:14,160
ocean than the oxygen would be

1154
00:41:17,190 --> 00:41:15,839
but if you have a lot of oxygen maybe

1155
00:41:18,950 --> 00:41:17,200
you might have a lot of carbon dioxide

1156
00:41:20,470 --> 00:41:18,960
dissolved in the water and that could

1157
00:41:22,390 --> 00:41:20,480
make it more acidic

1158
00:41:24,230 --> 00:41:22,400
okay you know how it is when you there's

1159
00:41:27,510 --> 00:41:24,240
an old experiment you did in in high

1160
00:41:29,270 --> 00:41:27,520
school you blew into a straw into water

1161
00:41:30,870 --> 00:41:29,280
and the water changed color because you

1162
00:41:32,950 --> 00:41:30,880
had something in the water to change the

1163
00:41:34,550 --> 00:41:32,960

color and you said oh look it made

1164
00:41:36,630 --> 00:41:34,560
carbonic acid

1165
00:41:37,910 --> 00:41:36,640
right well that whole process is

1166
00:41:39,910 --> 00:41:37,920
something we have to be careful about

1167
00:41:43,030 --> 00:41:39,920
and that that ph is a measure of acidity

1168
00:41:44,150 --> 00:41:43,040
too much acidity is not good for life as

1169
00:41:46,390 --> 00:41:44,160
we know it

1170
00:41:49,030 --> 00:41:46,400
but there are extremophiles that love

1171
00:41:51,430 --> 00:41:49,040
acidic water so you know we can get

1172
00:41:53,589 --> 00:41:51,440
proven wrong but the you got to look at

1173
00:41:55,910 --> 00:41:53,599
the flexibility of the niche to support

1174
00:41:58,550 --> 00:41:55,920
many other types of life forms

1175
00:42:00,630 --> 00:41:58,560
and if it's an acidic niche

1176
00:42:01,829 --> 00:42:00,640
then that's going to be somewhat limited

1177
00:42:03,670 --> 00:42:01,839
you know you might get life but it's

1178
00:42:06,150 --> 00:42:03,680
going to be somewhat limited so

1179
00:42:08,870 --> 00:42:06,160
we have to be careful about too much

1180
00:42:11,030 --> 00:42:08,880
oxygen which could result in in possibly

1181
00:42:12,150 --> 00:42:11,040
too much carbon dioxide

1182
00:42:15,109 --> 00:42:12,160
but

1183
00:42:17,190 --> 00:42:15,119
oxygen makes fuel for carbon-based uh

1184
00:42:19,510 --> 00:42:17,200
you know beings like ourselves

1185
00:42:22,230 --> 00:42:19,520
right we need oxygen to start doing this

1186
00:42:24,790 --> 00:42:22,240
metabolizing in our systems

1187
00:42:26,870 --> 00:42:24,800
here's a question that came in chat and

1188
00:42:28,470 --> 00:42:26,880

it is is it possible that europa could

1189
00:42:30,470 --> 00:42:28,480
have intelligent life as smart as

1190
00:42:34,309 --> 00:42:30,480
dolphins or whales or octopus

1191
00:42:36,630 --> 00:42:34,319
as far as we know those type of uh

1192
00:42:37,990 --> 00:42:36,640
beings need to

1193
00:42:40,870 --> 00:42:38,000
uh

1194
00:42:43,670 --> 00:42:40,880
they need to like eat other beings to

1195
00:42:44,950 --> 00:42:43,680
survive right it's the fish the big yeah

1196
00:42:46,710 --> 00:42:44,960
it's a little fish and you know et

1197
00:42:47,910 --> 00:42:46,720
cetera et cetera i think that would be

1198
00:42:50,230 --> 00:42:47,920
interesting to hear what you have to say

1199
00:42:52,150 --> 00:42:50,240
about that becky i got my own ideas okay

1200
00:42:54,550 --> 00:42:52,160
also they i think they're all sunlight

1201
00:42:55,910 --> 00:42:54,560
uh dependent to some degree but uh but

1202
00:42:58,790 --> 00:42:55,920
yeah um

1203
00:43:01,030 --> 00:42:58,800
i i see no reason why not frankly i mean

1204
00:43:03,030 --> 00:43:01,040
i i think i'm a little

1205
00:43:05,109 --> 00:43:03,040
um i always want to like represent the

1206
00:43:07,270 --> 00:43:05,119
microbes i think that they're

1207
00:43:09,589 --> 00:43:07,280
underrated because of course

1208
00:43:10,550 --> 00:43:09,599
we're we're macro animals and you know

1209
00:43:13,190 --> 00:43:10,560
um

1210
00:43:15,349 --> 00:43:13,200
this question there those are three very

1211
00:43:17,910 --> 00:43:15,359
charismatic animals right that we really

1212
00:43:20,950 --> 00:43:17,920
relate to that we know are intelligent

1213
00:43:22,790 --> 00:43:20,960

um have relationships like we can

1214
00:43:25,589 --> 00:43:22,800
actually communicate with them

1215
00:43:27,670 --> 00:43:25,599
um to some degree so i think it's always

1216
00:43:30,230 --> 00:43:27,680
like really exciting to bring up those

1217
00:43:31,910 --> 00:43:30,240
examples but i just uh

1218
00:43:33,750 --> 00:43:31,920
er planet earth despite the fact that it

1219
00:43:35,589 --> 00:43:33,760
has complex life on it and we think that

1220
00:43:37,589 --> 00:43:35,599
we're the big guys here

1221
00:43:39,270 --> 00:43:37,599
it's a it's still a bacterial planet

1222
00:43:40,790 --> 00:43:39,280
it's a microbial planet still they're

1223
00:43:43,190 --> 00:43:40,800
they're they're uh they were here long

1224
00:43:45,109 --> 00:43:43,200
before us they will be here long after

1225
00:43:48,150 --> 00:43:45,119
us they take up most of the biomass it's

1226
00:43:50,630 --> 00:43:48,160
still on their planet so i i think about

1227
00:43:53,670 --> 00:43:50,640
that no reason if there's if there's

1228
00:43:56,069 --> 00:43:53,680
life um if it is a habitable ocean why

1229
00:43:57,670 --> 00:43:56,079
not have larger intelligent

1230
00:43:59,589 --> 00:43:57,680
beings but um

1231
00:44:02,630 --> 00:43:59,599
also like microbes would be great that's

1232
00:44:05,510 --> 00:44:02,640
all yeah and i i will say uh i like that

1233
00:44:07,750 --> 00:44:05,520
answer very much that that says it all

1234
00:44:10,390 --> 00:44:07,760
um so i almost don't have to say it but

1235
00:44:13,190 --> 00:44:10,400
i think that the octopus i did a whole

1236
00:44:15,030 --> 00:44:13,200
uh radio show we we have a radio show on

1237
00:44:17,349 --> 00:44:15,040
kg array called sky tour radio it's an

1238
00:44:19,190 --> 00:44:17,359

astronomy show on sundays right and we

1239
00:44:20,470 --> 00:44:19,200
go from 6 to 8 p.m

1240
00:44:22,870 --> 00:44:20,480
and

1241
00:44:24,230 --> 00:44:22,880
we did a whole show on the octopus

1242
00:44:27,190 --> 00:44:24,240
and you say well how does that relate to

1243
00:44:29,510 --> 00:44:27,200
astronomy oh it really does because we

1244
00:44:32,790 --> 00:44:29,520
look at how life evolved on the planet

1245
00:44:35,109 --> 00:44:32,800
all right and it tells us a great deal

1246
00:44:37,270 --> 00:44:35,119
by looking at the octopus the octopus i

1247
00:44:38,870 --> 00:44:37,280
think i think is the smartest animal in

1248
00:44:41,430 --> 00:44:38,880
the ocean

1249
00:44:44,309 --> 00:44:41,440
i do it's it's it's got you can it

1250
00:44:45,190 --> 00:44:44,319
registers feelings it has the ability to

1251
00:44:48,150 --> 00:44:45,200
reason

1252
00:44:50,470 --> 00:44:48,160
and it has the ability to

1253
00:44:52,630 --> 00:44:50,480
move itself out of a dangerous situation

1254
00:44:53,589 --> 00:44:52,640
because it wants to not because it has

1255
00:44:54,550 --> 00:44:53,599
to

1256
00:44:56,710 --> 00:44:54,560
um

1257
00:44:59,190 --> 00:44:56,720
it demonstrates choice making which is

1258
00:45:01,190 --> 00:44:59,200
something that is different

1259
00:45:03,990 --> 00:45:01,200
most animals in the ocean react to

1260
00:45:06,230 --> 00:45:04,000
stimuli that say oh too hot too cold oh

1261
00:45:07,910 --> 00:45:06,240
danger move out of the way the octopus

1262
00:45:08,870 --> 00:45:07,920
is inquisitive and curious what's in

1263
00:45:12,710 --> 00:45:08,880

there

1264
00:45:14,790 --> 00:45:12,720
uh and how can i get out of this this

1265
00:45:17,829 --> 00:45:14,800
this maze

1266
00:45:19,109 --> 00:45:17,839
and the octopus could also observe and

1267
00:45:20,790 --> 00:45:19,119
retain

1268
00:45:21,910 --> 00:45:20,800
what it saw

1269
00:45:23,990 --> 00:45:21,920
i don't know if you heard the study or

1270
00:45:26,550 --> 00:45:24,000
saw the study there were two cages

1271
00:45:28,790 --> 00:45:26,560
underwater one was just a clear open

1272
00:45:31,430 --> 00:45:28,800
cage the other one had access to a set

1273
00:45:32,790 --> 00:45:31,440
of tubes which went out and there were

1274
00:45:35,030 --> 00:45:32,800
there was a maze that went out to dead

1275
00:45:37,589 --> 00:45:35,040
ends all over the place okay and finally

1276
00:45:39,670 --> 00:45:37,599
there was one path one and only path

1277
00:45:41,190 --> 00:45:39,680
that led to the outside back to the

1278
00:45:43,349 --> 00:45:41,200
aquarium

1279
00:45:45,510 --> 00:45:43,359
and one octopus was putting this first

1280
00:45:47,109 --> 00:45:45,520
side and the left side over here and the

1281
00:45:48,790 --> 00:45:47,119
other one was put in the other side and

1282
00:45:50,630 --> 00:45:48,800
did all the probing to find the way out

1283
00:45:52,790 --> 00:45:50,640
and when it found the way out they took

1284
00:45:54,710 --> 00:45:52,800
the other octopus put it in and it went

1285
00:45:56,950 --> 00:45:54,720
all the way out the first time

1286
00:46:00,069 --> 00:45:56,960
it watched and remembered what the first

1287
00:46:01,030 --> 00:46:00,079
one did isn't that something we can't do

1288
00:46:01,829 --> 00:46:01,040

that

1289
00:46:03,510 --> 00:46:01,839
yeah

1290
00:46:05,589 --> 00:46:03,520
we can't do that

1291
00:46:06,870 --> 00:46:05,599
the cuttlefish are pretty the cuttlefish

1292
00:46:08,870 --> 00:46:06,880
are you familiar with those those are

1293
00:46:11,030 --> 00:46:08,880
really smart too yes

1294
00:46:13,109 --> 00:46:11,040
and they're very old

1295
00:46:14,790 --> 00:46:13,119
not you know particularly each one but

1296
00:46:15,990 --> 00:46:14,800
they're very old evolutionarily on the

1297
00:46:18,630 --> 00:46:16,000
planet

1298
00:46:20,470 --> 00:46:18,640
yeah right the chambered nautilus those

1299
00:46:21,430 --> 00:46:20,480
examples are also great martin too

1300
00:46:23,829 --> 00:46:21,440
because

1301
00:46:25,589 --> 00:46:23,839
um you know speaking of dolphins whales

1302
00:46:27,270 --> 00:46:25,599
and apes of course they're all mammals

1303
00:46:29,430 --> 00:46:27,280
like us they're on our branch of the

1304
00:46:31,589 --> 00:46:29,440
tree and i think uh octopuses are so

1305
00:46:33,510 --> 00:46:31,599
exciting um and cuttlefish and things

1306
00:46:35,829 --> 00:46:33,520
like that to have a truly an

1307
00:46:37,510 --> 00:46:35,839
intelligence that is not really closely

1308
00:46:39,349 --> 00:46:37,520
related at all to us

1309
00:46:40,710 --> 00:46:39,359
right good point

1310
00:46:43,109 --> 00:46:40,720
another thing too you know about

1311
00:46:44,230 --> 00:46:43,119
dolphins in particular um

1312
00:46:45,829 --> 00:46:44,240
dolphins

1313
00:46:49,510 --> 00:46:45,839

like elephants

1314
00:46:51,190 --> 00:46:49,520
have a place that they go to die

1315
00:46:53,510 --> 00:46:51,200
very interesting i actually have up

1316
00:46:55,510 --> 00:46:53,520
there on my shelf i actually have a

1317
00:46:58,950 --> 00:46:55,520
dolphin skeleton

1318
00:47:00,550 --> 00:46:58,960
that came from cape verde islands

1319
00:47:01,990 --> 00:47:00,560
and it was given to me by another

1320
00:47:03,750 --> 00:47:02,000
science writer actually from woods hole

1321
00:47:06,069 --> 00:47:03,760
oceanographic institution

1322
00:47:08,710 --> 00:47:06,079
and this dolphin skeleton was collected

1323
00:47:10,950 --> 00:47:08,720
on a beach full of tens of thousands of

1324
00:47:13,030 --> 00:47:10,960
dolphin skeletons and this wasn't from a

1325
00:47:15,349 --> 00:47:13,040
mass beaching it's from the

1326
00:47:17,910 --> 00:47:15,359
location where they all seem to come

1327
00:47:20,230 --> 00:47:17,920
many of them come to die and live their

1328
00:47:21,430 --> 00:47:20,240
last days like an elephant graveyard

1329
00:47:24,069 --> 00:47:21,440
like an elephant graveyard that's a

1330
00:47:25,190 --> 00:47:24,079
dolphin graveyard really fascinating

1331
00:47:26,630 --> 00:47:25,200
incredible

1332
00:47:29,430 --> 00:47:26,640
yeah

1333
00:47:31,750 --> 00:47:29,440
well let's uh let's talk about life the

1334
00:47:33,670 --> 00:47:31,760
possibility of life in our solar system

1335
00:47:34,470 --> 00:47:33,680
since that's what we're talking about

1336
00:47:37,829 --> 00:47:34,480
um

1337
00:47:39,349 --> 00:47:37,839
the places i i believe it was venus they

1338
00:47:41,829 --> 00:47:39,359

thought their pop there was a

1339
00:47:43,349 --> 00:47:41,839
possibility that there could have been

1340
00:47:46,069 --> 00:47:43,359
some type of life in the upper

1341
00:47:47,670 --> 00:47:46,079
atmosphere um i've always wondered if

1342
00:47:50,790 --> 00:47:47,680
they'll ever find

1343
00:47:52,790 --> 00:47:50,800
you know fossilized microbes say on mars

1344
00:47:54,549 --> 00:47:52,800
with it seems like with all the rovers

1345
00:47:56,710 --> 00:47:54,559
and things that they have there

1346
00:47:58,309 --> 00:47:56,720
that they should be

1347
00:48:01,190 --> 00:47:58,319
looking into that

1348
00:48:02,790 --> 00:48:01,200
more than it seems that they do i mean

1349
00:48:04,790 --> 00:48:02,800
anyway i'm kind of throwing a couple

1350
00:48:06,549 --> 00:48:04,800
different topics out there becky what

1351
00:48:08,069 --> 00:48:06,559
have you done with venus or mars have

1352
00:48:09,109 --> 00:48:08,079
you done anything with them i i love

1353
00:48:10,870 --> 00:48:09,119
venus and there's actually a couple

1354
00:48:12,950 --> 00:48:10,880
missions now finally going there venus

1355
00:48:15,109 --> 00:48:12,960
is in style again this is you know very

1356
00:48:17,990 --> 00:48:15,119
exciting um i think there was just a

1357
00:48:21,030 --> 00:48:18,000
study that came out that was kind of uh

1358
00:48:23,349 --> 00:48:21,040
that refuted a lot of the idea of the

1359
00:48:26,150 --> 00:48:23,359
microbes in in the atmosphere which is

1360
00:48:27,589 --> 00:48:26,160
sad of course but um that's science for

1361
00:48:29,510 --> 00:48:27,599
you um

1362
00:48:31,109 --> 00:48:29,520
i think i think the venetian um

1363
00:48:31,990 --> 00:48:31,119

atmosphere is really interesting it's

1364
00:48:33,510 --> 00:48:32,000
very

1365
00:48:34,950 --> 00:48:33,520
you know obviously you think of venus

1366
00:48:37,109 --> 00:48:34,960
you think oh god

1367
00:48:38,549 --> 00:48:37,119
hellscape nightmare don't wanna i think

1368
00:48:40,870 --> 00:48:38,559
i'd live there but yeah the atmosphere

1369
00:48:42,390 --> 00:48:40,880
is this um much more mild place and

1370
00:48:44,710 --> 00:48:42,400
could be really interesting to explore

1371
00:48:47,030 --> 00:48:44,720
more and then you mentioned you know the

1372
00:48:49,670 --> 00:48:47,040
rovers on mars um perseverance which

1373
00:48:51,990 --> 00:48:49,680
landed last last year um

1374
00:48:55,510 --> 00:48:52,000
it it's its mission is to pick up these

1375
00:48:57,750 --> 00:48:55,520
samples from this ancient lake bed um

1376
00:48:59,109 --> 00:48:57,760
and to like you know put them aside so

1377
00:49:00,069 --> 00:48:59,119
that another another mission can come

1378
00:49:01,750 --> 00:49:00,079
and send them back to earth which would

1379
00:49:03,270 --> 00:49:01,760
be the first time we'd ever had pristine

1380
00:49:05,190 --> 00:49:03,280
samples from mars

1381
00:49:07,270 --> 00:49:05,200
and um i i think i think it would be

1382
00:49:08,790 --> 00:49:07,280
really fascinating if they obviously if

1383
00:49:10,390 --> 00:49:08,800
they found fossils there i mean there's

1384
00:49:12,069 --> 00:49:10,400
this whole question of just like finding

1385
00:49:14,069 --> 00:49:12,079
life and then knowing that it went

1386
00:49:16,630 --> 00:49:14,079
extinct four billion years ago which is

1387
00:49:18,630 --> 00:49:16,640
kind of uh like a bittersweet thing but

1388
00:49:21,670 --> 00:49:18,640

there's also like one of my favorite uh

1389
00:49:24,470 --> 00:49:21,680
um kind of pet speculations this idea of

1390
00:49:26,549 --> 00:49:24,480
panspermia that you could have microbes

1391
00:49:28,309 --> 00:49:26,559
traveling from planet to planet on

1392
00:49:30,390 --> 00:49:28,319
meteorites um

1393
00:49:32,470 --> 00:49:30,400
and um i love this kind of idea that

1394
00:49:34,150 --> 00:49:32,480
maybe like mars and venus were both

1395
00:49:36,309 --> 00:49:34,160
capital lack in the day in the early

1396
00:49:38,230 --> 00:49:36,319
days of the solar system and potentially

1397
00:49:39,510 --> 00:49:38,240
earth life comes from one of those and

1398
00:49:41,670 --> 00:49:39,520
that we're just all descended from

1399
00:49:44,470 --> 00:49:41,680
martians or venusians or whatever right

1400
00:49:46,549 --> 00:49:44,480
very very uh you know it's it's wild

1401
00:49:48,549 --> 00:49:46,559
speculation but it's just it's it's a

1402
00:49:50,790 --> 00:49:48,559
possibility we do exchange meteorites

1403
00:49:52,230 --> 00:49:50,800
from these planets so yeah well have you

1404
00:49:54,150 --> 00:49:52,240
heard um

1405
00:49:56,390 --> 00:49:54,160
one of the latest findings actually

1406
00:49:57,750 --> 00:49:56,400
maybe you have becky is that

1407
00:50:00,390 --> 00:49:57,760
much of the

1408
00:50:02,390 --> 00:50:00,400
debris disk left over from formation in

1409
00:50:03,910 --> 00:50:02,400
our solar system much of this the small

1410
00:50:05,030 --> 00:50:03,920
particles of these small particles of

1411
00:50:07,430 --> 00:50:05,040
dust

1412
00:50:09,109 --> 00:50:07,440
were actually created from big impacts

1413
00:50:10,390 --> 00:50:09,119

on mars

1414
00:50:17,510 --> 00:50:10,400
and

1415
00:50:19,030 --> 00:50:17,520
study uh but

1416
00:50:20,870 --> 00:50:19,040
of these impacts right they're gonna

1417
00:50:23,910 --> 00:50:20,880
blow off lots of stuff potentially

1418
00:50:25,589 --> 00:50:23,920
organic molecules into space where

1419
00:50:26,790 --> 00:50:25,599
they're gonna get flash frozen if not

1420
00:50:28,630 --> 00:50:26,800
destroyed

1421
00:50:31,349 --> 00:50:28,640
and then make their way to earth

1422
00:50:33,750 --> 00:50:31,359
and perhaps they the whole concept of

1423
00:50:35,670 --> 00:50:33,760
panspermia did occur

1424
00:50:37,829 --> 00:50:35,680
uh courtesy of mars

1425
00:50:39,349 --> 00:50:37,839
and then mars right and then mars lost

1426
00:50:40,870 --> 00:50:39,359
its magnetic field

1427
00:50:42,870 --> 00:50:40,880
mars died

1428
00:50:44,470 --> 00:50:42,880
uh the lakes dried up because the water

1429
00:50:46,470 --> 00:50:44,480
went away the vapor pressure the

1430
00:50:48,549 --> 00:50:46,480
pressure dropped down to six pascals

1431
00:50:49,589 --> 00:50:48,559
which is a really tiny you know

1432
00:50:50,710 --> 00:50:49,599
pressure

1433
00:50:52,950 --> 00:50:50,720
okay

1434
00:50:55,430 --> 00:50:52,960
and next thing you know um

1435
00:50:56,630 --> 00:50:55,440
we live so it's kind of interesting uh

1436
00:50:58,470 --> 00:50:56,640
it's almost like

1437
00:51:00,470 --> 00:50:58,480
the martian population knew they were

1438
00:51:02,069 --> 00:51:00,480

gonna die so they left mars and came

1439
00:51:03,750 --> 00:51:02,079
here but there were only microbes when

1440
00:51:06,470 --> 00:51:03,760
they did it

1441
00:51:09,750 --> 00:51:06,480
i love that it's cool i see a science

1442
00:51:12,069 --> 00:51:09,760
fiction story yeah definitely yeah

1443
00:51:13,990 --> 00:51:12,079
so becky this is your opinion what do

1444
00:51:16,790 --> 00:51:14,000
you think would

1445
00:51:19,270 --> 00:51:16,800
it would be like if all of a sudden

1446
00:51:21,430 --> 00:51:19,280
we could say hey we have found life

1447
00:51:23,589 --> 00:51:21,440
elsewhere what do you think would change

1448
00:51:25,670 --> 00:51:23,599
in society or do you think nothing would

1449
00:51:27,430 --> 00:51:25,680
change oh it's so fun martin to get this

1450
00:51:29,510 --> 00:51:27,440
question because i ask it to a lot of

1451
00:51:31,510 --> 00:51:29,520
people so it's kind of like what i've

1452
00:51:34,309 --> 00:51:31,520
always wanted to be asked but no i mean

1453
00:51:36,230 --> 00:51:34,319
i think it would be um enormous and even

1454
00:51:38,230 --> 00:51:36,240
if it is just microbes right and let's

1455
00:51:39,910 --> 00:51:38,240
assume that it is because i think um i'm

1456
00:51:42,230 --> 00:51:39,920
much more skeptical about intelligent

1457
00:51:44,470 --> 00:51:42,240
life being a being yeah it's just much

1458
00:51:46,069 --> 00:51:44,480
more rare but microbes i mean it would

1459
00:51:47,990 --> 00:51:46,079
mean that uh

1460
00:51:48,790 --> 00:51:48,000
another sample set we could answer that

1461
00:51:51,990 --> 00:51:48,800
question that we were talking about

1462
00:51:54,309 --> 00:51:52,000
earlier does all life require dna uh

1463
00:51:55,990 --> 00:51:54,319

just the nature of it would allow us to

1464
00:51:57,750 --> 00:51:56,000
know where to look for it in other

1465
00:52:00,069 --> 00:51:57,760
places but i think you know imagine

1466
00:52:01,990 --> 00:52:00,079
finding fossils on mars that's just like

1467
00:52:03,750 --> 00:52:02,000
you know a planet next door and we're

1468
00:52:06,790 --> 00:52:03,760
already finding life there that really

1469
00:52:08,230 --> 00:52:06,800
kind of implies that it's very common um

1470
00:52:10,870 --> 00:52:08,240
so i think i think it would just be

1471
00:52:13,190 --> 00:52:10,880
amazing for that perspective of just uh

1472
00:52:14,870 --> 00:52:13,200
you know it's it's a natural process

1473
00:52:17,109 --> 00:52:14,880
like anything else that we see in in the

1474
00:52:18,470 --> 00:52:17,119
world and society i think would have a

1475
00:52:19,270 --> 00:52:18,480
whole bunch of different

1476
00:52:20,630 --> 00:52:19,280
um

1477
00:52:23,030 --> 00:52:20,640
reactions to that because we all know

1478
00:52:26,150 --> 00:52:23,040
we're living in a pretty fractured world

1479
00:52:27,990 --> 00:52:26,160
but uh overall i think it would just be

1480
00:52:28,950 --> 00:52:28,000
kind of one of all and wonder don't you

1481
00:52:31,030 --> 00:52:28,960
i mean

1482
00:52:33,349 --> 00:52:31,040
finally after this

1483
00:52:35,990 --> 00:52:33,359
millennia-long kind of search

1484
00:52:39,510 --> 00:52:36,000
to know that we're not alone

1485
00:52:42,630 --> 00:52:39,520
yeah i i to add um not to throw some

1486
00:52:45,030 --> 00:52:42,640
fuel on the fire here but uh the chinese

1487
00:52:46,230 --> 00:52:45,040
just announced uh in the last couple

1488
00:52:48,710 --> 00:52:46,240

days you know this what i'm talking

1489
00:52:49,990 --> 00:52:48,720
about right yeah yeah yeah yeah i uh

1490
00:52:51,270 --> 00:52:50,000
almost i don't want to steal your

1491
00:52:53,510 --> 00:52:51,280
thunder on that if you're gonna talk

1492
00:52:55,109 --> 00:52:53,520
about it oh okay they just announced

1493
00:52:57,510 --> 00:52:55,119
that they thought that maybe they found

1494
00:52:59,589 --> 00:52:57,520
an extraterrestrial signal that was of

1495
00:53:00,470 --> 00:52:59,599
intelligent origin

1496
00:53:01,670 --> 00:53:00,480
okay

1497
00:53:05,510 --> 00:53:01,680
now

1498
00:53:07,349 --> 00:53:05,520
you how that could have happened it

1499
00:53:09,910 --> 00:53:07,359
could have been that somebody listening

1500
00:53:11,670 --> 00:53:09,920
to say some type of strange fast radio

1501
00:53:12,829 --> 00:53:11,680
burst which we've talked about before

1502
00:53:15,589 --> 00:53:12,839
martin

1503
00:53:17,910 --> 00:53:15,599
uh could have said

1504
00:53:20,630 --> 00:53:17,920
uh wow this looks like life to me and

1505
00:53:21,510 --> 00:53:20,640
they put it out and then finally when

1506
00:53:26,390 --> 00:53:21,520
the

1507
00:53:28,549 --> 00:53:26,400
uh media said wait a minute wait wait a

1508
00:53:30,309 --> 00:53:28,559
minute you can't say that is this really

1509
00:53:31,750 --> 00:53:30,319
life and then other scientists came

1510
00:53:32,870 --> 00:53:31,760
along and said it might have been a fast

1511
00:53:35,510 --> 00:53:32,880
radio burst and so they would have

1512
00:53:37,750 --> 00:53:35,520
pulled it back but the but the outward

1513
00:53:39,190 --> 00:53:37,760

view is that they announced that life

1514
00:53:40,470 --> 00:53:39,200
was present and then the story got

1515
00:53:42,630 --> 00:53:40,480
quashed

1516
00:53:44,150 --> 00:53:42,640
so that leads to all these great the

1517
00:53:45,589 --> 00:53:44,160
whole conspiracy worlds are you know

1518
00:53:47,109 --> 00:53:45,599
going to be up in arms for the next

1519
00:53:49,030 --> 00:53:47,119
several weeks until

1520
00:53:50,790 --> 00:53:49,040
it leaves the news cycle

1521
00:53:51,430 --> 00:53:50,800
but it is an interesting concept isn't

1522
00:53:52,630 --> 00:53:51,440
it

1523
00:53:55,430 --> 00:53:52,640
and that's what's going to happen

1524
00:53:57,829 --> 00:53:55,440
eventually when we find life or intel

1525
00:53:59,589 --> 00:53:57,839
intelligence signals it's probably gonna

1526
00:54:01,750 --> 00:53:59,599
be from one of these radio telescopes

1527
00:54:03,190 --> 00:54:01,760
that's paying attention to

1528
00:54:06,150 --> 00:54:03,200
you know something out there that's

1529
00:54:08,150 --> 00:54:06,160
that's doing something really exotic

1530
00:54:08,950 --> 00:54:08,160
what about the james webb do you think

1531
00:54:09,829 --> 00:54:08,960
that

1532
00:54:11,430 --> 00:54:09,839
could

1533
00:54:13,190 --> 00:54:11,440
actually capture something that would

1534
00:54:15,430 --> 00:54:13,200
tell us more

1535
00:54:17,589 --> 00:54:15,440
yeah definitely i think i think again

1536
00:54:19,750 --> 00:54:17,599
and i'll just i just wanted to add

1537
00:54:21,750 --> 00:54:19,760
one thing i think is important is that

1538
00:54:23,510 --> 00:54:21,760

candidates for extraterrestrial

1539
00:54:26,069 --> 00:54:23,520
intelligence are very common and it's

1540
00:54:27,510 --> 00:54:26,079
almost always human interference that's

1541
00:54:29,510 --> 00:54:27,520
right radius

1542
00:54:31,349 --> 00:54:29,520
bounced into the telescope so i think

1543
00:54:32,950 --> 00:54:31,359
that they kind of like thought like oh

1544
00:54:33,910 --> 00:54:32,960
crap like everyone's paying attention to

1545
00:54:36,630 --> 00:54:33,920
this and this could just be like

1546
00:54:39,510 --> 00:54:36,640
someone's cell phone um but um

1547
00:54:42,230 --> 00:54:39,520
but uh exactly what she says yeah with

1548
00:54:44,150 --> 00:54:42,240
james webb like um i i just think it's

1549
00:54:46,150 --> 00:54:44,160
so exciting because uh there's

1550
00:54:47,829 --> 00:54:46,160
definitely again the the techno

1551
00:54:49,510 --> 00:54:47,839
signature side of it but what it's going

1552
00:54:51,750 --> 00:54:49,520
to be really good at is looking at

1553
00:54:54,390 --> 00:54:51,760
atmospheres of exoplanets it's great for

1554
00:54:56,789 --> 00:54:54,400
a telescope it can

1555
00:54:58,549 --> 00:54:56,799
refine in great detail the kind of

1556
00:55:01,270 --> 00:54:58,559
chemical compositions of these planets

1557
00:55:02,549 --> 00:55:01,280
so um i think this is one of the kind of

1558
00:55:05,109 --> 00:55:02,559
again bittersweet things about the

1559
00:55:06,950 --> 00:55:05,119
modern search for uh extra

1560
00:55:08,309 --> 00:55:06,960
extraterrestrial life is that i think

1561
00:55:10,470 --> 00:55:08,319
the most likely way we'll find it is

1562
00:55:12,870 --> 00:55:10,480
like okay we have ozone and methane in

1563
00:55:15,349 --> 00:55:12,880

an atmosphere it looks like life don't

1564
00:55:18,069 --> 00:55:15,359
know it's 300 light years away but

1565
00:55:19,270 --> 00:55:18,079
that's like our moment of discovery so

1566
00:55:21,430 --> 00:55:19,280
it's going to be this kind of thing

1567
00:55:23,430 --> 00:55:21,440
where it's just looking like at how

1568
00:55:26,150 --> 00:55:23,440
how common these habitable worlds are it

1569
00:55:28,069 --> 00:55:26,160
might not be this kind of very smoke and

1570
00:55:29,910 --> 00:55:28,079
gun kind of evidence but i think just

1571
00:55:32,230 --> 00:55:29,920
the fact that james webb will be able to

1572
00:55:33,990 --> 00:55:32,240
tell us how common the ingredients for

1573
00:55:36,789 --> 00:55:34,000
life in an atmosphere are is going to be

1574
00:55:38,789 --> 00:55:36,799
really revelatory yeah what type of

1575
00:55:41,910 --> 00:55:38,799
what types of things will it be able to

1576
00:55:43,670 --> 00:55:41,920
detect as far as an atmosphere like

1577
00:55:45,589 --> 00:55:43,680
if we were looked at

1578
00:55:47,430 --> 00:55:45,599
we could it would obviously we have you

1579
00:55:50,069 --> 00:55:47,440
know pollution and you know all

1580
00:55:52,390 --> 00:55:50,079
different things uh that would show that

1581
00:55:54,150 --> 00:55:52,400
there's actually life here as long as it

1582
00:55:55,829 --> 00:55:54,160
shows in the infrared

1583
00:55:58,390 --> 00:55:55,839
uh they'll it'll see it

1584
00:56:01,190 --> 00:55:58,400
okay it can't detect oxygen by the way

1585
00:56:03,030 --> 00:56:01,200
it's not gonna see oxygen not directly

1586
00:56:05,190 --> 00:56:03,040
but when oxygen atoms collide with each

1587
00:56:07,750 --> 00:56:05,200
other they create byproducts those

1588
00:56:10,549 --> 00:56:07,760

byproducts have a single signal in the

1589
00:56:12,230 --> 00:56:10,559
infrared so the relative abundances of

1590
00:56:13,589 --> 00:56:12,240
these collision products

1591
00:56:15,109 --> 00:56:13,599
will show

1592
00:56:17,910 --> 00:56:15,119
how much oxygen might be in an

1593
00:56:20,630 --> 00:56:17,920
atmosphere so just to so you know about

1594
00:56:22,150 --> 00:56:20,640
the the james webb so i think that that

1595
00:56:25,030 --> 00:56:22,160
process is something that's going to be

1596
00:56:27,589 --> 00:56:25,040
exploited to the nth degree with these

1597
00:56:29,030 --> 00:56:27,599
exoplanet studies

1598
00:56:30,710 --> 00:56:29,040
and it's not the only one that's what's

1599
00:56:32,069 --> 00:56:30,720
exciting about this time is that

1600
00:56:34,230 --> 00:56:32,079
obviously it's a it's you know an

1601
00:56:35,910 --> 00:56:34,240
amazing telescope but you have like so

1602
00:56:37,190 --> 00:56:35,920
many amazing telescopes they're about to

1603
00:56:38,870 --> 00:56:37,200
come online you've got you know

1604
00:56:41,430 --> 00:56:38,880
obviously fast is really interesting and

1605
00:56:43,349 --> 00:56:41,440
i think it's a great um intelligence

1606
00:56:45,030 --> 00:56:43,359
hunter and then you have like this

1607
00:56:46,950 --> 00:56:45,040
square kilometer array that's going to

1608
00:56:49,109 --> 00:56:46,960
be coming on in in the next decade just

1609
00:56:51,270 --> 00:56:49,119
the biggest radio array on earth

1610
00:56:53,030 --> 00:56:51,280
and the nancy roman telescope and the

1611
00:56:55,670 --> 00:56:53,040
extremely large telescope in chile like

1612
00:56:57,990 --> 00:56:55,680
it's just a heyday right now so

1613
00:56:59,990 --> 00:56:58,000

um lots of answers maybe not definitive

1614
00:57:01,349 --> 00:57:00,000
ones but certainly no but that's right

1615
00:57:02,789 --> 00:57:01,359
that's all good though becky you're

1616
00:57:04,390 --> 00:57:02,799
absolutely you're right on the mark with

1617
00:57:05,750 --> 00:57:04,400
that i'll tell you

1618
00:57:07,670 --> 00:57:05,760
well

1619
00:57:09,829 --> 00:57:07,680
this has been wonderful i've really

1620
00:57:12,470 --> 00:57:09,839
enjoyed this conversation a lot

1621
00:57:14,069 --> 00:57:12,480
and becky are you reachable do you like

1622
00:57:16,630 --> 00:57:14,079
people to reach out to you

1623
00:57:19,430 --> 00:57:16,640
yeah sure um i'm on twitter becky

1624
00:57:21,190 --> 00:57:19,440
ferreira um and i have my email up there

1625
00:57:23,510 --> 00:57:21,200
just thank you for your advice so always

1626
00:57:25,270 --> 00:57:23,520
interested to hear what people think oh

1627
00:57:26,950 --> 00:57:25,280
let's see we have we have one more

1628
00:57:29,589 --> 00:57:26,960
question up here let's see

1629
00:57:31,990 --> 00:57:29,599
um how this is let's see how does europa

1630
00:57:33,270 --> 00:57:32,000
have so much water and other moons of

1631
00:57:35,990 --> 00:57:33,280
jupiter have

1632
00:57:39,190 --> 00:57:36,000
so much less water another is it the way

1633
00:57:41,109 --> 00:57:39,200
the moon developed or something

1634
00:57:41,910 --> 00:57:41,119
any ideas on that mark

1635
00:57:43,750 --> 00:57:41,920
oh

1636
00:57:46,549 --> 00:57:43,760
why are you watching me

1637
00:57:47,829 --> 00:57:46,559
yeah oh okay well i i was i'm praying

1638
00:57:49,430 --> 00:57:47,839

for becky i thought she was gonna answer

1639
00:57:52,069 --> 00:57:49,440
but that's okay um oh that's a good

1640
00:57:55,109 --> 00:57:52,079
question okay hey

1641
00:57:57,589 --> 00:57:55,119
well europa is 2000 miles across just

1642
00:57:58,390 --> 00:57:57,599
under so relatively speaking

1643
00:58:01,030 --> 00:57:58,400
um

1644
00:58:03,910 --> 00:58:01,040
the amount of water that's there is

1645
00:58:05,589 --> 00:58:03,920
probably less than what's on ganymede

1646
00:58:07,109 --> 00:58:05,599
okay i mean we have to look at the

1647
00:58:08,789 --> 00:58:07,119
internal structure of ganymede and

1648
00:58:10,230 --> 00:58:08,799
kalisto to know

1649
00:58:12,470 --> 00:58:10,240
and it's not the only one keep in mind

1650
00:58:14,470 --> 00:58:12,480
that the entire kuiper belt way way out

1651
00:58:16,710 --> 00:58:14,480
and the oort cloud beyond that

1652
00:58:19,430 --> 00:58:16,720
are made of all icy bodies full of a lot

1653
00:58:21,190 --> 00:58:19,440
of different types of ices including h2o

1654
00:58:22,390 --> 00:58:21,200
you'll have carbon dioxide ices you have

1655
00:58:24,230 --> 00:58:22,400
methanol you have all kinds of

1656
00:58:27,030 --> 00:58:24,240
formaldehyde stuff but you're not going

1657
00:58:29,270 --> 00:58:27,040
to find a dearth or a lack of this water

1658
00:58:31,270 --> 00:58:29,280
ice anywhere water is very common

1659
00:58:32,710 --> 00:58:31,280
hydrogen is very common hydrogen is the

1660
00:58:34,470 --> 00:58:32,720
most abundant element in the entire

1661
00:58:36,789 --> 00:58:34,480
universe oxygen is the third most

1662
00:58:37,750 --> 00:58:36,799
abundant element in the universe next is

1663
00:58:40,470 --> 00:58:37,760

carbon

1664
00:58:42,870 --> 00:58:40,480
so the top four are hydrogen helium

1665
00:58:44,390 --> 00:58:42,880
oxygen and carbon so it stands to reason

1666
00:58:46,390 --> 00:58:44,400
that we're going to get many many

1667
00:58:48,870 --> 00:58:46,400
different types of compounds made of

1668
00:58:51,589 --> 00:58:48,880
those in my view and and water is one of

1669
00:58:53,910 --> 00:58:51,599
them interesting

1670
00:58:56,069 --> 00:58:53,920
well again thank you both so much it's

1671
00:58:57,030 --> 00:58:56,079
been uh my pleasure to talk to both of

1672
00:58:59,910 --> 00:58:57,040
you

1673
00:59:01,829 --> 00:58:59,920
good talking

1674
00:59:04,309 --> 00:59:01,839
thank you so much for convening us

1675
00:59:05,030 --> 00:59:04,319
martin this is fantastic well i hope you

1676
00:59:06,950 --> 00:59:05,040
have

1677
00:59:09,430 --> 00:59:06,960
some wonderful stories to write about in

1678
00:59:11,190 --> 00:59:09,440
the future including

1679
00:59:13,349 --> 00:59:11,200
that we have discovered life somewhere

1680
00:59:15,270 --> 00:59:13,359
that'll be great to be able to god becky

1681
00:59:18,710 --> 00:59:15,280
maybe we can collaborate on some things

1682
00:59:19,750 --> 00:59:18,720
don't tell martin don't