Ask An Astrobiologist

Episode 42: June 22nd, 2021

Dr. Heather Graham

NASA Astrobiology Program

1
00:00:00,510 --> 00:00:30,230
[Music]

2
00:00:33,670 --> 00:00:30,950
greetings

3
00:00:35,910 --> 00:00:33,680
friends fellow earthlings and fellow

4
00:00:38,150 --> 00:00:35,920
producers of biosignatures

5
00:00:40,389 --> 00:00:38,160
and welcome to ask an astrobiologist the

6
00:00:43,190 --> 00:00:40,399
show that celebrates the science

7
00:00:45,510 --> 00:00:43,200
and celebrates the scientists involved

8
00:00:47,430 --> 00:00:45,520
in our quest to understand the nature of

9
00:00:49,590 --> 00:00:47,440
life in the cosmos

10
00:00:51,750 --> 00:00:49,600
i'm your host dr graham lemao and we're

11
00:00:52,709 --> 00:00:51,760
brought to you by the nasa astrobiology

12
00:00:55,750 --> 00:00:52,719
program

13
00:00:56,310 --> 00:00:55,760

and saginet.org and this show is going

14
00:00:58,709 --> 00:00:56,320
to be

15
00:01:00,950 --> 00:00:58,719
really really groovy folks we're going

16
00:01:01,830 --> 00:01:00,960
to talk about asteroids agnostic bio

17
00:01:04,630 --> 00:01:01,840
signatures

18
00:01:04,950 --> 00:01:04,640
experimental rock opera and way more i

19
00:01:07,590 --> 00:01:04,960
mean

20
00:01:08,469 --> 00:01:07,600
it's episode 42 right so we have to

21
00:01:11,109 --> 00:01:08,479
discuss

22
00:01:11,750 --> 00:01:11,119
life the universe and everything or very

23
00:01:14,469 --> 00:01:11,760
nearly

24
00:01:16,469 --> 00:01:14,479
everything uh but you know before we get

25
00:01:18,469 --> 00:01:16,479
into our featured guests today we have

26
00:01:20,550 --> 00:01:18,479
our usual housekeeping to do

27
00:01:22,070 --> 00:01:20,560
to show some love to those of you out

28
00:01:24,469 --> 00:01:22,080
there showing us love

29
00:01:25,510 --> 00:01:24,479
and sharing information about our show

30
00:01:28,149 --> 00:01:25,520
online

31
00:01:29,910 --> 00:01:28,159
uh you know retweeting us liking getting

32
00:01:31,429 --> 00:01:29,920
involved in the conversation about our

33
00:01:32,390 --> 00:01:31,439
guests about their research the things

34
00:01:34,789 --> 00:01:32,400
they're doing

35
00:01:35,830 --> 00:01:34,799
in the realm of astrobiology this month

36
00:01:39,270 --> 00:01:35,840
we'd like to highlight

37
00:01:41,670 --> 00:01:39,280
two ambassadors for the show denise who

38
00:01:43,429 --> 00:01:41,680

is always very active and sharing about

39
00:01:46,389 --> 00:01:43,439
ask an astrobiologist

40
00:01:47,350 --> 00:01:46,399
and this month a new ambassador aeronava

41
00:01:49,990 --> 00:01:47,360
padar

42
00:01:51,270 --> 00:01:50,000
uh these two twitter users have shared a

43
00:01:52,149 --> 00:01:51,280
lot about our show

44
00:01:54,230 --> 00:01:52,159
they've gotten involved in the

45
00:01:55,270 --> 00:01:54,240
conversation and we really really

46
00:01:58,069 --> 00:01:55,280
appreciate that

47
00:01:59,749 --> 00:01:58,079
it helps us to show our guests how much

48
00:02:00,950 --> 00:01:59,759
we care about what they're doing in

49
00:02:03,830 --> 00:02:00,960
astrobiology

50
00:02:05,590 --> 00:02:03,840
from around the world now that said i

51
00:02:06,950 --> 00:02:05,600
get the the pleasure of introducing our

52
00:02:09,109 --> 00:02:06,960
guest for this show

53
00:02:10,229 --> 00:02:09,119
dr heather graham who is an organic

54
00:02:12,390 --> 00:02:10,239
geochemist

55
00:02:14,470 --> 00:02:12,400
and a research scientist at nasa's

56
00:02:16,470 --> 00:02:14,480
goddard space flight center

57
00:02:18,309 --> 00:02:16,480
dr graham's research focuses on the

58
00:02:19,190 --> 00:02:18,319
scientific development of tools and

59
00:02:21,589 --> 00:02:19,200
techniques

60
00:02:23,030 --> 00:02:21,599
that can help us identify agnostic

61
00:02:25,110 --> 00:02:23,040
biosignatures

62
00:02:26,790 --> 00:02:25,120
she's involved in work for sample return

63
00:02:28,550 --> 00:02:26,800

missions from an asteroid

64
00:02:30,949 --> 00:02:28,560
and mars she's a member of the

65
00:02:32,550 --> 00:02:30,959
laboratory for agnostic biosignatures

66
00:02:35,110 --> 00:02:32,560
as well as for the network for life

67
00:02:36,949 --> 00:02:35,120
detection and she's also an experienced

68
00:02:38,710 --> 00:02:36,959
communicator of science having

69
00:02:40,309 --> 00:02:38,720
even co-wrote and directed an

70
00:02:42,390 --> 00:02:40,319
experimental rock opera

71
00:02:43,509 --> 00:02:42,400
about hidden figures catherine johnson

72
00:02:45,670 --> 00:02:43,519
mary jackson

73
00:02:46,790 --> 00:02:45,680
and dorothy vaughn i'm so excited to

74
00:02:48,830 --> 00:02:46,800
have her on the show

75
00:02:51,589 --> 00:02:48,840
dr graham welcome to ask an astro

76
00:02:52,710 --> 00:02:51,599
biologist thanks dr graham it's great to

77
00:02:53,910 --> 00:02:52,720
be here

78
00:02:55,910 --> 00:02:53,920
yeah just before the show we were

79
00:02:57,589 --> 00:02:55,920
talking how some folks they prefer to

80
00:02:59,430 --> 00:02:57,599
mention doctor and then first name

81
00:03:01,589 --> 00:02:59,440
and so for some people out there this is

82
00:03:03,750 --> 00:03:01,599
dr graham talking to dr graham

83
00:03:04,710 --> 00:03:03,760
um today's ask an astrobiologist which i

84
00:03:08,309 --> 00:03:04,720
love

85
00:03:09,670 --> 00:03:08,319
to do with all of our guests when they

86
00:03:11,430 --> 00:03:09,680
first come on the show

87
00:03:12,710 --> 00:03:11,440
uh since we do have some younger viewers

88
00:03:14,589 --> 00:03:12,720

very often who

89
00:03:15,990 --> 00:03:14,599
want to know how they can become

90
00:03:18,390 --> 00:03:16,000
astrobiologists and

91
00:03:20,229 --> 00:03:18,400
and what pathways are available to them

92
00:03:21,589 --> 00:03:20,239
i'd love to hear if you have a science

93
00:03:23,030 --> 00:03:21,599
origin story and

94
00:03:24,710 --> 00:03:23,040
and what kind of drove you on your

95
00:03:27,750 --> 00:03:24,720
mission to earn your doctorate and

96
00:03:30,470 --> 00:03:27,760
become a researcher in astrobiology

97
00:03:30,949 --> 00:03:30,480
yeah you know i love talking about this

98
00:03:33,910 --> 00:03:30,959
because

99
00:03:36,070 --> 00:03:33,920
i'm hoping that um when people hear

100
00:03:38,630 --> 00:03:36,080
about my science origin story they

101
00:03:39,190 --> 00:03:38,640
can understand that it can happen at any

102
00:03:41,430 --> 00:03:39,200
point

103
00:03:42,470 --> 00:03:41,440
and it's not a singular event for a lot

104
00:03:44,949 --> 00:03:42,480
of people

105
00:03:45,750 --> 00:03:44,959
for me i actually didn't go to college

106
00:03:48,949 --> 00:03:45,760
until i was

107
00:03:51,270 --> 00:03:48,959
almost 30 years old which

108
00:03:52,869 --> 00:03:51,280
you know i'm not telling any students

109
00:03:55,350 --> 00:03:52,879
out there that this is licensed for you

110
00:03:56,710 --> 00:03:55,360
to quit school and go off and

111
00:03:58,710 --> 00:03:56,720
enjoy other pursuits i don't want to get

112
00:04:00,630 --> 00:03:58,720
angry letters from your parents

113
00:04:02,229 --> 00:04:00,640

um but you know i just had other things

114
00:04:03,910 --> 00:04:02,239
other pursuits that i was interested in

115
00:04:06,470 --> 00:04:03,920
when i was a young adult

116
00:04:07,270 --> 00:04:06,480
and when i think about my interest in

117
00:04:10,149 --> 00:04:07,280
science

118
00:04:11,190 --> 00:04:10,159
it didn't necessarily come from school

119
00:04:14,309 --> 00:04:11,200
it came from just

120
00:04:14,789 --> 00:04:14,319
observing nature and i lived in the

121
00:04:17,590 --> 00:04:14,799
woods

122
00:04:18,390 --> 00:04:17,600
growing up and my parents were always

123
00:04:20,629 --> 00:04:18,400
they didn't have

124
00:04:22,310 --> 00:04:20,639
answers for me a lot of times but they

125
00:04:25,030 --> 00:04:22,320
would take me to the library

126
00:04:25,749 --> 00:04:25,040
and so if i found a weird thing on a

127
00:04:27,030 --> 00:04:25,759
stick

128
00:04:29,909 --> 00:04:27,040
they would take me to the library and i

129
00:04:31,830 --> 00:04:29,919
find out it's an insect egg case and

130
00:04:33,110 --> 00:04:31,840
you know what's that strange hole let's

131
00:04:34,950 --> 00:04:33,120
dig down there and see what

132
00:04:36,790 --> 00:04:34,960
horrible you know snake we just

133
00:04:39,350 --> 00:04:36,800
unearthed and things like that

134
00:04:39,990 --> 00:04:39,360
so for me science and a science origin

135
00:04:42,790 --> 00:04:40,000
story

136
00:04:43,670 --> 00:04:42,800
is really embedded in the observation of

137
00:04:45,430 --> 00:04:43,680
nature

138
00:04:47,110 --> 00:04:45,440

and i like to tell people that because

139
00:04:49,670 --> 00:04:47,120
everybody can do that

140
00:04:50,870 --> 00:04:49,680
maybe you don't have access to a great

141
00:04:53,189 --> 00:04:50,880
chemistry library

142
00:04:54,390 --> 00:04:53,199
or a laboratory in your high school or

143
00:04:56,710 --> 00:04:54,400
wherever you might be at

144
00:04:58,070 --> 00:04:56,720
but you can observe nature and even if

145
00:04:59,590 --> 00:04:58,080
you live in a city

146
00:05:01,270 --> 00:04:59,600
there's nature all around you it's

147
00:05:03,189 --> 00:05:01,280
creeping up out of the cracks in the

148
00:05:04,150 --> 00:05:03,199
pavement it's living on the bricks of

149
00:05:05,830 --> 00:05:04,160
your house

150
00:05:08,230 --> 00:05:05,840
and if you look close enough you'll find

151
00:05:09,110 --> 00:05:08,240
life everywhere and you'll find nature

152
00:05:11,430 --> 00:05:09,120
there

153
00:05:13,270 --> 00:05:11,440
and and it thinks of us as its habitat

154
00:05:15,189 --> 00:05:13,280
and its pursuit as well

155
00:05:16,790 --> 00:05:15,199
and so so that's how i think of my

156
00:05:20,150 --> 00:05:16,800
origin story is just

157
00:05:21,029 --> 00:05:20,160
looking around the world and um and then

158
00:05:23,590 --> 00:05:21,039
eventually

159
00:05:25,350 --> 00:05:23,600
i formalized that by going to college a

160
00:05:26,469 --> 00:05:25,360
little bit later than a lot of people

161
00:05:28,310 --> 00:05:26,479
would have

162
00:05:30,070 --> 00:05:28,320
i love that so much and like i have a

163
00:05:31,590 --> 00:05:30,080

young child at home right now and i

164
00:05:32,950 --> 00:05:31,600
watch him when he just like interacts

165
00:05:33,830 --> 00:05:32,960
with the world and i see that that

166
00:05:35,990 --> 00:05:33,840
curious

167
00:05:38,629 --> 00:05:36,000
scientist nature you know as mary voitek

168
00:05:39,830 --> 00:05:38,639
says everyone is an astro biologist when

169
00:05:41,430 --> 00:05:39,840
it comes down to it

170
00:05:43,189 --> 00:05:41,440
uh and so i love that you know it's the

171
00:05:44,230 --> 00:05:43,199
curiosity that drives you and i

172
00:05:45,189 --> 00:05:44,240
appreciate that

173
00:05:46,870 --> 00:05:45,199
you know you have this slightly

174
00:05:48,310 --> 00:05:46,880
different story from from some who went

175
00:05:49,590 --> 00:05:48,320
straight into college and then straight

176
00:05:50,710 --> 00:05:49,600
to graduate school and

177
00:05:52,870 --> 00:05:50,720
and kind of you know did all those

178
00:05:53,430 --> 00:05:52,880
things right away in that usual pathway

179
00:05:56,710 --> 00:05:53,440
there

180
00:05:57,830 --> 00:05:56,720
and many of us have taken some

181
00:06:00,710 --> 00:05:57,840
non-traditional

182
00:06:02,629 --> 00:06:00,720
trajectories along the way uh so what

183
00:06:04,230 --> 00:06:02,639
was it about organic geochemistry that

184
00:06:06,790 --> 00:06:04,240
that really drove you in that direction

185
00:06:08,790 --> 00:06:06,800
for earning your phd in that field

186
00:06:10,710 --> 00:06:08,800
yeah so that's kind of funny because

187
00:06:12,629 --> 00:06:10,720
when i first started out in college i

188
00:06:14,870 --> 00:06:12,639

actually went to community college

189
00:06:15,749 --> 00:06:14,880
and um i actually went to a community

190
00:06:19,909 --> 00:06:15,759
college for about

191
00:06:20,550 --> 00:06:19,919
five years and part of that was because

192
00:06:23,749 --> 00:06:20,560
i just

193
00:06:26,230 --> 00:06:23,759
couldn't decide what i wanted to study

194
00:06:28,550 --> 00:06:26,240
and um at the end of five years i'd

195
00:06:30,870 --> 00:06:28,560
taken literally every science class that

196
00:06:32,550 --> 00:06:30,880
was offered at santa monica college

197
00:06:34,150 --> 00:06:32,560
and my chemistry professor i loved

198
00:06:35,430 --> 00:06:34,160
chemistry and everything always came

199
00:06:37,430 --> 00:06:35,440
back to chemistry for me

200
00:06:38,870 --> 00:06:37,440
if i was taking a biology class i wanted

201
00:06:39,830 --> 00:06:38,880
to relate it to chemistry if i was

202
00:06:42,150 --> 00:06:39,840
taking physics

203
00:06:43,270 --> 00:06:42,160
i wanted to understand the physics of

204
00:06:44,950 --> 00:06:43,280
those molecules

205
00:06:47,189 --> 00:06:44,960
and finally my organic chemistry

206
00:06:47,990 --> 00:06:47,199
professor dr jamie anderson sat me down

207
00:06:50,150 --> 00:06:48,000
and was like

208
00:06:51,589 --> 00:06:50,160
we have no more classes for you to take

209
00:06:53,029 --> 00:06:51,599
you're gonna have to leave

210
00:06:55,350 --> 00:06:53,039
you're gonna have to be a big girl and

211
00:06:57,110 --> 00:06:55,360
go to another college i was like no

212
00:06:58,950 --> 00:06:57,120
i've literally taken everything even

213
00:07:01,430 --> 00:06:58,960

field ornithology

214
00:07:02,710 --> 00:07:01,440
and i think that i look back on that as

215
00:07:06,230 --> 00:07:02,720
being so

216
00:07:06,790 --> 00:07:06,240
um pivotal and uh foundational for what

217
00:07:09,350 --> 00:07:06,800
i do

218
00:07:11,749 --> 00:07:09,360
now because i have this breadth of

219
00:07:14,710 --> 00:07:11,759
knowledge that i was able to kind of

220
00:07:16,870 --> 00:07:14,720
have the time to synthesize into a grand

221
00:07:18,550 --> 00:07:16,880
vision of how nature

222
00:07:20,309 --> 00:07:18,560
and when i say nature i don't just mean

223
00:07:22,390 --> 00:07:20,319
life i mean everything around us the

224
00:07:23,430 --> 00:07:22,400
universe is nature how that all works

225
00:07:26,469 --> 00:07:23,440
together

226
00:07:29,270 --> 00:07:26,479
and so when i went to a four-year school

227
00:07:29,990 --> 00:07:29,280
occidental college i did want to focus

228
00:07:32,469 --> 00:07:30,000
on chemistry

229
00:07:34,950 --> 00:07:32,479
because for me it was the language that

230
00:07:37,909 --> 00:07:34,960
all of nature was using to communicate

231
00:07:40,150 --> 00:07:37,919
with the rest of nature and then when i

232
00:07:43,029 --> 00:07:40,160
started looking at going to grad school

233
00:07:45,029 --> 00:07:43,039
it was really interesting because i um i

234
00:07:47,270 --> 00:07:45,039
wanted to learn more about evolution and

235
00:07:49,350 --> 00:07:47,280
the history of life in deep time

236
00:07:51,270 --> 00:07:49,360
and so i started looking at grad school

237
00:07:53,830 --> 00:07:51,280
and i thought i would probably

238
00:07:55,990 --> 00:07:53,840

study biology or study you know go to

239
00:07:58,550 --> 00:07:56,000
botany or something like that

240
00:08:01,189 --> 00:07:58,560
and everywhere that i looked was very

241
00:08:03,350 --> 00:08:01,199
contemporary and focused on

242
00:08:05,350 --> 00:08:03,360
um scales of evolution that we can

243
00:08:06,469 --> 00:08:05,360
understand by looking at contemporary

244
00:08:08,469 --> 00:08:06,479
modern life

245
00:08:09,909 --> 00:08:08,479
and one of my professors was like you

246
00:08:11,749 --> 00:08:09,919
know i think you're going to have to

247
00:08:14,230 --> 00:08:11,759
study geology

248
00:08:16,710 --> 00:08:14,240
and i was like no that's rocks i do

249
00:08:18,309 --> 00:08:16,720
molecules

250
00:08:20,469 --> 00:08:18,319
and that's how i learned about this idea

251
00:08:22,869 --> 00:08:20,479
of organic geochemistry and for those of

252
00:08:25,830 --> 00:08:22,879
you who don't know that's just the study

253
00:08:26,790 --> 00:08:25,840
of organic molecules that are preserved

254
00:08:29,189 --> 00:08:26,800
in the geologic

255
00:08:31,110 --> 00:08:29,199
record so all of these biosignatures

256
00:08:33,190 --> 00:08:31,120
that are falling off of us and

257
00:08:35,430 --> 00:08:33,200
and every other creature and slowly

258
00:08:37,350 --> 00:08:35,440
getting incorporated into rocks

259
00:08:38,550 --> 00:08:37,360
part of grad school was for me learning

260
00:08:40,790 --> 00:08:38,560
how to dig that back

261
00:08:43,190 --> 00:08:40,800
up out of the ground and learn from what

262
00:08:46,310 --> 00:08:43,200
those chemicals have now become

263
00:08:47,269 --> 00:08:46,320

um what life was like in the past that's

264
00:08:49,750 --> 00:08:47,279
so groovy and

265
00:08:50,790 --> 00:08:49,760
as soon as you said like rocks no i i do

266
00:08:51,910 --> 00:08:50,800
i do molecules

267
00:08:53,829 --> 00:08:51,920
the first thing that hit my mind is

268
00:08:54,550 --> 00:08:53,839
organic geochemistry is molecules and

269
00:08:57,430 --> 00:08:54,560
rocks right

270
00:08:59,269 --> 00:08:57,440
so um that's really cool you know you've

271
00:09:00,230 --> 00:08:59,279
had so many experiences along the way

272
00:09:01,910 --> 00:09:00,240
you've been involved in science

273
00:09:02,870 --> 00:09:01,920
communication and so many areas of

274
00:09:04,630 --> 00:09:02,880
research

275
00:09:07,190 --> 00:09:04,640
and you also have some really cool

276
00:09:09,509 --> 00:09:07,200
tattoos that we chose to add

277
00:09:11,670 --> 00:09:09,519
our twitter audience about online

278
00:09:14,470 --> 00:09:11,680
through nasa astrobiology

279
00:09:15,110 --> 00:09:14,480
um there they are uh and so we asked

280
00:09:17,430 --> 00:09:15,120
everyone

281
00:09:18,550 --> 00:09:17,440
what do you think these tattoos are

282
00:09:21,829 --> 00:09:18,560
showing

283
00:09:23,910 --> 00:09:21,839
uh and so we had a winner who didn't

284
00:09:24,630 --> 00:09:23,920
quite get it exactly right but very very

285
00:09:27,750 --> 00:09:24,640
close

286
00:09:29,509 --> 00:09:27,760
uh brian halligan user at brian halligan

287
00:09:31,350 --> 00:09:29,519
said it was sub-atomic particle tracks

288
00:09:32,550 --> 00:09:31,360

from a super collider or was it the

289
00:09:34,790 --> 00:09:32,560
higgs discovery

290
00:09:36,070 --> 00:09:34,800
and so i i think brian threw out one or

291
00:09:37,829 --> 00:09:36,080
the other maybe

292
00:09:39,910 --> 00:09:37,839
um but i'd love for you to share the

293
00:09:40,630 --> 00:09:39,920
story of your tattoos and the science

294
00:09:41,990 --> 00:09:40,640
behind them

295
00:09:45,509 --> 00:09:42,000
and then why you got them in the first

296
00:09:46,790 --> 00:09:45,519
place yeah so a lot of my phd work was

297
00:09:49,829 --> 00:09:46,800
actually studying

298
00:09:52,630 --> 00:09:49,839
light and the effect of light on

299
00:09:53,990 --> 00:09:52,640
ecology and plants in particular what i

300
00:09:57,990 --> 00:09:54,000
really was interested in

301
00:10:01,910 --> 00:09:58,000
is when did plants develop the ability

302
00:10:04,470 --> 00:10:01,920
to live in energy limited situations

303
00:10:06,150 --> 00:10:04,480
so if we think about deep dark forests

304
00:10:07,990 --> 00:10:06,160
of the tropics now

305
00:10:09,750 --> 00:10:08,000
um there's all of these plants that are

306
00:10:11,829 --> 00:10:09,760
purposefully living where there's no

307
00:10:14,150 --> 00:10:11,839
energy the sun is their energy

308
00:10:16,069 --> 00:10:14,160
and they're competing at another level

309
00:10:18,870 --> 00:10:16,079
down in the bottom of those forests

310
00:10:19,990 --> 00:10:18,880
but that's not how plants always worked

311
00:10:23,110 --> 00:10:20,000
in the deep past

312
00:10:25,670 --> 00:10:23,120
plants didn't have all of those layers

313
00:10:26,550 --> 00:10:25,680

and i was curious when did plants learn

314
00:10:31,269 --> 00:10:26,560
to do that and

315
00:10:33,430 --> 00:10:31,279
why was it so um late in their evolution

316
00:10:35,750 --> 00:10:33,440
and it's around the time of the kt

317
00:10:38,550 --> 00:10:35,760
extinction that plants developed that

318
00:10:39,670 --> 00:10:38,560
technology to live in energy limited

319
00:10:41,829 --> 00:10:39,680
situations so

320
00:10:44,310 --> 00:10:41,839
so much of my thinking was about this

321
00:10:46,870 --> 00:10:44,320
interaction between light and life

322
00:10:48,949 --> 00:10:46,880
and energy in life and so i told myself

323
00:10:49,269 --> 00:10:48,959
when i was in grad school okay my reward

324
00:10:50,790 --> 00:10:49,279
for

325
00:10:54,150 --> 00:10:50,800
working this hard is i'm going to get a

326
00:10:56,310 --> 00:10:54,160
cool tattoo to celebrate my phd

327
00:10:58,069 --> 00:10:56,320
and then like with many people when you

328
00:11:01,110 --> 00:10:58,079
get done writing your dissertation

329
00:11:03,750 --> 00:11:01,120
you don't particularly want to uh

330
00:11:04,790 --> 00:11:03,760
memorialize it that way anymore because

331
00:11:08,150 --> 00:11:04,800
it just represents

332
00:11:09,190 --> 00:11:08,160
a lot of work so i was i'd but i'd

333
00:11:12,550 --> 00:11:09,200
learned so much about

334
00:11:14,630 --> 00:11:12,560
other forms of light and if you read the

335
00:11:15,590 --> 00:11:14,640
information about this experiment you're

336
00:11:17,829 --> 00:11:15,600
right brian

337
00:11:19,670 --> 00:11:17,839
this is a particle collision experiment

338
00:11:22,310 --> 00:11:19,680

that was done in a bubble chamber

339
00:11:23,910 --> 00:11:22,320
at cern at the large hadron collider it

340
00:11:26,550 --> 00:11:23,920
was called the ua5

341
00:11:28,550 --> 00:11:26,560
experiment and it was done in the 90s

342
00:11:31,430 --> 00:11:28,560
and they were trying to

343
00:11:33,829 --> 00:11:31,440
crash together particles to make a

344
00:11:36,310 --> 00:11:33,839
particular kind of particle called the w

345
00:11:38,550 --> 00:11:36,320
particle and what's really enticing and

346
00:11:39,829 --> 00:11:38,560
interesting about the w particle and how

347
00:11:43,350 --> 00:11:39,839
i got to it

348
00:11:45,590 --> 00:11:43,360
through botany and organic geochemistry

349
00:11:47,190 --> 00:11:45,600
is that this is a particle that we think

350
00:11:48,389 --> 00:11:47,200
might actually be something like a

351
00:11:51,590 --> 00:11:48,399
photon that had

352
00:11:53,030 --> 00:11:51,600
mass and being an astrobiologist you're

353
00:11:55,350 --> 00:11:53,040
constantly imagining

354
00:11:57,190 --> 00:11:55,360
what is it like on other worlds what

355
00:11:59,190 --> 00:11:57,200
would it be like to be

356
00:12:00,710 --> 00:11:59,200
you know a living organism on another

357
00:12:01,190 --> 00:12:00,720
world what would you have to contend

358
00:12:03,590 --> 00:12:01,200
with

359
00:12:04,230 --> 00:12:03,600
and that just blew my mind to think what

360
00:12:07,110 --> 00:12:04,240
if your

361
00:12:07,910 --> 00:12:07,120
star was pelting photons at you that

362
00:12:11,110 --> 00:12:07,920
actually had

363
00:12:11,430 --> 00:12:11,120

mass and it really made me rethink kind

364
00:12:14,389 --> 00:12:11,440
of

365
00:12:16,470 --> 00:12:14,399
how i think about photons from our sun

366
00:12:19,190 --> 00:12:16,480
and how glorious it is that they're not

367
00:12:19,990 --> 00:12:19,200
hitting me with any sort of mass that's

368
00:12:22,790 --> 00:12:20,000
you know

369
00:12:23,110 --> 00:12:22,800
perceptible so it just really blew away

370
00:12:26,550 --> 00:12:23,120
my

371
00:12:28,710 --> 00:12:26,560
and at the end of your

372
00:12:29,910 --> 00:12:28,720
dissertation when you're so tired to

373
00:12:32,629 --> 00:12:29,920
find a cool new

374
00:12:34,069 --> 00:12:32,639
angle on it is really wonderful so i

375
00:12:35,030 --> 00:12:34,079
decided yeah that's what i'm going to

376
00:12:36,710 --> 00:12:35,040
commemorate

377
00:12:39,269 --> 00:12:36,720
and it just means i have lots of

378
00:12:42,710 --> 00:12:39,279
conversations about particle physics at

379
00:12:44,310 --> 00:12:42,720
gas stations and in the grocery store

380
00:12:46,069 --> 00:12:44,320
and then people will be like oh so

381
00:12:49,670 --> 00:12:46,079
you're a physicist and i'll say

382
00:12:51,350 --> 00:12:49,680
no i'm an organic geochemist

383
00:12:53,509 --> 00:12:51,360
i love that crossover though yeah i have

384
00:12:55,190 --> 00:12:53,519
a tattoo for the second net logo

385
00:12:56,470 --> 00:12:55,200
um which those who are watching on sega

386
00:12:57,990 --> 00:12:56,480
net can just look up to the top of their

387
00:13:00,069 --> 00:12:58,000
screen and see that low notes

388
00:13:02,310 --> 00:13:00,079

on my forearm and it leads to lots of

389
00:13:02,710 --> 00:13:02,320
cool conversations about astrobiology

390
00:13:07,509 --> 00:13:02,720
and

391
00:13:09,910 --> 00:13:07,519
it's fun to try to add that kind of

392
00:13:12,550 --> 00:13:09,920
science inc to ourselves as carl zimmer

393
00:13:13,670 --> 00:13:12,560
uh once called it um so after after your

394
00:13:15,190 --> 00:13:13,680
phd then

395
00:13:16,790 --> 00:13:15,200
uh you got more involved in doing

396
00:13:19,030 --> 00:13:16,800
research and lots of kinds of realms

397
00:13:19,670 --> 00:13:19,040
organic chemistry leading you to working

398
00:13:22,150 --> 00:13:19,680
now

399
00:13:24,310 --> 00:13:22,160
at nasa goddard i understand you've been

400
00:13:26,470 --> 00:13:24,320
involved now in sample return missions

401
00:13:28,310 --> 00:13:26,480
uh with o-rex as well as for the

402
00:13:29,670 --> 00:13:28,320
upcoming mars sample return

403
00:13:31,990 --> 00:13:29,680
i wonder if you could speak to our

404
00:13:32,870 --> 00:13:32,000
audience about why sample return is so

405
00:13:35,030 --> 00:13:32,880
important

406
00:13:35,910 --> 00:13:35,040
especially for an organic geochemist

407
00:13:37,590 --> 00:13:35,920
yeah

408
00:13:40,389 --> 00:13:37,600
you know there's this funny idea that we

409
00:13:43,189 --> 00:13:40,399
have about like oh we gotta send rovers

410
00:13:44,710 --> 00:13:43,199
and orbiters and landers and things like

411
00:13:47,509 --> 00:13:44,720
this but if you actually

412
00:13:48,310 --> 00:13:47,519
look at what we've done a lot of really

413
00:13:51,670 --> 00:13:48,320

well

414
00:13:52,629 --> 00:13:51,680
as space scientists worldwide is sample

415
00:13:54,629 --> 00:13:52,639
return

416
00:13:56,150 --> 00:13:54,639
um the many things that we've brought

417
00:13:59,269 --> 00:13:56,160
back from the moon

418
00:14:02,790 --> 00:13:59,279
um we've had multiple comet and

419
00:14:04,710 --> 00:14:02,800
an asteroid you know or solar particles

420
00:14:06,230 --> 00:14:04,720
you know small bodies that we've brought

421
00:14:08,470 --> 00:14:06,240
back chunks of

422
00:14:09,750 --> 00:14:08,480
and so it's actually something we do

423
00:14:12,870 --> 00:14:09,760
really well

424
00:14:15,269 --> 00:14:12,880
um there's a scientist at um ames

425
00:14:17,829 --> 00:14:15,279
research center scott sanford

426
00:14:19,670 --> 00:14:17,839
who did a talk for the university of

427
00:14:20,310 --> 00:14:19,680
florida you can find it online if you're

428
00:14:21,990 --> 00:14:20,320
interested

429
00:14:24,710 --> 00:14:22,000
and he has this wonderful graph that he

430
00:14:27,110 --> 00:14:24,720
showed from a paper by queenie chan

431
00:14:28,949 --> 00:14:27,120
of all of the times we've actually gone

432
00:14:30,310 --> 00:14:28,959
out left our planet and brought

433
00:14:31,750 --> 00:14:30,320
something back so it's something we

434
00:14:34,230 --> 00:14:31,760
actually do good

435
00:14:36,389 --> 00:14:34,240
and i'm really interested in it because

436
00:14:38,790 --> 00:14:36,399
you know no matter how

437
00:14:40,470 --> 00:14:38,800
great we get at rovers and instruments

438
00:14:43,430 --> 00:14:40,480

that we put on spaceships

439
00:14:44,470 --> 00:14:43,440
there's honestly nothing quite as as

440
00:14:46,310 --> 00:14:44,480
great as

441
00:14:47,910 --> 00:14:46,320
the instruments i have just down the

442
00:14:48,870 --> 00:14:47,920
hall from me here at goddard space

443
00:14:52,310 --> 00:14:48,880
flight center

444
00:14:54,310 --> 00:14:52,320
we we have so much more um sensitivity

445
00:14:56,629 --> 00:14:54,320
and resolution and we can actually

446
00:14:57,110 --> 00:14:56,639
manipulate samples so much better and

447
00:14:59,350 --> 00:14:57,120
actually

448
00:15:01,670 --> 00:14:59,360
prepare them in a way that we haven't

449
00:15:03,670 --> 00:15:01,680
been able to develop technology for yet

450
00:15:05,110 --> 00:15:03,680
that there's just really no substitute

451
00:15:07,030 --> 00:15:05,120
for it quite yet

452
00:15:08,310 --> 00:15:07,040
and so i'm really enthusiastic about

453
00:15:10,310 --> 00:15:08,320
sample return

454
00:15:12,310 --> 00:15:10,320
and i also want to kind of make a

455
00:15:15,030 --> 00:15:12,320
connection between these two

456
00:15:15,509 --> 00:15:15,040
um sample return efforts that i'm part

457
00:15:18,310 --> 00:15:15,519
of

458
00:15:20,470 --> 00:15:18,320
to get people thinking about other uh

459
00:15:22,629 --> 00:15:20,480
solar system bodies that they might not

460
00:15:24,949 --> 00:15:22,639
i find a lot of people focus on planets

461
00:15:27,189 --> 00:15:24,959
like mars and mars sample return

462
00:15:28,470 --> 00:15:27,199
because mars we can imagine being

463
00:15:31,829 --> 00:15:28,480

earth-like

464
00:15:32,870 --> 00:15:31,839
um and having life but planets are

465
00:15:35,910 --> 00:15:32,880
really born as

466
00:15:39,189 --> 00:15:35,920
as the kind of objects that osiris-rex

467
00:15:41,269 --> 00:15:39,199
is um investigating the asteroid bennu

468
00:15:43,110 --> 00:15:41,279
and that's the birthplace of so many of

469
00:15:44,949 --> 00:15:43,120
these organic chemicals that we think

470
00:15:46,790 --> 00:15:44,959
were part of early life

471
00:15:48,230 --> 00:15:46,800
so if you ever want to really understand

472
00:15:50,629 --> 00:15:48,240
the origin of life

473
00:15:51,990 --> 00:15:50,639
or actually agnostic bias signatures

474
00:15:54,470 --> 00:15:52,000
where we're trying to

475
00:15:56,629 --> 00:15:54,480
really think broadly about life you have

476
00:15:58,790 --> 00:15:56,639
to be able to understand that primordial

477
00:16:00,870 --> 00:15:58,800
material that's in those asteroids

478
00:16:02,870 --> 00:16:00,880
so those are there those are two really

479
00:16:05,269 --> 00:16:02,880
important kind of bookends for

480
00:16:06,550 --> 00:16:05,279
understanding astrobiology you know

481
00:16:07,430 --> 00:16:06,560
that's that's really great and it really

482
00:16:09,110 --> 00:16:07,440
leads me to

483
00:16:10,550 --> 00:16:09,120
the next topic i want to discuss but but

484
00:16:11,590 --> 00:16:10,560
first i do want to say scott sanford has

485
00:16:13,509 --> 00:16:11,600
been on our show

486
00:16:15,189 --> 00:16:13,519
yeah or a previous episode when we

487
00:16:16,790 --> 00:16:15,199
talked about osiris-rex

488
00:16:18,069 --> 00:16:16,800

uh i wish i'd seen that graphic i

489
00:16:19,749 --> 00:16:18,079
haven't seen it i had to go and hunt

490
00:16:21,189 --> 00:16:19,759
down myself all of the different

491
00:16:22,710 --> 00:16:21,199
sample returns that we've done so i

492
00:16:24,150 --> 00:16:22,720
would love to find that graphic and

493
00:16:25,509 --> 00:16:24,160
share it with our audience on twitter

494
00:16:27,829 --> 00:16:25,519
and elsewhere

495
00:16:29,030 --> 00:16:27,839
oh absolutely yeah i love this idea too

496
00:16:30,949 --> 00:16:29,040
like bennu and some of these other

497
00:16:32,949 --> 00:16:30,959
bodies how important it is for us to

498
00:16:34,710 --> 00:16:32,959
understand you know the primordial

499
00:16:36,389 --> 00:16:34,720
populations of these these

500
00:16:38,310 --> 00:16:36,399
bodies that formed the planets of our

501
00:16:40,470 --> 00:16:38,320
solar system and where some of our

502
00:16:41,990 --> 00:16:40,480
organic chemistry started in the solar

503
00:16:42,949 --> 00:16:42,000
system in cometary and asteroid

504
00:16:44,310 --> 00:16:42,959
materials and

505
00:16:46,150 --> 00:16:44,320
and also with sample return as a

506
00:16:48,150 --> 00:16:46,160
geochemist myself and i was earning my

507
00:16:50,790 --> 00:16:48,160
phd i did a lot of synchrotron

508
00:16:52,790 --> 00:16:50,800
uh based work so x-ray x-ray absorption

509
00:16:54,389 --> 00:16:52,800
and these large particle accelerators

510
00:16:56,470 --> 00:16:54,399
which you can't carry you know this

511
00:16:58,069 --> 00:16:56,480
massive you know trillions of tons of

512
00:16:59,990 --> 00:16:58,079
particle accelerator you know across

513
00:17:01,350 --> 00:17:00,000

across the solar system to mars

514
00:17:02,790 --> 00:17:01,360
but those samples when they come back

515
00:17:05,029 --> 00:17:02,800
there are supposed to be using those

516
00:17:06,630 --> 00:17:05,039
kinds of high-resolution techniques to

517
00:17:08,390 --> 00:17:06,640
really interrogate those samples which

518
00:17:10,390 --> 00:17:08,400
are super exciting

519
00:17:11,990 --> 00:17:10,400
but you also then transitioned us into

520
00:17:15,510 --> 00:17:12,000
our next topic which is

521
00:17:17,189 --> 00:17:15,520
agnostic biosignatures and honestly i've

522
00:17:18,870 --> 00:17:17,199
i've been talking about them now more in

523
00:17:19,909 --> 00:17:18,880
my my own conversations with people

524
00:17:21,909 --> 00:17:19,919
online

525
00:17:23,029 --> 00:17:21,919
and i even know some astrobiologists who

526
00:17:25,029 --> 00:17:23,039
are still a little

527
00:17:26,230 --> 00:17:25,039
maybe fuzzy about what an agnostic

528
00:17:28,150 --> 00:17:26,240
biosignature

529
00:17:29,590 --> 00:17:28,160
is maybe they're agnostic and they're

530
00:17:30,870 --> 00:17:29,600
thinking towards where an agnostic

531
00:17:32,470 --> 00:17:30,880
biosignature is

532
00:17:34,870 --> 00:17:32,480
i wonder for our audience if you could

533
00:17:36,470 --> 00:17:34,880
explain what are agnostic biosignatures

534
00:17:39,190 --> 00:17:36,480
and why is this kind of becoming

535
00:17:39,669 --> 00:17:39,200
a new realm of thinking in astrobiology

536
00:17:41,750 --> 00:17:39,679
yeah

537
00:17:43,029 --> 00:17:41,760
i you know i i feel like agnostic

538
00:17:45,350 --> 00:17:43,039

biosignatures

539
00:17:46,230 --> 00:17:45,360
first people kind of have to struggle

540
00:17:49,110 --> 00:17:46,240
through whatever

541
00:17:50,470 --> 00:17:49,120
their definition of agnostic is before

542
00:17:51,830 --> 00:17:50,480
they can even get to the word

543
00:17:53,830 --> 00:17:51,840
biosignature

544
00:17:54,950 --> 00:17:53,840
and decide how they think those two

545
00:17:57,029 --> 00:17:54,960
things relate

546
00:17:59,029 --> 00:17:57,039
but when we say agnostic biosignature

547
00:18:02,549 --> 00:17:59,039
what we're really trying to say

548
00:18:04,150 --> 00:18:02,559
is a biosignature a piece of evidence of

549
00:18:07,510 --> 00:18:04,160
past or present life

550
00:18:09,190 --> 00:18:07,520
that doesn't rely on any similar analogy

551
00:18:11,909 --> 00:18:09,200
to life on earth

552
00:18:13,510 --> 00:18:11,919
um and you know when i first say that

553
00:18:15,190 --> 00:18:13,520
most people are like are you talking

554
00:18:18,310 --> 00:18:15,200
about silicon-based life

555
00:18:21,270 --> 00:18:18,320
and it's not even about that it's about

556
00:18:23,350 --> 00:18:21,280
understanding what is the most basic

557
00:18:27,190 --> 00:18:23,360
general features of life

558
00:18:29,590 --> 00:18:27,200
that you can define and putting together

559
00:18:31,110 --> 00:18:29,600
a search pattern based on that for a

560
00:18:34,150 --> 00:18:31,120
biosignature

561
00:18:36,789 --> 00:18:34,160
um when we think about life you know go

562
00:18:38,630 --> 00:18:36,799
even deeper go even farther than silicon

563
00:18:39,350 --> 00:18:38,640

or carbon or things like that what is

564
00:18:42,390 --> 00:18:39,360
the major

565
00:18:45,909 --> 00:18:42,400
thing that life is really doing life is

566
00:18:48,510 --> 00:18:45,919
harnessing energy and um

567
00:18:51,110 --> 00:18:48,520
creating a state that is in

568
00:18:53,990 --> 00:18:51,120
disequilibrium with its environment

569
00:18:54,870 --> 00:18:54,000
my body your body right now all of life

570
00:18:57,029 --> 00:18:54,880
around us is in

571
00:18:58,549 --> 00:18:57,039
disequilibrium with its environment it's

572
00:19:01,190 --> 00:18:58,559
taking an energy

573
00:19:01,990 --> 00:19:01,200
and and uh creating a chemical

574
00:19:03,590 --> 00:19:02,000
environment

575
00:19:05,190 --> 00:19:03,600
that is different than we would be that

576
00:19:06,070 --> 00:19:05,200
if we weren't life where we're just

577
00:19:09,110 --> 00:19:06,080
basically gonna

578
00:19:11,990 --> 00:19:09,120
you know go back into dust and um

579
00:19:13,909 --> 00:19:12,000
so thinking about it as an energy state

580
00:19:14,950 --> 00:19:13,919
might help people feel a little bit more

581
00:19:17,750 --> 00:19:14,960
comfortable

582
00:19:19,350 --> 00:19:17,760
with the idea of agnostic biosignatures

583
00:19:20,630 --> 00:19:19,360
so when we're looking for agnostic

584
00:19:23,190 --> 00:19:20,640
biosignatures

585
00:19:24,390 --> 00:19:23,200
um we're not necessarily looking for you

586
00:19:26,310 --> 00:19:24,400
know a microbe or

587
00:19:28,390 --> 00:19:26,320
or some sort of creature like that we're

588
00:19:31,830 --> 00:19:28,400

looking for evidence

589
00:19:33,750 --> 00:19:31,840
of a perturbation to

590
00:19:35,430 --> 00:19:33,760
an energy environment or to physics

591
00:19:37,909 --> 00:19:35,440
something that tells us that there was

592
00:19:38,630 --> 00:19:37,919
extra energy in this environment that

593
00:19:42,549 --> 00:19:38,640
made this

594
00:19:45,430 --> 00:19:42,559
physical or chemical manifestation of

595
00:19:47,590 --> 00:19:45,440
past or present life so that's the most

596
00:19:49,590 --> 00:19:47,600
general definition i could give i hope

597
00:19:50,150 --> 00:19:49,600
that helps if that's not helpful let me

598
00:19:51,990 --> 00:19:50,160
know

599
00:19:53,190 --> 00:19:52,000
i hope so yeah and i've heard you

600
00:19:54,710 --> 00:19:53,200
mentioned before that this is more about

601
00:19:56,310 --> 00:19:54,720
being like a physics detector more than

602
00:19:57,590 --> 00:19:56,320
being like a life detector

603
00:19:59,270 --> 00:19:57,600
for what we're doing right now in the

604
00:20:00,470 --> 00:19:59,280
solar system and even here on earth for

605
00:20:01,909 --> 00:20:00,480
understanding life

606
00:20:03,750 --> 00:20:01,919
here on earth i mean there could be some

607
00:20:05,110 --> 00:20:03,760
forms of life around us that we don't

608
00:20:06,230 --> 00:20:05,120
even know about here in our own planet

609
00:20:07,990 --> 00:20:06,240
for us to go

610
00:20:10,070 --> 00:20:08,000
explore and so understanding you know

611
00:20:11,750 --> 00:20:10,080
these the energy the information

612
00:20:13,830 --> 00:20:11,760
and how that changes due to life i think

613
00:20:15,590 --> 00:20:13,840

is a very important process

614
00:20:16,950 --> 00:20:15,600
um there's one thing i'd love for you to

615
00:20:18,630 --> 00:20:16,960
explain to our audience that i've heard

616
00:20:20,390 --> 00:20:18,640
about and we mentioned uh before the

617
00:20:21,830 --> 00:20:20,400
show you and i together uh is the

618
00:20:23,270 --> 00:20:21,840
whiskey analogy

619
00:20:25,270 --> 00:20:23,280
that's been brought up in the agnostic

620
00:20:26,470 --> 00:20:25,280
biosignature realm uh i'd

621
00:20:28,149 --> 00:20:26,480
love it if you could share that with our

622
00:20:30,310 --> 00:20:28,159
audience since i imagine they'll enjoy

623
00:20:33,510 --> 00:20:30,320
uh understanding it through that analogy

624
00:20:35,430 --> 00:20:33,520
oh yeah this is a this was actually

625
00:20:37,430 --> 00:20:35,440
um refers to some samples that we

626
00:20:38,390 --> 00:20:37,440
actually analyze because whiskey is this

627
00:20:41,029 --> 00:20:38,400
amazing

628
00:20:42,230 --> 00:20:41,039
pastiche of a bunch of biological

629
00:20:44,950 --> 00:20:42,240
activity

630
00:20:46,710 --> 00:20:44,960
and um you can think of the fact that

631
00:20:48,750 --> 00:20:46,720
it's a whole bunch of

632
00:20:50,230 --> 00:20:48,760
starches that aren't particularly

633
00:20:53,510 --> 00:20:50,240
bioavailable

634
00:20:56,230 --> 00:20:53,520
but were um heated and so there was

635
00:20:57,430 --> 00:20:56,240
this thermal component and then it was

636
00:21:00,230 --> 00:20:57,440
given to a bunch of

637
00:21:00,870 --> 00:21:00,240
organisms and they they worked on it and

638
00:21:03,830 --> 00:21:00,880

they for

639
00:21:04,710 --> 00:21:03,840
they produce fermentation and they um

640
00:21:06,789 --> 00:21:04,720
left behind

641
00:21:08,710 --> 00:21:06,799
in that fluid a bunch of the evidence of

642
00:21:10,149 --> 00:21:08,720
their metabolism the metabolites that

643
00:21:11,270 --> 00:21:10,159
they make as they perform that

644
00:21:13,430 --> 00:21:11,280
fermentation

645
00:21:14,470 --> 00:21:13,440
and then it's distilled it's gone

646
00:21:18,549 --> 00:21:14,480
through this other

647
00:21:21,750 --> 00:21:18,559
thermal and physical separation process

648
00:21:23,510 --> 00:21:21,760
which if you were to imagine any sort of

649
00:21:25,430 --> 00:21:23,520
natural environment where that's

650
00:21:28,149 --> 00:21:25,440
happening that would be challenging like

651
00:21:29,909 --> 00:21:28,159
what's left over after you do that to

652
00:21:30,549 --> 00:21:29,919
any sort of fluid that once contained

653
00:21:34,149 --> 00:21:30,559
life

654
00:21:35,350 --> 00:21:34,159
and then you sink it into a um a cask

655
00:21:38,630 --> 00:21:35,360
that's made of

656
00:21:40,630 --> 00:21:38,640
dead plants dead life and but there's

657
00:21:42,710 --> 00:21:40,640
all of these leftover metabolites in

658
00:21:43,350 --> 00:21:42,720
that wood that are slowly leached into

659
00:21:46,950 --> 00:21:43,360
that

660
00:21:49,430 --> 00:21:46,960
so whiskey has this evidence of

661
00:21:50,870 --> 00:21:49,440
life in terrible turmoil life that went

662
00:21:53,590 --> 00:21:50,880
through a whole bunch of

663
00:21:55,270 --> 00:21:53,600

crazy steps not dissimilar to what

664
00:21:57,990 --> 00:21:55,280
geology might do

665
00:21:59,110 --> 00:21:58,000
to evidence of past life and then

666
00:22:03,750 --> 00:21:59,120
saturated it

667
00:22:06,230 --> 00:22:03,760
into a solution that's exposed to other

668
00:22:06,950 --> 00:22:06,240
molecules that came from life so it's

669
00:22:08,630 --> 00:22:06,960
not

670
00:22:11,270 --> 00:22:08,640
terribly different than how you might

671
00:22:14,070 --> 00:22:11,280
think of life as it's being preserved

672
00:22:16,070 --> 00:22:14,080
in organic you know organic molecules as

673
00:22:18,950 --> 00:22:16,080
they're being preserved in geology

674
00:22:21,190 --> 00:22:18,960
whiskey's just this other slightly more

675
00:22:23,990 --> 00:22:21,200
enjoyable

676
00:22:25,110 --> 00:22:24,000
version of all of those same forcings on

677
00:22:27,190 --> 00:22:25,120
metabolites

678
00:22:28,710 --> 00:22:27,200
and you end up having to analyze it and

679
00:22:30,230 --> 00:22:28,720
backtrack through

680
00:22:32,470 --> 00:22:30,240
because there's nothing in there that's

681
00:22:34,950 --> 00:22:32,480
still living by the time whiskey gets to

682
00:22:35,590 --> 00:22:34,960
your glass or my mass spectrometer it's

683
00:22:37,750 --> 00:22:35,600
dead

684
00:22:39,350 --> 00:22:37,760
but it has all of this evidence of these

685
00:22:42,470 --> 00:22:39,360
past organisms

686
00:22:46,230 --> 00:22:42,480
from microbes to eukaryotes um

687
00:22:47,990 --> 00:22:46,240
still in that reservoir of information

688
00:22:49,669 --> 00:22:48,000

i love it it's the things that biology

689
00:22:50,230 --> 00:22:49,679
has done and then the transformations

690
00:22:53,350 --> 00:22:50,240
through

691
00:22:54,870 --> 00:22:53,360
processes that have occurred

692
00:22:56,470 --> 00:22:54,880
uh and so folks who are watching next

693
00:22:56,950 --> 00:22:56,480
time you enjoy a glass of whiskey maybe

694
00:22:58,789 --> 00:22:56,960
just

695
00:23:01,029 --> 00:22:58,799
hold the glass for a minute and let

696
00:23:02,630 --> 00:23:01,039
yourself think through that process

697
00:23:04,230 --> 00:23:02,640
uh i would love to talk a lot more about

698
00:23:05,350 --> 00:23:04,240
agnostic bio signatures but

699
00:23:06,710 --> 00:23:05,360
i do want to speak about a few more

700
00:23:08,149 --> 00:23:06,720
things with you before we open it up to

701
00:23:10,070 --> 00:23:08,159
the audience q a

702
00:23:11,830 --> 00:23:10,080
for those watching you can ask questions

703
00:23:14,390 --> 00:23:11,840
right now from dr graham

704
00:23:15,830 --> 00:23:14,400
uh in the chats on nasa astrobiology's

705
00:23:17,909 --> 00:23:15,840
facebook page or

706
00:23:19,430 --> 00:23:17,919
on segonlive wherever you happen to be

707
00:23:20,710 --> 00:23:19,440
watching right now

708
00:23:22,870 --> 00:23:20,720
if you're watching the recording on

709
00:23:24,390 --> 00:23:22,880
youtube obviously not live but

710
00:23:25,830 --> 00:23:24,400
many of us do go in and check the

711
00:23:26,710 --> 00:23:25,840
questions there from time to time as

712
00:23:28,310 --> 00:23:26,720
well

713
00:23:30,710 --> 00:23:28,320

um before we transition into the

714
00:23:31,990 --> 00:23:30,720
audience q a i'd like to chat a little

715
00:23:33,909 --> 00:23:32,000
bit about some of the science

716
00:23:36,149 --> 00:23:33,919
communication work that you've done

717
00:23:37,990 --> 00:23:36,159
uh for instance uh i was very fortunate

718
00:23:40,549 --> 00:23:38,000
back in 2016 to

719
00:23:42,470 --> 00:23:40,559
compete in the national final of nasa's

720
00:23:44,230 --> 00:23:42,480
fame lab or fame lab usa

721
00:23:45,990 --> 00:23:44,240
in which you were a judge and you judged

722
00:23:48,470 --> 00:23:46,000
myself and several others

723
00:23:49,430 --> 00:23:48,480
and are speaking uh and you have you

724
00:23:50,870 --> 00:23:49,440
know a great skill

725
00:23:52,870 --> 00:23:50,880
a personality when you come to your

726
00:23:55,269 --> 00:23:52,880
science communication you've been on

727
00:23:57,110 --> 00:23:55,279
nasa's gravity assist podcasts

728
00:23:59,669 --> 00:23:57,120
previously you were on the countdown to

729
00:24:00,950 --> 00:23:59,679
mars features from nasa astrobiology

730
00:24:03,350 --> 00:24:00,960
and you've been doing a lot to share

731
00:24:04,789 --> 00:24:03,360
your science i wonder if you could share

732
00:24:07,909 --> 00:24:04,799
a little bit of your your vision

733
00:24:09,190 --> 00:24:07,919
for why we should share our science

734
00:24:11,510 --> 00:24:09,200
and maybe even you know what really

735
00:24:13,510 --> 00:24:11,520
drives you to share your science

736
00:24:14,710 --> 00:24:13,520
you know that's an interesting question

737
00:24:15,190 --> 00:24:14,720
because i think there's a lot of

738
00:24:17,510 --> 00:24:15,200

different

739
00:24:18,230 --> 00:24:17,520
motivations and audiences that people

740
00:24:20,390 --> 00:24:18,240
think about

741
00:24:21,750 --> 00:24:20,400
when they talk about science

742
00:24:24,789 --> 00:24:21,760
communication

743
00:24:26,390 --> 00:24:24,799
and i'm really reminded of conversations

744
00:24:29,029 --> 00:24:26,400
i had with the director

745
00:24:30,070 --> 00:24:29,039
of the rock opera that you mentioned i

746
00:24:32,149 --> 00:24:30,080
wrote

747
00:24:33,750 --> 00:24:32,159
about some of the early mathematicians

748
00:24:34,630 --> 00:24:33,760
that were part of the apollo space

749
00:24:37,590 --> 00:24:34,640
program

750
00:24:39,110 --> 00:24:37,600
um where she was asking me like what are

751
00:24:40,549 --> 00:24:39,120
you trying to get out of the script do

752
00:24:43,190 --> 00:24:40,559
you want people to leave

753
00:24:44,070 --> 00:24:43,200
understanding math um or are you trying

754
00:24:47,510 --> 00:24:44,080
to inform

755
00:24:49,909 --> 00:24:47,520
more about um the

756
00:24:51,029 --> 00:24:49,919
the players the people in the story like

757
00:24:52,310 --> 00:24:51,039
what do you want

758
00:24:53,990 --> 00:24:52,320
and i think that's a really important

759
00:24:55,830 --> 00:24:54,000
thing to think about when you're doing

760
00:24:57,190 --> 00:24:55,840
science communication do i want people

761
00:24:59,990 --> 00:24:57,200
to leave this

762
00:25:01,190 --> 00:25:00,000
this talk that we're having right now um

763
00:25:03,510 --> 00:25:01,200

understanding

764
00:25:04,549 --> 00:25:03,520
particle physics or do i want them to

765
00:25:07,590 --> 00:25:04,559
understand

766
00:25:08,310 --> 00:25:07,600
more about um how science saturates our

767
00:25:10,149 --> 00:25:08,320
life

768
00:25:11,590 --> 00:25:10,159
and that's kind of how i think about

769
00:25:15,430 --> 00:25:11,600
things you know

770
00:25:17,190 --> 00:25:15,440
um when i when i go to audiences i want

771
00:25:18,630 --> 00:25:17,200
them to be able to realize that

772
00:25:21,590 --> 00:25:18,640
that this thing that they're doing of

773
00:25:22,149 --> 00:25:21,600
observing nature is at its most basic

774
00:25:24,390 --> 00:25:22,159
level

775
00:25:25,669 --> 00:25:24,400
the business of science so when you're

776
00:25:28,070 --> 00:25:25,679
observing nature

777
00:25:29,190 --> 00:25:28,080
you are engaging in the world as a

778
00:25:31,590 --> 00:25:29,200
scientist does

779
00:25:33,750 --> 00:25:31,600
only we do it with graphs and clipboards

780
00:25:35,590 --> 00:25:33,760
and you know large worrying machines

781
00:25:37,190 --> 00:25:35,600
but that's really what it's about and so

782
00:25:40,230 --> 00:25:37,200
getting people engaged and

783
00:25:42,390 --> 00:25:40,240
rethinking what science is and how they

784
00:25:43,669 --> 00:25:42,400
are actually part of that activity and

785
00:25:45,669 --> 00:25:43,679
how they relate to

786
00:25:48,310 --> 00:25:45,679
those results is really what i'm trying

787
00:25:50,070 --> 00:25:48,320
to to do when i talk to audiences

788
00:25:51,909 --> 00:25:50,080

it's not quite like oh here i am a

789
00:25:54,549 --> 00:25:51,919
scientist you can be one too

790
00:25:55,110 --> 00:25:54,559
but but just understanding what science

791
00:25:57,909 --> 00:25:55,120
is

792
00:25:59,269 --> 00:25:57,919
and how it's actually a really common

793
00:26:01,269 --> 00:25:59,279
and engaging

794
00:26:03,190 --> 00:26:01,279
natural pursuit for just about any

795
00:26:04,310 --> 00:26:03,200
humans i bet your son's somewhere doing

796
00:26:06,310 --> 00:26:04,320
it right now

797
00:26:07,669 --> 00:26:06,320
i'm sure he's out right now on a walk

798
00:26:10,070 --> 00:26:07,679
somewhere in our neighborhood checking

799
00:26:11,190 --> 00:26:10,080
out some bugs and doing some science uh

800
00:26:12,549 --> 00:26:11,200
even though it's a different kind of

801
00:26:14,950 --> 00:26:12,559
science you know it's still that

802
00:26:16,789 --> 00:26:14,960
curiosity that wonder that engagement

803
00:26:18,630 --> 00:26:16,799
uh and so i love that vision for sharing

804
00:26:19,350 --> 00:26:18,640
science and i think communication is so

805
00:26:20,470 --> 00:26:19,360
important

806
00:26:22,070 --> 00:26:20,480
and something we really should be

807
00:26:23,590 --> 00:26:22,080
teaching you know scientists in their

808
00:26:24,310 --> 00:26:23,600
learning and engineers and everyone

809
00:26:26,070 --> 00:26:24,320
really is

810
00:26:27,669 --> 00:26:26,080
how do you share what you're interested

811
00:26:29,269 --> 00:26:27,679
in you know and when you're in love you

812
00:26:31,029 --> 00:26:29,279
want to tell the universe right and so

813
00:26:32,870 --> 00:26:31,039

how do you tell the universe

814
00:26:34,549 --> 00:26:32,880
is a really important thing and you

815
00:26:35,350 --> 00:26:34,559
mentioned the rock opera and we want to

816
00:26:37,830 --> 00:26:35,360
talk about it

817
00:26:39,909 --> 00:26:37,840
determination of azimuth uh we had a

818
00:26:41,750 --> 00:26:39,919
small clip of it we shared on the nasa

819
00:26:44,950 --> 00:26:41,760
astro bio twitter account

820
00:26:48,070 --> 00:26:44,960
and then we asked uh people online about

821
00:26:50,789 --> 00:26:48,080
which nash nasa mission was featured

822
00:26:52,070 --> 00:26:50,799
both in the rock opera as well as in

823
00:26:55,110 --> 00:26:52,080
hidden figures

824
00:26:58,149 --> 00:26:55,120
and we had

825
00:27:02,149 --> 00:26:58,159
we had potential to list apollo 7

826
00:27:04,630 --> 00:27:02,159
apollo 11 friendship 7 or gemini 10

827
00:27:07,029 --> 00:27:04,640
and interestingly about 42 percent of

828
00:27:10,149 --> 00:27:07,039
the audience said apollo 11

829
00:27:12,870 --> 00:27:10,159
but the real answer was friendship seven

830
00:27:14,710 --> 00:27:12,880
everyone um now i will admit i've not

831
00:27:16,149 --> 00:27:14,720
read the book nor have i actually seen

832
00:27:17,430 --> 00:27:16,159
the movie i really have to catch up on

833
00:27:19,510 --> 00:27:17,440
my film watching

834
00:27:21,190 --> 00:27:19,520
um i'm i'm so i'm like a decade behind

835
00:27:22,149 --> 00:27:21,200
on films honestly maybe even more than

836
00:27:25,110 --> 00:27:22,159
that now

837
00:27:27,029 --> 00:27:25,120
um but i'd love to hear more about the

838
00:27:29,430 --> 00:27:27,039

creation of this rock opera

839
00:27:31,590 --> 00:27:29,440
uh what inspired you to share the story

840
00:27:33,830 --> 00:27:31,600
of the hidden figures of nasa

841
00:27:37,110 --> 00:27:33,840
um and and to really to really share

842
00:27:41,029 --> 00:27:37,120
this in that format too as a rock opera

843
00:27:42,389 --> 00:27:41,039
yeah so um that's a that's a couple of

844
00:27:44,310 --> 00:27:42,399
great questions i think

845
00:27:45,990 --> 00:27:44,320
the first thing to know about where i

846
00:27:47,830 --> 00:27:46,000
came to the inspiration

847
00:27:49,110 --> 00:27:47,840
is that when i was in grad school i was

848
00:27:51,830 --> 00:27:49,120
part of a

849
00:27:53,510 --> 00:27:51,840
program that was funded by the nsf it's

850
00:27:55,750 --> 00:27:53,520
it doesn't exist anymore sadly it was

851
00:27:57,669 --> 00:27:55,760
called the gk12 fellowship program

852
00:27:58,950 --> 00:27:57,679
and what they did is they took graduate

853
00:28:01,029 --> 00:27:58,960
students and

854
00:28:03,190 --> 00:28:01,039
embedded them in public schools that

855
00:28:07,190 --> 00:28:03,200
were underperforming in science

856
00:28:07,830 --> 00:28:07,200
and so one day a week i was at a middle

857
00:28:10,549 --> 00:28:07,840
school

858
00:28:12,230 --> 00:28:10,559
where i was helping the teachers there

859
00:28:14,310 --> 00:28:12,240
update their curriculum

860
00:28:15,269 --> 00:28:14,320
i was running science clubs and you know

861
00:28:16,630 --> 00:28:15,279
doing all these things

862
00:28:18,710 --> 00:28:16,640
the teachers honestly don't have time to

863
00:28:20,070 --> 00:28:18,720

do because they're swamped and you know

864
00:28:21,750 --> 00:28:20,080
a lot of times these schools

865
00:28:23,350 --> 00:28:21,760
don't have enough money and they've got

866
00:28:24,789 --> 00:28:23,360
a lot of students and all those students

867
00:28:26,389 --> 00:28:24,799
are eager to learn but there's just not

868
00:28:28,470 --> 00:28:26,399
enough teacher to go around

869
00:28:29,510 --> 00:28:28,480
so that's where the nsf fellows really

870
00:28:31,350 --> 00:28:29,520
came in

871
00:28:33,430 --> 00:28:31,360
and the school where i was at was

872
00:28:34,630 --> 00:28:33,440
largely african-american and so i got to

873
00:28:37,430 --> 00:28:34,640
talking to the teacher

874
00:28:38,389 --> 00:28:37,440
about like okay let's put together um

875
00:28:40,789 --> 00:28:38,399
some curriculum

876
00:28:42,710 --> 00:28:40,799
for african american history month and

877
00:28:43,990 --> 00:28:42,720
she says oh no we've got that covered we

878
00:28:46,310 --> 00:28:44,000
always do something about george

879
00:28:48,070 --> 00:28:46,320
washington carver and i said oh my

880
00:28:48,710 --> 00:28:48,080
goodness he has been dead for a very

881
00:28:51,750 --> 00:28:48,720
long time

882
00:28:53,990 --> 00:28:51,760
i think we have other heroes of science

883
00:28:56,789 --> 00:28:54,000
in the african-american community

884
00:28:58,950 --> 00:28:56,799
that we can that we can teach about and

885
00:29:01,830 --> 00:28:58,960
so i started putting together a list

886
00:29:04,070 --> 00:29:01,840
of all of these people um and i you know

887
00:29:06,070 --> 00:29:04,080
me being me and my interests i was

888
00:29:07,830 --> 00:29:06,080

really focused on space science and

889
00:29:09,190 --> 00:29:07,840
that's when i discovered the story of

890
00:29:15,029 --> 00:29:09,200
catherine johnson

891
00:29:18,149 --> 00:29:15,039
and this was in oh i want to say 2010

892
00:29:20,950 --> 00:29:18,159
um so no maybe no

893
00:29:22,549 --> 00:29:20,960
2013 anyhow it was a long time before

894
00:29:25,190 --> 00:29:22,559
the movie came out

895
00:29:26,870 --> 00:29:25,200
and so i was just like watching all

896
00:29:28,470 --> 00:29:26,880
these interviews of catherine johnson

897
00:29:31,669 --> 00:29:28,480
because she's been a hero

898
00:29:34,070 --> 00:29:31,679
in her own community for a long time

899
00:29:35,750 --> 00:29:34,080
and at nasa but just not really known to

900
00:29:38,549 --> 00:29:35,760
the general public

901
00:29:38,950 --> 00:29:38,559
and of all the stories that i i looked

902
00:29:44,789 --> 00:29:38,960
at

903
00:29:46,789 --> 00:29:44,799
story just stuck with me and came

904
00:29:49,669 --> 00:29:46,799
kept coming back to me and i've been

905
00:29:52,230 --> 00:29:49,679
really involved in theater for a while

906
00:29:52,710 --> 00:29:52,240
and so when there was this opportunity

907
00:29:58,230 --> 00:29:52,720
to

908
00:29:59,990 --> 00:29:58,240
i pitched the idea of a short opera

909
00:30:02,630 --> 00:30:00,000
about katherine johnson

910
00:30:03,669 --> 00:30:02,640
and i love the medium of theater i'm not

911
00:30:06,149 --> 00:30:03,679
you know gonna

912
00:30:07,510 --> 00:30:06,159
say anything good or bad about the movie

913
00:30:09,750 --> 00:30:07,520

you know they don't pay me

914
00:30:11,029 --> 00:30:09,760
um but the medium of theater really

915
00:30:14,549 --> 00:30:11,039
gives you a chance to

916
00:30:15,430 --> 00:30:14,559
engage um a whole lot of of imagery and

917
00:30:18,549 --> 00:30:15,440
a whole lot of

918
00:30:20,389 --> 00:30:18,559
content in a much more um

919
00:30:22,549 --> 00:30:20,399
deep and involved way than you can do in

920
00:30:25,750 --> 00:30:22,559
a movie where you're really relying

921
00:30:26,789 --> 00:30:25,760
just on keeping eyes on that screen the

922
00:30:29,110 --> 00:30:26,799
whole time

923
00:30:30,630 --> 00:30:29,120
so in our show you know we have

924
00:30:32,470 --> 00:30:30,640
simultaneous timelines

925
00:30:35,269 --> 00:30:32,480
past and present katherine johnson we

926
00:30:37,750 --> 00:30:35,279
have actors going out into the audience

927
00:30:39,190 --> 00:30:37,760
um everyone in the audience had all of

928
00:30:40,950 --> 00:30:39,200
this paperwork that was

929
00:30:43,110 --> 00:30:40,960
you know supposed to go along with the

930
00:30:45,269 --> 00:30:43,120
script so it's this really engaging

931
00:30:48,230 --> 00:30:45,279
interactive way of doing things

932
00:30:49,669 --> 00:30:48,240
and when you know i like i said i talked

933
00:30:51,190 --> 00:30:49,679
to the director she's like

934
00:30:53,110 --> 00:30:51,200
my goodness there's a lot of math in

935
00:30:54,950 --> 00:30:53,120
this because all of the songs in the

936
00:30:58,070 --> 00:30:54,960
opera are taken directly from

937
00:30:59,990 --> 00:30:58,080
papers catherine johnson wrote and so a

938
00:31:00,870 --> 00:31:00,000

lot of times the actors if you guys go

939
00:31:03,509 --> 00:31:00,880
out and find

940
00:31:04,070 --> 00:31:03,519
this opera online the actors are just

941
00:31:07,269 --> 00:31:04,080
singing

942
00:31:09,350 --> 00:31:07,279
equations which you know god bless them

943
00:31:11,830 --> 00:31:09,360
what a horrible thing for for a

944
00:31:12,310 --> 00:31:11,840
screenwriter for a scriptwriter to do to

945
00:31:14,470 --> 00:31:12,320
them

946
00:31:15,430 --> 00:31:14,480
but they're just singing equations and i

947
00:31:17,029 --> 00:31:15,440
wanted to

948
00:31:18,789 --> 00:31:17,039
have that happen because that was

949
00:31:20,230 --> 00:31:18,799
katherine johnson's language

950
00:31:21,990 --> 00:31:20,240
just like when we watched opera in

951
00:31:23,029 --> 00:31:22,000
italian because that's that was the

952
00:31:25,430 --> 00:31:23,039
language of

953
00:31:27,909 --> 00:31:25,440
of that writer and those people her

954
00:31:30,310 --> 00:31:27,919
language was math and getting to hear

955
00:31:32,070 --> 00:31:30,320
singers just belting out math really

956
00:31:36,070 --> 00:31:32,080
felt to me like connecting

957
00:31:39,029 --> 00:31:36,080
with what her language was and um

958
00:31:40,789 --> 00:31:39,039
and the you know some other things that

959
00:31:42,070 --> 00:31:40,799
i would think about that were important

960
00:31:44,789 --> 00:31:42,080
there is that we really

961
00:31:46,630 --> 00:31:44,799
kept it focused on the scientists every

962
00:31:48,549 --> 00:31:46,640
other part of the space program was just

963
00:31:49,430 --> 00:31:48,559

kind of in the background in our show

964
00:31:51,830 --> 00:31:49,440
you had no

965
00:31:54,149 --> 00:31:51,840
chiseled jawed astronauts or anything

966
00:31:56,389 --> 00:31:54,159
like that it was all about the science

967
00:31:57,990 --> 00:31:56,399
and more importantly how the science was

968
00:32:01,110 --> 00:31:58,000
embedded in those people's

969
00:32:02,310 --> 00:32:01,120
lives again you know she was a mom and

970
00:32:04,470 --> 00:32:02,320
she was a wife

971
00:32:06,470 --> 00:32:04,480
but her science was so important to her

972
00:32:07,190 --> 00:32:06,480
and it really drove the way she saw the

973
00:32:08,950 --> 00:32:07,200
world

974
00:32:10,389 --> 00:32:08,960
and so when you watch interviews of

975
00:32:12,630 --> 00:32:10,399
katherine johnson talking about the

976
00:32:14,630 --> 00:32:12,640
civil rights movement for example

977
00:32:16,870 --> 00:32:14,640
you can feel that she's seeing it

978
00:32:18,070 --> 00:32:16,880
through this physics lens of pushing

979
00:32:19,909 --> 00:32:18,080
back on the world

980
00:32:21,669 --> 00:32:19,919
and i really wanted to capture that in

981
00:32:24,389 --> 00:32:21,679
the story as well

982
00:32:25,269 --> 00:32:24,399
i love that so much and before the show

983
00:32:27,110 --> 00:32:25,279
you and i had a chance we were

984
00:32:28,470 --> 00:32:27,120
conversing a little bit about this

985
00:32:30,070 --> 00:32:28,480
and you'd mention you know how a lot of

986
00:32:31,350 --> 00:32:30,080
her work in the mathematics was really

987
00:32:33,990 --> 00:32:31,360
understanding how he

988
00:32:35,750 --> 00:32:34,000

can manipulate regimes of gravity you

989
00:32:36,310 --> 00:32:35,760
know for instance to get astronauts to

990
00:32:38,549 --> 00:32:36,320
the moon

991
00:32:39,909 --> 00:32:38,559
and back without having to put extra

992
00:32:42,070 --> 00:32:39,919
energy into it

993
00:32:43,029 --> 00:32:42,080
and you made the analogy to her own life

994
00:32:44,789 --> 00:32:43,039
and and and

995
00:32:46,710 --> 00:32:44,799
and what it took for her in her life you

996
00:32:49,509 --> 00:32:46,720
know with the civil rights movement and

997
00:32:51,350 --> 00:32:49,519
manipulating other regimes to try to put

998
00:32:52,710 --> 00:32:51,360
as little energy in as you need to but

999
00:32:55,430 --> 00:32:52,720
still kind of have these major

1000
00:32:57,430 --> 00:32:55,440
transitions occur um yeah i really

1001
00:32:59,190 --> 00:32:57,440
appreciated that viewpoint from you know

1002
00:33:00,950 --> 00:32:59,200
yeah i i think that's something really

1003
00:33:03,590 --> 00:33:00,960
special about how her work

1004
00:33:04,310 --> 00:33:03,600
um really influenced her thinking of

1005
00:33:07,350 --> 00:33:04,320
that time

1006
00:33:08,870 --> 00:33:07,360
too that you know you can you know you

1007
00:33:11,190 --> 00:33:08,880
can try to

1008
00:33:13,110 --> 00:33:11,200
speed around space in a rocket or you

1009
00:33:16,470 --> 00:33:13,120
can just make the world a place

1010
00:33:17,430 --> 00:33:16,480
where things things fall fall more

1011
00:33:21,669 --> 00:33:17,440
naturally

1012
00:33:24,149 --> 00:33:21,679
and and you know like she always said

1013
00:33:25,830 --> 00:33:24,159

rockets get astronauts off the planet

1014
00:33:27,830 --> 00:33:25,840
math gets it back home

1015
00:33:28,950 --> 00:33:27,840
and i i just love the way she thought

1016
00:33:32,789 --> 00:33:28,960
about paths and

1017
00:33:34,310 --> 00:33:32,799
math and life as all of this package

1018
00:33:35,909 --> 00:33:34,320
yeah and in the end i mean we ended up

1019
00:33:38,389 --> 00:33:35,919
saving three people and bringing them

1020
00:33:40,230 --> 00:33:38,399
home from the moon because of that math

1021
00:33:42,389 --> 00:33:40,240
she you know worked to make the map that

1022
00:33:43,909 --> 00:33:42,399
we used to bring those people back

1023
00:33:45,669 --> 00:33:43,919
when really i mean when you read up on

1024
00:33:47,190 --> 00:33:45,679
apollo 13 it really sounds like they

1025
00:33:49,190 --> 00:33:47,200
should not have made it

1026
00:33:50,830 --> 00:33:49,200
um it was an impressive feat of

1027
00:33:52,149 --> 00:33:50,840
mathematics and engineering to make that

1028
00:33:55,110 --> 00:33:52,159
happen

1029
00:33:55,590 --> 00:33:55,120
like they say space is hard exactly yeah

1030
00:33:57,590 --> 00:33:55,600
space

1031
00:33:59,110 --> 00:33:57,600
is hard um but we're getting good at it

1032
00:34:00,470 --> 00:33:59,120
you know and it's thanks to people like

1033
00:34:02,149 --> 00:34:00,480
katherine johnson who

1034
00:34:04,470 --> 00:34:02,159
have helped us to get better at it

1035
00:34:05,990 --> 00:34:04,480
through time um i do want to open it up

1036
00:34:07,430 --> 00:34:06,000
now to our audience q

1037
00:34:09,669 --> 00:34:07,440
a session to allow those who are

1038
00:34:11,270 --> 00:34:09,679

watching to ask questions of you

1039
00:34:12,869 --> 00:34:11,280
so for the folks out there feel free you

1040
00:34:13,829 --> 00:34:12,879
can drop your questions in the chat

1041
00:34:16,310 --> 00:34:13,839
right now

1042
00:34:17,510 --> 00:34:16,320
uh our support staff maryam nasim and

1043
00:34:19,030 --> 00:34:17,520
anna rupp mohanty

1044
00:34:21,270 --> 00:34:19,040
are both standing by to get your

1045
00:34:21,829 --> 00:34:21,280
questions over if there are a lot of

1046
00:34:23,270 --> 00:34:21,839
questions

1047
00:34:24,629 --> 00:34:23,280
i promise i'll do my best to get to all

1048
00:34:25,990 --> 00:34:24,639
of them but sometimes we can't just

1049
00:34:27,510 --> 00:34:26,000
because we have so many

1050
00:34:29,990 --> 00:34:27,520
and i know many of you are excited to

1051
00:34:31,190 --> 00:34:30,000
ask heather all kinds of cool things

1052
00:34:33,750 --> 00:34:31,200
and the first question comes from

1053
00:34:34,550 --> 00:34:33,760
someone who is a long-time fan of our

1054
00:34:37,030 --> 00:34:34,560
show

1055
00:34:39,589 --> 00:34:37,040
uh jim pass who's also uh the leader of

1056
00:34:41,109 --> 00:34:39,599
the astro sociology research institute

1057
00:34:43,349 --> 00:34:41,119
and often wants to consider you know the

1058
00:34:44,629 --> 00:34:43,359
social dynamic of astrobiology and space

1059
00:34:46,950 --> 00:34:44,639
exploration

1060
00:34:48,550 --> 00:34:46,960
uh jim says that astrobiology dominates

1061
00:34:49,270 --> 00:34:48,560
the search for biosignatures beyond

1062
00:34:51,190 --> 00:34:49,280
earth

1063
00:34:52,550 --> 00:34:51,200

while the social and behavioral sciences

1064
00:34:53,829 --> 00:34:52,560
have focused more on terrestrial

1065
00:34:55,990 --> 00:34:53,839
societies

1066
00:34:57,349 --> 00:34:56,000
uh what what lessons learned here do you

1067
00:34:59,750 --> 00:34:57,359
think can be applied when we start

1068
00:35:02,630 --> 00:34:59,760
traveling out there to do our work

1069
00:35:05,109 --> 00:35:02,640
wow that's a you know that's a i think

1070
00:35:07,670 --> 00:35:05,119
what jim's asking is how do we

1071
00:35:09,510 --> 00:35:07,680
um let sociology a science that i have

1072
00:35:12,950 --> 00:35:09,520
no experience in inform

1073
00:35:14,630 --> 00:35:12,960
our search for life and i think you know

1074
00:35:15,990 --> 00:35:14,640
a way that i would approach this

1075
00:35:18,310 --> 00:35:16,000
question might be to say that

1076
00:35:20,390 --> 00:35:18,320
science and and what we choose to do in

1077
00:35:21,750 --> 00:35:20,400
science is really a reflection of our

1078
00:35:24,470 --> 00:35:21,760
values

1079
00:35:26,150 --> 00:35:24,480
and so when we say that looking for life

1080
00:35:26,710 --> 00:35:26,160
elsewhere is important it says something

1081
00:35:28,630 --> 00:35:26,720
about

1082
00:35:30,230 --> 00:35:28,640
what we believe that that we really

1083
00:35:32,550 --> 00:35:30,240
aren't alone and that there is this

1084
00:35:35,510 --> 00:35:32,560
other possibility out there

1085
00:35:36,470 --> 00:35:35,520
and so i see that you know if we can

1086
00:35:38,870 --> 00:35:36,480
make sure that

1087
00:35:40,950 --> 00:35:38,880
what our search pattern is and where we

1088
00:35:42,790 --> 00:35:40,960

search actually reflects our values

1089
00:35:46,150 --> 00:35:42,800
that's where i see sociology

1090
00:35:48,310 --> 00:35:46,160
overlapping with astrobiology i think

1091
00:35:50,390 --> 00:35:48,320
another thing that i would kind of drill

1092
00:35:52,790 --> 00:35:50,400
down to in that question is

1093
00:35:54,710 --> 00:35:52,800
um on a more you know agnostic

1094
00:35:55,829 --> 00:35:54,720
biosignatures point of view or from my

1095
00:35:58,710 --> 00:35:55,839
science point of view

1096
00:36:01,589 --> 00:35:58,720
is like i said i'm not a sociologist but

1097
00:36:04,230 --> 00:36:01,599
i do think about community structure

1098
00:36:06,630 --> 00:36:04,240
when i look at any sort of assemblage of

1099
00:36:07,510 --> 00:36:06,640
chemicals or any habitat or potential

1100
00:36:10,950 --> 00:36:07,520
habitat

1101
00:36:13,349 --> 00:36:10,960
the idea that no organisms here on earth

1102
00:36:14,230 --> 00:36:13,359
or anywhere are likely doing anything by

1103
00:36:17,349 --> 00:36:14,240
themselves

1104
00:36:20,069 --> 00:36:17,359
we're all dependent on an enormous

1105
00:36:21,109 --> 00:36:20,079
network of organisms past and present

1106
00:36:23,349 --> 00:36:21,119
that make our life

1107
00:36:24,150 --> 00:36:23,359
possible and i think we need a much

1108
00:36:25,990 --> 00:36:24,160
better

1109
00:36:27,829 --> 00:36:26,000
understanding of that i think as people

1110
00:36:28,870 --> 00:36:27,839
start realizing that they themselves are

1111
00:36:31,750 --> 00:36:28,880
a biome

1112
00:36:34,069 --> 00:36:31,760
um this becomes more more evident and as

1113
00:36:36,230 --> 00:36:34,079

astrobiologists stop just looking for

1114
00:36:37,910 --> 00:36:36,240
this amazing microbe that can live here

1115
00:36:41,430 --> 00:36:37,920
or there and understand

1116
00:36:43,030 --> 00:36:41,440
what network of biology it took to make

1117
00:36:45,589 --> 00:36:43,040
that place habitable

1118
00:36:46,710 --> 00:36:45,599
um that becomes a really a much stronger

1119
00:36:48,390 --> 00:36:46,720
search pattern

1120
00:36:51,589 --> 00:36:48,400
when we think of things as communities

1121
00:36:53,670 --> 00:36:51,599
an ecological approach to astrobiology

1122
00:36:55,109 --> 00:36:53,680
oh yeah i appreciate that so much i've

1123
00:36:56,790 --> 00:36:55,119
talked a lot with carol cleland a

1124
00:36:58,390 --> 00:36:56,800
philosopher of science

1125
00:36:59,990 --> 00:36:58,400
who's considered this a lot too you know

1126
00:37:01,190 --> 00:37:00,000
that you can't just have just you know a

1127
00:37:02,790 --> 00:37:01,200
hydrothermal vent

1128
00:37:04,230 --> 00:37:02,800
system ecology occurring because it's

1129
00:37:05,430 --> 00:37:04,240
connected to so many other things like

1130
00:37:06,710 --> 00:37:05,440
the ocean around it

1131
00:37:08,550 --> 00:37:06,720
and so many other living things that

1132
00:37:10,790 --> 00:37:08,560
have occurred on earth through time

1133
00:37:12,550 --> 00:37:10,800
um we have a question from facebook from

1134
00:37:14,470 --> 00:37:12,560
user tom caruso

1135
00:37:15,670 --> 00:37:14,480
who maybe wants a little bit more of an

1136
00:37:17,190 --> 00:37:15,680
understanding of what agnostic

1137
00:37:20,390 --> 00:37:17,200
biosignatures are

1138
00:37:21,829 --> 00:37:20,400

tom is asked uh uh if maybe one driving

1139
00:37:24,310 --> 00:37:21,839
motivation for our missions of

1140
00:37:27,430 --> 00:37:24,320
exploration should be to search for how

1141
00:37:29,270 --> 00:37:27,440
systems uniquely harness energy um is

1142
00:37:31,670 --> 00:37:29,280
that is that we are looking for then to

1143
00:37:34,069 --> 00:37:31,680
understand agnostic biosignatures

1144
00:37:34,790 --> 00:37:34,079
you know i do think that's a really uh

1145
00:37:37,910 --> 00:37:34,800
astute

1146
00:37:38,790 --> 00:37:37,920
uh observation that he's made um and

1147
00:37:40,390 --> 00:37:38,800
part of

1148
00:37:41,910 --> 00:37:40,400
you know when we think about agnostic

1149
00:37:43,910 --> 00:37:41,920
biosignatures or really think about

1150
00:37:47,430 --> 00:37:43,920
astrobiology writ large

1151
00:37:49,990 --> 00:37:47,440
it's not just enough to say like oh this

1152
00:37:51,349 --> 00:37:50,000
place on this planet has water and is

1153
00:37:53,109 --> 00:37:51,359
warm enough

1154
00:37:55,430 --> 00:37:53,119
but to also think about what would be a

1155
00:37:57,349 --> 00:37:55,440
potential energy source here

1156
00:37:58,790 --> 00:37:57,359
what would be you know the electron

1157
00:38:02,630 --> 00:37:58,800
transfer chain

1158
00:38:04,790 --> 00:38:02,640
at this location do you have

1159
00:38:05,990 --> 00:38:04,800
reduced carbon that you could use things

1160
00:38:09,190 --> 00:38:06,000
like that so

1161
00:38:11,750 --> 00:38:09,200
so yeah get getting a little bit more um

1162
00:38:13,990 --> 00:38:11,760
systems level information about what

1163
00:38:15,030 --> 00:38:14,000

sort of metabolism would be possible for

1164
00:38:17,030 --> 00:38:15,040
any place

1165
00:38:18,870 --> 00:38:17,040
is how i think about it and you know

1166
00:38:21,349 --> 00:38:18,880
that gets that

1167
00:38:23,510 --> 00:38:21,359
you know sounds like it's being very

1168
00:38:25,670 --> 00:38:23,520
specific and not quite agnostic

1169
00:38:27,670 --> 00:38:25,680
when i put it that way except that what

1170
00:38:28,069 --> 00:38:27,680
i'm really saying is to be aware of

1171
00:38:34,310 --> 00:38:28,079
these

1172
00:38:36,710 --> 00:38:34,320
of energy sources and other

1173
00:38:38,550 --> 00:38:36,720
you know substrates that would actually

1174
00:38:40,710 --> 00:38:38,560
make a metabolism possible

1175
00:38:41,990 --> 00:38:40,720
whatever you think that metabolism is

1176
00:38:44,550 --> 00:38:42,000
and there's a lot of them

1177
00:38:46,310 --> 00:38:44,560
you know when i say metabolism you might

1178
00:38:48,470 --> 00:38:46,320
just think about your own

1179
00:38:49,829 --> 00:38:48,480
but the the metabolic diversity of our

1180
00:38:53,510 --> 00:38:49,839
planet tells us that there's

1181
00:38:55,270 --> 00:38:53,520
lots of ways to eat energy out of raw

1182
00:38:58,230 --> 00:38:55,280
materials by life

1183
00:39:00,390 --> 00:38:58,240
yeah life life uh finds a way right

1184
00:39:02,630 --> 00:39:00,400
there's lots of metabolisms out there

1185
00:39:05,109 --> 00:39:02,640
uh and otter who's supporting us for the

1186
00:39:07,109 --> 00:39:05,119
show dropped in his own question here

1187
00:39:09,430 --> 00:39:07,119
um he wants to know a bit more about

1188
00:39:11,349 --> 00:39:09,440

biosignatures and about detection

1189
00:39:12,950 --> 00:39:11,359
um he'd like to know how would we

1190
00:39:15,030 --> 00:39:12,960
actually make agnostic biosignature

1191
00:39:17,190 --> 00:39:15,040
detections what kinds of instruments do

1192
00:39:18,950 --> 00:39:17,200
you envision us needing

1193
00:39:21,109 --> 00:39:18,960
yeah so you know in our group the

1194
00:39:22,710 --> 00:39:21,119
laboratory for agnostic biosignatures we

1195
00:39:24,630 --> 00:39:22,720
have a couple of different things that

1196
00:39:26,710 --> 00:39:24,640
we're investigating

1197
00:39:28,390 --> 00:39:26,720
and we have a couple recent papers that

1198
00:39:29,030 --> 00:39:28,400
have come out that talk about these

1199
00:39:32,230 --> 00:39:29,040
things

1200
00:39:33,589 --> 00:39:32,240
and some of these tools

1201
00:39:35,510 --> 00:39:33,599
that we would use are things that are

1202
00:39:36,470 --> 00:39:35,520
currently developed and are really

1203
00:39:38,950 --> 00:39:36,480
relying on new

1204
00:39:40,550 --> 00:39:38,960
interpretive frameworks so we have a

1205
00:39:42,069 --> 00:39:40,560
paper that just came out

1206
00:39:43,910 --> 00:39:42,079
led by a postdoc at university of

1207
00:39:46,710 --> 00:39:43,920
glasgow stewart marshall

1208
00:39:48,230 --> 00:39:46,720
it's all about new ways of interrogating

1209
00:39:51,270 --> 00:39:48,240
mass spec data

1210
00:39:53,750 --> 00:39:51,280
mass specs are a mature technology

1211
00:39:54,470 --> 00:39:53,760
we've got them at one point there was

1212
00:39:56,870 --> 00:39:54,480
like

1213
00:39:57,670 --> 00:39:56,880

you know eight planets or eight moons or

1214
00:39:59,829 --> 00:39:57,680
you know eight

1215
00:40:01,510 --> 00:39:59,839
solar system bodies that had a mass spec

1216
00:40:03,270 --> 00:40:01,520
going around it you know

1217
00:40:04,790 --> 00:40:03,280
there there's something that is a very

1218
00:40:08,069 --> 00:40:04,800
mature technology

1219
00:40:09,270 --> 00:40:08,079
but thinking about um particular

1220
00:40:11,910 --> 00:40:09,280
molecules or

1221
00:40:14,630 --> 00:40:11,920
again back to the the community idea

1222
00:40:16,710 --> 00:40:14,640
thinking about particular molecules or

1223
00:40:18,309 --> 00:40:16,720
collections of molecules could tell you

1224
00:40:19,990 --> 00:40:18,319
much more about life

1225
00:40:21,750 --> 00:40:20,000
and not by saying oh this is a

1226
00:40:22,309 --> 00:40:21,760
metabolite or something like that but

1227
00:40:24,630 --> 00:40:22,319
just

1228
00:40:25,910 --> 00:40:24,640
this molecule is very complex and would

1229
00:40:29,750 --> 00:40:25,920
require

1230
00:40:31,190 --> 00:40:29,760
an organized system like life to even be

1231
00:40:33,510 --> 00:40:31,200
produced

1232
00:40:35,349 --> 00:40:33,520
then on the other hand we've got other

1233
00:40:37,990 --> 00:40:35,359
you know crazier ideas

1234
00:40:40,390 --> 00:40:38,000
um which are new ways of mapping say

1235
00:40:43,109 --> 00:40:40,400
surface complexity of a particle

1236
00:40:45,510 --> 00:40:43,119
or understanding just elemental

1237
00:40:47,990 --> 00:40:45,520
abundances of particles

1238
00:40:50,150 --> 00:40:48,000

as a way of detecting another kind of

1239
00:40:52,950 --> 00:40:50,160
complexity that's indicative of life

1240
00:40:53,990 --> 00:40:52,960
so we've got old tools and new that

1241
00:40:56,870 --> 00:40:54,000
we're working on

1242
00:40:57,349 --> 00:40:56,880
as part of this and we're also trying to

1243
00:40:59,270 --> 00:40:57,359
be

1244
00:41:00,630 --> 00:40:59,280
you know non-selective for any

1245
00:41:02,309 --> 00:41:00,640
particular analyte

1246
00:41:04,150 --> 00:41:02,319
type in our group we want to be able to

1247
00:41:04,829 --> 00:41:04,160
imagine that we could interrogate fluids

1248
00:41:07,750 --> 00:41:04,839
as well as

1249
00:41:08,309 --> 00:41:07,760
rocks that's fantastic and i i think you

1250
00:41:09,430 --> 00:41:08,319
know also

1251
00:41:11,829 --> 00:41:09,440
i think a lot about like machine

1252
00:41:13,030 --> 00:41:11,839
learning and ai and upcoming processes

1253
00:41:14,710 --> 00:41:13,040
for automation

1254
00:41:16,870 --> 00:41:14,720
for data collection which is necessary

1255
00:41:18,550 --> 00:41:16,880
because we're in the age of big data

1256
00:41:19,990 --> 00:41:18,560
and it's getting bigger and bigger you

1257
00:41:22,230 --> 00:41:20,000
know and data analysis

1258
00:41:24,150 --> 00:41:22,240
is such a huge task now you know and

1259
00:41:26,470 --> 00:41:24,160
that's something else that i think is

1260
00:41:28,230 --> 00:41:26,480
really important especially if there are

1261
00:41:29,750 --> 00:41:28,240
viewers here who are thinking about ways

1262
00:41:31,829 --> 00:41:29,760
they can contribute

1263
00:41:33,670 --> 00:41:31,839

is that if you think about the data

1264
00:41:35,349 --> 00:41:33,680
volumes that we generate with these

1265
00:41:36,230 --> 00:41:35,359
instruments when we send them to other

1266
00:41:37,910 --> 00:41:36,240
planets

1267
00:41:39,190 --> 00:41:37,920
and we're starting to move to farther

1268
00:41:41,109 --> 00:41:39,200
and farther planets think about

1269
00:41:44,230 --> 00:41:41,119
dragonfly going to titan

1270
00:41:45,109 --> 00:41:44,240
the necessity for having some sort of

1271
00:41:48,309 --> 00:41:45,119
autonomous

1272
00:41:50,710 --> 00:41:48,319
science system as part of that lander

1273
00:41:52,790 --> 00:41:50,720
is really growing because there's you

1274
00:41:54,150 --> 00:41:52,800
know it's very hard to get that volume

1275
00:41:57,109 --> 00:41:54,160
of data back to earth

1276
00:41:58,710 --> 00:41:57,119
for us to look at it and a lot of times

1277
00:42:00,790 --> 00:41:58,720
that instrument is just sitting there

1278
00:42:01,990 --> 00:42:00,800
waiting for the next thing to be told

1279
00:42:03,910 --> 00:42:02,000
what to do

1280
00:42:05,430 --> 00:42:03,920
and it and if we had an intelligent

1281
00:42:07,750 --> 00:42:05,440
system that could help

1282
00:42:10,069 --> 00:42:07,760
you know line up experiments for it

1283
00:42:12,309 --> 00:42:10,079
while we're waiting for all that data to

1284
00:42:13,510 --> 00:42:12,319
download i think um for all of your

1285
00:42:14,550 --> 00:42:13,520
viewers who are going to get into

1286
00:42:16,790 --> 00:42:14,560
astrobiology

1287
00:42:18,550 --> 00:42:16,800
you're going to be so sad to learn how

1288
00:42:19,190 --> 00:42:18,560

much we're constrained by just how

1289
00:42:22,390 --> 00:42:19,200
quickly

1290
00:42:24,790 --> 00:42:22,400
you can move bites across space and how

1291
00:42:27,190 --> 00:42:24,800
big those packages of bites can be

1292
00:42:29,030 --> 00:42:27,200
that's a real constraint especially for

1293
00:42:30,470 --> 00:42:29,040
the outer solar system

1294
00:42:32,550 --> 00:42:30,480
absolutely whenever whenever i tune into

1295
00:42:34,630 --> 00:42:32,560
the deep space network and i see like

1296
00:42:36,150 --> 00:42:34,640
voyager 1 communicating back to us and i

1297
00:42:37,829 --> 00:42:36,160
think about the data stream

1298
00:42:39,670 --> 00:42:37,839
and then i try to compare it in my mind

1299
00:42:41,430 --> 00:42:39,680
to like where we are with percy and

1300
00:42:43,270 --> 00:42:41,440
curiosity and even upcoming missions

1301
00:42:44,150 --> 00:42:43,280
that will certainly have more data

1302
00:42:45,589 --> 00:42:44,160
collection

1303
00:42:47,109 --> 00:42:45,599
not just you know tens of points or

1304
00:42:47,670 --> 00:42:47,119
hundreds of points thousands of points

1305
00:42:49,430 --> 00:42:47,680
but

1306
00:42:51,510 --> 00:42:49,440
tens of thousands millions of data

1307
00:42:53,510 --> 00:42:51,520
points you know that's so much data

1308
00:42:55,030 --> 00:42:53,520
and so having some automation to process

1309
00:42:57,510 --> 00:42:55,040
you know on the front end before

1310
00:42:58,550 --> 00:42:57,520
sending data back is a huge task and one

1311
00:43:00,630 --> 00:42:58,560
that's very important

1312
00:43:03,349 --> 00:43:00,640
for all of our explorations highly

1313
00:43:07,430 --> 00:43:05,589

awesome that's science for super

1314
00:43:10,150 --> 00:43:07,440
important

1315
00:43:11,270 --> 00:43:10,160
we have a question here from user jessie

1316
00:43:13,589 --> 00:43:11,280
uh de la plane

1317
00:43:15,109 --> 00:43:13,599
from facebook and so jessie wants to

1318
00:43:16,630 --> 00:43:15,119
know a bit about your theater work and

1319
00:43:17,190 --> 00:43:16,640
i'm gonna change her question a little

1320
00:43:19,190 --> 00:43:17,200
bit

1321
00:43:20,790 --> 00:43:19,200
um she wanted to know how your skills in

1322
00:43:22,630 --> 00:43:20,800
organic chemistry and astrobiology

1323
00:43:24,550 --> 00:43:22,640
contribute to your theater work

1324
00:43:26,790 --> 00:43:24,560
um beyond clear influences for things

1325
00:43:28,390 --> 00:43:26,800
like determination of azimuth

1326
00:43:29,910 --> 00:43:28,400
i'd like to know you know how has

1327
00:43:31,030 --> 00:43:29,920
theater contributed to your work as a

1328
00:43:33,270 --> 00:43:31,040
scientist

1329
00:43:34,470 --> 00:43:33,280
and vice versa you know that's really

1330
00:43:36,470 --> 00:43:34,480
interesting and i'm gonna

1331
00:43:37,750 --> 00:43:36,480
i'm gonna clue everyone in on a little

1332
00:43:39,589 --> 00:43:37,760
secret about me

1333
00:43:41,510 --> 00:43:39,599
um i i know i said that i didn't go to

1334
00:43:42,710 --> 00:43:41,520
college till i was 30 but something

1335
00:43:45,430 --> 00:43:42,720
that's actually

1336
00:43:46,790 --> 00:43:45,440
a a little bit deeper back in my past is

1337
00:43:49,510 --> 00:43:46,800
that right out of high school

1338
00:43:50,230 --> 00:43:49,520

i tried to go to art school and uh i

1339
00:43:54,790 --> 00:43:50,240
didn't

1340
00:43:55,430 --> 00:43:54,800
last a year and um things that i learned

1341
00:43:57,510 --> 00:43:55,440
in art

1342
00:43:58,470 --> 00:43:57,520
really got me ready for science because

1343
00:44:01,589 --> 00:43:58,480
in art you're

1344
00:44:03,750 --> 00:44:01,599
working with really um objective

1345
00:44:04,870 --> 00:44:03,760
or subjective material and it's very

1346
00:44:06,470 --> 00:44:04,880
much based on

1347
00:44:07,990 --> 00:44:06,480
how do people interact with that

1348
00:44:10,309 --> 00:44:08,000
material and so a lot of what you're

1349
00:44:13,030 --> 00:44:10,319
learning in art school is basically how

1350
00:44:14,390 --> 00:44:13,040
to accept and give critique

1351
00:44:16,630 --> 00:44:14,400
and that's something that has been

1352
00:44:17,670 --> 00:44:16,640
really helpful for me in science because

1353
00:44:21,190 --> 00:44:17,680
science is

1354
00:44:23,670 --> 00:44:21,200
a a activity that is built on a

1355
00:44:26,630 --> 00:44:23,680
community helping each other and

1356
00:44:28,309 --> 00:44:26,640
um grow through peer review and also

1357
00:44:30,230 --> 00:44:28,319
review of our proposals

1358
00:44:31,829 --> 00:44:30,240
so learning how to give and take

1359
00:44:34,230 --> 00:44:31,839
critique has been

1360
00:44:36,069 --> 00:44:34,240
really helpful for me it you know when

1361
00:44:38,069 --> 00:44:36,079
you get back those paper reviews and

1362
00:44:40,150 --> 00:44:38,079
first you're mad but then you're like no

1363
00:44:42,309 --> 00:44:40,160

wait what do i need to learn from this

1364
00:44:43,430 --> 00:44:42,319
that's actually a skill that artists do

1365
00:44:45,349 --> 00:44:43,440
all the time

1366
00:44:47,430 --> 00:44:45,359
and they're taught how to do it and

1367
00:44:49,349 --> 00:44:47,440
they're taught how to give good critique

1368
00:44:50,710 --> 00:44:49,359
and i feel like scientists would be in a

1369
00:44:53,190 --> 00:44:50,720
much better position

1370
00:44:53,750 --> 00:44:53,200
if we all had to do a year of art school

1371
00:44:56,150 --> 00:44:53,760
and learn

1372
00:44:57,589 --> 00:44:56,160
how to give and accept critique and how

1373
00:44:59,829 --> 00:44:57,599
to grow from it

1374
00:45:00,870 --> 00:44:59,839
because when we get critiques back from

1375
00:45:02,630 --> 00:45:00,880
our peers

1376
00:45:04,069 --> 00:45:02,640
that's all part of the scientific

1377
00:45:05,910 --> 00:45:04,079
process trying to make

1378
00:45:07,990 --> 00:45:05,920
sure that we fix all those little

1379
00:45:10,470 --> 00:45:08,000
mistakes that we didn't see there

1380
00:45:11,750 --> 00:45:10,480
um through this community activity of

1381
00:45:13,829 --> 00:45:11,760
peer review

1382
00:45:15,430 --> 00:45:13,839
well it's fantastic and it's i i would

1383
00:45:16,230 --> 00:45:15,440
love for all scientists to have a year

1384
00:45:17,910 --> 00:45:16,240
of art school

1385
00:45:20,309 --> 00:45:17,920
i think taking some philosophy courses

1386
00:45:21,829 --> 00:45:20,319
is also super important for scientists

1387
00:45:23,510 --> 00:45:21,839
and i would hope that you know artists

1388
00:45:25,030 --> 00:45:23,520

out there are also taking some courses

1389
00:45:26,870 --> 00:45:25,040
here and there in science

1390
00:45:28,630 --> 00:45:26,880
uh understanding the chemistry of the

1391
00:45:29,670 --> 00:45:28,640
media that you're using for instance is

1392
00:45:31,510 --> 00:45:29,680
kind of

1393
00:45:33,510 --> 00:45:31,520
understanding some of the physics of how

1394
00:45:34,630 --> 00:45:33,520
we build our graphic design programs and

1395
00:45:37,670 --> 00:45:34,640
stuff like that so there's

1396
00:45:39,190 --> 00:45:37,680
so many awesome crossovers there um i

1397
00:45:42,390 --> 00:45:39,200
think we're gonna go back now a bit

1398
00:45:44,470 --> 00:45:42,400
into some of uh by uh agnostic

1399
00:45:48,390 --> 00:45:44,480
biosignatures in astrobiology

1400
00:45:50,069 --> 00:45:48,400
uh user gothmusiclatum on twitter

1401
00:45:51,990 --> 00:45:50,079
uh wants to know how we might properly

1402
00:45:53,670 --> 00:45:52,000
identify life that doesn't have the same

1403
00:45:56,790 --> 00:45:53,680
chemical requirements

1404
00:45:58,550 --> 00:45:56,800
as earth-like life so you know if there

1405
00:45:59,190 --> 00:45:58,560
is life out there that's not life as we

1406
00:46:01,109 --> 00:45:59,200
know it

1407
00:46:02,390 --> 00:46:01,119
how might we best then search for that

1408
00:46:04,550 --> 00:46:02,400
life

1409
00:46:06,230 --> 00:46:04,560
yeah so that's an interesting question

1410
00:46:08,309 --> 00:46:06,240
and i think one thing that i always try

1411
00:46:08,630 --> 00:46:08,319
to get people to understand when we talk

1412
00:46:11,190 --> 00:46:08,640
about

1413
00:46:12,630 --> 00:46:11,200

agnostic biosignatures is when you're

1414
00:46:15,109 --> 00:46:12,640
dealing with a truly

1415
00:46:17,190 --> 00:46:15,119
unknown a lot of times you're not saying

1416
00:46:19,829 --> 00:46:17,200
like oh look i found i found a life

1417
00:46:22,309 --> 00:46:19,839
it's over there um you're really

1418
00:46:24,790 --> 00:46:22,319
speaking in probability windows

1419
00:46:26,630 --> 00:46:24,800
and so for example when i was talking

1420
00:46:27,430 --> 00:46:26,640
about complexity of molecules you're

1421
00:46:30,710 --> 00:46:27,440
saying there's

1422
00:46:31,750 --> 00:46:30,720
you know very low probability anything

1423
00:46:34,790 --> 00:46:31,760
outside of life

1424
00:46:36,950 --> 00:46:34,800
made this and the the

1425
00:46:38,630 --> 00:46:36,960
real business of agnostic bio signatures

1426
00:46:41,109 --> 00:46:38,640
is narrowing down

1427
00:46:42,390 --> 00:46:41,119
those probability windows to to

1428
00:46:45,349 --> 00:46:42,400
something

1429
00:46:46,710 --> 00:46:45,359
resembling certainty um through using uh

1430
00:46:49,030 --> 00:46:46,720
different methods

1431
00:46:49,750 --> 00:46:49,040
um and so complementary methods that can

1432
00:46:52,470 --> 00:46:49,760
help you

1433
00:46:53,510 --> 00:46:52,480
uh identify through through

1434
00:46:56,470 --> 00:46:53,520
probabilities

1435
00:46:58,870 --> 00:46:56,480
because yeah you're there's a strong

1436
00:47:01,349 --> 00:46:58,880
potential for misidentifications if

1437
00:47:02,630 --> 00:47:01,359
you're just using analogy for example to

1438
00:47:05,109 --> 00:47:02,640

life on earth

1439
00:47:06,470 --> 00:47:05,119
and not trying to employ this idea of

1440
00:47:09,750 --> 00:47:06,480
probability

1441
00:47:09,990 --> 00:47:09,760
i think another kind of example that i

1442
00:47:13,109 --> 00:47:10,000
try

1443
00:47:15,190 --> 00:47:13,119
to give for that is um the way people

1444
00:47:16,870 --> 00:47:15,200
have actually approached finding life in

1445
00:47:17,910 --> 00:47:16,880
deep time on earth

1446
00:47:19,829 --> 00:47:17,920
you know we like to think of

1447
00:47:21,270 --> 00:47:19,839
astrobiology as this new thing that's

1448
00:47:23,190 --> 00:47:21,280
very cutting edge and

1449
00:47:24,950 --> 00:47:23,200
you know buzzing machines and going to

1450
00:47:26,710 --> 00:47:24,960
space but finding life

1451
00:47:28,390 --> 00:47:26,720
is is something that paleontologists

1452
00:47:29,910 --> 00:47:28,400
have been doing for hundreds of years

1453
00:47:31,829 --> 00:47:29,920
and a lot of times you're looking at

1454
00:47:33,589 --> 00:47:31,839
life that doesn't didn't look anything

1455
00:47:35,589 --> 00:47:33,599
like life looks like now

1456
00:47:37,589 --> 00:47:35,599
if you look at the ediacaran period

1457
00:47:40,069 --> 00:47:37,599
there's weird life life was

1458
00:47:40,630 --> 00:47:40,079
hugely experimental and making crazy

1459
00:47:43,030 --> 00:47:40,640
shaped

1460
00:47:43,670 --> 00:47:43,040
sea creatures that aren't around anymore

1461
00:47:46,390 --> 00:47:43,680
and so when

1462
00:47:47,430 --> 00:47:46,400
paleontologists would find that they

1463
00:47:49,030 --> 00:47:47,440

they could say

1464
00:47:50,870 --> 00:47:49,040
well this is clearly not life because

1465
00:47:53,270 --> 00:47:50,880
nothing i've ever seen looks like this

1466
00:47:53,990 --> 00:47:53,280
before we don't have six eyed creatures

1467
00:47:57,349 --> 00:47:54,000
that look like

1468
00:47:59,030 --> 00:47:57,359
a bathmat but the other

1469
00:48:01,190 --> 00:47:59,040
more sophisticated sort of agnostic

1470
00:48:04,870 --> 00:48:01,200
biosignatures approach would be to say

1471
00:48:07,670 --> 00:48:04,880
i don't know of any way in geology

1472
00:48:08,630 --> 00:48:07,680
that sediments would arrange themselves

1473
00:48:11,589 --> 00:48:08,640
in this way

1474
00:48:13,030 --> 00:48:11,599
without some sort of outside forcing

1475
00:48:15,109 --> 00:48:13,040
some sort of energy

1476
00:48:17,430 --> 00:48:15,119
that could be life to get them to take

1477
00:48:17,829 --> 00:48:17,440
this weird pattern that i'm seeing in

1478
00:48:20,790 --> 00:48:17,839
this

1479
00:48:22,470 --> 00:48:20,800
rock and so that's a way that i would

1480
00:48:23,990 --> 00:48:22,480
encourage people to really think about

1481
00:48:26,069 --> 00:48:24,000
agnostic bio signatures

1482
00:48:27,190 --> 00:48:26,079
that it's not that crazy that we've had

1483
00:48:30,230 --> 00:48:27,200
to do it before

1484
00:48:32,870 --> 00:48:30,240
and before when we had amazing you know

1485
00:48:35,510 --> 00:48:32,880
chemistry tool sets to complement

1486
00:48:37,030 --> 00:48:35,520
finding a strange critter in the rock

1487
00:48:39,829 --> 00:48:37,040
yeah i can't imagine some of those like

1488
00:48:40,630 --> 00:48:39,839

victorian era paleontology finding some

1489
00:48:42,390 --> 00:48:40,640
of these weird

1490
00:48:44,309 --> 00:48:42,400
structures and being like you know is

1491
00:48:45,589 --> 00:48:44,319
this the butt or the head what is this

1492
00:48:47,670 --> 00:48:45,599
that i'm looking at

1493
00:48:49,670 --> 00:48:47,680
um i mean these are aliens of the deep

1494
00:48:51,829 --> 00:48:49,680
time aliens of the past

1495
00:48:53,430 --> 00:48:51,839
and who knows what you know ten thousand

1496
00:48:55,109 --> 00:48:53,440
ten million a hundred million years from

1497
00:48:56,309 --> 00:48:55,119
now on earth what kinds of aliens will

1498
00:48:57,990 --> 00:48:56,319
exist here then

1499
00:48:59,510 --> 00:48:58,000
compared to what we think of right now

1500
00:49:00,390 --> 00:48:59,520
so i love that approach to kind of

1501
00:49:02,470 --> 00:49:00,400
thinking

1502
00:49:04,230 --> 00:49:02,480
not just in scales of space about alien

1503
00:49:05,829 --> 00:49:04,240
life but also scales of time

1504
00:49:07,270 --> 00:49:05,839
and how things have changed and how some

1505
00:49:09,510 --> 00:49:07,280
people have been thinking about this for

1506
00:49:12,230 --> 00:49:09,520
quite a long time now in our history

1507
00:49:13,589 --> 00:49:12,240
yeah so that that mode of thinking is

1508
00:49:16,790 --> 00:49:13,599
something that we can

1509
00:49:18,390 --> 00:49:16,800
we can use in this area as well

1510
00:49:20,150 --> 00:49:18,400
uh groovy so our next question i'm going

1511
00:49:22,309 --> 00:49:20,160
to preface just for a moment

1512
00:49:23,910 --> 00:49:22,319
uh it's going to be about titan uh and a

1513
00:49:24,230 --> 00:49:23,920

lot of folks they hear like titan might

1514
00:49:27,030 --> 00:49:24,240
have

1515
00:49:28,630 --> 00:49:27,040
life titan resembles early earth but

1516
00:49:29,430 --> 00:49:28,640
then they also very rarely will hear

1517
00:49:32,390 --> 00:49:29,440
like the surface

1518
00:49:33,829 --> 00:49:32,400
titan is extremely cold and so if there

1519
00:49:35,030 --> 00:49:33,839
is a chemistry of life occurring there

1520
00:49:36,710 --> 00:49:35,040
it's probably a slightly different

1521
00:49:38,870 --> 00:49:36,720
chemistry than what we have

1522
00:49:39,750 --> 00:49:38,880
uh and so our next uh question comes

1523
00:49:42,069 --> 00:49:39,760
from

1524
00:49:43,990 --> 00:49:42,079
this month's ambassador erinava who

1525
00:49:47,030 --> 00:49:44,000
wants to know what kinds of agnostic bio

1526
00:49:47,430 --> 00:49:47,040
signatures we might expect on an organic

1527
00:49:50,549 --> 00:49:47,440
rich

1528
00:49:51,349 --> 00:49:50,559
cold moon like titan oh that's really

1529
00:49:54,230 --> 00:49:51,359
interesting

1530
00:49:56,150 --> 00:49:54,240
so i think um one thing that makes titan

1531
00:49:58,470 --> 00:49:56,160
a little bit of a challenging place

1532
00:50:00,309 --> 00:49:58,480
is because as you say it's saturated

1533
00:50:02,549 --> 00:50:00,319
with all of this organic chemistry

1534
00:50:04,790 --> 00:50:02,559
that we imagine to be like a primordial

1535
00:50:06,630 --> 00:50:04,800
earth so when we think about

1536
00:50:09,030 --> 00:50:06,640
you know this cradle of the origin of

1537
00:50:09,990 --> 00:50:09,040
life um we might imagine a whole lot of

1538
00:50:11,829 --> 00:50:10,000

the kind of

1539
00:50:14,790 --> 00:50:11,839
naturally occurring chemistry that's on

1540
00:50:17,510 --> 00:50:14,800
titan and so then what becomes the real

1541
00:50:18,790 --> 00:50:17,520
uh business of agnostic biosignatures at

1542
00:50:21,349 --> 00:50:18,800
that point is saying

1543
00:50:22,630 --> 00:50:21,359
do i see any sort of chemistry that i

1544
00:50:24,309 --> 00:50:22,640
don't expect here

1545
00:50:25,670 --> 00:50:24,319
this goes back to that importance of

1546
00:50:27,190 --> 00:50:25,680
understanding what is in an

1547
00:50:28,950 --> 00:50:27,200
asteroid because there's a whole lot of

1548
00:50:29,910 --> 00:50:28,960
stuff in asteroids that's also in

1549
00:50:33,109 --> 00:50:29,920
critters

1550
00:50:36,390 --> 00:50:33,119
and so understanding like is this um

1551
00:50:37,990 --> 00:50:36,400
whole uh community of molecules

1552
00:50:40,470 --> 00:50:38,000
something that i would expect

1553
00:50:42,069 --> 00:50:40,480
just without having life there i think

1554
00:50:43,190 --> 00:50:42,079
another way to think about agnostic

1555
00:50:45,030 --> 00:50:43,200
biosignatures

1556
00:50:47,030 --> 00:50:45,040
is by always understanding that you're

1557
00:50:49,589 --> 00:50:47,040
looking at something that's different

1558
00:50:52,150 --> 00:50:49,599
than what you expect abiotically

1559
00:50:54,309 --> 00:50:52,160
and so you know we actually don't know

1560
00:50:57,190 --> 00:50:54,319
enough about titan

1561
00:50:59,030 --> 00:50:57,200
right now to really to really give us

1562
00:51:00,230 --> 00:50:59,040
that full picture and so we'll be

1563
00:51:02,470 --> 00:51:00,240

thinking a lot about

1564
00:51:03,910 --> 00:51:02,480
analogy to what we would expect just

1565
00:51:05,670 --> 00:51:03,920
abiotically

1566
00:51:07,109 --> 00:51:05,680
you know there's lots of organic

1567
00:51:09,750 --> 00:51:07,119
chemistry that

1568
00:51:10,870 --> 00:51:09,760
um happens abiotically we can think of

1569
00:51:14,390 --> 00:51:10,880
stuff going on

1570
00:51:18,230 --> 00:51:14,400
in you know the deep ophelites in oman

1571
00:51:19,990 --> 00:51:18,240
and um you know all sorts of

1572
00:51:22,309 --> 00:51:20,000
strange you know submarine sediments

1573
00:51:23,990 --> 00:51:22,319
things like that there's there's um

1574
00:51:25,190 --> 00:51:24,000
there's abiotic organic chemistry

1575
00:51:26,069 --> 00:51:25,200
happening so we'll really have to

1576
00:51:29,270 --> 00:51:26,079
deconvolve

1577
00:51:31,510 --> 00:51:29,280
what we know we would expect um so

1578
00:51:32,630 --> 00:51:31,520
as you said it's cold do we see

1579
00:51:35,109 --> 00:51:32,640
something that we think

1580
00:51:36,790 --> 00:51:35,119
involved heat well there would be there

1581
00:51:38,630 --> 00:51:36,800
would be a way that we'd want to explore

1582
00:51:40,870 --> 00:51:38,640
could this happen abiotically or does

1583
00:51:42,549 --> 00:51:40,880
this depend on that extra energy we call

1584
00:51:44,230 --> 00:51:42,559
life

1585
00:51:45,510 --> 00:51:44,240
very groovy and it kind of makes me

1586
00:51:46,390 --> 00:51:45,520
think too about you know why we want

1587
00:51:49,589 --> 00:51:46,400
samples from

1588
00:51:51,190 --> 00:51:49,599

places to analyze to

1589
00:51:52,630 --> 00:51:51,200
kind of have a better understanding of

1590
00:51:54,630 --> 00:51:52,640
some of the abiotic

1591
00:51:57,030 --> 00:51:54,640
organic chemistry occurring in our solar

1592
00:51:58,549 --> 00:51:57,040
system not just on planetary surfaces

1593
00:52:00,470 --> 00:51:58,559
yeah i think it's really important to

1594
00:52:01,270 --> 00:52:00,480
understand what is our inheritance from

1595
00:52:03,030 --> 00:52:01,280
the universe

1596
00:52:04,630 --> 00:52:03,040
because all of this stuff came from

1597
00:52:06,230 --> 00:52:04,640
somewhere and then life did a whole

1598
00:52:07,589 --> 00:52:06,240
bunch of work on it and made a whole

1599
00:52:11,030 --> 00:52:07,599
bunch of new things that

1600
00:52:13,270 --> 00:52:11,040
new uh structures new molecules uh new

1601
00:52:14,630 --> 00:52:13,280
new patterns in nature that we wouldn't

1602
00:52:16,390 --> 00:52:14,640
have expected otherwise

1603
00:52:18,069 --> 00:52:16,400
but in order for us to really say oh

1604
00:52:19,589 --> 00:52:18,079
yeah this is a thing that came from life

1605
00:52:20,549 --> 00:52:19,599
even though i don't know that kind of

1606
00:52:22,790 --> 00:52:20,559
life that made it

1607
00:52:25,190 --> 00:52:22,800
we have to really exquisitely understand

1608
00:52:27,190 --> 00:52:25,200
that inheritance from the stars

1609
00:52:28,470 --> 00:52:27,200
absolutely so our next question comes

1610
00:52:29,910 --> 00:52:28,480
from nada linda

1611
00:52:32,309 --> 00:52:29,920
on facebook and this kind of comes to

1612
00:52:33,829 --> 00:52:32,319
that then like our inheritance as living

1613
00:52:36,630 --> 00:52:33,839

organisms on earth

1614
00:52:37,030 --> 00:52:36,640
um we have very much the same chemistry

1615
00:52:38,390 --> 00:52:37,040
across

1616
00:52:40,150 --> 00:52:38,400
all of life on earth there are some

1617
00:52:42,390 --> 00:52:40,160
small differences but

1618
00:52:43,190 --> 00:52:42,400
all of life as we know it is using dna

1619
00:52:45,910 --> 00:52:43,200
and rna

1620
00:52:47,190 --> 00:52:45,920
and proteins we're constructed of cells

1621
00:52:48,470 --> 00:52:47,200
that are roughly constrained to a

1622
00:52:50,549 --> 00:52:48,480
certain size

1623
00:52:51,829 --> 00:52:50,559
um life as we know it has a lot of

1624
00:52:53,349 --> 00:52:51,839
similarities

1625
00:52:55,510 --> 00:52:53,359
and nato wants to know from your

1626
00:52:56,230 --> 00:52:55,520
perspective uh whether or not there

1627
00:52:57,990 --> 00:52:56,240
could be other

1628
00:52:59,910 --> 00:52:58,000
information systems so do you believe

1629
00:53:01,270 --> 00:52:59,920
that dna will be a common recipe for

1630
00:53:03,030 --> 00:53:01,280
life in the universe

1631
00:53:04,790 --> 00:53:03,040
or do you think we'll most likely find

1632
00:53:05,829 --> 00:53:04,800
other other systems of storage of

1633
00:53:07,670 --> 00:53:05,839
information

1634
00:53:09,349 --> 00:53:07,680
um and i would i would offer also do you

1635
00:53:10,630 --> 00:53:09,359
think the same of things like proteins

1636
00:53:12,309 --> 00:53:10,640
in cells

1637
00:53:14,150 --> 00:53:12,319
you know that's really interesting i

1638
00:53:16,390 --> 00:53:14,160

know there's some really interesting

1639
00:53:17,430 --> 00:53:16,400
work that people do to try and

1640
00:53:19,589 --> 00:53:17,440
understand how

1641
00:53:20,549 --> 00:53:19,599
optimized certain molecules are for

1642
00:53:22,630 --> 00:53:20,559
their jobs

1643
00:53:23,670 --> 00:53:22,640
so for example there's work that shows

1644
00:53:25,910 --> 00:53:23,680
that um

1645
00:53:26,870 --> 00:53:25,920
it would be really hard to make a

1646
00:53:30,069 --> 00:53:26,880
molecule

1647
00:53:32,710 --> 00:53:30,079
as as good as or

1648
00:53:35,829 --> 00:53:32,720
not a molecule macromolecule as good as

1649
00:53:38,549 --> 00:53:35,839
ribosomes for doing the job of ribosomes

1650
00:53:41,190 --> 00:53:38,559
so if you had an information system that

1651
00:53:44,150 --> 00:53:41,200
used amino acids like ours and and

1652
00:53:45,990 --> 00:53:44,160
then you know as complementary um

1653
00:53:49,190 --> 00:53:46,000
complementarity with dna

1654
00:53:51,030 --> 00:53:49,200
you would probably have a ribosome um so

1655
00:53:52,230 --> 00:53:51,040
i think that that's one way to look at

1656
00:53:53,910 --> 00:53:52,240
it like try to think about

1657
00:53:55,750 --> 00:53:53,920
optimization of structures and

1658
00:53:58,230 --> 00:53:55,760
macromolecules is there

1659
00:53:58,870 --> 00:53:58,240
is there a potential better way i think

1660
00:54:01,030 --> 00:53:58,880
the one

1661
00:54:02,870 --> 00:54:01,040
thing that's a little bit worrisome when

1662
00:54:04,549 --> 00:54:02,880
you do that is whenever you're thinking

1663
00:54:06,470 --> 00:54:04,559

that something is optimized you're

1664
00:54:08,829 --> 00:54:06,480
making a value judgment

1665
00:54:10,470 --> 00:54:08,839
and everything about our bio our

1666
00:54:13,109 --> 00:54:10,480
biochemistry

1667
00:54:14,790 --> 00:54:13,119
has been influenced by the history of

1668
00:54:16,790 --> 00:54:14,800
this planet that we're on

1669
00:54:18,069 --> 00:54:16,800
and the raw ingredients we've had

1670
00:54:20,790 --> 00:54:18,079
available to us

1671
00:54:21,349 --> 00:54:20,800
so my caution about all of that and i

1672
00:54:23,589 --> 00:54:21,359
this is

1673
00:54:24,790 --> 00:54:23,599
kind of an answer but not really is to

1674
00:54:26,549 --> 00:54:24,800
always be thinking about

1675
00:54:27,910 --> 00:54:26,559
signals of life in their planetary

1676
00:54:29,990 --> 00:54:27,920
context

1677
00:54:31,270 --> 00:54:30,000
the one way you could think about dna is

1678
00:54:33,349 --> 00:54:31,280
that there's a lot of the raw

1679
00:54:35,589 --> 00:54:33,359
ingredients for dna

1680
00:54:37,270 --> 00:54:35,599
that come to us in meteorites there's

1681
00:54:40,230 --> 00:54:37,280
things like nucleobases

1682
00:54:40,950 --> 00:54:40,240
so just try to open up your mind to in

1683
00:54:43,349 --> 00:54:40,960
another

1684
00:54:44,710 --> 00:54:43,359
system though what possible chemistry

1685
00:54:45,589 --> 00:54:44,720
would have happened with those raw

1686
00:54:48,870 --> 00:54:45,599
ingredients

1687
00:54:50,150 --> 00:54:48,880
and it may be dna-like we have so many

1688
00:54:52,309 --> 00:54:50,160

more questions i do want to pop on my

1689
00:54:53,910 --> 00:54:52,319
own in real quick following on with that

1690
00:54:55,510 --> 00:54:53,920
because often i think about you know

1691
00:54:56,870 --> 00:54:55,520
origins of life on earth and

1692
00:54:59,190 --> 00:54:56,880
i wonder you know could there have been

1693
00:55:00,870 --> 00:54:59,200
multiple origins of life where there are

1694
00:55:03,030 --> 00:55:00,880
multiple life forms

1695
00:55:04,390 --> 00:55:03,040
and did the stuff with dna and proteins

1696
00:55:06,870 --> 00:55:04,400
and ribosomes just eat

1697
00:55:08,630 --> 00:55:06,880
everything else i wonder what your your

1698
00:55:10,230 --> 00:55:08,640
vision of the earliest

1699
00:55:12,069 --> 00:55:10,240
life on earth might be do you think it

1700
00:55:13,430 --> 00:55:12,079
was something like multiple forms of

1701
00:55:14,870 --> 00:55:13,440
life kind of doing all these different

1702
00:55:17,030 --> 00:55:14,880
energy transitions

1703
00:55:18,230 --> 00:55:17,040
um what would you envision for for early

1704
00:55:21,510 --> 00:55:18,240
life on earth

1705
00:55:22,950 --> 00:55:21,520
you know i think um i'm going to answer

1706
00:55:25,430 --> 00:55:22,960
that by augmenting that

1707
00:55:27,829 --> 00:55:25,440
which is to say why do we think there

1708
00:55:28,789 --> 00:55:27,839
was only one time period where life was

1709
00:55:30,549 --> 00:55:28,799
originating

1710
00:55:33,270 --> 00:55:30,559
what would keep us from thinking there's

1711
00:55:34,309 --> 00:55:33,280
maybe not a new kind of life originating

1712
00:55:36,390 --> 00:55:34,319
right now

1713
00:55:37,670 --> 00:55:36,400

in some far-flung weird part of our

1714
00:55:39,750 --> 00:55:37,680
planet that's

1715
00:55:42,390 --> 00:55:39,760
a little bit chemically different from

1716
00:55:45,349 --> 00:55:42,400
us that would have a different set of

1717
00:55:46,950 --> 00:55:45,359
um constraints that a different system

1718
00:55:48,630 --> 00:55:46,960
might be more amenable to

1719
00:55:50,710 --> 00:55:48,640
that's something to think about it may

1720
00:55:54,069 --> 00:55:50,720
have not just been one event

1721
00:55:55,109 --> 00:55:54,079
and um so when i also think about the

1722
00:55:56,630 --> 00:55:55,119
origin of life

1723
00:55:58,789 --> 00:55:56,640
and that sort of thing i also think

1724
00:56:02,470 --> 00:55:58,799
about the fact that we've had

1725
00:56:04,390 --> 00:56:02,480
billions of years of history and there's

1726
00:56:06,630 --> 00:56:04,400
every possibility that there are things

1727
00:56:08,549 --> 00:56:06,640
that aren't quite related enough to us

1728
00:56:11,030 --> 00:56:08,559
that we don't have the tools to see

1729
00:56:13,030 --> 00:56:11,040
so sometimes when we're thinking about

1730
00:56:15,750 --> 00:56:13,040
life that's a little bit different from

1731
00:56:16,390 --> 00:56:15,760
ours um we should be thinking about here

1732
00:56:18,630 --> 00:56:16,400
on earth

1733
00:56:20,710 --> 00:56:18,640
if you've heard recently about you know

1734
00:56:22,069 --> 00:56:20,720
this virus that has slightly different

1735
00:56:24,470 --> 00:56:22,079
dna than we do

1736
00:56:26,549 --> 00:56:24,480
is that a new life form how do we decide

1737
00:56:27,349 --> 00:56:26,559
if that is that's a really intriguing

1738
00:56:29,510 --> 00:56:27,359

question

1739
00:56:31,270 --> 00:56:29,520
so i think my answer to that is i don't

1740
00:56:33,109 --> 00:56:31,280
really think about the origin of life

1741
00:56:34,230 --> 00:56:33,119
but the origins of life and the fact

1742
00:56:36,630 --> 00:56:34,240
that that could be

1743
00:56:38,710 --> 00:56:36,640
a contemporary activity as well as

1744
00:56:40,470 --> 00:56:38,720
something in the distant past

1745
00:56:42,309 --> 00:56:40,480
i love it and so that kind of feeds into

1746
00:56:45,670 --> 00:56:42,319
our next question uh so t

1747
00:56:48,069 --> 00:56:45,680
vent reedy uh on facebook wants to know

1748
00:56:49,990 --> 00:56:48,079
um about the concept of panspermia and

1749
00:56:52,309 --> 00:56:50,000
this idea that maybe life didn't

1750
00:56:53,349 --> 00:56:52,319
you know didn't have an origin at all

1751
00:56:54,950 --> 00:56:53,359
here on earth or

1752
00:56:57,030 --> 00:56:54,960
at least the main origin here on earth

1753
00:56:57,990 --> 00:56:57,040
maybe there were origins on mars origins

1754
00:56:59,750 --> 00:56:58,000
on venus

1755
00:57:01,910 --> 00:56:59,760
and other worlds that kind of came here

1756
00:57:04,710 --> 00:57:01,920
later or you know born on rocks

1757
00:57:05,990 --> 00:57:04,720
uh tiven wants to know then um bringing

1758
00:57:07,349 --> 00:57:06,000
samples back from something like

1759
00:57:09,750 --> 00:57:07,359
osiris-rex

1760
00:57:11,510 --> 00:57:09,760
do we expect there could be signs of

1761
00:57:14,470 --> 00:57:11,520
actual biosignatures agnostic

1762
00:57:15,670 --> 00:57:14,480
biosignatures from osiris-rex

1763
00:57:17,670 --> 00:57:15,680

you know i don't really look at

1764
00:57:19,829 --> 00:57:17,680
osiris-rex that way or

1765
00:57:21,910 --> 00:57:19,839
or bennu that way i really look at that

1766
00:57:22,870 --> 00:57:21,920
as understanding what is our abiotic

1767
00:57:26,069 --> 00:57:22,880
background

1768
00:57:26,950 --> 00:57:26,079
and you know i think you know maybe

1769
00:57:28,710 --> 00:57:26,960
that's sad to

1770
00:57:29,990 --> 00:57:28,720
know that i don't necessarily think that

1771
00:57:32,870 --> 00:57:30,000
could be something living there

1772
00:57:33,270 --> 00:57:32,880
but space is a really terrible place and

1773
00:57:34,870 --> 00:57:33,280
so

1774
00:57:37,109 --> 00:57:34,880
the kind of constraints that you would

1775
00:57:39,349 --> 00:57:37,119
have to deal with on a rocky

1776
00:57:40,549 --> 00:57:39,359
body hurtling around in the solar system

1777
00:57:42,870 --> 00:57:40,559
for billions of years

1778
00:57:44,630 --> 00:57:42,880
where there's not a whole lot of

1779
00:57:46,069 --> 00:57:44,640
protection there's not a whole lot of

1780
00:57:48,150 --> 00:57:46,079
water

1781
00:57:50,549 --> 00:57:48,160
there's not a whole lot of weathering

1782
00:57:52,470 --> 00:57:50,559
making anything particularly available

1783
00:57:55,109 --> 00:57:52,480
to you if you are an organism

1784
00:57:56,870 --> 00:57:55,119
added on to the fact that you're exposed

1785
00:57:59,510 --> 00:57:56,880
to all this cosmic radiation

1786
00:58:00,950 --> 00:57:59,520
it's a tough life if it is one um so i

1787
00:58:01,270 --> 00:58:00,960
think that's part of the motivation for

1788
00:58:03,030 --> 00:58:01,280

not

1789
00:58:04,549 --> 00:58:03,040
necessarily thinking there's something

1790
00:58:06,309 --> 00:58:04,559
on those rocks

1791
00:58:07,829 --> 00:58:06,319
and i think the other thing that i would

1792
00:58:09,030 --> 00:58:07,839
always get people to remember when

1793
00:58:10,230 --> 00:58:09,040
you're talking about something like

1794
00:58:12,870 --> 00:58:10,240
panspermia

1795
00:58:14,950 --> 00:58:12,880
is is the pathways that these rocks are

1796
00:58:17,510 --> 00:58:14,960
taking through the solar system

1797
00:58:18,390 --> 00:58:17,520
it's not necessarily a highway to a

1798
00:58:21,030 --> 00:58:18,400
planet where

1799
00:58:22,630 --> 00:58:21,040
life you know hops off at that bus stop

1800
00:58:24,950 --> 00:58:22,640
um we're all we're part of these

1801
00:58:27,510 --> 00:58:24,960
enormous ellipses in space that

1802
00:58:28,870 --> 00:58:27,520
aren't necessarily colliding in the way

1803
00:58:31,589 --> 00:58:28,880
that you would imagine

1804
00:58:34,230 --> 00:58:31,599
if you're trying to think about um a

1805
00:58:35,910 --> 00:58:34,240
galactic pathway for life

1806
00:58:37,670 --> 00:58:35,920
well that's so cool heather it's been so

1807
00:58:39,270 --> 00:58:37,680
much fun having you on the show

1808
00:58:40,950 --> 00:58:39,280
i knew i was just like my little nerd

1809
00:58:42,789 --> 00:58:40,960
tingles going on over here thinking

1810
00:58:43,589 --> 00:58:42,799
about agnostic bio signatures and rock

1811
00:58:46,150 --> 00:58:43,599
operas and

1812
00:58:47,030 --> 00:58:46,160
all of this cool stuff um for those who

1813
00:58:48,549 --> 00:58:47,040

are watching

1814
00:58:50,309 --> 00:58:48,559
you know what do you think when you hear

1815
00:58:52,309 --> 00:58:50,319
agnostic biosignature

1816
00:58:55,190 --> 00:58:52,319
uh what do you want to explore in

1817
00:58:57,109 --> 00:58:55,200
looking for potential signs of life or

1818
00:58:58,870 --> 00:58:57,119
in doing physics detections out there in

1819
00:59:01,430 --> 00:58:58,880
the cosmos let us know

1820
00:59:03,270 --> 00:59:01,440
on twitter and on our other social media

1821
00:59:04,309 --> 00:59:03,280
on twitter you can find us at nasa

1822
00:59:07,270 --> 00:59:04,319
astrobio

1823
00:59:09,349 --> 00:59:07,280
and at seganorg you can certainly reach

1824
00:59:10,150 --> 00:59:09,359
out to myself i'm sure dr graham would

1825
00:59:11,589 --> 00:59:10,160
love to also

1826
00:59:13,510 --> 00:59:11,599
continue the conversation with you

1827
00:59:15,270 --> 00:59:13,520
online in the public arena

1828
00:59:16,630 --> 00:59:15,280
i do apologize i couldn't get to all of

1829
00:59:19,589 --> 00:59:16,640
the questions but there were just so

1830
00:59:20,870 --> 00:59:19,599
many good ones uh it's so hard uh but dr

1831
00:59:23,109 --> 00:59:20,880
heather graham thank you so much for

1832
00:59:25,109 --> 00:59:23,119
joining us for ask an astrobiologist

1833
00:59:26,230 --> 00:59:25,119
thank you so much everyone it's been a

1834
00:59:28,710 --> 00:59:26,240
pleasure

1835
00:59:29,990 --> 00:59:28,720
so great having you on um for those who

1836
00:59:30,470 --> 00:59:30,000
do want to stay in the loop with our

1837
00:59:32,710 --> 00:59:30,480
show

1838
00:59:34,630 --> 00:59:32,720

or other events and activities going on

1839
00:59:36,309 --> 00:59:34,640
through nasa astrobiology

1840
00:59:37,829 --> 00:59:36,319
including things from the laboratory for

1841
00:59:40,069 --> 00:59:37,839
agnostic biosignatures

1842
00:59:41,670 --> 00:59:40,079
or the network for life detection you

1843
00:59:45,430 --> 00:59:41,680
can sign up to join

1844
00:59:47,589 --> 00:59:45,440
the email list from nasa astrobiology

1845
00:59:48,710 --> 00:59:47,599
and so once again thank you dr heather

1846
00:59:51,109 --> 00:59:48,720
graham for joining us

1847
00:59:51,910 --> 00:59:51,119
thank you everyone for watching we truly

1848
00:59:55,200 --> 00:59:51,920
appreciate it

1849
00:59:58,829 --> 00:59:55,210
and until next time remember stay

1850
01:00:00,650 --> 00:59:58,839
[Music]