



EPISODE 48: MARCH 30TH, 2022

DR. STEPHANIE GETTY & DR. RICHARD QUINN



Astrobiology Program

1
00:00:01,120 --> 00:00:30,230

[Music]

2
00:00:36,310 --> 00:00:33,030

greetings friends fellow enthusiasts of

3
00:00:38,549 --> 00:00:36,320

astrobiology and explorers of all ages

4
00:00:40,790 --> 00:00:38,559

and welcome to ask an astrobiologist a

5
00:00:42,950 --> 00:00:40,800

show that celebrates the science and

6
00:00:44,549 --> 00:00:42,960

celebrates the scientists involved in

7
00:00:45,510 --> 00:00:44,559

our quest to understand the nature of

8
00:00:47,910 --> 00:00:45,520

life

9
00:00:49,750 --> 00:00:47,920

i'm your host dr graham wow and we're

10
00:00:52,150 --> 00:00:49,760

brought to you by the nasa astrobiology

11
00:00:53,750 --> 00:00:52,160

program and saginet.org

12
00:00:56,069 --> 00:00:53,760

as always we want to give a huge shout

13
00:00:57,990 --> 00:00:56,079

out to those out there who share about

14

00:01:00,069 --> 00:00:58,000

our show and interact with our guests

15

00:01:01,670 --> 00:01:00,079

and talk about astrobiology with us on

16

00:01:02,790 --> 00:01:01,680

twitter and all the other places you can

17

00:01:04,549 --> 00:01:02,800

find us

18

00:01:07,030 --> 00:01:04,559

this month we want to highlight garrett

19

00:01:09,190 --> 00:01:07,040

champion for sharing on twitter about

20

00:01:10,789 --> 00:01:09,200

today's episode though later on in the

21

00:01:12,710 --> 00:01:10,799

show we'll also talk about many of you

22

00:01:14,550 --> 00:01:12,720

who've been sharing and talking about

23

00:01:16,789 --> 00:01:14,560

technology and instruments in

24

00:01:19,190 --> 00:01:16,799

astrobiology and that's exactly what

25

00:01:20,950 --> 00:01:19,200

today's episode is is going to focus on

26

00:01:23,749 --> 00:01:20,960

we have two researchers from nasa

27

00:01:25,590 --> 00:01:23,759

joining us who've both been involved in

28

00:01:27,990 --> 00:01:25,600

the technology and the science of

29

00:01:30,469 --> 00:01:28,000

astrobiology and how we look for life

30

00:01:32,710 --> 00:01:30,479

out there just this past week the nasa

31

00:01:34,630 --> 00:01:32,720

astrobiology program

32

00:01:38,149 --> 00:01:34,640

and the enfold or network for life

33

00:01:40,950 --> 00:01:38,159

detection rcn together put on a workshop

34

00:01:43,830 --> 00:01:40,960

called the future of the search for life

35

00:01:46,389 --> 00:01:43,840

or fossil bringing together researchers

36

00:01:48,230 --> 00:01:46,399

and technologists involved in the

37

00:01:50,710 --> 00:01:48,240

synergies and the intersections of how

38

00:01:53,030 --> 00:01:50,720

we develop instruments and technology

39

00:01:55,270 --> 00:01:53,040

for conducting life detection science

40

00:01:57,670 --> 00:01:55,280

and both of today's guests were involved

41

00:01:59,830 --> 00:01:57,680

in the committee organizing this exact

42

00:02:01,590 --> 00:01:59,840

meeting so without further ado i'd like

43

00:02:03,510 --> 00:02:01,600

to bring both of them on i'll introduce

44

00:02:05,670 --> 00:02:03,520

both first and then we can say hello

45

00:02:08,150 --> 00:02:05,680

uh dr stephanie getty is the acting

46

00:02:10,070 --> 00:02:08,160

director of the solar system exploration

47

00:02:12,309 --> 00:02:10,080

division and a planetary research

48

00:02:14,630 --> 00:02:12,319

scientist at nasa's goddard space flight

49

00:02:17,670 --> 00:02:14,640

center her research interests are in the

50

00:02:19,350 --> 00:02:17,680

area of in-situ planetary exploration

51
00:02:21,830 --> 00:02:19,360
particularly in the pursuit of

52
00:02:23,350 --> 00:02:21,840
understanding the origin and evolution

53
00:02:25,750 --> 00:02:23,360
of past and present habitable

54
00:02:27,030 --> 00:02:25,760
environments in our solar system she is

55
00:02:28,790 --> 00:02:27,040
currently the deputy principal

56
00:02:30,470 --> 00:02:28,800
investigator as well of the da vinci

57
00:02:32,070 --> 00:02:30,480
mission to venus

58
00:02:34,229 --> 00:02:32,080
and then we also have joining us dr

59
00:02:36,309 --> 00:02:34,239
richard quinn he's a research scientist

60
00:02:38,309 --> 00:02:36,319
at nasa's ames research center he's been

61
00:02:40,070 --> 00:02:38,319
involved in a variety of projects

62
00:02:42,070 --> 00:02:40,080
involving instrument and technology

63
00:02:44,309 --> 00:02:42,080

development for earth and space

64

00:02:46,949 --> 00:02:44,319

exploration including research in the

65

00:02:49,910 --> 00:02:46,959

atacama desert on instrumentation for

66

00:02:51,830 --> 00:02:49,920

mars exploration and technologies for

67

00:02:53,670 --> 00:02:51,840

exploring the icy worlds of our solar

68

00:02:55,589 --> 00:02:53,680

system he's also a member of the

69

00:02:58,229 --> 00:02:55,599

steering committee for the rcn called

70

00:02:59,830 --> 00:02:58,239

the network for ocean worlds or now uh

71

00:03:00,949 --> 00:02:59,840

so doctors getty and quinn thank you

72

00:03:03,190 --> 00:03:00,959

both for joining us for ask an

73

00:03:05,509 --> 00:03:03,200

astrobiologist

74

00:03:07,030 --> 00:03:05,519

uh you're welcome glad to be here

75

00:03:09,190 --> 00:03:07,040

glad to be here graham thanks for the

76

00:03:11,430 --> 00:03:09,200

invitation yeah this is super exciting

77

00:03:13,509 --> 00:03:11,440

to have you on uh i wanted to talk about

78

00:03:15,509 --> 00:03:13,519

the builder show for some time now but

79

00:03:17,670 --> 00:03:15,519

our main impetus was to talk primarily

80

00:03:19,030 --> 00:03:17,680

to start off with this workshop that

81

00:03:21,030 --> 00:03:19,040

we've convened

82

00:03:23,030 --> 00:03:21,040

after biology

83

00:03:24,789 --> 00:03:23,040

and so i'm wondering um

84

00:03:27,670 --> 00:03:24,799

stephanie you don't mind what were the

85

00:03:29,350 --> 00:03:27,680

motivations for the fossil workshop uh

86

00:03:31,190 --> 00:03:29,360

and what was really the need to have

87

00:03:34,229 --> 00:03:31,200

this workshop

88

00:03:35,910 --> 00:03:34,239

well that is um an appreciated question

89

00:03:37,990 --> 00:03:35,920

and i hope that richard gets a chance to

90

00:03:39,830 --> 00:03:38,000

respond to because he's been so central

91

00:03:40,949 --> 00:03:39,840

to the organization of this workshop but

92

00:03:42,390 --> 00:03:40,959

of course

93

00:03:44,869 --> 00:03:42,400

you know life detection is one of those

94

00:03:46,550 --> 00:03:44,879

profound um

95

00:03:48,550 --> 00:03:46,560

opportunities that we have now that

96

00:03:50,710 --> 00:03:48,560

we're learning more about habitable

97

00:03:53,030 --> 00:03:50,720

environments throughout our solar system

98

00:03:55,589 --> 00:03:53,040

and beyond right but this workshop

99

00:03:57,509 --> 00:03:55,599

really focuses on the concept of being

100

00:04:00,789 --> 00:03:57,519

able to go and visit a habitable

101
00:04:04,630 --> 00:04:00,799
environment and how would we confidently

102
00:04:06,470 --> 00:04:04,640
um detect life uh uh you know answers we

103
00:04:09,350 --> 00:04:06,480
have questions about

104
00:04:11,509 --> 00:04:09,360
uh the development of life in some of

105
00:04:14,550 --> 00:04:11,519
these

106
00:04:18,150 --> 00:04:14,560
solar system so we don't

107
00:04:19,749 --> 00:04:18,160
uh fully know how uh how to to do that

108
00:04:21,990 --> 00:04:19,759
in a comprehensive way and for all

109
00:04:24,070 --> 00:04:22,000
environments and so we're holding this

110
00:04:25,909 --> 00:04:24,080
workshop to really engage

111
00:04:27,749 --> 00:04:25,919
um the communities that are gonna be

112
00:04:29,670 --> 00:04:27,759
thankful to answering this question from

113
00:04:32,870 --> 00:04:29,680

the science community

114

00:04:35,430 --> 00:04:32,880

really broadly engaging

115

00:04:36,390 --> 00:04:35,440

not only seasoned planetary scientists

116

00:04:39,430 --> 00:04:36,400

but also

117

00:04:41,430 --> 00:04:39,440

new minds uh in the pursuit of this this

118

00:04:43,350 --> 00:04:41,440

question but also we also need

119

00:04:45,350 --> 00:04:43,360

technologists and we need engineers to

120

00:04:47,909 --> 00:04:45,360

realize those goals so this workshop is

121

00:04:50,390 --> 00:04:47,919

really um you know has the objective of

122

00:04:53,189 --> 00:04:50,400

bringing together those communities and

123

00:04:55,670 --> 00:04:53,199

uh and taking a systematic um a

124

00:04:58,550 --> 00:04:55,680

combination of systematic and kind of

125

00:05:00,870 --> 00:04:58,560

creative approaches uh to uh to coming

126

00:05:02,870 --> 00:05:00,880

up with new ideas and then following

127

00:05:05,350 --> 00:05:02,880

those ideas through to thinking through

128

00:05:06,629 --> 00:05:05,360

you know what would really face um those

129

00:05:08,710 --> 00:05:06,639

uh those

130

00:05:10,870 --> 00:05:08,720

measurements and the technologies would

131

00:05:12,390 --> 00:05:10,880

be that would be required to be a

132

00:05:14,070 --> 00:05:12,400

reality

133

00:05:15,189 --> 00:05:14,080

fantastic yeah i'm glad to mention these

134

00:05:17,189 --> 00:05:15,199

different communities that are coming

135

00:05:18,950 --> 00:05:17,199

together for this workshop as well you

136

00:05:20,550 --> 00:05:18,960

know a lot of us think about things like

137

00:05:22,390 --> 00:05:20,560

you know engineers tell scientists we

138

00:05:24,070 --> 00:05:22,400

can only land in certain places on mars

139

00:05:25,189 --> 00:05:24,080

but then scientists want to do certain

140

00:05:27,029 --> 00:05:25,199

science and so we have to ask the

141

00:05:29,110 --> 00:05:27,039

engineers what can we do

142

00:05:31,430 --> 00:05:29,120

and so richard for you

143

00:05:33,110 --> 00:05:31,440

what do we actually need to do to

144

00:05:35,189 --> 00:05:33,120

integrate more of this knowledge from

145

00:05:37,189 --> 00:05:35,199

science and engineering

146

00:05:38,629 --> 00:05:37,199

and will this workshop get us there or

147

00:05:40,629 --> 00:05:38,639

what is kind of the long-term product

148

00:05:43,029 --> 00:05:40,639

then from this meeting

149

00:05:45,990 --> 00:05:43,039

well i think that this workshop is is a

150

00:05:47,430 --> 00:05:46,000

start and there are other um you know uh

151
00:05:49,909 --> 00:05:47,440
people working to bring these

152
00:05:53,029 --> 00:05:49,919
communities together and and you know

153
00:05:54,710 --> 00:05:53,039
early on when people were being invited

154
00:05:56,230 --> 00:05:54,720
and started participating they

155
00:05:58,390 --> 00:05:56,240
immediately recognized that there's a

156
00:06:00,950 --> 00:05:58,400
real need to get engineers into the

157
00:06:01,909 --> 00:06:00,960
conversation early i think a lot of

158
00:06:03,510 --> 00:06:01,919
times

159
00:06:05,510 --> 00:06:03,520
you know the scientists they have their

160
00:06:06,870 --> 00:06:05,520
ideas their hypothesis and they pursue

161
00:06:08,790 --> 00:06:06,880
it down a path

162
00:06:10,629 --> 00:06:08,800
and it's uh quite a while before they

163
00:06:12,150 --> 00:06:10,639

actually come back to the reality of how

164

00:06:13,749 --> 00:06:12,160

do you actually implement this and

165

00:06:15,430 --> 00:06:13,759

getting that conversation going with

166

00:06:17,189 --> 00:06:15,440

engineers

167

00:06:18,710 --> 00:06:17,199

so i think that this workshop is a

168

00:06:20,950 --> 00:06:18,720

really good forum for that for bringing

169

00:06:21,909 --> 00:06:20,960

those two groups together

170

00:06:23,189 --> 00:06:21,919

wonderful

171

00:06:25,590 --> 00:06:23,199

so

172

00:06:27,510 --> 00:06:25,600

a little bit with both of you to talk a

173

00:06:30,469 --> 00:06:27,520

little bit about the pathways of

174

00:06:32,070 --> 00:06:30,479

instrument development um so stephanie

175

00:06:34,150 --> 00:06:32,080

what instruments have you personally

176

00:06:35,510 --> 00:06:34,160

been involved with for one thing but

177

00:06:36,710 --> 00:06:35,520

then also what is it like to be a

178

00:06:38,309 --> 00:06:36,720

scientist working with these

179

00:06:40,309 --> 00:06:38,319

technologies that we send to other

180

00:06:41,670 --> 00:06:40,319

worlds and then we have you know years

181

00:06:43,189 --> 00:06:41,680

of data collection bringing that

182

00:06:44,629 --> 00:06:43,199

information back to us

183

00:06:46,390 --> 00:06:44,639

studying it

184

00:06:48,790 --> 00:06:46,400

there are so many questions in that

185

00:06:50,710 --> 00:06:48,800

question graham but i will try to answer

186

00:06:52,870 --> 00:06:50,720

them

187

00:06:54,629 --> 00:06:52,880

so i'll run through the list i guess

188

00:06:57,029 --> 00:06:54,639

i've i've watched um

189

00:07:00,230 --> 00:06:57,039

several instruments get built during my

190

00:07:01,189 --> 00:07:00,240

career at nasa they've primarily been in

191

00:07:02,550 --> 00:07:01,199

situ

192

00:07:04,629 --> 00:07:02,560

analytical

193

00:07:06,150 --> 00:07:04,639

instruments

194

00:07:07,350 --> 00:07:06,160

typically with mass spectrometry

195

00:07:10,150 --> 00:07:07,360

involved

196

00:07:12,790 --> 00:07:10,160

i watched uh the sample analysis at mars

197

00:07:14,550 --> 00:07:12,800

instrument suite get built and delivered

198

00:07:17,110 --> 00:07:14,560

to myers science laboratory and now it's

199

00:07:20,070 --> 00:07:17,120

nearing 10 years of incredible

200

00:07:23,189 --> 00:07:20,080

operations at gale crater on mars um

201
00:07:25,510 --> 00:07:23,199
watched the neutral gas and ion mass

202
00:07:27,029 --> 00:07:25,520
spectrometer engines get developed from

203
00:07:29,430 --> 00:07:27,039
the maven mission which is still

204
00:07:31,189 --> 00:07:29,440
orbiting around mars making discoveries

205
00:07:33,189 --> 00:07:31,199
there um

206
00:07:35,909 --> 00:07:33,199
ionic neutral mass spectrometer for

207
00:07:38,390 --> 00:07:35,919
laddie uh which was an orbiter around

208
00:07:41,749 --> 00:07:38,400
the moon um and then you know i was

209
00:07:43,749 --> 00:07:41,759
really uh in the room for a lot of um

210
00:07:47,350 --> 00:07:43,759
the development of the mars organic

211
00:07:50,950 --> 00:07:47,360
molecule analyzer moma mass spectrometer

212
00:07:53,510 --> 00:07:50,960
which was delivered to the mars rover

213
00:07:56,790 --> 00:07:53,520

and now i have the real privilege to

214

00:07:58,070 --> 00:07:56,800

work in the same groups that are

215

00:08:00,550 --> 00:07:58,080

and with the same groups that are

216

00:08:03,749 --> 00:08:00,560

developing drams the dragonfly mass

217

00:08:06,070 --> 00:08:03,759

spectrometer for uh titan titan moon uh

218

00:08:08,469 --> 00:08:06,080

mission dragonfly um

219

00:08:10,869 --> 00:08:08,479

and you mentioned a deputy pi one of the

220

00:08:12,710 --> 00:08:10,879

two wpi's for davinci

221

00:08:14,950 --> 00:08:12,720

admission to venus and we'll be flying

222

00:08:17,589 --> 00:08:14,960

the venus mass spectrometer on that

223

00:08:21,189 --> 00:08:17,599

probe through the atmosphere uh to the

224

00:08:22,230 --> 00:08:21,199

near surface of venus um so uh so that's

225

00:08:25,270 --> 00:08:22,240

that's

226

00:08:28,309 --> 00:08:25,280

my most direct connection to

227

00:08:30,550 --> 00:08:28,319

in-situ instrumentation for space flight

228

00:08:33,190 --> 00:08:30,560

and then you kind of asked um you know

229

00:08:35,350 --> 00:08:33,200

what does it take to you know to really

230

00:08:37,589 --> 00:08:35,360

develop these things i think of it as

231

00:08:39,110 --> 00:08:37,599

like kind of a series of questions i

232

00:08:42,230 --> 00:08:39,120

promise i will not describe all the

233

00:08:44,070 --> 00:08:42,240

technology readiness levels um right now

234

00:08:46,150 --> 00:08:44,080

which there are nine of them um they're

235

00:08:47,190 --> 00:08:46,160

called trls um but i'm not going to talk

236

00:08:48,630 --> 00:08:47,200

about them

237

00:08:49,990 --> 00:08:48,640

but you can think about a series of

238

00:08:52,150 --> 00:08:50,000

questions like

239

00:08:54,150 --> 00:08:52,160

you know you have a science question

240

00:08:56,070 --> 00:08:54,160

what measurement or piece of measurement

241

00:08:58,230 --> 00:08:56,080

do you want to make to answer that

242

00:09:00,230 --> 00:08:58,240

science question how do you do that with

243

00:09:02,230 --> 00:09:00,240

a particular instrument or a particular

244

00:09:05,190 --> 00:09:02,240

technique does that

245

00:09:07,430 --> 00:09:05,200

technique work in the lab does that

246

00:09:08,790 --> 00:09:07,440

thing measure the other thing you're

247

00:09:11,110 --> 00:09:08,800

trying to measure with sufficient

248

00:09:13,509 --> 00:09:11,120

performance you know can the thing fit

249

00:09:15,509 --> 00:09:13,519

on a spacecraft and if not you have to

250

00:09:16,710 --> 00:09:15,519

probably build a you know a version of

251
00:09:18,870 --> 00:09:16,720
it that does

252
00:09:21,670 --> 00:09:18,880
um to fit within volume and mass and

253
00:09:23,430 --> 00:09:21,680
power requirements of the mission then

254
00:09:24,949 --> 00:09:23,440
you ask does the thing still work after

255
00:09:27,350 --> 00:09:24,959
you make it small enough to fit on a

256
00:09:29,269 --> 00:09:27,360
spacecraft and then you have to test it

257
00:09:30,550 --> 00:09:29,279
under the environments that it will

258
00:09:32,630 --> 00:09:30,560
experience so not only in the

259
00:09:34,870 --> 00:09:32,640
environment of the eventual you know

260
00:09:36,870 --> 00:09:34,880
mission

261
00:09:39,670 --> 00:09:36,880
for operate science operations but also

262
00:09:41,829 --> 00:09:39,680
will it survive launch and will it's if

263
00:09:44,230 --> 00:09:41,839

it has to land does it survive the

264

00:09:46,550 --> 00:09:44,240

landing conditions so you really put i

265

00:09:49,670 --> 00:09:46,560

mean it's a it's a process it takes

266

00:09:51,910 --> 00:09:49,680

years as you might imagine um but uh but

267

00:09:55,030 --> 00:09:51,920

it's but it's logical and it you know in

268

00:09:56,870 --> 00:09:55,040

a series of steps you you just ask these

269

00:09:58,790 --> 00:09:56,880

harder and harder questions of the of

270

00:10:00,790 --> 00:09:58,800

the thing you want to build

271

00:10:01,829 --> 00:10:00,800

that's so awesome i do have to say i'm a

272

00:10:02,790 --> 00:10:01,839

little jealous with all these

273

00:10:04,870 --> 00:10:02,800

instruments you mentioned that you've

274

00:10:06,630 --> 00:10:04,880

had involvement with um

275

00:10:08,310 --> 00:10:06,640

you know being involved around

276

00:10:09,990 --> 00:10:08,320

instruments going to the moon and mars

277

00:10:11,110 --> 00:10:10,000

and venus and all these different places

278

00:10:14,150 --> 00:10:11,120

i mean that's fantastic and then

279

00:10:15,509 --> 00:10:14,160

dragonfly coming up um that's so cool uh

280

00:10:16,710 --> 00:10:15,519

and i love you know that you share with

281

00:10:18,550 --> 00:10:16,720

our audience decided there are some

282

00:10:20,310 --> 00:10:18,560

trade-offs that come into instrument

283

00:10:21,670 --> 00:10:20,320

development and how we actually can

284

00:10:23,670 --> 00:10:21,680

answer the questions that we're sending

285

00:10:25,269 --> 00:10:23,680

these instruments out to do

286

00:10:26,630 --> 00:10:25,279

uh and so richard i'd like to come to

287

00:10:28,630 --> 00:10:26,640

you you mentioned when we were first

288

00:10:30,310 --> 00:10:28,640

prepping for this episode to us

289

00:10:32,470 --> 00:10:30,320

that that instrument development is a

290

00:10:34,389 --> 00:10:32,480

process of try and try again

291

00:10:36,550 --> 00:10:34,399

and i wonder if you can can kind of you

292

00:10:38,230 --> 00:10:36,560

know go deeper on that expound on that

293

00:10:39,910 --> 00:10:38,240

idea a little bit uh with what

294

00:10:41,829 --> 00:10:39,920

instruments you've been involved in and

295

00:10:42,949 --> 00:10:41,839

and how is it a process of try and try

296

00:10:46,310 --> 00:10:42,959

again

297

00:10:47,750 --> 00:10:46,320

uh sure um well um i i can guess i can

298

00:10:50,310 --> 00:10:47,760

start at the beginning which was quite a

299

00:10:52,949 --> 00:10:50,320

while ago um but when i first started in

300

00:10:54,949 --> 00:10:52,959

in this business or in astrobiology i

301

00:10:58,230 --> 00:10:54,959

was dispatched down to

302

00:10:59,030 --> 00:10:58,240

jpl's micro devices lab and i worked on

303

00:11:01,509 --> 00:10:59,040

the

304

00:11:04,069 --> 00:11:01,519

uh mars occident instrument

305

00:11:07,030 --> 00:11:04,079

which was launched on a russian mission

306

00:11:09,110 --> 00:11:07,040

uh unfortunately it it failed uh before

307

00:11:10,949 --> 00:11:09,120

reaching um yeah

308

00:11:12,550 --> 00:11:10,959

there was common back then

309

00:11:14,470 --> 00:11:12,560

um

310

00:11:16,150 --> 00:11:14,480

but but that really started trajectory

311

00:11:18,389 --> 00:11:16,160

for technology development and different

312

00:11:19,509 --> 00:11:18,399

ways to interrogate environments i would

313

00:11:22,550 --> 00:11:19,519

say that it

314

00:11:23,750 --> 00:11:22,560

it it took two paths um the first path

315

00:11:25,750 --> 00:11:23,760

is

316

00:11:27,110 --> 00:11:25,760

the mars oxygen instrument then morphed

317

00:11:32,310 --> 00:11:27,120

into

318

00:11:35,350 --> 00:11:32,320

the mars oxidant instrument and that was

319

00:11:39,030 --> 00:11:35,360

pursued and pushed towards um

320

00:11:40,870 --> 00:11:39,040

implementation on exomars

321

00:11:42,790 --> 00:11:40,880

which was

322

00:11:44,790 --> 00:11:42,800

initially on the payload but then got

323

00:11:48,949 --> 00:11:44,800

de-scoped

324

00:11:51,350 --> 00:11:48,959

but simultaneously in another direction

325

00:11:53,990 --> 00:11:51,360

the mars oxidant experiment was looking

326
00:11:56,069 --> 00:11:54,000
at solid regulated material parallel to

327
00:11:57,430 --> 00:11:56,079
interrogate the service chemistry of

328
00:11:59,750 --> 00:11:57,440
mars

329
00:12:02,150 --> 00:11:59,760
went on a path of developing

330
00:12:03,829 --> 00:12:02,160
the mecca white chemistry experiment

331
00:12:05,269 --> 00:12:03,839
which was eventually launched on the

332
00:12:07,750 --> 00:12:05,279
phoenix mission

333
00:12:10,389 --> 00:12:07,760
um in the interim i was involved in

334
00:12:12,629 --> 00:12:10,399
another a number of

335
00:12:14,470 --> 00:12:12,639
different technologies that

336
00:12:17,030 --> 00:12:14,480
were developed for instance the first

337
00:12:19,509 --> 00:12:17,040
prototype of tega

338
00:12:21,910 --> 00:12:19,519

which was uh the thermal involved gas

339

00:12:24,550 --> 00:12:21,920

analysis which defensively was also

340

00:12:27,990 --> 00:12:24,560

included on the phoenix mission and the

341

00:12:31,350 --> 00:12:28,000

mars oxygen experiment after getting

342

00:12:33,590 --> 00:12:31,360

de-scoped from exomars it was sort of

343

00:12:35,350 --> 00:12:33,600

retooled and finally that technology was

344

00:12:38,230 --> 00:12:35,360

implemented on the first

345

00:12:40,629 --> 00:12:38,240

astrobiology nano satellite mission i'm

346

00:12:43,829 --> 00:12:40,639

looking at how do

347

00:12:45,990 --> 00:12:43,839

biological materials have organics

348

00:12:48,389 --> 00:12:46,000

how are they changed in space

349

00:12:51,030 --> 00:12:48,399

environment and how might we apply that

350

00:12:53,910 --> 00:12:51,040

science to um to what's happening on

351
00:12:56,550 --> 00:12:53,920
other planetary surfaces

352
00:12:58,710 --> 00:12:56,560
yeah very cool

353
00:13:00,389 --> 00:12:58,720
evolution of progress

354
00:13:02,069 --> 00:13:00,399
they might not work sometimes or we

355
00:13:03,430 --> 00:13:02,079
might lose them on launch but we can

356
00:13:05,670 --> 00:13:03,440
still continue you know the research

357
00:13:07,509 --> 00:13:05,680
forward which i appreciate a lot that

358
00:13:09,990 --> 00:13:07,519
reminds me a lot of the the loss of

359
00:13:11,590 --> 00:13:10,000
phobos grunt many years ago uh and the

360
00:13:13,750 --> 00:13:11,600
life disc that many of us had support

361
00:13:15,430 --> 00:13:13,760
from the planetary society going out to

362
00:13:17,670 --> 00:13:15,440
phobos and back i hope to see something

363
00:13:18,629 --> 00:13:17,680

similar in the near future um but you

364

00:13:19,750 --> 00:13:18,639

said to me something in the very

365

00:13:21,590 --> 00:13:19,760

beginning there richard i'd like to come

366

00:13:23,829 --> 00:13:21,600

back to you mentioned environmental

367

00:13:25,350 --> 00:13:23,839

context and i know in talking to you

368

00:13:26,790 --> 00:13:25,360

previously that you've done field work

369

00:13:28,230 --> 00:13:26,800

before you've gone to the atacama and

370

00:13:30,710 --> 00:13:28,240

some other places

371

00:13:32,629 --> 00:13:30,720

i wonder if you could connect to us

372

00:13:34,790 --> 00:13:32,639

some of the challenges one of doing

373

00:13:36,710 --> 00:13:34,800

field work and also how how we make

374

00:13:39,590 --> 00:13:36,720

connections from the field to some of

375

00:13:41,189 --> 00:13:39,600

the missions you've been involved in

376

00:13:43,269 --> 00:13:41,199

um well that's a really interesting

377

00:13:44,870 --> 00:13:43,279

question in terms of the atacama desert

378

00:13:47,670 --> 00:13:44,880

um i think uh

379

00:13:50,230 --> 00:13:47,680

about almost 20 years ago i was down

380

00:13:52,069 --> 00:13:50,240

there with uh raphael navarro gonzalez

381

00:13:54,069 --> 00:13:52,079

and a number of other researchers and

382

00:13:56,470 --> 00:13:54,079

and really um

383

00:13:59,189 --> 00:13:56,480

published the first paper in science you

384

00:14:00,470 --> 00:13:59,199

know that accommodates a mars analog and

385

00:14:03,110 --> 00:14:00,480

sort of set

386

00:14:05,269 --> 00:14:03,120

forth this whole you know trajectory of

387

00:14:08,550 --> 00:14:05,279

research that was done done down in that

388

00:14:11,430 --> 00:14:08,560

field um and and i think that the

389

00:14:13,350 --> 00:14:11,440

the the challenges of doing field work

390

00:14:15,430 --> 00:14:13,360

and how do you apply it to

391

00:14:17,829 --> 00:14:15,440

your science and technology are little

392

00:14:19,829 --> 00:14:17,839

they're two different things uh i think

393

00:14:21,430 --> 00:14:19,839

the technology implementation is a

394

00:14:23,509 --> 00:14:21,440

little more straightforward you go down

395

00:14:25,590 --> 00:14:23,519

the attic

396

00:14:28,949 --> 00:14:25,600

water dirt is very

397

00:14:31,189 --> 00:14:28,959

mars like you know physically it's very

398

00:14:33,670 --> 00:14:31,199

similar to mars

399

00:14:35,670 --> 00:14:33,680

minus atmosphere and things like that

400

00:14:38,150 --> 00:14:35,680

that allows you to do technology

401
00:14:40,949 --> 00:14:38,160
demonstration more challenging is the

402
00:14:43,030 --> 00:14:40,959
science um and in particular say for the

403
00:14:46,230 --> 00:14:43,040
atacama desert the atacama desert is

404
00:14:48,470 --> 00:14:46,240
vast and most of it is not mars-like in

405
00:14:51,269 --> 00:14:48,480
fact you always have to be considering

406
00:14:54,470 --> 00:14:51,279
from the science side um even you know

407
00:14:57,030 --> 00:14:54,480
where it seemingly seems to be like

408
00:14:59,509 --> 00:14:57,040
another planet really how is it and how

409
00:15:01,189 --> 00:14:59,519
is it you know not um and now i think

410
00:15:03,829 --> 00:15:01,199
that's really the challenge i think that

411
00:15:06,470 --> 00:15:03,839
it can uh it can be a little deceptive

412
00:15:08,949 --> 00:15:06,480
you think you're actually you get

413
00:15:11,590 --> 00:15:08,959

mars analog field work but in fact when

414

00:15:13,189 --> 00:15:11,600

you dig down the science or really

415

00:15:15,670 --> 00:15:13,199

fundamental differences that need to be

416

00:15:17,670 --> 00:15:15,680

understood otherwise uh you know when

417

00:15:20,629 --> 00:15:17,680

you do get to your destination you might

418

00:15:24,069 --> 00:15:20,639

be subject to to misinterpretations or

419

00:15:27,350 --> 00:15:24,079

uh you know not complete understanding

420

00:15:33,189 --> 00:15:30,310

biology graphic histories uh for our

421

00:15:35,350 --> 00:15:33,199

artistic works um where we explore some

422

00:15:38,230 --> 00:15:35,360

of the history of astrobiology uh at

423

00:15:40,069 --> 00:15:38,240

nasa uh peter doran is quoted as saying

424

00:15:41,990 --> 00:15:40,079

that analog environments have

425

00:15:43,670 --> 00:15:42,000

life-threatening characteristics that's

426

00:15:44,949 --> 00:15:43,680

what they share with other worlds i

427

00:15:45,990 --> 00:15:44,959

always like to also remind people that

428

00:15:47,990 --> 00:15:46,000

they have life-supporting

429

00:15:50,550 --> 00:15:48,000

characteristics too which is what makes

430

00:15:52,870 --> 00:15:50,560

them kind of habitable systems uh and so

431

00:15:55,509 --> 00:15:52,880

stephanie i wonder for you

432

00:15:57,430 --> 00:15:55,519

um and your role at goddard uh what does

433

00:15:59,030 --> 00:15:57,440

your team do to bring knowledge from

434

00:16:01,749 --> 00:15:59,040

field science into what we're actually

435

00:16:03,430 --> 00:16:01,759

using then to look uh for for life or

436

00:16:04,310 --> 00:16:03,440

for understanding geology in other

437

00:16:06,949 --> 00:16:04,320

worlds

438

00:16:09,590 --> 00:16:06,959

yeah oh i love this question um because

439

00:16:12,150 --> 00:16:09,600

it you know it really ties together

440

00:16:14,949 --> 00:16:12,160

field work is you know is one element of

441

00:16:17,430 --> 00:16:14,959

how you really prepare to go

442

00:16:19,829 --> 00:16:17,440

uh to another destination and your

443

00:16:22,069 --> 00:16:19,839

investigations there we have our um our

444

00:16:24,790 --> 00:16:22,079

gift team goddard instrument field team

445

00:16:27,110 --> 00:16:24,800

with members from ames as well

446

00:16:29,110 --> 00:16:27,120

who go out into a variety of

447

00:16:31,910 --> 00:16:29,120

environments that planetary analog

448

00:16:34,790 --> 00:16:31,920

environments um you know beyond atacama

449

00:16:36,790 --> 00:16:34,800

which is you know a canonical one and a

450

00:16:40,629 --> 00:16:36,800

really great one um but also you know

451
00:16:42,870 --> 00:16:40,639
other other areas to look at uh lunar um

452
00:16:44,710 --> 00:16:42,880
analog environments other mars analog

453
00:16:47,030 --> 00:16:44,720
environments and even you know some

454
00:16:48,550 --> 00:16:47,040
aspects it's really hard to emulate an

455
00:16:51,430 --> 00:16:48,560
ocean world

456
00:16:53,189 --> 00:16:51,440
um perfectly on earth

457
00:16:55,269 --> 00:16:53,199
but there are some regions of earth that

458
00:16:57,910 --> 00:16:55,279
are really hostile

459
00:17:00,389 --> 00:16:57,920
and um and really energy starved and are

460
00:17:02,790 --> 00:17:00,399
good analog environments as well and

461
00:17:04,390 --> 00:17:02,800
kind of represent the interface between

462
00:17:07,510 --> 00:17:04,400
you know maybe ice

463
00:17:10,309 --> 00:17:07,520

water energy sources um you know

464

00:17:11,829 --> 00:17:10,319

substrates in terms of rocks and

465

00:17:13,669 --> 00:17:11,839

mineralogy

466

00:17:15,909 --> 00:17:13,679

and and understanding uh that

467

00:17:18,789 --> 00:17:15,919

environment as a system

468

00:17:20,549 --> 00:17:18,799

really makes field work critical

469

00:17:24,069 --> 00:17:20,559

in putting together the pieces and

470

00:17:26,630 --> 00:17:24,079

practicing what that data interpretation

471

00:17:28,470 --> 00:17:26,640

would be like with even less information

472

00:17:30,230 --> 00:17:28,480

and less of an ability to go and service

473

00:17:32,150 --> 00:17:30,240

your instrument which you have a little

474

00:17:33,990 --> 00:17:32,160

bit ability when you're in the field

475

00:17:36,710 --> 00:17:34,000

right so um

476
00:17:37,830 --> 00:17:36,720
so uh the the teams that go out into the

477
00:17:40,310 --> 00:17:37,840
field

478
00:17:43,029 --> 00:17:40,320
the ones that goddard particularly who

479
00:17:44,789 --> 00:17:43,039
collaborate a lot with outside um

480
00:17:46,470 --> 00:17:44,799
teams as well

481
00:17:49,190 --> 00:17:46,480
they have the opportunity to bring back

482
00:17:51,430 --> 00:17:49,200
relevant samples to our laboratories at

483
00:17:54,390 --> 00:17:51,440
goddard as well we have

484
00:17:56,630 --> 00:17:54,400
chemistry and noble gas laboratories

485
00:17:58,870 --> 00:17:56,640
lots of analytical capabilities that

486
00:18:01,190 --> 00:17:58,880
goddard and with our partners

487
00:18:03,029 --> 00:18:01,200
to really help tease out all of the

488
00:18:04,549 --> 00:18:03,039

different aspects of what uh what a

489

00:18:06,630 --> 00:18:04,559

sample is made out of what the

490

00:18:08,630 --> 00:18:06,640

environment is telling you look at

491

00:18:11,430 --> 00:18:08,640

atmospheric phases you can look at rock

492

00:18:13,430 --> 00:18:11,440

phases you can look at the biology um

493

00:18:15,590 --> 00:18:13,440

and so so that's one benefit of field

494

00:18:18,950 --> 00:18:15,600

work is the sample collection

495

00:18:20,710 --> 00:18:18,960

aspect um you also have your testing uh

496

00:18:23,190 --> 00:18:20,720

in remote environments um that you're

497

00:18:25,830 --> 00:18:23,200

able to do to really put your instrument

498

00:18:27,350 --> 00:18:25,840

uh you know um through some tough

499

00:18:29,990 --> 00:18:27,360

challenges

500

00:18:32,390 --> 00:18:30,000

on the way uh to maturing it um to be

501
00:18:34,470 --> 00:18:32,400
ready for space flight um and then

502
00:18:36,870 --> 00:18:34,480
there's like the operational side there

503
00:18:38,950 --> 00:18:36,880
are advantages um to being out into the

504
00:18:42,150 --> 00:18:38,960
field and testing you know operational

505
00:18:44,630 --> 00:18:42,160
sequences that really respond to the the

506
00:18:47,510 --> 00:18:44,640
um constraints that you have in

507
00:18:49,669 --> 00:18:47,520
planetary exploration on how much you

508
00:18:52,390 --> 00:18:49,679
can do in a particular message mission

509
00:18:56,070 --> 00:18:52,400
how quickly you can do each thing and

510
00:18:59,029 --> 00:18:56,080
how investigations build upon each other

511
00:19:00,789 --> 00:18:59,039
with analysis in between where you can

512
00:19:02,470 --> 00:19:00,799
to really get to the end goal of

513
00:19:03,750 --> 00:19:02,480

answering your your big science

514

00:19:05,830 --> 00:19:03,760

questions

515

00:19:08,150 --> 00:19:05,840

i want to mention one more thing our

516

00:19:10,310 --> 00:19:08,160

gift team has

517

00:19:11,990 --> 00:19:10,320

taken the opportunity to bring students

518

00:19:13,830 --> 00:19:12,000

into the field students not only in

519

00:19:16,470 --> 00:19:13,840

traditional fields but also in

520

00:19:19,590 --> 00:19:16,480

journalism programs and other programs

521

00:19:21,990 --> 00:19:19,600

um to engage uh you know

522

00:19:23,590 --> 00:19:22,000

really all of the diverse disciplines

523

00:19:26,150 --> 00:19:23,600

that you really need to

524

00:19:28,549 --> 00:19:26,160

not only accomplish the science but

525

00:19:31,590 --> 00:19:28,559

communicate that science to a wider

526

00:19:33,029 --> 00:19:31,600

audience it's a really exciting uh it's

527

00:19:35,430 --> 00:19:33,039

a really exciting group to have at

528

00:19:36,390 --> 00:19:35,440

goddard and i'm privileged to work with

529

00:19:38,230 --> 00:19:36,400

them

530

00:19:39,990 --> 00:19:38,240

oh that's so cool now so glad you

531

00:19:41,669 --> 00:19:40,000

mentioned that a lot of our viewers are

532

00:19:43,350 --> 00:19:41,679

high school students undergraduate

533

00:19:45,190 --> 00:19:43,360

students graduate students who are very

534

00:19:47,190 --> 00:19:45,200

interested in how they can become

535

00:19:48,870 --> 00:19:47,200

involved in things like field work and

536

00:19:50,710 --> 00:19:48,880

instrument development and working at

537

00:19:52,549 --> 00:19:50,720

nasa and so it's great to have those

538

00:19:53,590 --> 00:19:52,559

connections for them to hear about

539

00:19:54,950 --> 00:19:53,600

and i do want to come back to something

540

00:19:56,870 --> 00:19:54,960

you mentioned about bringing samples

541

00:19:58,470 --> 00:19:56,880

back when you're in the field and

542

00:20:00,630 --> 00:19:58,480

bringing them back to goddard and other

543

00:20:01,990 --> 00:20:00,640

nasa centers for instance but but one

544

00:20:03,270 --> 00:20:02,000

thing you mentioned there too was this

545

00:20:04,870 --> 00:20:03,280

idea you know we're trying to understand

546

00:20:06,710 --> 00:20:04,880

the characteristics of the environment

547

00:20:08,950 --> 00:20:06,720

and relate that to these other places i

548

00:20:10,149 --> 00:20:08,960

get that question a lot in public talks

549

00:20:11,669 --> 00:20:10,159

when i'm speaking especially with the

550

00:20:13,830 --> 00:20:11,679

filter and then you know how is this

551
00:20:15,830 --> 00:20:13,840
like mars how is this like europa how is

552
00:20:17,830 --> 00:20:15,840
this like venus and they also asked like

553
00:20:20,310 --> 00:20:17,840
big questions and so we wanted to ask a

554
00:20:23,430 --> 00:20:20,320
big question of our twitter audience who

555
00:20:26,149 --> 00:20:23,440
follow along at nasa astrobio on twitter

556
00:20:28,230 --> 00:20:26,159
and we asked them the question of if we

557
00:20:30,070 --> 00:20:28,240
had an unlimited budget which is always

558
00:20:31,909 --> 00:20:30,080
kind of a grand weight hand waving thing

559
00:20:34,870 --> 00:20:31,919
but if we had an unlimited budget with

560
00:20:36,950 --> 00:20:34,880
nasa what scientific instrument would

561
00:20:39,750 --> 00:20:36,960
you develop to search for life beyond

562
00:20:42,230 --> 00:20:39,760
earth and we had so many really

563
00:20:44,310 --> 00:20:42,240

intriguing answers uh dr shawn

564

00:20:46,789 --> 00:20:44,320

damogoldman came on

565

00:20:48,310 --> 00:20:46,799

and mentioned the lavoisier telescope which

566

00:20:50,390 --> 00:20:48,320

we have this idea to build a very cool

567

00:20:52,470 --> 00:20:50,400

large telescope that can look in uv

568

00:20:54,070 --> 00:20:52,480

infrared visible light and and do some

569

00:20:55,830 --> 00:20:54,080

really cool things uh several other

570

00:20:58,230 --> 00:20:55,840

people mentioned large telescopes like

571

00:21:00,310 --> 00:20:58,240

arecibo or building large telescopes in

572

00:21:02,230 --> 00:21:00,320

space we had people mention drilling

573

00:21:04,630 --> 00:21:02,240

through the ice on europa and different

574

00:21:06,549 --> 00:21:04,640

kinds of drills dr pauly lane

575

00:21:08,950 --> 00:21:06,559

from finland mentioned using a terahertz

576

00:21:11,830 --> 00:21:08,960

detector to explore biosignatures and

577

00:21:13,430 --> 00:21:11,840

watery plumes from enceladus dr option

578

00:21:15,029 --> 00:21:13,440

khan mentioned

579

00:21:16,950 --> 00:21:15,039

building a high-end instrument for

580

00:21:18,710 --> 00:21:16,960

looking at chirality and even for

581

00:21:20,789 --> 00:21:18,720

concentrating biomolecules or

582

00:21:22,870 --> 00:21:20,799

biosignatures which i thought was pretty

583

00:21:25,510 --> 00:21:22,880

cool we had several answers like things

584

00:21:28,149 --> 00:21:25,520

like warp drive um you know some higher

585

00:21:29,750 --> 00:21:28,159

end stuff that's kind of out there um

586

00:21:30,789 --> 00:21:29,760

maybe the funniest ones though we had

587

00:21:33,990 --> 00:21:30,799

one person mentioned that they would

588

00:21:35,909 --> 00:21:34,000

build a hal 9000 um which that'd be

589

00:21:38,390 --> 00:21:35,919

interesting like in 2001 a space odyssey

590

00:21:41,190 --> 00:21:38,400

let's just not lie to it um and then

591

00:21:42,710 --> 00:21:41,200

someone else chris colosse uh shared

592

00:21:44,549 --> 00:21:42,720

with us a picture from pirates of the

593

00:21:45,990 --> 00:21:44,559

caribbean at world's end where the two

594

00:21:48,390 --> 00:21:46,000

captains are battling over who has the

595

00:21:49,590 --> 00:21:48,400

longest telescope um which i thought was

596

00:21:50,789 --> 00:21:49,600

kind of interesting for some of what

597

00:21:53,990 --> 00:21:50,799

we've done in the past in building

598

00:21:56,230 --> 00:21:54,000

really big telescopes um so for both of

599

00:21:59,270 --> 00:21:56,240

you just a fun question if you had an

600

00:22:01,510 --> 00:21:59,280

unlimited budget um what instrument

601
00:22:02,549 --> 00:22:01,520
would you want to build and send out

602
00:22:04,220 --> 00:22:02,559
there

603
00:22:08,870 --> 00:22:04,230
stephanie how about you

604
00:22:13,990 --> 00:22:11,750
so much of my life is like responding to

605
00:22:17,990 --> 00:22:14,000
the constraints that are put on me this

606
00:22:21,750 --> 00:22:19,350
whatever you think you could imagine

607
00:22:22,549 --> 00:22:21,760
would be awesome

608
00:22:30,470 --> 00:22:22,559
i

609
00:22:34,789 --> 00:22:31,990
because they really complement each

610
00:22:38,549 --> 00:22:34,799
other you know look at mineralogy

611
00:22:41,669 --> 00:22:38,559
petrology you know the organic chemistry

612
00:22:43,750 --> 00:22:41,679
from various angles prebiotic chemistry

613
00:22:46,630 --> 00:22:43,760

what can be biological you know what can

614

00:22:49,510 --> 00:22:46,640

you tell um from the refractory uh

615

00:22:51,590 --> 00:22:49,520

components of the organic composition um

616

00:22:53,350 --> 00:22:51,600

what about the atmospheric chemistry

617

00:22:54,470 --> 00:22:53,360

what about the noble gases what can they

618

00:22:56,390 --> 00:22:54,480

tell you about the evolution of a

619

00:22:59,110 --> 00:22:56,400

particular planetary body where it came

620

00:23:00,630 --> 00:22:59,120

from what's happened to it um all that

621

00:23:03,029 --> 00:23:00,640

ultimately

622

00:23:05,590 --> 00:23:03,039

our goal right is to

623

00:23:08,549 --> 00:23:05,600

is to build upon mission

624

00:23:10,870 --> 00:23:08,559

ask question upon question to answer as

625

00:23:12,390 --> 00:23:10,880

many of these questions as possible so

626

00:23:15,270 --> 00:23:12,400

that we know as much as possible and

627

00:23:17,110 --> 00:23:15,280

we're as confident as possible about the

628

00:23:18,789 --> 00:23:17,120

conclusions and interpretations that

629

00:23:22,070 --> 00:23:18,799

we're drawing from the data sets that we

630

00:23:24,390 --> 00:23:22,080

have which are just by nature limited um

631

00:23:25,510 --> 00:23:24,400

uh when uh when you when you work

632

00:23:27,909 --> 00:23:25,520

in situ

633

00:23:29,590 --> 00:23:27,919

the finite volume power

634

00:23:31,350 --> 00:23:29,600

absolutely and there's so many cool

635

00:23:33,110 --> 00:23:31,360

concepts and things being developed out

636

00:23:35,590 --> 00:23:33,120

there i would toss in the uranus and

637

00:23:37,590 --> 00:23:35,600

neptune missions as well just for fun um

638

00:23:39,350 --> 00:23:37,600

richard how about you unlimited budget

639

00:23:41,510 --> 00:23:39,360

what would you build

640

00:23:43,110 --> 00:23:41,520

um well if i had an unlimited budget i

641

00:23:44,870 --> 00:23:43,120

might approach it a little differently

642

00:23:47,029 --> 00:23:44,880

you know i i think the ideas that we

643

00:23:48,950 --> 00:23:47,039

just heard coming in from the community

644

00:23:51,669 --> 00:23:48,960

are fantastic and that's really the

645

00:23:54,310 --> 00:23:51,679

purpose of the workshop to get new ideas

646

00:23:56,149 --> 00:23:54,320

and there are different combinations of

647

00:23:59,110 --> 00:23:56,159

instruments approaches that you could

648

00:24:01,669 --> 00:23:59,120

use for you know searching for life and

649

00:24:04,070 --> 00:24:01,679

they might vary depending on your target

650

00:24:06,470 --> 00:24:04,080

if i had an unlimited budget though i

651
00:24:08,470 --> 00:24:06,480
honestly would probably take a core set

652
00:24:10,310 --> 00:24:08,480
of instruments and really we've been

653
00:24:12,950 --> 00:24:10,320
thinking about this for a long time so

654
00:24:16,070 --> 00:24:12,960
we have some really solid approaches

655
00:24:17,510 --> 00:24:16,080
and rather than spend a lot of money on

656
00:24:20,070 --> 00:24:17,520
you know developing an instrument i

657
00:24:22,950 --> 00:24:20,080
would spend that money to make many many

658
00:24:25,350 --> 00:24:22,960
many copies of that same instrument and

659
00:24:27,110 --> 00:24:25,360
send it to many many many places so i

660
00:24:28,470 --> 00:24:27,120
think that the need in terms of budget

661
00:24:30,310 --> 00:24:28,480
is actually

662
00:24:33,029 --> 00:24:30,320
more missions

663
00:24:36,230 --> 00:24:33,039

rather than necessarily bigger budget

664

00:24:38,390 --> 00:24:36,240

for instruments um you know the the more

665

00:24:40,470 --> 00:24:38,400

we can look the frequency that we can

666

00:24:42,149 --> 00:24:40,480

look increases the probability of

667

00:24:44,549 --> 00:24:42,159

success so that's how i would spend the

668

00:24:46,470 --> 00:24:44,559

money instead of a mission every couple

669

00:24:47,350 --> 00:24:46,480

of years i would have a mission every

670

00:24:50,230 --> 00:24:47,360

month

671

00:24:51,590 --> 00:24:50,240

oh interesting i love that one

672

00:24:52,950 --> 00:24:51,600

budget right so we can just you know we

673

00:24:56,149 --> 00:24:52,960

can do a mission every month and that's

674

00:24:57,350 --> 00:24:56,159

fantastic i love it um so i i do have a

675

00:24:58,630 --> 00:24:57,360

few more minutes in my own questioning

676

00:25:00,549 --> 00:24:58,640

here with you i want to remind our

677

00:25:02,870 --> 00:25:00,559

audience watching on youtube that you

678

00:25:03,990 --> 00:25:02,880

can ask questions in the chat right now

679

00:25:05,990 --> 00:25:04,000

and they will come through to my

680

00:25:07,430 --> 00:25:06,000

teleprompter for me to ask of doctors

681

00:25:09,110 --> 00:25:07,440

getty and quinn

682

00:25:10,950 --> 00:25:09,120

i see some questions coming in already

683

00:25:12,710 --> 00:25:10,960

so please keep those coming

684

00:25:14,310 --> 00:25:12,720

i want to come back now stephanie you

685

00:25:16,470 --> 00:25:14,320

mentioned this idea of bringing samples

686

00:25:18,390 --> 00:25:16,480

back from the field to maybe our you

687

00:25:20,310 --> 00:25:18,400

know our higher precision higher end

688

00:25:22,230 --> 00:25:20,320

instrumentation that we have in the

689

00:25:24,470 --> 00:25:22,240

laboratory at nasa centers and other

690

00:25:26,789 --> 00:25:24,480

institutions um but you know when it

691

00:25:28,630 --> 00:25:26,799

comes to returning samples from space

692

00:25:30,549 --> 00:25:28,640

that's a much different process it's far

693

00:25:32,470 --> 00:25:30,559

more expensive there's infrastructure

694

00:25:34,310 --> 00:25:32,480

that has to be built around getting

695

00:25:36,149 --> 00:25:34,320

missions out there to collect samples

696

00:25:37,669 --> 00:25:36,159

and bring them back and in the case of

697

00:25:39,029 --> 00:25:37,679

mars for instance there's a large

698

00:25:40,950 --> 00:25:39,039

infrastructure that we still have to

699

00:25:43,190 --> 00:25:40,960

develop to to get samples back from

700

00:25:44,310 --> 00:25:43,200

perseverance right now i'm wondering if

701
00:25:46,630 --> 00:25:44,320
you could talk a bit about the

702
00:25:48,470 --> 00:25:46,640
trade-offs of you know developing these

703
00:25:49,909 --> 00:25:48,480
infrastructures for sample return

704
00:25:52,149 --> 00:25:49,919
compared to developing better

705
00:25:53,029 --> 00:25:52,159
infrastructure for instrumentation in

706
00:25:56,230 --> 00:25:53,039
space

707
00:25:58,630 --> 00:25:56,240
yeah i mean the answer is both please um

708
00:26:00,950 --> 00:25:58,640
obviously we can do so much

709
00:26:03,029 --> 00:26:00,960
with laboratory instruments that just

710
00:26:05,430 --> 00:26:03,039
can't be done

711
00:26:07,029 --> 00:26:05,440
but at the same time when you're

712
00:26:09,750 --> 00:26:07,039
exploring

713
00:26:11,190 --> 00:26:09,760

scientifically a new environment um you

714

00:26:13,269 --> 00:26:11,200

know i think

715

00:26:15,350 --> 00:26:13,279

the best approach is really an interplay

716

00:26:17,110 --> 00:26:15,360

between in-situ emissions and sample

717

00:26:18,870 --> 00:26:17,120

return missions where is possible i mean

718

00:26:20,789 --> 00:26:18,880

there are some sample return missions

719

00:26:22,630 --> 00:26:20,799

that are kind of beyond uh near-term

720

00:26:25,190 --> 00:26:22,640

capabilities obviously just for

721

00:26:27,669 --> 00:26:25,200

proximity reasons um

722

00:26:29,510 --> 00:26:27,679

but even for return missions i mean

723

00:26:31,029 --> 00:26:29,520

without the in-situ

724

00:26:32,549 --> 00:26:31,039

science it can be really hard to

725

00:26:34,310 --> 00:26:32,559

convince yourself that you're going to

726

00:26:35,830 --> 00:26:34,320

the right location i mean

727

00:26:37,350 --> 00:26:35,840

that you're picking up the best sample

728

00:26:38,950 --> 00:26:37,360

for return to earth and as you know

729

00:26:41,350 --> 00:26:38,960

there's a lot as you mentioned graham

730

00:26:43,669 --> 00:26:41,360

there's a lot riding on that return

731

00:26:45,110 --> 00:26:43,679

right so you want to know enough

732

00:26:46,470 --> 00:26:45,120

about the environment to be able to

733

00:26:48,470 --> 00:26:46,480

interpret the results like we were

734

00:26:50,470 --> 00:26:48,480

talking about before and that can't be

735

00:26:53,110 --> 00:26:50,480

done without thinking about the science

736

00:26:55,269 --> 00:26:53,120

of the system and so that really

737

00:26:57,669 --> 00:26:55,279

requires sustained questioning of like

738

00:27:00,470 --> 00:26:57,679

what what that system is and how it came

739

00:27:03,190 --> 00:27:00,480

to be and how it's different from other

740

00:27:05,029 --> 00:27:03,200

places we've seen before and

741

00:27:07,669 --> 00:27:05,039

you know richard you mentioned too all

742

00:27:10,549 --> 00:27:07,679

planetary environments are not one thing

743

00:27:12,310 --> 00:27:10,559

about mars and how varied the surface

744

00:27:15,110 --> 00:27:12,320

geology is and we we haven't even

745

00:27:17,110 --> 00:27:15,120

started to explore the subsurface right

746

00:27:19,190 --> 00:27:17,120

and we think about an ocean world like

747

00:27:22,310 --> 00:27:19,200

enceladus um there are several

748

00:27:24,710 --> 00:27:22,320

environmental targets there um the plume

749

00:27:26,710 --> 00:27:24,720

at the southern pole the icy surface

750

00:27:29,430 --> 00:27:26,720

that expresses signatures of the ocean

751
00:27:32,149 --> 00:27:29,440
potentially directly visiting the ocean

752
00:27:33,830 --> 00:27:32,159
um you know in the future so no single

753
00:27:36,149 --> 00:27:33,840
mission can visit all of those

754
00:27:37,430 --> 00:27:36,159
environments in situ but we we have to

755
00:27:38,710 --> 00:27:37,440
like be

756
00:27:40,350 --> 00:27:38,720
um

757
00:27:44,870 --> 00:27:40,360
we have to be

758
00:27:47,430 --> 00:27:44,880
our curiosity has to

759
00:27:48,950 --> 00:27:47,440
be somewhat happy with building upon

760
00:27:50,950 --> 00:27:48,960
those questions that

761
00:27:53,269 --> 00:27:50,960
get answered you know in a sequential

762
00:27:55,029 --> 00:27:53,279
way um with missions building upon

763
00:27:56,710 --> 00:27:55,039

previous missions and then you know

764

00:27:58,310 --> 00:27:56,720

getting inspired by the next set of

765

00:28:00,950 --> 00:27:58,320

questions um

766

00:28:02,870 --> 00:28:00,960

so i i think that there's definitely

767

00:28:05,590 --> 00:28:02,880

a good role and

768

00:28:07,269 --> 00:28:05,600

importance to um to both in situ and

769

00:28:08,950 --> 00:28:07,279

sample return

770

00:28:10,549 --> 00:28:08,960

i love that so much and i love that you

771

00:28:12,230 --> 00:28:10,559

have missions building upon admissions

772

00:28:13,990 --> 00:28:12,240

and kind of you know expanding what we

773

00:28:15,029 --> 00:28:14,000

know and and you know what you said

774

00:28:17,029 --> 00:28:15,039

there are two kind of minds this

775

00:28:18,710 --> 00:28:17,039

importance of context in in the

776

00:28:20,630 --> 00:28:18,720

environment and understanding where

777

00:28:21,990 --> 00:28:20,640

these examples come from all three of us

778

00:28:24,549 --> 00:28:22,000

are part of the center for life

779

00:28:26,710 --> 00:28:24,559

detection uh headquartered at nasa ames

780

00:28:28,870 --> 00:28:26,720

which is one of the three main pieces of

781

00:28:30,549 --> 00:28:28,880

the network for life detection or unfold

782

00:28:31,830 --> 00:28:30,559

um you know and with the center for life

783

00:28:32,950 --> 00:28:31,840

detection right now we're building

784

00:28:34,870 --> 00:28:32,960

something called the life detection

785

00:28:36,310 --> 00:28:34,880

knowledge base which will allow

786

00:28:39,110 --> 00:28:36,320

scientists in the community to come

787

00:28:41,110 --> 00:28:39,120

together and to explore not just you

788

00:28:43,350 --> 00:28:41,120

know the the biogenicity of certain

789

00:28:44,789 --> 00:28:43,360

features but also their context which is

790

00:28:46,389 --> 00:28:44,799

really important

791

00:28:47,830 --> 00:28:46,399

and richard for for you you're not only

792

00:28:49,430 --> 00:28:47,840

a part of the center for life detection

793

00:28:50,230 --> 00:28:49,440

but also on the steering committee for

794

00:28:51,830 --> 00:28:50,240

now

795

00:28:55,190 --> 00:28:51,840

um i wonder if you could talk a bit

796

00:28:57,430 --> 00:28:55,200

about um the maybe the the challenges of

797

00:28:59,110 --> 00:28:57,440

taking instruments to icy worlds and

798

00:29:00,870 --> 00:28:59,120

using them in those places and in the

799

00:29:02,149 --> 00:29:00,880

context of those environments which are

800

00:29:04,070 --> 00:29:02,159

very different from the environments we

801
00:29:06,230 --> 00:29:04,080
have here on earth

802
00:29:07,909 --> 00:29:06,240
sure absolutely but if one i would like

803
00:29:10,470 --> 00:29:07,919
to just add a little bit to the question

804
00:29:13,990 --> 00:29:10,480
that you that you posed to stephanie

805
00:29:15,750 --> 00:29:14,000
because as a you know uh

806
00:29:18,149 --> 00:29:15,760
somebody who's

807
00:29:20,950 --> 00:29:18,159
his career has been in situ exploration

808
00:29:24,070 --> 00:29:20,960
now initially sample return i thought

809
00:29:25,269 --> 00:29:24,080
well it's expensive it's unnecessary

810
00:29:27,110 --> 00:29:25,279
but my

811
00:29:28,789 --> 00:29:27,120
thought has shifted over years because i

812
00:29:30,230 --> 00:29:28,799
think what we've learned from mars

813
00:29:33,750 --> 00:29:30,240

exploration

814

00:29:38,630 --> 00:29:36,870

an expression of the presence of life is

815

00:29:41,909 --> 00:29:38,640

going to be subtle

816

00:29:44,549 --> 00:29:41,919

um and so that makes it important to

817

00:29:47,110 --> 00:29:44,559

bring samples back because as much as we

818

00:29:48,470 --> 00:29:47,120

learn uh with in-situ instruments and

819

00:29:50,870 --> 00:29:48,480

even if we

820

00:29:53,029 --> 00:29:50,880

uh you know when we hit on a signal and

821

00:29:53,990 --> 00:29:53,039

we think okay we've done it we've found

822

00:29:55,269 --> 00:29:54,000

it

823

00:29:57,110 --> 00:29:55,279

still those

824

00:29:59,029 --> 00:29:57,120

it has to be confirmed and i think that

825

00:30:01,909 --> 00:29:59,039

confirmation really does need to be done

826

00:30:04,549 --> 00:30:01,919

in the laboratory um so i am like

827

00:30:07,510 --> 00:30:04,559

stephanie said i think both are hand in

828

00:30:09,750 --> 00:30:07,520

hand um now the question about ocean

829

00:30:12,470 --> 00:30:09,760

worlds and and in recent years i have

830

00:30:14,710 --> 00:30:12,480

pivoted um you know to to looking

831

00:30:15,750 --> 00:30:14,720

farther out to those types of missions

832

00:30:16,950 --> 00:30:15,760

and

833

00:30:19,269 --> 00:30:16,960

um

834

00:30:21,269 --> 00:30:19,279

again going into you know environmental

835

00:30:23,110 --> 00:30:21,279

context of course the

836

00:30:25,510 --> 00:30:23,120

the environments are

837

00:30:27,909 --> 00:30:25,520

radically different compared to how we

838

00:30:29,909 --> 00:30:27,919

would explore for say for mars

839

00:30:32,389 --> 00:30:29,919

exploration particularly

840

00:30:34,470 --> 00:30:32,399

um a destination like the european

841

00:30:36,070 --> 00:30:34,480

surface which was a

842

00:30:37,590 --> 00:30:36,080

focus of a potential mission in the

843

00:30:39,590 --> 00:30:37,600

future where you have this incredible

844

00:30:41,430 --> 00:30:39,600

radiation

845

00:30:43,510 --> 00:30:41,440

environment that really

846

00:30:45,029 --> 00:30:43,520

alters and distorts

847

00:30:48,070 --> 00:30:45,039

um you know

848

00:30:50,789 --> 00:30:48,080

any feature or any artifact that you may

849

00:30:51,909 --> 00:30:50,799

expect to see relative to the presence

850

00:30:54,310 --> 00:30:51,919

of life

851
00:30:55,669 --> 00:30:54,320
and you know going back i think we see

852
00:30:59,029 --> 00:30:55,679
on mars

853
00:31:01,909 --> 00:30:59,039
um the the tremendous um challenges that

854
00:31:03,909 --> 00:31:01,919
the radiation environment imposes on the

855
00:31:05,669 --> 00:31:03,919
search for life or even just doing the

856
00:31:08,149 --> 00:31:05,679
science there from the whole

857
00:31:09,590 --> 00:31:08,159
uh elevated oxidation chemistry the

858
00:31:11,190 --> 00:31:09,600
chlorate the

859
00:31:13,269 --> 00:31:11,200
um the

860
00:31:15,990 --> 00:31:13,279
search for organic signatures that have

861
00:31:18,630 --> 00:31:16,000
been altered both

862
00:31:21,669 --> 00:31:18,640
in the environment and also in the

863
00:31:23,430 --> 00:31:21,679

sample processing during um

864

00:31:26,470 --> 00:31:23,440

during exploration

865

00:31:28,470 --> 00:31:26,480

those challenges are just compounded

866

00:31:29,909 --> 00:31:28,480

when we move out to ocean worlds

867

00:31:33,669 --> 00:31:29,919

particularly

868

00:31:34,710 --> 00:31:33,679

moving out to a place like europa

869

00:31:37,110 --> 00:31:34,720

very cool

870

00:31:41,110 --> 00:31:39,430

with cassini very lucky to have the iron

871

00:31:42,870 --> 00:31:41,120

and neutral mass spectrometer on because

872

00:31:44,789 --> 00:31:42,880

you could actually fly through these

873

00:31:46,470 --> 00:31:44,799

plumes of water and there might be

874

00:31:47,830 --> 00:31:46,480

something from europa it's not of the

875

00:31:49,830 --> 00:31:47,840

question there's actually some data that

876
00:31:51,269 --> 00:31:49,840
has suggested there could be european

877
00:31:52,870 --> 00:31:51,279
plumes as well

878
00:31:54,230 --> 00:31:52,880
um and so one instrument for instance

879
00:31:56,230 --> 00:31:54,240
being developed for europa clipper

880
00:31:58,230 --> 00:31:56,240
called suda uh could could not just

881
00:32:00,630 --> 00:31:58,240
explore the dust and materials around

882
00:32:02,549 --> 00:32:00,640
europa but also potentially explore for

883
00:32:04,230 --> 00:32:02,559
plumes there and so there's a bit of

884
00:32:06,070 --> 00:32:04,240
serendipity too that comes into this

885
00:32:08,149 --> 00:32:06,080
right with discovering plumes from an

886
00:32:09,830 --> 00:32:08,159
ocean world that we didn't expect and

887
00:32:11,509 --> 00:32:09,840
who knows if we go to uranus or neptune

888
00:32:13,350 --> 00:32:11,519

what other weird things are happening on

889

00:32:14,870 --> 00:32:13,360

moons in our solar system that we have

890

00:32:16,950 --> 00:32:14,880

no idea about

891

00:32:18,230 --> 00:32:16,960

so i wonder for both of you

892

00:32:19,750 --> 00:32:18,240

before i open it up to the audience

893

00:32:21,830 --> 00:32:19,760

questions here if we could just briefly

894

00:32:24,230 --> 00:32:21,840

talk about the future of instrument

895

00:32:25,669 --> 00:32:24,240

development and data analysis

896

00:32:28,070 --> 00:32:25,679

what are the key things you think we

897

00:32:30,070 --> 00:32:28,080

should be prepared for or maybe be open

898

00:32:32,230 --> 00:32:30,080

to in the very near future

899

00:32:32,950 --> 00:32:32,240

um and stephanie i think i'll start with

900

00:32:37,990 --> 00:32:32,960

you

901
00:32:38,789 --> 00:32:38,000
are key things we should be prepared for

902
00:32:40,230 --> 00:32:38,799
yeah

903
00:32:43,029 --> 00:32:40,240
um i

904
00:32:44,070 --> 00:32:43,039
you know i think go

905
00:32:47,750 --> 00:32:44,080
moving

906
00:32:48,470 --> 00:32:47,760
forward in um in in situ analysis i

907
00:32:51,430 --> 00:32:48,480
think

908
00:32:52,389 --> 00:32:51,440
what you touched on there graham with um

909
00:32:55,110 --> 00:32:52,399
being

910
00:32:58,470 --> 00:32:55,120
prepared for what the what the uh what

911
00:33:01,269 --> 00:32:58,480
the environment has to present to you uh

912
00:33:01,990 --> 00:33:01,279
and being able to um you know to adapt

913
00:33:03,350 --> 00:33:02,000

to

914

00:33:04,710 --> 00:33:03,360

uh

915

00:33:06,470 --> 00:33:04,720

really what this

916

00:33:08,789 --> 00:33:06,480

what the sampling

917

00:33:10,630 --> 00:33:08,799

uh needs to look like to get the right

918

00:33:13,750 --> 00:33:10,640

sample into

919

00:33:16,149 --> 00:33:13,760

into your instrumentation uh is is a

920

00:33:18,310 --> 00:33:16,159

really important factor

921

00:33:20,789 --> 00:33:18,320

i think that for you know as we become

922

00:33:24,789 --> 00:33:20,799

more sophisticated in the way that we

923

00:33:27,430 --> 00:33:24,799

explore certain environments um we we

924

00:33:28,789 --> 00:33:27,440

have the opportunity to you know build

925

00:33:30,789 --> 00:33:28,799

from um

926
00:33:33,350 --> 00:33:30,799
you know kind of you know an approach

927
00:33:35,190 --> 00:33:33,360
where you learn what you can from a

928
00:33:37,269 --> 00:33:35,200
particular fraction that's accessible

929
00:33:39,430 --> 00:33:37,279
with what with the instrumentation that

930
00:33:42,549 --> 00:33:39,440
you have to trying to get the most ease

931
00:33:44,230 --> 00:33:42,559
out the most information out of um out

932
00:33:45,909 --> 00:33:44,240
of the samples that are accessible so

933
00:33:47,269 --> 00:33:45,919
that means you know paying really close

934
00:33:51,190 --> 00:33:47,279
attention to

935
00:33:52,789 --> 00:33:51,200
how cleanly you're sampling um how

936
00:33:54,870 --> 00:33:52,799
how carefully you're treating that

937
00:33:57,509 --> 00:33:54,880
sample as you're moving it between

938
00:34:00,710 --> 00:33:57,519

different elements of um of a payload

939

00:34:03,190 --> 00:34:00,720

for example making taking great care not

940

00:34:05,029 --> 00:34:03,200

to alter that sample and and confusing

941

00:34:06,789 --> 00:34:05,039

yourself what you're seeing at the end

942

00:34:09,510 --> 00:34:06,799

of the day and then just really making

943

00:34:12,950 --> 00:34:09,520

the most of all that sample has to offer

944

00:34:14,069 --> 00:34:12,960

to you um i think um

945

00:34:16,790 --> 00:34:14,079

you know i think

946

00:34:20,310 --> 00:34:16,800

there's there's a there's an evolution

947

00:34:23,589 --> 00:34:20,320

in instrumentation um and uh and i'm

948

00:34:25,750 --> 00:34:23,599

really excited to see the energy um that

949

00:34:27,589 --> 00:34:25,760

uh that we're hearing in this workshop

950

00:34:30,230 --> 00:34:27,599

and from the community and really

951
00:34:32,470 --> 00:34:30,240
treating the hard problems about how to

952
00:34:34,470 --> 00:34:32,480
get um the right sample and the right

953
00:34:35,990 --> 00:34:34,480
fidelity of sample into our

954
00:34:37,510 --> 00:34:36,000
instrumentation

955
00:34:41,669 --> 00:34:37,520
yeah it's always the scientists right

956
00:34:43,750 --> 00:34:41,679
samples um it reminds me an avatar

957
00:34:44,950 --> 00:34:43,760
did we get samples you know we need to

958
00:34:46,069 --> 00:34:44,960
know the samples we also need to know

959
00:34:47,750 --> 00:34:46,079
where they come from and how they've

960
00:34:48,710 --> 00:34:47,760
been treated and i really appreciate

961
00:34:50,149 --> 00:34:48,720
that

962
00:34:51,990 --> 00:34:50,159
um richard how about you what do you

963
00:34:53,030 --> 00:34:52,000

think is the future for for instrument

964

00:34:55,510 --> 00:34:53,040

development

965

00:34:57,030 --> 00:34:55,520

well i i agree 100 with what stephanie

966

00:34:58,630 --> 00:34:57,040

just said i think you know a lot of

967

00:35:00,069 --> 00:34:58,640

times when we talk about instruments

968

00:35:01,349 --> 00:35:00,079

you'll hear people say well my

969

00:35:04,150 --> 00:35:01,359

instrument has

970

00:35:06,230 --> 00:35:04,160

a sensitivity of parts per trillion

971

00:35:07,910 --> 00:35:06,240

or you know it can do this

972

00:35:09,270 --> 00:35:07,920

that and really what you're talking

973

00:35:10,390 --> 00:35:09,280

about there is i'm talking about the

974

00:35:12,390 --> 00:35:10,400

detector

975

00:35:14,150 --> 00:35:12,400

they're you know so they're summing up

976

00:35:16,310 --> 00:35:14,160

their instrument in terms of the

977

00:35:20,069 --> 00:35:16,320

detector but stephanie just pointed out

978

00:35:22,870 --> 00:35:20,079

really the challenges is sample access

979

00:35:24,150 --> 00:35:22,880

sample handling and sample processing

980

00:35:26,390 --> 00:35:24,160

because if you have an instrument

981

00:35:28,470 --> 00:35:26,400

particularly you know an in-situ

982

00:35:31,190 --> 00:35:28,480

instrument that needs to ingest or it

983

00:35:32,470 --> 00:35:31,200

needs to take a sample uh to get a

984

00:35:34,710 --> 00:35:32,480

result

985

00:35:37,430 --> 00:35:34,720

the form of that sample is really what

986

00:35:39,270 --> 00:35:37,440

drives your ability to make a proper

987

00:35:42,230 --> 00:35:39,280

analysis and proper interpretation of

988

00:35:46,230 --> 00:35:42,240

the data so i agree 100 the real

989

00:35:49,430 --> 00:35:46,240

challenges is to future exploration is

990

00:35:51,109 --> 00:35:49,440

is the sample um acquisition sample

991

00:35:53,349 --> 00:35:51,119

processing

992

00:35:55,030 --> 00:35:53,359

very cool uh i i

993

00:35:57,030 --> 00:35:55,040

i view so much right now and i have so

994

00:35:58,870 --> 00:35:57,040

many more questions of my own but i also

995

00:36:00,790 --> 00:35:58,880

have to be a good host and respect our

996

00:36:03,109 --> 00:36:00,800

audience and allow them to ask some

997

00:36:05,430 --> 00:36:03,119

questions too and when one actually came

998

00:36:06,950 --> 00:36:05,440

to us through an email at info

999

00:36:08,950 --> 00:36:06,960

secondnet.org

1000

00:36:11,910 --> 00:36:08,960

was from a person who i know named bob

1001

00:36:14,069 --> 00:36:11,920

bruner he's an 83 year old man who works

1002

00:36:15,430 --> 00:36:14,079

as a volunteer at our local museum

1003

00:36:17,910 --> 00:36:15,440

here in denver the denver museum of

1004

00:36:20,150 --> 00:36:17,920

nature and science he's been developing

1005

00:36:21,829 --> 00:36:20,160

this idea for some time of sharing with

1006

00:36:24,310 --> 00:36:21,839

children and families the kinds of

1007

00:36:25,829 --> 00:36:24,320

minerals we look for on mars but he

1008

00:36:28,630 --> 00:36:25,839

wanted to know since it's not his area

1009

00:36:31,510 --> 00:36:28,640

of expertise um about spectrometers that

1010

00:36:34,710 --> 00:36:31,520

we use in orbit and i wonder if you

1011

00:36:36,310 --> 00:36:34,720

could speak maybe to remote sensing uh

1012

00:36:38,310 --> 00:36:36,320

from orbit or you know even from

1013

00:36:42,230 --> 00:36:38,320

telescopes from far away compared to

1014

00:36:45,109 --> 00:36:43,430

and that could be for either of you

1015

00:36:47,430 --> 00:36:45,119

honestly

1016

00:36:49,670 --> 00:36:47,440

well i mean

1017

00:36:51,670 --> 00:36:49,680

i'll take a step here i mean that's a

1018

00:36:53,910 --> 00:36:51,680

tough question because i am really an

1019

00:36:57,430 --> 00:36:53,920

institute you know where i want a sample

1020

00:37:00,870 --> 00:36:57,440

i want the instrument to touch it

1021

00:37:01,750 --> 00:37:00,880

um interrogate it um i i think that that

1022

00:37:03,910 --> 00:37:01,760

you know

1023

00:37:05,270 --> 00:37:03,920

remote sensing is gonna in terms of

1024

00:37:07,030 --> 00:37:05,280

light detection

1025

00:37:08,630 --> 00:37:07,040

you know eventually will be particularly

1026
00:37:09,430 --> 00:37:08,640
relevant for

1027
00:37:11,510 --> 00:37:09,440
um

1028
00:37:14,069 --> 00:37:11,520
for exoplanets and looking at

1029
00:37:15,589 --> 00:37:14,079
atmospheres and trying to understand um

1030
00:37:17,670 --> 00:37:15,599
you know are these

1031
00:37:19,910 --> 00:37:17,680
is do they have atmospheres that are

1032
00:37:21,589 --> 00:37:19,920
indicative processes that might suggest

1033
00:37:25,109 --> 00:37:21,599
the presence of life

1034
00:37:27,270 --> 00:37:26,069
you know

1035
00:37:29,270 --> 00:37:27,280
remotely

1036
00:37:31,270 --> 00:37:29,280
in terms of mars just our ability to

1037
00:37:34,069 --> 00:37:31,280
understand the whole planet and really

1038
00:37:37,670 --> 00:37:34,079

when we landed there in 1976 we saw this

1039

00:37:40,390 --> 00:37:37,680

landscape of of just you know

1040

00:37:41,990 --> 00:37:40,400

red dust everywhere and for a long time

1041

00:37:43,829 --> 00:37:42,000

people thought well that's the planet

1042

00:37:46,310 --> 00:37:43,839

but really it was the remote sensing

1043

00:37:48,630 --> 00:37:46,320

that really before we even got back to

1044

00:37:50,390 --> 00:37:48,640

the planet again you know 20 more than

1045

00:37:52,310 --> 00:37:50,400

20 years later

1046

00:37:54,069 --> 00:37:52,320

really really gave us an in-depth

1047

00:37:56,630 --> 00:37:54,079

understanding of the habitability the

1048

00:37:59,190 --> 00:37:56,640

potential for life so understanding

1049

00:38:00,950 --> 00:37:59,200

those mineral assemblages the geology is

1050

00:38:02,630 --> 00:38:00,960

really critical and that's all achieved

1051

00:38:03,990 --> 00:38:02,640

through remote sensing

1052

00:38:06,310 --> 00:38:04,000

not all of them

1053

00:38:07,589 --> 00:38:06,320

and i'll just add to that richard you

1054

00:38:10,390 --> 00:38:07,599

know what you're

1055

00:38:12,790 --> 00:38:10,400

you're you're referring to also just the

1056

00:38:15,190 --> 00:38:12,800

the connection i think between what you

1057

00:38:17,990 --> 00:38:15,200

can learn remote sensing on a planetary

1058

00:38:20,150 --> 00:38:18,000

global scale particularly if you're if

1059

00:38:23,270 --> 00:38:20,160

you have an orbiter which is like the

1060

00:38:27,270 --> 00:38:23,280

dream of many geologists is to have

1061

00:38:29,670 --> 00:38:27,280

global mapping um of of an entire planet

1062

00:38:31,829 --> 00:38:29,680

at sufficient resolution so that you can

1063

00:38:33,510 --> 00:38:31,839

you know just decipher some of the

1064

00:38:36,390 --> 00:38:33,520

signatures on the surface and trace it

1065

00:38:38,870 --> 00:38:36,400

back to geological processes that that

1066

00:38:42,150 --> 00:38:38,880

we might already know and then that

1067

00:38:45,109 --> 00:38:42,160

gives you such amazing context for

1068

00:38:48,470 --> 00:38:45,119

in-situ exploration because oftentimes

1069

00:38:50,950 --> 00:38:48,480

you're picking one place or one region

1070

00:38:54,150 --> 00:38:50,960

of the surface of the surface of a

1071

00:38:56,390 --> 00:38:54,160

planet and um you know

1072

00:38:59,270 --> 00:38:56,400

there is surface mobility but but often

1073

00:39:01,990 --> 00:38:59,280

you need when you want to understand how

1074

00:39:04,630 --> 00:39:02,000

this um this particular region or

1075

00:39:07,430 --> 00:39:04,640

landing site um you know relates to the

1076

00:39:08,950 --> 00:39:07,440

planetary and uh processes at large you

1077

00:39:11,589 --> 00:39:08,960

need that global understanding so

1078

00:39:14,390 --> 00:39:11,599

there's absolutely um you know

1079

00:39:16,470 --> 00:39:14,400

importance in remote sensing uh

1080

00:39:18,150 --> 00:39:16,480

not only for global mapping but just

1081

00:39:21,030 --> 00:39:18,160

global you know more

1082

00:39:21,910 --> 00:39:21,040

larger context you don't throw away any

1083

00:39:25,430 --> 00:39:21,920

of your

1084

00:39:27,990 --> 00:39:25,440

coming off the surface at you so you can

1085

00:39:31,109 --> 00:39:28,000

tell different things about the surface

1086

00:39:35,109 --> 00:39:31,119

um whether it's you know uh mineralogy

1087

00:39:38,150 --> 00:39:35,119

or um or uh um you know for water or

1088

00:39:42,790 --> 00:39:38,160

potentially hydrated minerals

1089

00:39:45,109 --> 00:39:42,800

all these things can be uh

1090

00:39:47,430 --> 00:39:45,119

who are experts out there um but but you

1091

00:39:49,750 --> 00:39:47,440

can learn quite a lot um within the

1092

00:39:52,150 --> 00:39:49,760

resolution limitations of course um but

1093

00:39:53,430 --> 00:39:52,160

by remote sensing um

1094

00:39:54,230 --> 00:39:53,440

we're we're

1095

00:39:56,150 --> 00:39:54,240

uh

1096

00:39:58,630 --> 00:39:56,160

not to talk too much about da vinci but

1097

00:40:01,430 --> 00:39:58,640

we're um you know we have two elements

1098

00:40:04,150 --> 00:40:01,440

to our mission one we'll do a couple of

1099

00:40:06,870 --> 00:40:04,160

flybys of the planet

1100

00:40:10,150 --> 00:40:06,880

um and uh with some remote sensing

1101
00:40:11,910 --> 00:40:10,160
capabilities um and look at the clouds

1102
00:40:13,910 --> 00:40:11,920
look at cloud dynamics look at cloud

1103
00:40:15,349 --> 00:40:13,920
chemistry uh look at the night side of

1104
00:40:16,870 --> 00:40:15,359
the planet see if we can peer through

1105
00:40:19,030 --> 00:40:16,880
the clouds in certain wavelengths and

1106
00:40:20,950 --> 00:40:19,040
tell something about the um the rock

1107
00:40:23,349 --> 00:40:20,960
types on the surface and then connect

1108
00:40:24,870 --> 00:40:23,359
that to our descent imagery as our probe

1109
00:40:27,750 --> 00:40:24,880
goes through the clouds i mean the

1110
00:40:30,390 --> 00:40:27,760
clouds are hard on venus and uh and so

1111
00:40:32,710 --> 00:40:30,400
um remote sensing certainly has uh

1112
00:40:33,910 --> 00:40:32,720
provides context um you know but it's

1113
00:40:36,309 --> 00:40:33,920

it's uh

1114

00:40:38,630 --> 00:40:36,319

it's a it's a compliment to uh to

1115

00:40:39,990 --> 00:40:38,640

in-situ investigation

1116

00:40:41,589 --> 00:40:40,000

i love that

1117

00:40:43,589 --> 00:40:41,599

scale of different ways of looking but

1118

00:40:46,069 --> 00:40:43,599

also the complementation you know the

1119

00:40:47,430 --> 00:40:46,079

nature of these orbiters and landers and

1120

00:40:49,430 --> 00:40:47,440

things like that i know with europa

1121

00:40:50,550 --> 00:40:49,440

clipper for instance at first you know

1122

00:40:52,710 --> 00:40:50,560

some of us thought we would get like

1123

00:40:54,790 --> 00:40:52,720

little micro landers or little things

1124

00:40:56,550 --> 00:40:54,800

that would drop off the spacecraft that

1125

00:40:58,309 --> 00:40:56,560

didn't happen in the end unfortunately i

1126
00:40:59,670 --> 00:40:58,319
really wish it had but maybe in the

1127
00:41:01,270 --> 00:40:59,680
future we'll see more of these

1128
00:41:03,510 --> 00:41:01,280
complementary missions that have the

1129
00:41:05,589 --> 00:41:03,520
orbiter lander maybe even rover all as

1130
00:41:06,870 --> 00:41:05,599
you know one package together

1131
00:41:09,030 --> 00:41:06,880
we do have one question that came in

1132
00:41:10,390 --> 00:41:09,040
from a new eraser

1133
00:41:12,150 --> 00:41:10,400
i apologize and nuke that's not the

1134
00:41:13,910 --> 00:41:12,160
correct pronunciation

1135
00:41:15,190 --> 00:41:13,920
a nuke has asked

1136
00:41:17,190 --> 00:41:15,200
what would you say is the main

1137
00:41:19,829 --> 00:41:17,200
limitation for scientific instruments on

1138
00:41:21,829 --> 00:41:19,839

mars rovers is it power availability

1139

00:41:24,069 --> 00:41:21,839

size the weight robustness of

1140

00:41:25,430 --> 00:41:24,079

instruments for space missions um and i

1141

00:41:26,710 --> 00:41:25,440

guess stephanie i'll start with you what

1142

00:41:29,109 --> 00:41:26,720

do you think are the main limitations

1143

00:41:33,109 --> 00:41:29,119

for for our scientific instruments

1144

00:41:34,470 --> 00:41:33,119

um yeah mars well so mars in particular

1145

00:41:36,309 --> 00:41:34,480

is hard

1146

00:41:38,710 --> 00:41:36,319

um from the perspective that there's

1147

00:41:39,829 --> 00:41:38,720

enough atmosphere to try to kill you on

1148

00:41:42,630 --> 00:41:39,839

the way down

1149

00:41:43,910 --> 00:41:42,640

but not enough um to really make it easy

1150

00:41:45,190 --> 00:41:43,920

on you like venus is easy because

1151
00:41:47,349 --> 00:41:45,200
there's a huge amount of atmosphere you

1152
00:41:50,150 --> 00:41:47,359
need a tiny parachute for only part of

1153
00:41:52,390 --> 00:41:50,160
your descent right but um but for mars

1154
00:41:54,470 --> 00:41:52,400
the the the atmosphere is in this zone

1155
00:41:56,470 --> 00:41:54,480
where you need huge parachutes and you

1156
00:41:59,510 --> 00:41:56,480
also need like you know oftentimes some

1157
00:42:02,230 --> 00:41:59,520
other uh mechanism to help you land um

1158
00:42:03,750 --> 00:42:02,240
safely and so what that translates to is

1159
00:42:07,670 --> 00:42:03,760
of course limitations on how much you

1160
00:42:12,069 --> 00:42:07,680
can land um in terms of mass and uh

1161
00:42:14,710 --> 00:42:12,079
um and capability and so i it um i mean

1162
00:42:17,270 --> 00:42:14,720
obviously to fit inside a rocket fairing

1163
00:42:18,390 --> 00:42:17,280

you you have some limitations to your

1164

00:42:22,950 --> 00:42:18,400

volume

1165

00:42:24,230 --> 00:42:22,960

between how many different capabilities

1166

00:42:25,829 --> 00:42:24,240

you can send and how big those

1167

00:42:29,270 --> 00:42:25,839

capabilities are

1168

00:42:31,030 --> 00:42:29,280

um and so so you so you somehow just

1169

00:42:32,950 --> 00:42:31,040

find this optimum

1170

00:42:34,390 --> 00:42:32,960

for the particular opportunity that you

1171

00:42:36,710 --> 00:42:34,400

have that

1172

00:42:40,630 --> 00:42:36,720

you know that fits within your fairing

1173

00:42:43,109 --> 00:42:40,640

that can be landed with uh safely onto

1174

00:42:46,470 --> 00:42:43,119

the surface of the planet if that's your

1175

00:42:49,910 --> 00:42:46,480

mission goal um and uh and it has enough

1176

00:42:52,630 --> 00:42:49,920

breadth to be able to um you know to put

1177

00:42:54,069 --> 00:42:52,640

your core discoveries into context um in

1178

00:42:55,829 --> 00:42:54,079

that environment

1179

00:42:57,910 --> 00:42:55,839

i don't know if that helps it's very

1180

00:42:59,030 --> 00:42:57,920

very helpful uh next we have a second

1181

00:43:01,589 --> 00:42:59,040

question from a nuke that i think i'm

1182

00:43:03,430 --> 00:43:01,599

going to answer first so a nuke says i

1183

00:43:05,589 --> 00:43:03,440

use raman spectroscopy in my research

1184

00:43:06,710 --> 00:43:05,599

i'm a big fan what are the limitations

1185

00:43:08,470 --> 00:43:06,720

that stop us from putting a very

1186

00:43:11,030 --> 00:43:08,480

sensitive raman spectroscope on mars and

1187

00:43:13,190 --> 00:43:11,040

looking for organics um a nuke we have a

1188

00:43:15,349 --> 00:43:13,200

raman spectroscopy on mars and it can

1189

00:43:17,190 --> 00:43:15,359

look for organics um own perseverance

1190

00:43:18,950 --> 00:43:17,200

the sherlock instrument uh i also use

1191

00:43:21,589 --> 00:43:18,960

ramon spectroscopy in my graduate

1192

00:43:23,910 --> 00:43:21,599

research uh and and super excited for

1193

00:43:26,150 --> 00:43:23,920

perseverance and for sherlock

1194

00:43:27,670 --> 00:43:26,160

and so richard maybe for you um what are

1195

00:43:29,589 --> 00:43:27,680

the limitations we've had in getting

1196

00:43:31,349 --> 00:43:29,599

some of these more these newer kind of

1197

00:43:34,630 --> 00:43:31,359

uh instrumental approaches onto some of

1198

00:43:35,990 --> 00:43:34,640

our rovers and our spacecraft

1199

00:43:39,030 --> 00:43:36,000

well i think

1200

00:43:41,670 --> 00:43:39,040

you know you take something like

1201

00:43:43,750 --> 00:43:41,680

we are bringing new technologies and new

1202

00:43:45,990 --> 00:43:43,760

approaches on these rovers

1203

00:43:48,630 --> 00:43:46,000

um so i don't think it's it's an issue

1204

00:43:50,870 --> 00:43:48,640

of the technologies but i agree with

1205

00:43:52,870 --> 00:43:50,880

with stephanie every mission has

1206

00:43:56,870 --> 00:43:52,880

multiple objectives

1207

00:43:59,349 --> 00:43:56,880

you have to have multiple instruments

1208

00:44:02,309 --> 00:43:59,359

multiple instruments types that need to

1209

00:44:04,710 --> 00:44:02,319

share resources and so particularly on a

1210

00:44:07,190 --> 00:44:04,720

rover you have all sorts of resource

1211

00:44:09,349 --> 00:44:07,200

limitations so i think that that that

1212

00:44:12,069 --> 00:44:09,359

um you know

1213

00:44:14,790 --> 00:44:12,079

each each time we go the rose rovers get

1214

00:44:18,390 --> 00:44:14,800

bigger and more capable um but still i

1215

00:44:20,390 --> 00:44:18,400

think that that's a a primary limitation

1216

00:44:21,430 --> 00:44:20,400

we try to do a number of different

1217

00:44:23,190 --> 00:44:21,440

things

1218

00:44:26,790 --> 00:44:23,200

and we need a number of different tools

1219

00:44:30,069 --> 00:44:26,800

to do that um and so that that you know

1220

00:44:33,190 --> 00:44:30,079

spreads resources around

1221

00:44:37,910 --> 00:44:33,200

very good um questions john rose told

1222

00:44:42,230 --> 00:44:39,430

i imagine john's thinking of maybe

1223

00:44:44,470 --> 00:44:42,240

metabolisms that rely on producing and

1224

00:44:47,349 --> 00:44:44,480

probably more more likely consuming

1225

00:44:48,390 --> 00:44:47,359

methane so methanotrophs perhaps um so

1226

00:44:50,390 --> 00:44:48,400

john wants to know what kinds of

1227

00:44:52,390 --> 00:44:50,400

scientific instruments you think

1228

00:44:54,790 --> 00:44:52,400

we would need to detect to detect these

1229

00:45:02,230 --> 00:44:54,800

life forms that could be in a place like

1230

00:45:05,109 --> 00:45:03,190

that's a

1231

00:45:06,950 --> 00:45:05,119

well we're not going to solve this here

1232

00:45:09,109 --> 00:45:06,960

but um

1233

00:45:11,109 --> 00:45:09,119

uh but i think it's a it's a valid

1234

00:45:12,630 --> 00:45:11,119

question i mean i think that we're um

1235

00:45:13,829 --> 00:45:12,640

and i'm going to hand it over to richard

1236

00:45:15,910 --> 00:45:13,839

in a second there are two things i want

1237

00:45:17,510 --> 00:45:15,920

to say first thing is that we're still

1238

00:45:19,670 --> 00:45:17,520

in the um

1239

00:45:21,750 --> 00:45:19,680

uh um

1240

00:45:23,589 --> 00:45:21,760

at the level of understanding at titan

1241

00:45:25,190 --> 00:45:23,599

that we're still asking basic questions

1242

00:45:27,750 --> 00:45:25,200

about what the

1243

00:45:29,430 --> 00:45:27,760

you know the resources are for any life

1244

00:45:30,790 --> 00:45:29,440

form there we know that it's cold there

1245

00:45:33,109 --> 00:45:30,800

we know that there's liquid there that's

1246

00:45:36,470 --> 00:45:33,119

great we know there's ice water ice

1247

00:45:38,069 --> 00:45:36,480

there that's also cool

1248

00:45:40,630 --> 00:45:38,079

and we know that there's a really rich

1249

00:45:43,109 --> 00:45:40,640

atmosphere that is a laboratory for

1250

00:45:45,910 --> 00:45:43,119

organic chemistry which is really cool

1251

00:45:48,390 --> 00:45:45,920

and definitely prebiotically

1252

00:45:51,109 --> 00:45:48,400

important if not biologically active

1253

00:45:52,390 --> 00:45:51,119

right now um but with with dragonfly and

1254

00:45:53,990 --> 00:45:52,400

i'm not on the dragonfly mission so

1255

00:45:54,790 --> 00:45:54,000

forgive me if i get anything wrong um

1256

00:45:56,710 --> 00:45:54,800

but

1257

00:45:58,870 --> 00:45:56,720

with dragonfly we're going to ask those

1258

00:46:01,510 --> 00:45:58,880

really foundational questions about what

1259

00:46:02,230 --> 00:46:01,520

the current chemistry is what the cycles

1260

00:46:03,829 --> 00:46:02,240

are

1261

00:46:06,470 --> 00:46:03,839

how the surface expresses those

1262

00:46:08,069 --> 00:46:06,480

different cycles what variability there

1263

00:46:10,710 --> 00:46:08,079

is across the surface for those who

1264

00:46:12,950 --> 00:46:10,720

don't know dragonfly is a quadcopter

1265

00:46:14,550 --> 00:46:12,960

with aerial mobility that will land

1266

00:46:17,190 --> 00:46:14,560

repeatedly

1267

00:46:19,990 --> 00:46:17,200

in in different regions of

1268

00:46:23,030 --> 00:46:20,000

saturn's moon titan and and take

1269

00:46:25,670 --> 00:46:23,040

analyses take in samples and analyze

1270

00:46:27,510 --> 00:46:25,680

those samples and look at variability in

1271

00:46:29,510 --> 00:46:27,520

the chemistry of the surface environment

1272

00:46:31,349 --> 00:46:29,520

and atmosphere near surface atmosphere

1273

00:46:32,630 --> 00:46:31,359

of titan um

1274

00:46:34,950 --> 00:46:32,640

through the course of that mission so

1275

00:46:37,190 --> 00:46:34,960

that's really exciting because it's like

1276
00:46:38,470 --> 00:46:37,200
um we're on the verge of understanding

1277
00:46:41,109 --> 00:46:38,480
an incredible

1278
00:46:43,190 --> 00:46:41,119
amount about titan where we can then

1279
00:46:44,230 --> 00:46:43,200
kind of engage

1280
00:46:45,750 --> 00:46:44,240
our best

1281
00:46:48,150 --> 00:46:45,760
thinkers on

1282
00:46:50,790 --> 00:46:48,160
the fundamentals of biology

1283
00:46:53,670 --> 00:46:50,800
and um and start to ask questions about

1284
00:46:55,910 --> 00:46:53,680
what a metabolism would look like right

1285
00:46:58,309 --> 00:46:55,920
but i think and and let me say that

1286
00:47:02,069 --> 00:46:58,319
dragonfly that instrument suite the

1287
00:47:04,870 --> 00:47:02,079
payload suite is um is capable of making

1288
00:47:06,790 --> 00:47:04,880

really broad analytical measurements

1289

00:47:08,390 --> 00:47:06,800

that can be interpreted and debated

1290

00:47:11,270 --> 00:47:08,400

probably right

1291

00:47:13,990 --> 00:47:11,280

about what they mean um so that that

1292

00:47:16,790 --> 00:47:14,000

mission is a good example of where you

1293

00:47:18,470 --> 00:47:16,800

can incorporate instrumentation you can

1294

00:47:21,109 --> 00:47:18,480

you know include instrumentation in your

1295

00:47:23,829 --> 00:47:21,119

payload that's capable of really broad

1296

00:47:26,870 --> 00:47:23,839

scientific inquiry and prepared to

1297

00:47:30,069 --> 00:47:26,880

discover new things and that is the one

1298

00:47:31,829 --> 00:47:30,079

of the really really exciting things

1299

00:47:33,910 --> 00:47:31,839

very cool and you know drones are so hot

1300

00:47:36,549 --> 00:47:33,920

right now um but dragonfly is going

1301

00:47:38,710 --> 00:47:36,559

someplace super cold uh the surface

1302

00:47:41,589 --> 00:47:38,720

titan is very cold perhaps too cold for

1303

00:47:42,950 --> 00:47:41,599

for metabolisms at the surface and so so

1304

00:47:45,510 --> 00:47:42,960

richard um if you can answer the

1305

00:47:46,790 --> 00:47:45,520

question as well but also i'd ask uh

1306

00:47:49,829 --> 00:47:46,800

what would we have to take to get into

1307

00:47:52,230 --> 00:47:49,839

the subsurface of titan as well

1308

00:47:54,710 --> 00:47:52,240

um well the first part of the question

1309

00:47:56,870 --> 00:47:54,720

i'll i again i agree with stephanie

1310

00:47:59,510 --> 00:47:56,880

completely you know we can look back to

1311

00:48:01,190 --> 00:47:59,520

viking and the first mission to viking

1312

00:48:03,990 --> 00:48:01,200

they were it's going to be light

1313

00:48:05,589 --> 00:48:04,000

detection and three of their four

1314

00:48:06,790 --> 00:48:05,599

primary instruments were all about

1315

00:48:08,470 --> 00:48:06,800

trying to

1316

00:48:10,390 --> 00:48:08,480

dig up a little bit of soil and trying

1317

00:48:12,549 --> 00:48:10,400

to grow microbes in it

1318

00:48:14,309 --> 00:48:12,559

um and so what did we miss in that

1319

00:48:16,549 --> 00:48:14,319

mission well we missed the opportunity

1320

00:48:19,349 --> 00:48:16,559

to get some of the real fundamental

1321

00:48:21,270 --> 00:48:19,359

understanding of the environment that we

1322

00:48:23,349 --> 00:48:21,280

then did with follow-on missions we

1323

00:48:25,030 --> 00:48:23,359

really changed our strategy as stephanie

1324

00:48:27,910 --> 00:48:25,040

has already mentioned you know

1325

00:48:31,829 --> 00:48:27,920

step-by-step building on your knowledge

1326

00:48:34,549 --> 00:48:31,839

titan is a incredibly alien um

1327

00:48:37,829 --> 00:48:34,559

environment that we really don't know

1328

00:48:39,910 --> 00:48:37,839

much about at all and so the strategy

1329

00:48:42,950 --> 00:48:39,920

that's being used as stephanie pointed

1330

00:48:45,349 --> 00:48:42,960

out is to really start out funding

1331

00:48:48,230 --> 00:48:45,359

increasing our fundamental understanding

1332

00:48:51,030 --> 00:48:48,240

of that environment and from there we

1333

00:48:53,030 --> 00:48:51,040

can start developing hypotheses about

1334

00:49:00,829 --> 00:48:53,040

the potential for life and how that

1335

00:49:04,390 --> 00:49:01,990

um it's something new and dear to my

1336

00:49:06,870 --> 00:49:04,400

heart but um i'll let you choose if you

1337

00:49:09,190 --> 00:49:06,880

want to answer this uh william creamer

1338

00:49:11,510 --> 00:49:09,200

on youtube has asked um where we have

1339

00:49:13,190 --> 00:49:11,520

experiments that can grab samples um you

1340

00:49:16,470 --> 00:49:13,200

know in situ so we're grabbing up some

1341

00:49:18,309 --> 00:49:16,480

regolith that might contain e.t life

1342

00:49:21,349 --> 00:49:18,319

um is there a consideration of the

1343

00:49:24,230 --> 00:49:21,359

bioethical consequences of potentially

1344

00:49:26,390 --> 00:49:24,240

harming any life in the sample

1345

00:49:28,470 --> 00:49:26,400

and so i'll start um since i'm currently

1346

00:49:31,430 --> 00:49:28,480

working on a collaboration with the

1347

00:49:33,349 --> 00:49:31,440

artist lucia monge she and i are going

1348

00:49:35,430 --> 00:49:33,359

to be growing ornamental plants in in

1349

00:49:37,670 --> 00:49:35,440

martian regal and marshall conditions

1350

00:49:40,710 --> 00:49:37,680

specifically on martian time with the

1351

00:49:42,950 --> 00:49:40,720

extra 40 minutes of day length

1352

00:49:44,630 --> 00:49:42,960

however we're also thinking about not

1353

00:49:46,790 --> 00:49:44,640

just the the impacts to the plants but

1354

00:49:48,710 --> 00:49:46,800

also the impacts to the humans as well

1355

00:49:51,430 --> 00:49:48,720

as the ethics uh the ethical

1356

00:49:53,430 --> 00:49:51,440

consequences of putting other organisms

1357

00:49:55,430 --> 00:49:53,440

into these conditions and so this is

1358

00:49:57,190 --> 00:49:55,440

kind of important for my own work in

1359

00:49:59,750 --> 00:49:57,200

considering you know how do we treat

1360

00:50:01,829 --> 00:49:59,760

other life out there um so i wonder for

1361

00:50:03,829 --> 00:50:01,839

either of you in your own conversations

1362

00:50:05,990 --> 00:50:03,839

um perhaps in the workshop have anything

1363

00:50:09,349 --> 00:50:06,000

around this kind of theme of bioethics

1364

00:50:13,349 --> 00:50:10,549

well

1365

00:50:14,710 --> 00:50:13,359

so i i would say that that that part of

1366

00:50:15,589 --> 00:50:14,720

that is

1367

00:50:18,549 --> 00:50:15,599

you know

1368

00:50:20,309 --> 00:50:18,559

falls within a broader discussion that

1369

00:50:22,790 --> 00:50:20,319

we have all the time about forward

1370

00:50:24,309 --> 00:50:22,800

contamination of another planet

1371

00:50:29,510 --> 00:50:24,319

and that has

1372

00:50:34,069 --> 00:50:31,510

so i would say that the community

1373

00:50:35,990 --> 00:50:34,079

or or you know planetary sciences it is

1374

00:50:37,190 --> 00:50:36,000

something that is thought about and is

1375

00:50:40,790 --> 00:50:37,200

considered

1376

00:50:43,349 --> 00:50:40,800

um and and our approaches to exploration

1377

00:50:44,950 --> 00:50:43,359

are you know also take that into account

1378

00:50:47,910 --> 00:50:44,960

in terms of planetary protection

1379

00:50:50,309 --> 00:50:47,920

requirements or you know ability to you

1380

00:50:53,109 --> 00:50:50,319

know contaminate the planet and also to

1381

00:50:55,109 --> 00:50:53,119

contaminate our own science

1382

00:50:56,549 --> 00:50:55,119

oh it's a very true

1383

00:50:57,910 --> 00:50:56,559

actually we have another question from

1384

00:51:00,309 --> 00:50:57,920

the nuke again he's asking some really

1385

00:51:03,109 --> 00:51:00,319

good ones here uh a nuke uh wants to

1386

00:51:06,230 --> 00:51:03,119

know with the possible contamination

1387

00:51:09,109 --> 00:51:06,240

of mars from human habitation um how

1388

00:51:12,470 --> 00:51:09,119

might that affect our search for current

1389

00:51:15,750 --> 00:51:12,480

or or past life on mars

1390

00:51:18,870 --> 00:51:17,190

because i

1391

00:51:20,630 --> 00:51:18,880

talked about this quite a bit

1392

00:51:22,870 --> 00:51:20,640

and and you know

1393

00:51:24,309 --> 00:51:22,880

so there's two parts of or there's you

1394

00:51:27,190 --> 00:51:24,319

know it's sort of a continuum right

1395

00:51:29,190 --> 00:51:27,200

they'll be the first discovery of life

1396

00:51:30,790 --> 00:51:29,200

um that'll happen sometime hopefully in

1397

00:51:32,790 --> 00:51:30,800

the very near future

1398

00:51:34,710 --> 00:51:32,800

um but we could compare that to say the

1399

00:51:37,349 --> 00:51:34,720

search for exoplanets

1400

00:51:39,349 --> 00:51:37,359

after the first exoplanet was discovered

1401

00:51:41,030 --> 00:51:39,359

that field exploded

1402

00:51:42,870 --> 00:51:41,040

trying to understand

1403

00:51:44,710 --> 00:51:42,880

where they are how many they are what's

1404

00:51:46,390 --> 00:51:44,720

their nature i think with human

1405

00:51:51,109 --> 00:51:46,400

exploration the same thing is going to

1406

00:51:53,589 --> 00:51:51,119

happen um there will be it will increase

1407

00:51:55,990 --> 00:51:53,599

um the effort to search for life by

1408

00:51:58,470 --> 00:51:56,000

orders of magnitude so it's not it's not

1409

00:52:01,589 --> 00:51:58,480

a negative it's actually a positive and

1410

00:52:03,589 --> 00:52:01,599

i would put it in comparison also to the

1411

00:52:04,390 --> 00:52:03,599

research that people do here on earth

1412

00:52:06,870 --> 00:52:04,400

right

1413

00:52:09,109 --> 00:52:06,880

we're constantly out in the field trying

1414

00:52:09,990 --> 00:52:09,119

to understand the origin of life on

1415

00:52:12,630 --> 00:52:10,000

earth

1416

00:52:14,470 --> 00:52:12,640

and the presence of humans well

1417

00:52:16,309 --> 00:52:14,480

no matter how much we pollute we're

1418

00:52:18,069 --> 00:52:16,319

still searching that answer and and

1419

00:52:18,870 --> 00:52:18,079

we're still successful i don't think

1420

00:52:22,069 --> 00:52:18,880

that

1421

00:52:24,470 --> 00:52:22,079

um you know the the the signs of life um

1422

00:52:26,470 --> 00:52:24,480

are vast and diverse and i don't think

1423

00:52:29,349 --> 00:52:26,480

we're going to be confusing

1424

00:52:31,190 --> 00:52:29,359

um say ancient fossil records on mars

1425

00:52:34,309 --> 00:52:31,200

with contemporary contamination that

1426

00:52:37,030 --> 00:52:34,319

come from humans so i see that you know

1427

00:52:39,270 --> 00:52:37,040

the the human exploration part of mars

1428

00:52:40,549 --> 00:52:39,280

really just expands our ability to

1429

00:52:42,630 --> 00:52:40,559

understand

1430

00:52:44,870 --> 00:52:42,640

uh the potential for life on mars and

1431

00:52:46,630 --> 00:52:44,880

its potential distribution so i look

1432

00:52:49,270 --> 00:52:46,640

really forward to it

1433

00:52:51,670 --> 00:52:49,280

and i'll just add a few programs

1434

00:52:54,390 --> 00:52:51,680

um a couple of things

1435

00:52:56,630 --> 00:52:54,400

really excellent answer um but you know

1436

00:52:58,870 --> 00:52:56,640

we're tackling we're tackling similar

1437

00:53:01,349 --> 00:52:58,880

questions already

1438

00:53:03,109 --> 00:53:01,359

um in terms of how do we distinguish

1439

00:53:05,750 --> 00:53:03,119

between what we've brought

1440

00:53:07,750 --> 00:53:05,760

and um and what's you know

1441

00:53:10,470 --> 00:53:07,760

indigenous to the sample or to the

1442

00:53:12,230 --> 00:53:10,480

environment and so um you know

1443

00:53:14,950 --> 00:53:12,240

so far we've tackled that most

1444

00:53:17,670 --> 00:53:14,960

explicitly for chemical signatures right

1445

00:53:20,069 --> 00:53:17,680

um so we um we

1446

00:53:22,950 --> 00:53:20,079

typically missions exercise very

1447

00:53:25,910 --> 00:53:22,960

rigorous contamination control

1448

00:53:28,870 --> 00:53:25,920

plans to um to document what you're

1449

00:53:32,069 --> 00:53:28,880

sending and to understand how

1450

00:53:34,549 --> 00:53:32,079

those signatures might be expressed by

1451
00:53:37,829 --> 00:53:34,559
um in situ you know analyses once you

1452
00:53:40,069 --> 00:53:37,839
get to a place the the other analogy is

1453
00:53:43,589 --> 00:53:40,079
you know looking at uh

1454
00:53:46,950 --> 00:53:43,599
analyzing meteorites for prebiotic

1455
00:53:49,510 --> 00:53:46,960
compounds like nucleobase amino acid

1456
00:53:51,430 --> 00:53:49,520
oxalic acids i mean routinely routinely

1457
00:53:54,470 --> 00:53:51,440
it takes a lot of effort but we've come

1458
00:53:55,990 --> 00:53:54,480
up with a protocol for for establishing

1459
00:53:58,549 --> 00:53:56,000
which of those amino acids are most

1460
00:54:01,589 --> 00:53:58,559
likely to have originated beyond earth

1461
00:54:04,069 --> 00:54:01,599
in prebiotic chemical pathways on on

1462
00:54:05,829 --> 00:54:04,079
these you know primitive bodies and

1463
00:54:07,910 --> 00:54:05,839

which are contamination from earth and

1464

00:54:10,790 --> 00:54:07,920

that comes from like you know just the

1465

00:54:13,270 --> 00:54:10,800

prevalence of those amino acids in life

1466

00:54:15,670 --> 00:54:13,280

on earth versus you know what we're um

1467

00:54:18,230 --> 00:54:15,680

what are very convincingly outside of

1468

00:54:20,150 --> 00:54:18,240

the typical regime of life that you

1469

00:54:22,150 --> 00:54:20,160

would see

1470

00:54:25,190 --> 00:54:22,160

terrestrially so i think that we have a

1471

00:54:26,790 --> 00:54:25,200

lot of great thinking to build upon

1472

00:54:28,870 --> 00:54:26,800

to try to tackle some of these

1473

00:54:30,150 --> 00:54:28,880

challenges i mean

1474

00:54:32,470 --> 00:54:30,160

you know i think

1475

00:54:34,630 --> 00:54:32,480

preparation is good and folding in some

1476

00:54:36,789 --> 00:54:34,640

of these concerns into

1477

00:54:39,270 --> 00:54:36,799

plans not only for robotic but for

1478

00:54:41,829 --> 00:54:39,280

future human missions is important and i

1479

00:54:43,829 --> 00:54:41,839

know that thinking is going on um but

1480

00:54:46,150 --> 00:54:43,839

also you know we have good strategies

1481

00:54:48,309 --> 00:54:46,160

for um for being able to differentiate

1482

00:54:50,630 --> 00:54:48,319

between the origin of signals

1483

00:54:51,829 --> 00:54:50,640

that's fantastic um so many important

1484

00:54:53,990 --> 00:54:51,839

things there and i'm going to switch the

1485

00:54:55,589 --> 00:54:54,000

gears a little bit more here again so we

1486

00:54:57,829 --> 00:54:55,599

we switch to like philosophy and

1487

00:54:59,990 --> 00:54:57,839

bioethics um our next question is more

1488

00:55:02,309 --> 00:55:00,000

in the norm of space law and comes from

1489

00:55:04,870 --> 00:55:02,319

adam robinson on youtube

1490

00:55:07,430 --> 00:55:04,880

and so we'll see how much you wish to

1491

00:55:08,950 --> 00:55:07,440

answer this question um adam kind of

1492

00:55:11,510 --> 00:55:08,960

wants to know

1493

00:55:14,630 --> 00:55:11,520

should we create laws or policy

1494

00:55:16,470 --> 00:55:14,640

um to control where private companies um

1495

00:55:17,910 --> 00:55:16,480

and i would actually add any government

1496

00:55:20,309 --> 00:55:17,920

agency as well

1497

00:55:22,549 --> 00:55:20,319

from going to certain areas perhaps on

1498

00:55:24,309 --> 00:55:22,559

mars or another world that we've deemed

1499

00:55:26,630 --> 00:55:24,319

potentially habitable or that could be a

1500

00:55:28,150 --> 00:55:26,640

good place to find signs of past or

1501

00:55:30,390 --> 00:55:28,160

present life

1502

00:55:32,470 --> 00:55:30,400

this kind of reminds me of the concept

1503

00:55:34,789 --> 00:55:32,480

of planetary parks for instance should

1504

00:55:36,870 --> 00:55:34,799

we have preserved areas of some of these

1505

00:55:38,870 --> 00:55:36,880

worlds where for instance we don't send

1506

00:55:40,230 --> 00:55:38,880

a rover because it might just be that

1507

00:55:42,950 --> 00:55:40,240

nice and pristine and we don't want to

1508

00:55:44,950 --> 00:55:42,960

ruin anything um stephanie what do you

1509

00:55:47,670 --> 00:55:44,960

think about that well i'm a big fan of

1510

00:55:49,510 --> 00:55:47,680

national parks on earth so

1511

00:55:51,910 --> 00:55:49,520

yes no

1512

00:55:54,309 --> 00:55:51,920

i don't know that um i it's obviously

1513

00:55:57,750 --> 00:55:54,319

outside of my field but um but i think

1514

00:56:02,390 --> 00:55:57,760

uh you know that there are good examples

1515

00:56:03,510 --> 00:56:02,400

of where um people from different uh um

1516

00:56:07,030 --> 00:56:03,520

you know

1517

00:56:09,829 --> 00:56:07,040

countries have come together and come to

1518

00:56:13,430 --> 00:56:09,839

agreements about how to um

1519

00:56:15,829 --> 00:56:13,440

uh you know rules of exploration and and

1520

00:56:18,549 --> 00:56:15,839

uh and some common um

1521

00:56:20,470 --> 00:56:18,559

values that we have in

1522

00:56:23,270 --> 00:56:20,480

exploring um

1523

00:56:25,750 --> 00:56:23,280

space and um and i think you know the

1524

00:56:28,390 --> 00:56:25,760

future is that there are

1525

00:56:31,670 --> 00:56:28,400

there's a proliferation of

1526

00:56:34,549 --> 00:56:31,680

entities that are capable of pushing

1527

00:56:36,789 --> 00:56:34,559

um exploration even further and so we

1528

00:56:37,670 --> 00:56:36,799

should i think we should acknowledge it

1529

00:56:39,030 --> 00:56:37,680

and

1530

00:56:41,589 --> 00:56:39,040

bring together

1531

00:56:44,150 --> 00:56:41,599

uh um you know all interested parties

1532

00:56:46,549 --> 00:56:44,160

into those discussions but i'm sorry i'm

1533

00:56:48,470 --> 00:56:46,559

like really out on a limb

1534

00:56:49,750 --> 00:56:48,480

i love that answer

1535

00:56:51,829 --> 00:56:49,760

and i guess so we actually are coming

1536

00:56:53,430 --> 00:56:51,839

down to the top of the hour and i'm

1537

00:56:54,710 --> 00:56:53,440

going to be a little selfish here and

1538

00:56:55,829 --> 00:56:54,720

ask you one more question and i think

1539

00:56:58,230 --> 00:56:55,839

it's kind of fun

1540

00:56:59,750 --> 00:56:58,240

um so for myself i was inspired at five

1541

00:57:02,390 --> 00:56:59,760

years old to become a scientist by

1542

00:57:03,990 --> 00:57:02,400

watching an an 80s movie that had some

1543

00:57:06,069 --> 00:57:04,000

rock and roll in it and talked about

1544

00:57:07,670 --> 00:57:06,079

mathematics and you know with my life i

1545

00:57:09,990 --> 00:57:07,680

was inspired by things like star trek

1546

00:57:11,670 --> 00:57:10,000

and star wars um i wonder for both of

1547

00:57:14,549 --> 00:57:11,680

you is there anything in like science

1548

00:57:16,470 --> 00:57:14,559

fiction or literature film comic books

1549

00:57:18,789 --> 00:57:16,480

or novels things that you know that

1550

00:57:21,670 --> 00:57:18,799

others have created maybe even art that

1551
00:57:23,990 --> 00:57:21,680
has inspired you to pursue these careers

1552
00:57:25,750 --> 00:57:24,000
that you've both taken on in your lives

1553
00:57:27,190 --> 00:57:25,760
and richard i'll start with you is there

1554
00:57:29,190 --> 00:57:27,200
anything that's really inspired you to

1555
00:57:31,430 --> 00:57:29,200
pursue this life

1556
00:57:33,190 --> 00:57:31,440
well i i started my career in science

1557
00:57:35,109 --> 00:57:33,200
education working at the national

1558
00:57:36,870 --> 00:57:35,119
science foundation and i never actually

1559
00:57:39,670 --> 00:57:36,880
thought i'd become a planetary science

1560
00:57:41,910 --> 00:57:39,680
or or an astrobiologist

1561
00:57:43,829 --> 00:57:41,920
and i can also say that i'm not a big

1562
00:57:47,430 --> 00:57:43,839
fan of science fiction

1563
00:57:48,870 --> 00:57:47,440

um but but what i do love is the process

1564

00:57:50,870 --> 00:57:48,880

of discovery

1565

00:57:53,190 --> 00:57:50,880

and if i were gonna read a book it

1566

00:57:54,950 --> 00:57:53,200

actually might be um you know it would

1567

00:57:56,950 --> 00:57:54,960

be a biography

1568

00:57:59,109 --> 00:57:56,960

or it might be a historic something

1569

00:58:01,670 --> 00:57:59,119

about history because the difference

1570

00:58:03,430 --> 00:58:01,680

between science fiction and

1571

00:58:06,150 --> 00:58:03,440

us is we're real

1572

00:58:07,670 --> 00:58:06,160

and what we're doing is very very real

1573

00:58:09,750 --> 00:58:07,680

and and and

1574

00:58:11,589 --> 00:58:09,760

pursuing that and really understanding

1575

00:58:13,910 --> 00:58:11,599

the real challenges

1576

00:58:15,589 --> 00:58:13,920

um i think is really what what makes

1577

00:58:17,990 --> 00:58:15,599

this job great

1578

00:58:19,990 --> 00:58:18,000

that's fantastic how about you

1579

00:58:23,270 --> 00:58:20,000

what's inspired you and your career i'll

1580

00:58:25,910 --> 00:58:23,280

be really quick um so cosmos the

1581

00:58:27,510 --> 00:58:25,920

original cosmo series earl sagan was on

1582

00:58:30,069 --> 00:58:27,520

all the time when i was a kid so

1583

00:58:32,870 --> 00:58:30,079

obviously that played a huge role um i

1584

00:58:35,109 --> 00:58:32,880

also remember being like a tween-ish

1585

00:58:37,349 --> 00:58:35,119

and um and really pushing myself i

1586

00:58:39,109 --> 00:58:37,359

picked up a brief history of time by

1587

00:58:41,349 --> 00:58:39,119

stephen hawking from the bookstore and i

1588

00:58:42,950 --> 00:58:41,359

really pushed myself to um to read it

1589

00:58:45,510 --> 00:58:42,960

even though i wasn't convinced i could

1590

00:58:47,349 --> 00:58:45,520

right um but but that was a huge source

1591

00:58:49,910 --> 00:58:47,359

of information of inspiration not only

1592

00:58:51,990 --> 00:58:49,920

to like inspire my love of you know the

1593

00:58:53,990 --> 00:58:52,000

universe exploring the universe but also

1594

00:58:56,150 --> 00:58:54,000

to build my own confidence that these

1595

00:58:58,309 --> 00:58:56,160

are concepts that are not beyond me and

1596

00:58:59,430 --> 00:58:58,319

you know i could pursue hard science in

1597

00:59:01,750 --> 00:58:59,440

my studies

1598

00:59:04,230 --> 00:59:01,760

well that's wonderful um i'm so happy

1599

00:59:06,309 --> 00:59:04,240

you've joined us for this show today i'm

1600

00:59:08,150 --> 00:59:06,319

so glad you were both inspired to pursue

1601
00:59:10,470 --> 00:59:08,160
these careers and become astrobiologists

1602
00:59:13,430 --> 00:59:10,480
and planetary scientists and help us to

1603
00:59:14,630 --> 00:59:13,440
continue exploring and being curious uh

1604
00:59:16,789 --> 00:59:14,640
the future of the search for life

1605
00:59:18,870 --> 00:59:16,799
workshop is continuing in two more weeks

1606
00:59:20,230 --> 00:59:18,880
from now there's still more to tackle

1607
00:59:22,069 --> 00:59:20,240
and more work for these communities

1608
00:59:24,069 --> 00:59:22,079
you're bringing together uh for our

1609
00:59:25,510 --> 00:59:24,079
audience watching right now at home even

1610
00:59:27,829 --> 00:59:25,520
if you can't take part in the in the

1611
00:59:29,510 --> 00:59:27,839
workshop um if you're interested in

1612
00:59:31,589 --> 00:59:29,520
telling us what do you think are the

1613
00:59:33,270 --> 00:59:31,599

main challenges in bringing together the

1614

00:59:35,589 --> 00:59:33,280

technology and the science of light

1615

00:59:38,789 --> 00:59:35,599

protection uh feel free to reach out on

1616

00:59:41,510 --> 00:59:38,799

twitter at nasa astro bio or at saganorg

1617

00:59:45,829 --> 00:59:41,520

or you can find me at cosmobiologist

1618

00:59:48,390 --> 00:59:45,839

or you can email us at info

1619

00:59:49,829 --> 00:59:48,400

uh so dr stephanie getty dr richard

1620

00:59:52,150 --> 00:59:49,839

quinn thank you so much for joining us

1621

00:59:53,910 --> 00:59:52,160

for ask an astrobiologist thanks so much

1622

00:59:56,230 --> 00:59:53,920

grandma

1623

00:59:57,990 --> 00:59:56,240

great having you on um if anyone out

1624

00:59:59,829 --> 00:59:58,000

there watching wants to stay in the loop

1625

01:00:03,030 --> 00:59:59,839

about info and opportunities from nasa

1626

01:00:04,309 --> 01:00:03,040

astro biology uh we'll drop a link in

1627

01:00:06,710 --> 01:00:04,319

the chat so you can sign up for our

1628

01:00:07,829 --> 01:00:06,720

official mailing list learn more about

1629

01:00:11,109 --> 01:00:07,839

all the wonderful things nasa

1630

01:00:12,549 --> 01:00:11,119

astrobiology is doing uh so to to all of

1631

01:00:14,950 --> 01:00:12,559

you out there who've been exploring with

1632

01:00:16,950 --> 01:00:14,960

us and learning more thanks for joining

1633

01:00:18,690 --> 01:00:16,960

and until next time remember to

1634

01:01:10,309 --> 01:00:18,700

stay curious