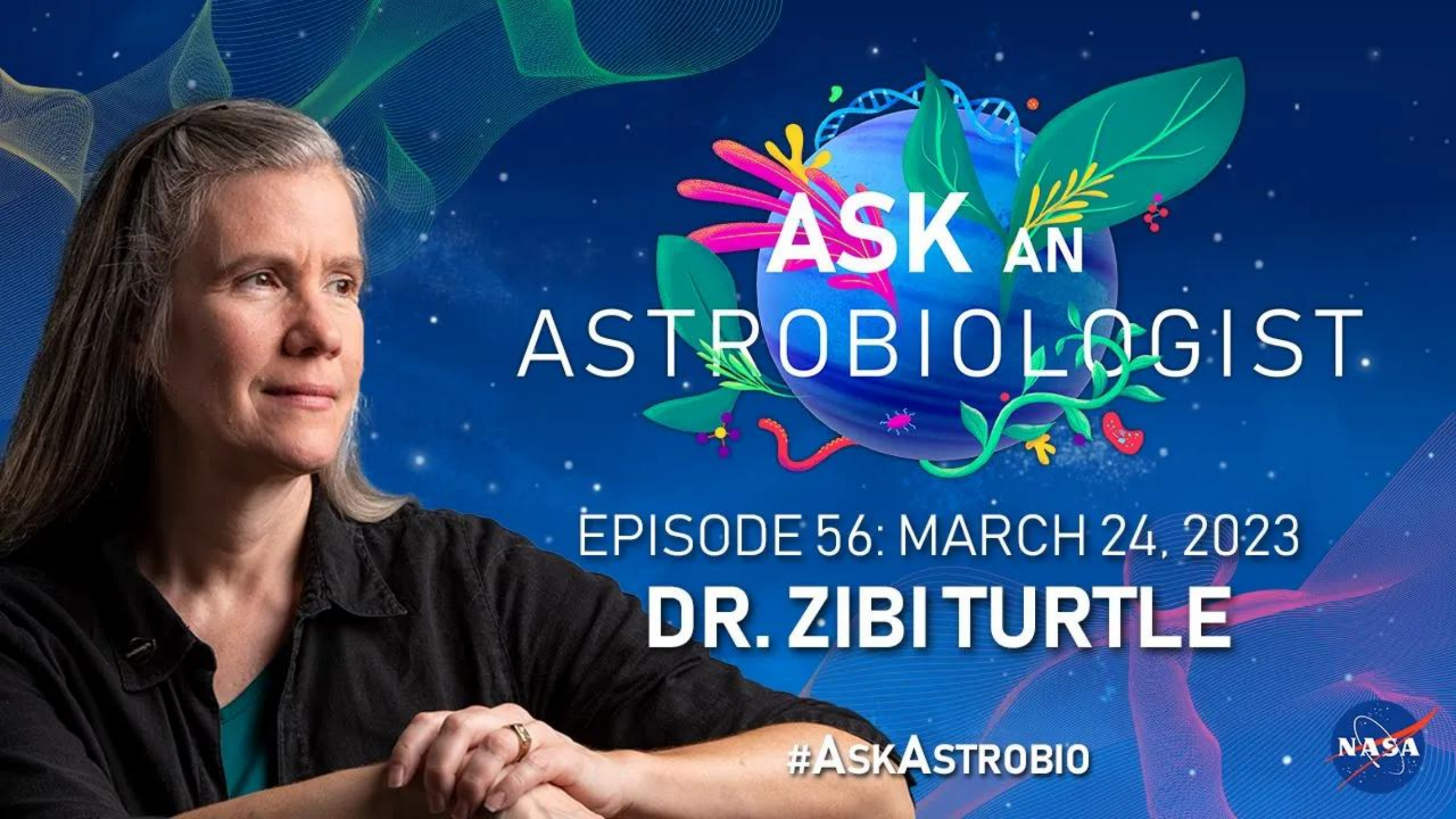
ASK AN
ASTROBIOLOGIST
EPISODE 56: MARCH 24, 2023
DR. ZIBI TURTLE
#AskAstrobio
NASA

1
00:00:01,840 --> 00:00:00,470
[Music]

2
00:00:22,730 --> 00:00:01,850
foreign

3
00:00:23,970 --> 00:00:22,740
[Music]

4
00:00:41,530 --> 00:00:23,980
[Applause]

5
00:00:44,690 --> 00:00:41,540
[Music]

6
00:00:47,450 --> 00:00:44,700
greetings friends fellow earthlings and

7
00:00:49,549 --> 00:00:47,460
explorers of the unknown welcome to ask

8
00:00:51,889 --> 00:00:49,559
an astrobiologist the show that

9
00:00:54,290 --> 00:00:51,899
celebrates the science as well as the

10
00:00:56,630 --> 00:00:54,300
scientists involved in our quest to

11
00:00:58,790 --> 00:00:56,640
understand the nature of life I'm your

12
00:01:01,250 --> 00:00:58,800
host Dr Graham Lau also known as the

13
00:01:03,290 --> 00:01:01,260

cosmo biologist this month we want to

14
00:01:06,649 --> 00:01:03,300
highlight one of our past guests

15
00:01:08,330 --> 00:01:06,659
actually shared about today's episode so

16
00:01:10,969 --> 00:01:08,340
very very a very huge thank you to

17
00:01:12,770 --> 00:01:10,979
Morgan cable on Twitter at stars are

18
00:01:15,230 --> 00:01:12,780
calling for sharing about this episode

19
00:01:18,410 --> 00:01:15,240
you might recall that Morgan was our

20
00:01:20,510 --> 00:01:18,420
guest on episode 16 of the show and we

21
00:01:23,090 --> 00:01:20,520
talked about worlds like Enceladus and

22
00:01:24,649 --> 00:01:23,100
Europa and Titan and so that's

23
00:01:27,350 --> 00:01:24,659
especially fitting for today's show

24
00:01:30,010 --> 00:01:27,360
which is going to be most excellent I'm

25
00:01:33,469 --> 00:01:30,020
super excited tomorrow is the the

26
00:01:35,749 --> 00:01:33,479
368th anniversary of the discovery of

27
00:01:37,249 --> 00:01:35,759
the Moon Titan the largest moon of

28
00:01:40,130 --> 00:01:37,259
Saturn and indeed the second largest

29
00:01:43,190 --> 00:01:40,140
moon of our solar system it is a world

30
00:01:45,170 --> 00:01:43,200
that is obscured by a thick hazy

31
00:01:47,870 --> 00:01:45,180
atmosphere rich in hydrocarbons and

32
00:01:50,090 --> 00:01:47,880
organic molecules and as we'll discuss

33
00:01:52,130 --> 00:01:50,100
in today's show there is an upcoming

34
00:01:53,389 --> 00:01:52,140
Mission being developed by NASA and

35
00:01:55,850 --> 00:01:53,399
through the John Hopkins University

36
00:01:58,310 --> 00:01:55,860
Applied Physics laboratory called

37
00:02:00,590 --> 00:01:58,320
dragonfly that's going to allow us to

38
00:02:04,010 --> 00:02:00,600

better explore the geology the chemistry

39
00:02:06,350 --> 00:02:04,020
the atmosphere the world of Titan and so

40
00:02:08,570 --> 00:02:06,360
that's super exciting I'm so glad to

41
00:02:10,370 --> 00:02:08,580
have today the principal investigator

42
00:02:14,030 --> 00:02:10,380
the lead on the team for dragonfly

43
00:02:16,550 --> 00:02:14,040
joining us Dr Zibby turtle is here uh Dr

44
00:02:18,589 --> 00:02:16,560
Turtle earned her BS in physics at MIT

45
00:02:20,690 --> 00:02:18,599
before going on to earn a PhD in

46
00:02:23,089 --> 00:02:20,700
planetary science at the University of

47
00:02:25,369 --> 00:02:23,099
Arizona she spent some time as a postdoc

48
00:02:27,350 --> 00:02:25,379
at U of A as well as with the planetary

49
00:02:30,830 --> 00:02:27,360
Science Institute before then joining

50
00:02:32,630 --> 00:02:30,840
APL in 2006 she's been involved in a

51
00:02:35,030 --> 00:02:32,640
number of missions like Galileo and

52
00:02:37,190 --> 00:02:35,040
Cassini the lunar reconnaissance Orbiter

53
00:02:40,910 --> 00:02:37,200
the upcoming Europa Clipper and like I

54
00:02:42,229 --> 00:02:40,920
said now dragonfly and so thank you so

55
00:02:44,449 --> 00:02:42,239
much for joining us for ask an

56
00:02:46,670 --> 00:02:44,459
astrobiologist Dr Turtle it's a pleasure

57
00:02:48,410 --> 00:02:46,680
to have you here thank you I'm so happy

58
00:02:51,110 --> 00:02:48,420
to be here talking with you today

59
00:02:53,750 --> 00:02:51,120
uh this is super exciting so tomorrow is

60
00:02:56,330 --> 00:02:53,760
the 368th anniversary of the discovery

61
00:02:59,150 --> 00:02:56,340
of Titan uh we've had a few spacecraft

62
00:03:00,710 --> 00:02:59,160
fly by Titan and one visited in the past

63
00:03:02,990 --> 00:03:00,720

but of course this is going to be a

64
00:03:04,850 --> 00:03:03,000
really cool Mission with dragonfly uh

65
00:03:06,410 --> 00:03:04,860
and with you as the lead

66
00:03:08,570 --> 00:03:06,420
um before we jump into my questions

67
00:03:10,490 --> 00:03:08,580
though about dragonfly and Titan and all

68
00:03:12,470 --> 00:03:10,500
of those cool things one thing we love

69
00:03:14,390 --> 00:03:12,480
to do on this show is celebrate the

70
00:03:16,910 --> 00:03:14,400
scientists and the career Pathways that

71
00:03:19,490 --> 00:03:16,920
we follow to to develop these careers in

72
00:03:20,990 --> 00:03:19,500
planetary science and astrobiology and

73
00:03:23,270 --> 00:03:21,000
so I'm wondering for our audience could

74
00:03:24,830 --> 00:03:23,280
you share with us kind of what was the

75
00:03:27,110 --> 00:03:24,840
beginning for you your your science

76
00:03:30,170 --> 00:03:27,120
origin story that really got you into

77
00:03:32,630 --> 00:03:30,180
this realm of planetary science

78
00:03:34,070 --> 00:03:32,640
um yeah absolutely I've I have always

79
00:03:36,649 --> 00:03:34,080
been

80
00:03:38,990 --> 00:03:36,659
um uh interested in astronomy since

81
00:03:40,970 --> 00:03:39,000
since uh since I can remember I don't

82
00:03:42,710 --> 00:03:40,980
actually remember learning the names of

83
00:03:45,949 --> 00:03:42,720
the planets they've always been kind of

84
00:03:49,550 --> 00:03:45,959
part of the part of the geography

85
00:03:52,130 --> 00:03:49,560
um my grandma mother knew all the

86
00:03:55,190 --> 00:03:52,140
mythology of the you know the

87
00:03:56,809 --> 00:03:55,200
constellations my father had majored in

88
00:03:58,850 --> 00:03:56,819

astronomy worked for you worked for the

89
00:04:01,610 --> 00:03:58,860
Air Force studying atmospheric phenomena

90
00:04:04,430 --> 00:04:01,620
uh you're on Earth and so we were always

91
00:04:06,229 --> 00:04:04,440
looking up as kids uh my sister and I

92
00:04:07,910 --> 00:04:06,239
even had a game called space hop where

93
00:04:10,910 --> 00:04:07,920
you got to

94
00:04:13,789 --> 00:04:10,920
um uh you would get different uh

95
00:04:15,770 --> 00:04:13,799
missions and so it had the board was a

96
00:04:17,509 --> 00:04:15,780
you know was a map of the solar system

97
00:04:19,250 --> 00:04:17,519
and the missions would be you know go to

98
00:04:21,590 --> 00:04:19,260
the planet that has this or go to you

99
00:04:23,510 --> 00:04:21,600
know the the world that has this

100
00:04:25,850 --> 00:04:23,520
um and one of the fascinating things

101
00:04:27,590 --> 00:04:25,860
that we got to see as we played that

102
00:04:30,890 --> 00:04:27,600
game growing up was that at the same

103
00:04:33,590 --> 00:04:30,900
time uh the Voyager spacecraft were

104
00:04:36,170 --> 00:04:33,600
moving out through the solar system and

105
00:04:37,430 --> 00:04:36,180
uh so we got to we learned you know the

106
00:04:39,110 --> 00:04:37,440
answers to the questions so that we

107
00:04:42,650 --> 00:04:39,120
could do our missions in the game and

108
00:04:45,230 --> 00:04:42,660
then we learned what what was updated as

109
00:04:47,870 --> 00:04:45,240
Voyager discovered that Jupiter had more

110
00:04:50,629 --> 00:04:47,880
than 12 moons and things like that and

111
00:04:52,129 --> 00:04:50,639
so it was is not only uh you know not

112
00:04:55,370 --> 00:04:52,139
only a fun game that we played all the

113
00:04:58,430 --> 00:04:55,380

time but it was also just so exciting to

114
00:05:00,170 --> 00:04:58,440
see how much we still had to learn about

115
00:05:02,030 --> 00:05:00,180
the the solar system and how to get to

116
00:05:03,830 --> 00:05:02,040
watch that and and uh and see it

117
00:05:05,689 --> 00:05:03,840
happening in real time

118
00:05:07,010 --> 00:05:05,699
um so that was that's what you know kind

119
00:05:10,129 --> 00:05:07,020
of you know

120
00:05:12,170 --> 00:05:10,139
um and it grabbed me into uh into that

121
00:05:14,330 --> 00:05:12,180
uh this uh this field

122
00:05:16,249 --> 00:05:14,340
I love that so much

123
00:05:17,990 --> 00:05:16,259
um and honestly I I almost steer clear

124
00:05:20,090 --> 00:05:18,000
of ever mentioning how many moons Saturn

125
00:05:21,830 --> 00:05:20,100
and Jupiter have anymore because we keep

126
00:05:23,810 --> 00:05:21,840
finding new ones

127
00:05:25,370 --> 00:05:23,820
um and also I was just speaking to some

128
00:05:27,170 --> 00:05:25,380
school students in California the other

129
00:05:29,090 --> 00:05:27,180
day and I mentioned how like they have

130
00:05:30,950 --> 00:05:29,100
Star Wars Legos now and when I was a kid

131
00:05:33,170 --> 00:05:30,960
I had to use a model rocket engine

132
00:05:35,930 --> 00:05:33,180
igniter and melt the Lego plastic myself

133
00:05:37,969 --> 00:05:35,940
to make my Star Wars Legos are there

134
00:05:39,590 --> 00:05:37,979
things that the kids these days have um

135
00:05:41,390 --> 00:05:39,600
to learn about planetary science that

136
00:05:43,430 --> 00:05:41,400
kind of makes you maybe a little jealous

137
00:05:45,950 --> 00:05:43,440
or maybe inspired to know that they have

138
00:05:47,570 --> 00:05:45,960

a brighter future here

139
00:05:49,610 --> 00:05:47,580
um I'm certainly jealous of all the

140
00:05:52,310 --> 00:05:49,620
Legos in fact I still I still uh build

141
00:05:54,830 --> 00:05:52,320
Lego models uh I did that a lot as a kid

142
00:05:56,870 --> 00:05:54,840
as well and uh uh all the the different

143
00:06:00,710 --> 00:05:56,880
kinds of of blocks you have these days

144
00:06:02,810 --> 00:06:00,720
compared to a few decades ago is uh

145
00:06:04,370 --> 00:06:02,820
um there's there's certainly a lot a lot

146
00:06:07,310 --> 00:06:04,380
more there that's uh that's really fun

147
00:06:10,370 --> 00:06:07,320
to play with which uh which I enjoy

148
00:06:12,050 --> 00:06:10,380
um I I mean we know a lot more

149
00:06:14,150 --> 00:06:12,060
um you know there's just so much we've

150
00:06:17,689 --> 00:06:14,160
discovered about our own solar system

151
00:06:20,330 --> 00:06:17,699
and solar systems now Beyond ours uh in

152
00:06:23,450 --> 00:06:20,340
the last few decades but a lot of times

153
00:06:25,010 --> 00:06:23,460
what that tells us is how much more we

154
00:06:27,110 --> 00:06:25,020
have to learn

155
00:06:29,210 --> 00:06:27,120
um and so they're you know they're just

156
00:06:31,070 --> 00:06:29,220
more Stepping Stones now I think uh

157
00:06:33,770 --> 00:06:31,080
especially as we learn about more and

158
00:06:36,529 --> 00:06:33,780
more extra solar solar systems which is

159
00:06:39,230 --> 00:06:36,539
just uh thrilling yeah absolutely I mean

160
00:06:41,990 --> 00:06:39,240
over 5 000 EXO planets now are are known

161
00:06:43,309 --> 00:06:42,000
to exist it's mind-boggling and that's a

162
00:06:45,830 --> 00:06:43,319
good transition to talk a bit about

163
00:06:47,330 --> 00:06:45,840

planetary science when in your career so

164
00:06:49,610 --> 00:06:47,340
you went to MIT and then went on for a

165
00:06:50,870 --> 00:06:49,620
PhD in planetary science but when did

166
00:06:52,730 --> 00:06:50,880
you realize that you know you really

167
00:06:54,430 --> 00:06:52,740
wanted to pursue a career in research

168
00:06:57,110 --> 00:06:54,440
and planetary science

169
00:07:02,150 --> 00:06:57,120
uh so when I

170
00:07:04,969 --> 00:07:02,160
um when I started uh at uh in college

171
00:07:06,529 --> 00:07:04,979
um I I knew I was interested in

172
00:07:09,050 --> 00:07:06,539
astronomy

173
00:07:11,390 --> 00:07:09,060
um I chose to major in physics because

174
00:07:13,249 --> 00:07:11,400
it was broad because I knew with a

175
00:07:15,409 --> 00:07:13,259
Physics degree I could go in a number of

176
00:07:17,689 --> 00:07:15,419
different directions and in fact

177
00:07:19,490 --> 00:07:17,699
initially I took a bunch of astrophysics

178
00:07:21,890 --> 00:07:19,500
courses which is fascinating right

179
00:07:23,529 --> 00:07:21,900
cosmology is is spectacular and

180
00:07:28,010 --> 00:07:23,539
mind-bending

181
00:07:30,110 --> 00:07:28,020
but as uh as I took more uh courses uh

182
00:07:33,050 --> 00:07:30,120
going through my undergraduate degree I

183
00:07:35,689 --> 00:07:33,060
I started taking more planetary classes

184
00:07:40,249 --> 00:07:35,699
planetary science classes

185
00:07:41,990 --> 00:07:40,259
um and uh the accessibility of the solar

186
00:07:44,330 --> 00:07:42,000
system was kind of what brought me back

187
00:07:47,390 --> 00:07:44,340
into the solar system from uh you know

188
00:07:50,749 --> 00:07:47,400

from the broad or astronom the broader

189
00:07:51,589 --> 00:07:50,759
field of astronomy in particular

190
00:07:55,129 --> 00:07:51,599
um

191
00:07:57,050 --> 00:07:55,139
the uh uh kind of again still watching

192
00:08:00,230 --> 00:07:57,060
the voyagers go out through the the

193
00:08:02,990 --> 00:08:00,240
solar system uh was uh was very

194
00:08:05,689 --> 00:08:03,000
inspirational and so that's uh that's um

195
00:08:07,309 --> 00:08:05,699
kind of what what uh prompted me to to

196
00:08:08,689 --> 00:08:07,319
continue study in planetary science

197
00:08:11,689 --> 00:08:08,699
specifically

198
00:08:14,749 --> 00:08:11,699
um but again I actually uh I I went to a

199
00:08:16,249 --> 00:08:14,759
graduate program that was very broad uh

200
00:08:18,529 --> 00:08:16,259
because

201
00:08:20,629 --> 00:08:18,539
um I wasn't sure which area of planetary

202
00:08:22,369 --> 00:08:20,639
science it's such a broad you know a

203
00:08:23,809 --> 00:08:22,379
broad field it's basically all of the

204
00:08:25,670 --> 00:08:23,819
fields that we have here on Earth but

205
00:08:27,469 --> 00:08:25,680
then applied to you know the solar

206
00:08:29,450 --> 00:08:27,479
system together so

207
00:08:31,490 --> 00:08:29,460
um uh so I went to a broad program so

208
00:08:33,949 --> 00:08:31,500
that I would have you know still some

209
00:08:36,829 --> 00:08:33,959
some uh opportunity to explore different

210
00:08:38,449 --> 00:08:36,839
areas uh and see see what I wanted to uh

211
00:08:39,469 --> 00:08:38,459
to study as you know moving forward in

212
00:08:41,449 --> 00:08:39,479
my career

213
00:08:42,469 --> 00:08:41,459

that's fantastic yeah I think for our

214
00:08:44,690 --> 00:08:42,479
audience you know who are interested in

215
00:08:45,949 --> 00:08:44,700
astrobiology they likely know that you

216
00:08:49,190 --> 00:08:45,959
know in the Realms of planetary science

217
00:08:51,410 --> 00:08:49,200
and astrobiology geobiology these kind

218
00:08:53,030 --> 00:08:51,420
of larger diverse Realms of study they

219
00:08:55,250 --> 00:08:53,040
really do include so many different

220
00:08:57,350 --> 00:08:55,260
Pursuits from different Sciences

221
00:08:58,850 --> 00:08:57,360
different Realms of engineering

222
00:08:59,990 --> 00:08:58,860
um now in your career like I mentioned

223
00:09:02,930 --> 00:09:00,000
earlier you've been involved with

224
00:09:05,030 --> 00:09:02,940
Galileo and Cassini lro and now the

225
00:09:06,769 --> 00:09:05,040
upcoming Europa Clipper what was the

226
00:09:08,810 --> 00:09:06,779
pathway for you to get involved in

227
00:09:10,610 --> 00:09:08,820
Mission science and then to kind of take

228
00:09:14,389 --> 00:09:10,620
on leadership roles in Mission science

229
00:09:17,690 --> 00:09:14,399
as well uh as a graduate student

230
00:09:19,550 --> 00:09:17,700
um for my dissertation I was studying

231
00:09:23,030 --> 00:09:19,560
impact cratering the the impact

232
00:09:25,970 --> 00:09:23,040
cratering process and I was using uh

233
00:09:27,530 --> 00:09:25,980
numerical models to simulate uh impact

234
00:09:30,430 --> 00:09:27,540
creators on the formation of impact

235
00:09:33,110 --> 00:09:30,440
craters on other planets to understand

236
00:09:36,710 --> 00:09:33,120
uh what we can learn about the planet

237
00:09:38,750 --> 00:09:36,720
itself what the the final morphology of

238
00:09:41,530 --> 00:09:38,760

an impact grader can tell us about the

239
00:09:44,930 --> 00:09:41,540
uh about the the planet itself

240
00:09:46,670 --> 00:09:44,940
and another graduate student a colleague

241
00:09:50,090 --> 00:09:46,680
of mine at the University of Arizona

242
00:09:52,910 --> 00:09:50,100
Cynthia Phillips and I were she was

243
00:09:56,090 --> 00:09:52,920
working with the Galileo Mission and she

244
00:09:57,650 --> 00:09:56,100
was studying images of the surface of

245
00:09:59,990 --> 00:09:57,660
Europa and Europa of course is a

246
00:10:02,389 --> 00:10:00,000
fascinating Target from a perspective of

247
00:10:05,690 --> 00:10:02,399
impact cratering because the ice shell

248
00:10:09,170 --> 00:10:05,700
on Europa may be relatively thin and so

249
00:10:12,530 --> 00:10:09,180
we started collaborating on uh um you

250
00:10:16,490 --> 00:10:12,540
know on modeling cratering into uh um

251
00:10:18,829 --> 00:10:16,500
into ice shells uh you know and uh using

252
00:10:20,990 --> 00:10:18,839
the data that Galileo was sending back

253
00:10:23,509 --> 00:10:21,000
at the time and another colleague Betty

254
00:10:25,250 --> 00:10:23,519
piratso and I uh model different aspects

255
00:10:27,350 --> 00:10:25,260
of the impact cratering so the you know

256
00:10:30,290 --> 00:10:27,360
so there was a uh kind of a project

257
00:10:32,690 --> 00:10:30,300
there and then that kind of started that

258
00:10:35,030 --> 00:10:32,700
connection to the you know the mission

259
00:10:38,269 --> 00:10:35,040
that was sending the data back and uh

260
00:10:40,370 --> 00:10:38,279
after I finished my graduate degree I

261
00:10:43,130 --> 00:10:40,380
did a postdoctoral at a postdoctoral

262
00:10:44,990 --> 00:10:43,140
position supporting the

263
00:10:47,329 --> 00:10:45,000

um Galileo program but planning the

264
00:10:49,009 --> 00:10:47,339
observations for Io which is a another

265
00:10:50,389 --> 00:10:49,019
totally fascinating Moon we could talk

266
00:10:52,970 --> 00:10:50,399
about but

267
00:10:54,350 --> 00:10:52,980
um but that was the first mission role I

268
00:10:56,930 --> 00:10:54,360
had

269
00:10:59,690 --> 00:10:56,940
um was uh planning the Imaging

270
00:11:01,130 --> 00:10:59,700
observations with Galileo of uh of the

271
00:11:01,970 --> 00:11:01,140
Moon IO

272
00:11:05,870 --> 00:11:01,980
um

273
00:11:08,090 --> 00:11:05,880
and uh from that uh the next step in my

274
00:11:10,310 --> 00:11:08,100
career was um after the end of the

275
00:11:12,230 --> 00:11:10,320
Galileo Mission I started working with

276
00:11:14,329 --> 00:11:12,240
the Cassini Mission

277
00:11:16,430 --> 00:11:14,339
um again using working with the the

278
00:11:19,430 --> 00:11:16,440
Imaging Team Planning the observations

279
00:11:21,829 --> 00:11:19,440
of Titan and so that was my first uh you

280
00:11:25,009 --> 00:11:21,839
know my first connection to uh to Titan

281
00:11:27,889 --> 00:11:25,019
uh and exploring that

282
00:11:30,110 --> 00:11:27,899
um which was uh spectacular right we

283
00:11:31,850 --> 00:11:30,120
went from and it's we did this so

284
00:11:33,590 --> 00:11:31,860
quickly right you know just two decades

285
00:11:36,470 --> 00:11:33,600
ago we didn't know what was on the

286
00:11:38,630 --> 00:11:36,480
surface of Titan we were you know uh

287
00:11:42,350 --> 00:11:38,640
just getting ready for Cassini to arrive

288
00:11:45,530 --> 00:11:42,360

in 2004 and we had this uh incredible

289
00:11:47,750 --> 00:11:45,540
Whirlwind of going from knowing very

290
00:11:50,150 --> 00:11:47,760
little about the nature of the geography

291
00:11:52,009 --> 00:11:50,160
and the geology of Titan to mapping it

292
00:11:54,829 --> 00:11:52,019
and understanding how Titan works as a

293
00:11:57,050 --> 00:11:54,839
system in just several years so that was

294
00:12:00,829 --> 00:11:57,060
uh that was spectacular

295
00:12:02,930 --> 00:12:00,839
um uh to to get to participate in

296
00:12:06,470 --> 00:12:02,940
um and of course an exceedingly valuable

297
00:12:08,389 --> 00:12:06,480
experience uh in terms of uh

298
00:12:10,190 --> 00:12:08,399
um future you know planning future

299
00:12:12,710 --> 00:12:10,200
future missions

300
00:12:14,449 --> 00:12:12,720
oh that's fantastic a great time just to

301
00:12:16,490 --> 00:12:14,459
drop in a quick Poll for our audience as

302
00:12:18,829 --> 00:12:16,500
well on YouTube since he just mentioned

303
00:12:20,329 --> 00:12:18,839
um Cassini arriving uh in the saturnian

304
00:12:22,670 --> 00:12:20,339
system we had of course the Huygens

305
00:12:24,230 --> 00:12:22,680
Lander uh which went down through the

306
00:12:26,870 --> 00:12:24,240
atmosphere of Titan and it really was an

307
00:12:28,490 --> 00:12:26,880
atmospheric probe not really intended to

308
00:12:30,050 --> 00:12:28,500
be a Lander but it did land and we have

309
00:12:31,670 --> 00:12:30,060
an image from it

310
00:12:33,530 --> 00:12:31,680
um and it did a lot of research and so

311
00:12:35,210 --> 00:12:33,540
we have a question for our audience with

312
00:12:37,970 --> 00:12:35,220
dragonfly we're looking at spending at

313
00:12:39,650 --> 00:12:37,980

least two years if not more uh on Titan

314
00:12:42,350 --> 00:12:39,660
and so our question for the audience is

315
00:12:45,050 --> 00:12:42,360
how long did the Huygens probe survive

316
00:12:46,970 --> 00:12:45,060
on the surface of Titan and we have a

317
00:12:50,269 --> 00:12:46,980
few answers popping up right now in the

318
00:12:52,610 --> 00:12:50,279
chat uh one year six months two weeks

319
00:12:54,069 --> 00:12:52,620
four hours uh tell us what you think and

320
00:12:56,750 --> 00:12:54,079
I'll come back to that in a little bit

321
00:12:58,490 --> 00:12:56,760
of course you know in talking about the

322
00:13:01,009 --> 00:12:58,500
Huygens probe and Cassini and talking

323
00:13:03,470 --> 00:13:01,019
about dragonfly we did have Melissa

324
00:13:06,949 --> 00:13:03,480
trainer on the show back in 2020 in

325
00:13:08,449 --> 00:13:06,959
November of 2024 our 37th episode

326
00:13:11,750 --> 00:13:08,459
um and so much has changed since then

327
00:13:14,389 --> 00:13:11,760
bringing us up now to have Dr turtle on

328
00:13:15,710 --> 00:13:14,399
to talk about where dragonfly is now

329
00:13:18,110 --> 00:13:15,720
um so it's so cool to hear this kind of

330
00:13:19,850 --> 00:13:18,120
this connection of Galileo and Cassini

331
00:13:22,009 --> 00:13:19,860
of course you worked on lro and Europa

332
00:13:23,509 --> 00:13:22,019
Clipper now as well which is also

333
00:13:26,389 --> 00:13:23,519
another incredible Mission coming up

334
00:13:27,889 --> 00:13:26,399
very soon but I think for for time sake

335
00:13:30,050 --> 00:13:27,899
and for our audience I know they want to

336
00:13:31,670 --> 00:13:30,060
hear about dragonfly I wonder if you can

337
00:13:33,949 --> 00:13:31,680
speak to us now a little bit about the

338
00:13:36,170 --> 00:13:33,959

mission of dragonfly uh what we will be

339
00:13:38,329 --> 00:13:36,180
observing with dragonfly and how much

340
00:13:40,550 --> 00:13:38,339
how much knowledge it could bring to us

341
00:13:43,670 --> 00:13:40,560
oh absolutely

342
00:13:46,370 --> 00:13:43,680
um so after the Cassini mission right we

343
00:13:50,449 --> 00:13:46,380
spent 13 years in the saturnian system

344
00:13:53,930 --> 00:13:50,459
you know with a 126 flybys of Titan uh

345
00:13:55,910 --> 00:13:53,940
we know a lot about Titan but we one of

346
00:13:58,730 --> 00:13:55,920
the big outstanding questions is what

347
00:14:00,110 --> 00:13:58,740
the solid surface materials are are made

348
00:14:04,850 --> 00:14:00,120
of

349
00:14:07,610 --> 00:14:04,860
um and when NASA added Titan to uh the

350
00:14:09,470 --> 00:14:07,620
New Frontiers Mission Target list uh in

351
00:14:11,750 --> 00:14:09,480
2016.

352
00:14:14,410 --> 00:14:11,760
um as as a you know an ocean worlds

353
00:14:17,509 --> 00:14:14,420
Target uh in the New Frontiers program

354
00:14:21,470 --> 00:14:17,519
uh we you know started brainstorming

355
00:14:24,470 --> 00:14:21,480
about how you know how we could uh best

356
00:14:26,329 --> 00:14:24,480
find answers to the question of what

357
00:14:27,829 --> 00:14:26,339
these materials are

358
00:14:29,629 --> 00:14:27,839
um and the reason this is important is

359
00:14:33,769 --> 00:14:29,639
that Titan

360
00:14:36,829 --> 00:14:33,779
um is a very special Target uh from an

361
00:14:39,170 --> 00:14:36,839
astrobiological perspective uh Titan's

362
00:14:41,329 --> 00:14:39,180
atmosphere which is unique among moons

363
00:14:43,009 --> 00:14:41,339

in the in the solar system in fact its

364
00:14:44,629 --> 00:14:43,019
atmosphere is denser than Earth's

365
00:14:47,629 --> 00:14:44,639
atmosphere

366
00:14:49,790 --> 00:14:47,639
um the second most common constituent in

367
00:14:53,210 --> 00:14:49,800
the atmosphere after nitrogen at Titan

368
00:14:55,670 --> 00:14:53,220
is car is methane and the methane breaks

369
00:14:58,550 --> 00:14:55,680
down at the top of the atmosphere uh and

370
00:15:01,550 --> 00:14:58,560
the more the and the molecules recombine

371
00:15:03,650 --> 00:15:01,560
to form very very complex carbon Rich

372
00:15:05,449 --> 00:15:03,660
molecules these are what form the haze

373
00:15:08,090 --> 00:15:05,459
and Titans atmosphere but they

374
00:15:10,069 --> 00:15:08,100
ultimately fall out onto the surface and

375
00:15:11,930 --> 00:15:10,079
Titan being an icy satellite when that

376
00:15:14,509 --> 00:15:11,940
surface melts at the site of an impact

377
00:15:17,210 --> 00:15:14,519
crater say or if there is cryovolcanism

378
00:15:19,069 --> 00:15:17,220
on the surface now you have all of the

379
00:15:21,590 --> 00:15:19,079
ingredients we know to be necessary for

380
00:15:23,509 --> 00:15:21,600
life in terms of these there's abundant

381
00:15:26,389 --> 00:15:23,519
carbon-rich material that's all over the

382
00:15:28,430 --> 00:15:26,399
surface liquid water at the surface in

383
00:15:31,490 --> 00:15:28,440
the past as well as in the present day

384
00:15:35,629 --> 00:15:31,500
in the Deep interior ocean in inside of

385
00:15:40,370 --> 00:15:35,639
Titan uh and energy and so what we want

386
00:15:42,550 --> 00:15:40,380
to do with with dragonfly is go to Titan

387
00:15:45,110 --> 00:15:42,560
surface and see

388
00:15:47,030 --> 00:15:45,120

and pick up the results basically of

389
00:15:49,009 --> 00:15:47,040
these chemistry experiments that Titan

390
00:15:50,750 --> 00:15:49,019
has been running for US these Prebiotic

391
00:15:52,310 --> 00:15:50,760
chemistry experiments if you put all of

392
00:15:55,069 --> 00:15:52,320
this together

393
00:15:57,110 --> 00:15:55,079
um you know for some period of Time how

394
00:15:58,910 --> 00:15:57,120
far does the chemistry uh the the

395
00:16:00,350 --> 00:15:58,920
chemistry progress the organic the

396
00:16:02,449 --> 00:16:00,360
organic synthesis

397
00:16:04,550 --> 00:16:02,459
and

398
00:16:06,470 --> 00:16:04,560
um because we know what Titan's surface

399
00:16:08,569 --> 00:16:06,480
is like we know there are a number of

400
00:16:09,949 --> 00:16:08,579
different places that we'd like to go to

401
00:16:11,449 --> 00:16:09,959
make these measurements of the different

402
00:16:13,129 --> 00:16:11,459
in different geologic environments

403
00:16:16,790 --> 00:16:13,139
environments with different geologic

404
00:16:19,670 --> 00:16:16,800
histories uh and the atmosphere again uh

405
00:16:22,069 --> 00:16:19,680
gives us this opportunity uh to travel

406
00:16:24,470 --> 00:16:22,079
on Titan by flying instead of driving

407
00:16:27,710 --> 00:16:24,480
and so dragonfly came out of this

408
00:16:31,670 --> 00:16:27,720
thought process uh and is uh an

409
00:16:34,189 --> 00:16:31,680
octocopter uh a rotor craft Lander

410
00:16:36,350 --> 00:16:34,199
um that is designed to like the Rovers

411
00:16:38,449 --> 00:16:36,360
on Mars take everything with us from

412
00:16:41,210 --> 00:16:38,459
place to place uh and to make

413
00:16:44,269 --> 00:16:41,220

measurements of the chemistry uh and the

414
00:16:47,749 --> 00:16:44,279
uh and observe aspects of the Titan

415
00:16:49,730 --> 00:16:47,759
environment uh in a variety of of places

416
00:16:51,530 --> 00:16:49,740
on the surface

417
00:16:52,850 --> 00:16:51,540
and it's so awesome

418
00:16:54,710 --> 00:16:52,860
um just looking at the pictures of

419
00:16:56,629 --> 00:16:54,720
dragonfly it looks like it's going to be

420
00:16:58,129 --> 00:16:56,639
a very cool spacecraft it must be so

421
00:17:00,710 --> 00:16:58,139
cool to be involved in that process too

422
00:17:01,910 --> 00:17:00,720
of development and design I've read that

423
00:17:04,549 --> 00:17:01,920
it's going to land somewhere in the

424
00:17:06,710 --> 00:17:04,559
Shangri-La Dune fields and um the

425
00:17:08,870 --> 00:17:06,720
primary Mission phase is maybe 100 miles

426
00:17:10,309 --> 00:17:08,880
worth of of flight maybe 20 different

427
00:17:12,470 --> 00:17:10,319
Landing sites

428
00:17:14,210 --> 00:17:12,480
um was there how much went into landing

429
00:17:15,949 --> 00:17:14,220
site selection

430
00:17:17,270 --> 00:17:15,959
um are we sure of even the pathway that

431
00:17:19,069 --> 00:17:17,280
we're going to follow yet or will that

432
00:17:20,750 --> 00:17:19,079
kind of like come you know as we're

433
00:17:24,230 --> 00:17:20,760
exploring

434
00:17:28,010 --> 00:17:24,240
know the the targeted landing area yeah

435
00:17:29,750 --> 00:17:28,020
um so the Titan uh environment is

436
00:17:32,690 --> 00:17:29,760
surprisingly Earth-like in terms of its

437
00:17:34,970 --> 00:17:32,700
geology uh right it's an an icy

438
00:17:37,909 --> 00:17:34,980

satellite in the outer solar system with

439
00:17:39,529 --> 00:17:37,919
a surface temperature of 94 Kelvin uh

440
00:17:41,930 --> 00:17:39,539
and yet the features we see on the

441
00:17:44,870 --> 00:17:41,940
surface are very familiar and Titan's

442
00:17:47,330 --> 00:17:44,880
equatorial region is covered in the

443
00:17:49,370 --> 00:17:47,340
spectacular organic sand dunes we don't

444
00:17:52,430 --> 00:17:49,380
know how you form organic sand but Titan

445
00:17:55,010 --> 00:17:52,440
does uh and it's there waiting for us

446
00:17:56,570 --> 00:17:55,020
um and so we want to land in the in and

447
00:17:59,630 --> 00:17:56,580
among the sand dunes for a couple of

448
00:18:01,430 --> 00:17:59,640
reasons one is that the sand is organic

449
00:18:04,669 --> 00:18:01,440
in composition

450
00:18:07,130 --> 00:18:04,679
um uh and uh and it's very widely

451
00:18:09,950 --> 00:18:07,140
sourced and so this will give us uh

452
00:18:12,230 --> 00:18:09,960
information about materials across the

453
00:18:14,150 --> 00:18:12,240
surface of of Titan kind of like the

454
00:18:15,529 --> 00:18:14,160
Mars Pathfinder Landing site was chosen

455
00:18:17,990 --> 00:18:15,539
to be a place where a lot of different

456
00:18:21,830 --> 00:18:18,000
materials came together in a you know at

457
00:18:23,510 --> 00:18:21,840
the the base of a outflow uh Channel

458
00:18:25,370 --> 00:18:23,520
um to uh you know so you had

459
00:18:26,510 --> 00:18:25,380
opportunities to to make measurements

460
00:18:28,669 --> 00:18:26,520
and materials that came from much

461
00:18:30,529 --> 00:18:28,679
further away than you can travel the

462
00:18:33,110 --> 00:18:30,539
other reason the dunes are great is that

463
00:18:36,549 --> 00:18:33,120

this is these are very specific kind of

464
00:18:40,789 --> 00:18:36,559
Dune these longitudinal dudes uh and so

465
00:18:43,310 --> 00:18:40,799
uh they have very broad flat inter-dune

466
00:18:45,470 --> 00:18:43,320
areas between them uh compositionally

467
00:18:46,909 --> 00:18:45,480
these are these areas have water ice as

468
00:18:48,470 --> 00:18:46,919
a component and so they will be able to

469
00:18:50,750 --> 00:18:48,480
tell us about the kind of primordial

470
00:18:52,669 --> 00:18:50,760
crust of Titan

471
00:18:55,610 --> 00:18:52,679
um in terms of its composition but

472
00:18:57,830 --> 00:18:55,620
they're also big broad flat areas and so

473
00:18:59,510 --> 00:18:57,840
that's perfect for initial Landing sites

474
00:19:00,950 --> 00:18:59,520
and so that's why we're Landing in the

475
00:19:02,750 --> 00:19:00,960
in the sand dunes because we've

476
00:19:05,930 --> 00:19:02,760
characterized these areas well with

477
00:19:08,750 --> 00:19:05,940
Cassini and we can design a Lander to

478
00:19:11,090 --> 00:19:08,760
land in these uh in these areas

479
00:19:13,310 --> 00:19:11,100
site is close to close to Silk impact

480
00:19:16,789 --> 00:19:13,320
crater which is an 80 kilometer diameter

481
00:19:20,330 --> 00:19:18,590
runes and inner dunes and then into the

482
00:19:22,430 --> 00:19:20,340
deposits associated with the impact

483
00:19:24,830 --> 00:19:22,440
crater itself will be able to make

484
00:19:26,690 --> 00:19:24,840
measurements of the composition of the

485
00:19:30,049 --> 00:19:26,700
chemistry in these environments where

486
00:19:31,610 --> 00:19:30,059
impact liquid water and uh and complex

487
00:19:33,950 --> 00:19:31,620
carbon molecules will have had the

488
00:19:36,169 --> 00:19:33,960

opportunity to mix well that's very cool

489
00:19:37,909 --> 00:19:36,179
and also so there there is some

490
00:19:39,710 --> 00:19:37,919
potential that there is an ocean under

491
00:19:41,570 --> 00:19:39,720
Titan's surface based on Cassini

492
00:19:43,250 --> 00:19:41,580
measurements do you think that that

493
00:19:45,230 --> 00:19:43,260
impactor might have even interacted with

494
00:19:46,789 --> 00:19:45,240
the subsurface ocean and potentially

495
00:19:49,190 --> 00:19:46,799
done some mixing as well from that

496
00:19:52,190 --> 00:19:49,200
material is that possible

497
00:19:54,169 --> 00:19:52,200
um so the The Ice crust on Titan is very

498
00:19:56,750 --> 00:19:54,179
thick uh probably at least 100

499
00:19:59,690 --> 00:19:56,760
kilometers thick if not if not thicker

500
00:20:02,810 --> 00:19:59,700
so this impact crater may not have you

501
00:20:05,150 --> 00:20:02,820
know been able to affect the the entire

502
00:20:06,890 --> 00:20:05,160
that entire ice shell

503
00:20:08,630 --> 00:20:06,900
um although there is always fracturing

504
00:20:11,330 --> 00:20:08,640
beneath you know beneath impact

505
00:20:14,390 --> 00:20:11,340
cratering uh and we don't know the you

506
00:20:16,730 --> 00:20:14,400
know the um structure of you know of ice

507
00:20:19,669 --> 00:20:16,740
shells in you know in general in detail

508
00:20:21,529 --> 00:20:19,679
on on these uh these satellites

509
00:20:23,690 --> 00:20:21,539
um so we don't necessarily expect that

510
00:20:26,390 --> 00:20:23,700
this crater will would have had a direct

511
00:20:29,090 --> 00:20:26,400
connection to the the Deep interior

512
00:20:32,330 --> 00:20:29,100
ocean but one of the things we want to

513
00:20:34,610 --> 00:20:32,340

understand is what the opportunities are

514
00:20:38,270 --> 00:20:34,620
for exchange through the through the ice

515
00:20:40,970 --> 00:20:38,280
shell so in addition to taking uh images

516
00:20:43,190 --> 00:20:40,980
to understand the you know the details

517
00:20:45,830 --> 00:20:43,200
of the geology and what that can tell us

518
00:20:48,230 --> 00:20:45,840
uh whether we see evidence of fractures

519
00:20:50,510 --> 00:20:48,240
for example at the at the surface one of

520
00:20:52,850 --> 00:20:50,520
the the other things uh dragonfly will

521
00:20:55,430 --> 00:20:52,860
carry is a seismometer and this will

522
00:20:58,370 --> 00:20:55,440
allow us to listen for Titan Quakes uh

523
00:21:00,890 --> 00:20:58,380
to understand how seismically active uh

524
00:21:02,930 --> 00:21:00,900
you know this icy ocean world is and

525
00:21:05,930 --> 00:21:02,940
that will help us uh you know constrain

526
00:21:07,549 --> 00:21:05,940
the the possibility for for exchange

527
00:21:09,710 --> 00:21:07,559
between the Surface and the Deep

528
00:21:11,810 --> 00:21:09,720
interior liquid water ocean

529
00:21:13,130 --> 00:21:11,820
you know it's fantastic I do want to

530
00:21:15,049 --> 00:21:13,140
come back for our audience real quick

531
00:21:17,150 --> 00:21:15,059
too that poll we asked earlier for how

532
00:21:18,950 --> 00:21:17,160
long Huygens survived on the surface we

533
00:21:21,770 --> 00:21:18,960
offered you options of one year six

534
00:21:23,570 --> 00:21:21,780
months two weeks or four hours and

535
00:21:25,130 --> 00:21:23,580
roughly sixty percent almost 60 percent

536
00:21:26,750 --> 00:21:25,140
of the respondents got that correct

537
00:21:28,190 --> 00:21:26,760
around four hours

538
00:21:29,930 --> 00:21:28,200

um that's including going down through

539
00:21:31,970 --> 00:21:29,940
the atmosphere and then the actual

540
00:21:33,830 --> 00:21:31,980
arrival at the surface there was a lot

541
00:21:35,029 --> 00:21:33,840
we didn't know with Legends when I got

542
00:21:39,289 --> 00:21:35,039
there

543
00:21:41,210 --> 00:21:39,299
potential of Huygens just sinking into

544
00:21:42,409 --> 00:21:41,220
one of those ethane Lakes

545
00:21:43,909 --> 00:21:42,419
um or just sinking into the surface

546
00:21:45,289 --> 00:21:43,919
because we really didn't know what the

547
00:21:47,630 --> 00:21:45,299
organic surface would be like at that

548
00:21:49,250 --> 00:21:47,640
point right we didn't we didn't know

549
00:21:53,450 --> 00:21:49,260
what the surface was going to be like

550
00:21:55,549 --> 00:21:53,460
and there were uh we did know that uh

551
00:21:57,770 --> 00:21:55,559
there was likely to be liquid in the

552
00:21:59,810 --> 00:21:57,780
system in fact Titan has a methane cycle

553
00:22:01,970 --> 00:21:59,820
like our water cycle right it's rainy

554
00:22:04,010 --> 00:22:01,980
here today right Titan has methane

555
00:22:05,090 --> 00:22:04,020
clouds and rain and lakes and rivers and

556
00:22:06,529 --> 00:22:05,100
seas

557
00:22:08,390 --> 00:22:06,539
um and we didn't know how much of the

558
00:22:11,630 --> 00:22:08,400
surface would be covered in liquid and

559
00:22:15,230 --> 00:22:11,640
how and where that liquid might be

560
00:22:17,810 --> 00:22:15,240
um so so Huygens the probe was actually

561
00:22:19,909 --> 00:22:17,820
this is this is spectacular Huygens was

562
00:22:21,830 --> 00:22:19,919
designed to be able to make measurements

563
00:22:25,070 --> 00:22:21,840

of a solid surface if it landed on a

564
00:22:28,549 --> 00:22:25,080
solid surface and to be able to float if

565
00:22:30,169 --> 00:22:28,559
it landed in uh in a liquid on the

566
00:22:32,690 --> 00:22:30,179
surface of Titan and make measurements

567
00:22:35,270 --> 00:22:32,700
of that liquid which is a a great feat

568
00:22:37,310 --> 00:22:35,280
of of engineering to be able to design a

569
00:22:39,169 --> 00:22:37,320
probe to land in two such different

570
00:22:40,850 --> 00:22:39,179
environments and make measurements and

571
00:22:43,789 --> 00:22:40,860
of course it landed on a solid surface

572
00:22:45,830 --> 00:22:43,799
uh and uh and sent us back into uh

573
00:22:46,730 --> 00:22:45,840
images as well as data about that

574
00:22:48,289 --> 00:22:46,740
surface

575
00:22:49,970 --> 00:22:48,299
absolutely and there's that one famous

576
00:22:51,770 --> 00:22:49,980
image I think that I've shared in so

577
00:22:53,630 --> 00:22:51,780
many of my own talks when speaking about

578
00:22:55,669 --> 00:22:53,640
Titan itself where we see just like this

579
00:22:58,130 --> 00:22:55,679
this surface with the haze above and

580
00:22:59,570 --> 00:22:58,140
then these Boulders of ice covered in

581
00:23:01,549 --> 00:22:59,580
organic goop

582
00:23:04,730 --> 00:23:01,559
um it's so incredible I'm so excited for

583
00:23:06,490 --> 00:23:04,740
dragonfly and also we just today before

584
00:23:09,590 --> 00:23:06,500
our show we can now talk about this

585
00:23:11,690 --> 00:23:09,600
dragonfly just passed a very momentous

586
00:23:13,669 --> 00:23:11,700
period in Mission design development and

587
00:23:15,049 --> 00:23:13,679
planning uh called the the preliminary

588
00:23:17,149 --> 00:23:15,059

design review I wonder if you could just

589
00:23:18,830 --> 00:23:17,159
speak to that process especially for

590
00:23:20,630 --> 00:23:18,840
those who maybe are more science focused

591
00:23:22,310 --> 00:23:20,640
and don't really understand how Mission

592
00:23:23,510 --> 00:23:22,320
development and the engineering side of

593
00:23:27,350 --> 00:23:23,520
things goes

594
00:23:28,549 --> 00:23:27,360
yeah uh so dragonfly was selected uh in

595
00:23:31,610 --> 00:23:28,559
2019

596
00:23:33,230 --> 00:23:31,620
um that that was a selection uh by NASA

597
00:23:35,810 --> 00:23:33,240
to be the next mission in the New

598
00:23:39,250 --> 00:23:35,820
Frontiers program and at that point we

599
00:23:42,890 --> 00:23:39,260
started our uh preliminary design phase

600
00:23:45,470 --> 00:23:42,900
uh so um there's a series of phases one

601
00:23:48,470 --> 00:23:45,480
goes through in terms of the mission uh

602
00:23:50,330 --> 00:23:48,480
development uh and so this this phase we

603
00:23:52,310 --> 00:23:50,340
spend more time looking at uh the

604
00:23:54,470 --> 00:23:52,320
aspects of the design really refining

605
00:23:56,390 --> 00:23:54,480
that design doing some of our testing of

606
00:23:58,610 --> 00:23:56,400
some of the hardware that's going to

607
00:24:01,909 --> 00:23:58,620
need to survive in the Titan environment

608
00:24:05,570 --> 00:24:01,919
for example and so it's been a very busy

609
00:24:09,110 --> 00:24:05,580
uh period of time and that culminates in

610
00:24:11,330 --> 00:24:09,120
a series of reviews uh of uh preliminary

611
00:24:13,310 --> 00:24:11,340
design reviews of our subsystems and our

612
00:24:16,250 --> 00:24:13,320
instruments and we had all of those last

613
00:24:18,710 --> 00:24:16,260

year there were uh more than 20

614
00:24:21,890 --> 00:24:18,720
individual reviews uh through last

615
00:24:23,450 --> 00:24:21,900
summer and fall uh and then we had a

616
00:24:25,850 --> 00:24:23,460
full up Mission review this is a week

617
00:24:28,909 --> 00:24:25,860
long review with an independent standing

618
00:24:30,470 --> 00:24:28,919
review board who come here to APL and we

619
00:24:33,110 --> 00:24:30,480
spend a week talking about all things

620
00:24:35,930 --> 00:24:33,120
dragonfly and presenting the the current

621
00:24:37,850 --> 00:24:35,940
design getting feedback from them uh

622
00:24:40,909 --> 00:24:37,860
that then we carry forward as we move

623
00:24:42,590 --> 00:24:40,919
into the next phase and so uh so that's

624
00:24:44,029 --> 00:24:42,600
what we're uh that's that that's the

625
00:24:46,430 --> 00:24:44,039
Milestone of that preliminary design

626
00:24:50,090 --> 00:24:46,440
review or PDR and the team did a

627
00:24:52,130 --> 00:24:50,100
spectacular job uh and uh and everyone's

628
00:24:55,070 --> 00:24:52,140
really uh um you know the review board

629
00:24:57,289 --> 00:24:55,080
was very uh uh gave us great feedback uh

630
00:24:59,029 --> 00:24:57,299
and uh we passed our preliminary design

631
00:25:00,590 --> 00:24:59,039
review and are now looking ahead toward

632
00:25:02,450 --> 00:25:00,600
uh toward the next steps

633
00:25:04,190 --> 00:25:02,460
uh fantastic

634
00:25:05,990 --> 00:25:04,200
um I do briefly want to mention another

635
00:25:09,110 --> 00:25:06,000
poll that we had online on Twitter

636
00:25:11,210 --> 00:25:09,120
through at Nasa astrobio which is the

637
00:25:14,029 --> 00:25:11,220
NASA astrobiology programs Twitter

638
00:25:15,169 --> 00:25:14,039

account we asked everyone who was tuning

639
00:25:23,330 --> 00:25:15,179
in

640
00:25:24,649 --> 00:25:23,340
Moon most excited them or we could learn

641
00:25:26,570 --> 00:25:24,659
about

642
00:25:29,390 --> 00:25:26,580
um and over half of respondents said

643
00:25:31,610 --> 00:25:29,400
surface sampling but a large number also

644
00:25:33,470 --> 00:25:31,620
said aerial imagery and Atmospheric

645
00:25:34,730 --> 00:25:33,480
measurements and we had a much smaller

646
00:25:36,230 --> 00:25:34,740
number who are interested in seismic

647
00:25:38,330 --> 00:25:36,240
studies that's kind of sad for me you

648
00:25:40,130 --> 00:25:38,340
know since I also love geophysics and

649
00:25:41,870 --> 00:25:40,140
geochemistry and understanding the

650
00:25:44,029 --> 00:25:41,880
interior of a word I think is super

651
00:25:45,830 --> 00:25:44,039
important but it was very interesting to

652
00:25:47,210 --> 00:25:45,840
see that from our audience as well so

653
00:25:49,430 --> 00:25:47,220
thank you for everyone out there who

654
00:25:51,230 --> 00:25:49,440
voted in that poll and who again Tunes

655
00:25:52,669 --> 00:25:51,240
in for our show

656
00:25:54,350 --> 00:25:52,679
um Dr Turtle I do want to just change

657
00:25:55,730 --> 00:25:54,360
now just a little bit I I do want to

658
00:25:57,769 --> 00:25:55,740
jump to our audience questions as soon

659
00:25:59,330 --> 00:25:57,779
as I can so I do want to hear a little

660
00:26:01,610 --> 00:25:59,340
bit from you if you wouldn't mind for

661
00:26:04,250 --> 00:26:01,620
our audience speaking to the value of

662
00:26:06,230 --> 00:26:04,260
mentorship in your own career as well as

663
00:26:08,930 --> 00:26:06,240

this process of now kind of becoming a

664
00:26:10,610 --> 00:26:08,940
leader of such a large team developing a

665
00:26:12,409 --> 00:26:10,620
mission that is taking it'll take time

666
00:26:14,149 --> 00:26:12,419
to develop and launch and land and then

667
00:26:15,950 --> 00:26:14,159
do the science I mean these are our

668
00:26:17,810 --> 00:26:15,960
long-term you know parts of your career

669
00:26:19,250 --> 00:26:17,820
and that you're now leading so I wonder

670
00:26:20,690 --> 00:26:19,260
if you could speak to especially our

671
00:26:23,830 --> 00:26:20,700
younger audience members who might want

672
00:26:27,529 --> 00:26:23,840
to follow in a similar pathway

673
00:26:30,230 --> 00:26:27,539
yes um and and especially uh in terms of

674
00:26:32,870 --> 00:26:30,240
outer planet exploration right this is a

675
00:26:36,470 --> 00:26:32,880
very these are long-term processes uh

676
00:26:37,850 --> 00:26:36,480
long-term projects and they give us uh

677
00:26:40,909 --> 00:26:37,860
the opportunity and I feel the

678
00:26:43,850 --> 00:26:40,919
responsibility to really

679
00:26:47,390 --> 00:26:43,860
um work with you know

680
00:26:50,090 --> 00:26:47,400
work with generations of uh you know of

681
00:26:51,470 --> 00:26:50,100
scientists and and Engineers as we go

682
00:26:53,870 --> 00:26:51,480
through the process and one of the

683
00:26:56,390 --> 00:26:53,880
things with dragonfly uh that we're able

684
00:26:58,070 --> 00:26:56,400
to do is Bridge the

685
00:27:00,230 --> 00:26:58,080
um you know Bridge from the the

686
00:27:03,409 --> 00:27:00,240
generation of scientists that uh

687
00:27:06,710 --> 00:27:03,419
designed and built and operated the

688
00:27:09,289 --> 00:27:06,720

Cassini and huygen's Mission uh to you

689
00:27:11,870 --> 00:27:09,299
know to the current uh generation and

690
00:27:14,269 --> 00:27:11,880
then forward uh to the Next Generation

691
00:27:17,210 --> 00:27:14,279
uh dragonfly is scheduled to arrive at

692
00:27:20,690 --> 00:27:17,220
Titan by 2034.

693
00:27:23,029 --> 00:27:20,700
um and so uh we will you know be working

694
00:27:25,549 --> 00:27:23,039
with uh students

695
00:27:26,930 --> 00:27:25,559
um and early career scientists along the

696
00:27:31,070 --> 00:27:26,940
way and that's something that we have

697
00:27:33,110 --> 00:27:31,080
built into our uh into our program uh to

698
00:27:35,870 --> 00:27:33,120
be able to

699
00:27:38,690 --> 00:27:35,880
um uh provide mentorship to provide

700
00:27:41,810 --> 00:27:38,700
experience to broaden participation in

701
00:27:44,570 --> 00:27:41,820
missions uh and find ways to give people

702
00:27:46,190 --> 00:27:44,580
opportunities to learn about missions

703
00:27:47,870 --> 00:27:46,200
even now in the mission development

704
00:27:49,789 --> 00:27:47,880
phase we're not getting data from Titan

705
00:27:52,310 --> 00:27:49,799
but there's so much to learn about how

706
00:27:55,310 --> 00:27:52,320
uh you know what's needed to put the you

707
00:27:57,289 --> 00:27:55,320
know to to design and and uh eventually

708
00:27:59,090 --> 00:27:57,299
you know integrate and test to the the

709
00:28:00,769 --> 00:27:59,100
hardware before we you know before we

710
00:28:03,110 --> 00:28:00,779
launch dragonfly to Titan and what we

711
00:28:05,810 --> 00:28:03,120
want to be able to do is bring people in

712
00:28:08,450 --> 00:28:05,820
at each each step of the way uh to give

713
00:28:11,149 --> 00:28:08,460

experience to the next generation of uh

714
00:28:13,430 --> 00:28:11,159
planetary Explorers I love that and so

715
00:28:15,230 --> 00:28:13,440
those watching right now maybe in the

716
00:28:17,450 --> 00:28:15,240
future you'll be part of the dragonfly

717
00:28:19,250 --> 00:28:17,460
Mission uh we've had past viewers of

718
00:28:21,890 --> 00:28:19,260
previous episodes reach out and find

719
00:28:23,210 --> 00:28:21,900
possible PhD mentors and guides and

720
00:28:25,010 --> 00:28:23,220
advisors along the way in their own

721
00:28:26,690 --> 00:28:25,020
careers through our show

722
00:28:28,430 --> 00:28:26,700
um so keep an eye out

723
00:28:30,830 --> 00:28:28,440
um another place Dr Turtle where you

724
00:28:33,289 --> 00:28:30,840
kind of been in this role of team work

725
00:28:35,390 --> 00:28:33,299
and and being part of a team

726
00:28:37,970 --> 00:28:35,400
um is in your own kind of Realm of of

727
00:28:39,590 --> 00:28:37,980
rowing of doing crew rowing and uh we

728
00:28:41,690 --> 00:28:39,600
always love hearing the human stories

729
00:28:43,310 --> 00:28:41,700
about the scientists who join us and so

730
00:28:44,690 --> 00:28:43,320
I'd love to hear about your rowing

731
00:28:47,269 --> 00:28:44,700
experience and how it's been part of

732
00:28:48,470 --> 00:28:47,279
your life as well as you're also a Tycho

733
00:28:49,730 --> 00:28:48,480
drummer

734
00:28:51,289 --> 00:28:49,740
um so I'd love to hear about these

735
00:28:53,110 --> 00:28:51,299
things and how they help make you kind

736
00:28:55,909 --> 00:28:53,120
of round out your life

737
00:28:58,010 --> 00:28:55,919
absolutely yeah I was uh I was fortunate

738
00:29:00,950 --> 00:28:58,020

enough to be able to learn Taiko when I

739
00:29:03,470 --> 00:29:00,960
was a uh when I was in Arizona in Tucson

740
00:29:06,830 --> 00:29:03,480
Arizona with a with a group there would

741
00:29:08,870 --> 00:29:06,840
I go Sonora um and it was a lot of you

742
00:29:11,450 --> 00:29:08,880
know a lot of fun uh and a very

743
00:29:13,789 --> 00:29:11,460
different dimension right to uh you know

744
00:29:14,990 --> 00:29:13,799
getting to getting to play drums uh to

745
00:29:18,110 --> 00:29:15,000
perform it was just such a different

746
00:29:20,750 --> 00:29:18,120
dimension from um uh you know from doing

747
00:29:22,250 --> 00:29:20,760
computer modeling during the day uh and

748
00:29:24,409 --> 00:29:22,260
it's always nice to have these you know

749
00:29:26,570 --> 00:29:24,419
these other kinds of outlets uh and when

750
00:29:29,570 --> 00:29:26,580
I moved uh I actually rode for a little

751
00:29:31,190 --> 00:29:29,580
bit in college uh and uh when I moved

752
00:29:32,870 --> 00:29:31,200
back from Arizona

753
00:29:34,250 --> 00:29:32,880
um there's not a lot of rowing in Tucson

754
00:29:36,289 --> 00:29:34,260
Arizona

755
00:29:38,810 --> 00:29:36,299
um uh given the climate there but moving

756
00:29:40,610 --> 00:29:38,820
back here to the east coast I was uh um

757
00:29:42,289 --> 00:29:40,620
I joined the

758
00:29:45,169 --> 00:29:42,299
um the Rowing Club up in uh everyone

759
00:29:47,149 --> 00:29:45,179
Club up in Baltimore uh and I've been uh

760
00:29:49,490 --> 00:29:47,159
rowing together uh with a team there and

761
00:29:52,190 --> 00:29:49,500
competing uh for

762
00:29:54,049 --> 00:29:52,200
um well for for quite a while now uh and

763
00:29:56,690 --> 00:29:54,059

it's uh it's really

764
00:29:59,690 --> 00:29:56,700
um it's really excellent to

765
00:30:01,130 --> 00:29:59,700
um again to kind of balance things you

766
00:30:02,870 --> 00:30:01,140
know to kind of balance things out right

767
00:30:04,250 --> 00:30:02,880
to you know if I'm out in the the boat

768
00:30:06,769 --> 00:30:04,260
you can't really be thinking about work

769
00:30:08,990 --> 00:30:06,779
or something's going to go wrong about

770
00:30:10,970 --> 00:30:09,000
um and so it's uh it's been a great

771
00:30:13,130 --> 00:30:10,980
balance in that sense and also in terms

772
00:30:15,350 --> 00:30:13,140
of the teamwork I love working uh

773
00:30:18,350 --> 00:30:15,360
together with teams

774
00:30:19,970 --> 00:30:18,360
um and uh so you know rowing in a you

775
00:30:22,070 --> 00:30:19,980
know in a boat together with a team

776
00:30:25,190 --> 00:30:22,080
where you're all all have to be in sync

777
00:30:26,930 --> 00:30:25,200
and you know uh everyone uh kind of

778
00:30:29,269 --> 00:30:26,940
playing their own role right and that's

779
00:30:31,669 --> 00:30:29,279
the same thing we do on you know on

780
00:30:35,930 --> 00:30:31,679
planetary missions these are very large

781
00:30:38,450 --> 00:30:35,940
and very broad teams with wide arrays of

782
00:30:42,350 --> 00:30:38,460
uh of expertise

783
00:30:45,889 --> 00:30:42,360
um and uh and I I really love that in uh

784
00:30:47,510 --> 00:30:45,899
whether it's for for play or or for work

785
00:30:48,529 --> 00:30:47,520
that's awesome

786
00:30:49,669 --> 00:30:48,539
um and it's always fun to hear but

787
00:30:51,289 --> 00:30:49,679
there's things that we all have in our

788
00:30:52,669 --> 00:30:51,299

lives that kind of bring us down to

789
00:30:54,409 --> 00:30:52,679
earth and give us a chance to be part of

790
00:30:55,789 --> 00:30:54,419
teams you know and whatever that looks

791
00:30:57,710 --> 00:30:55,799
like and have these other interests you

792
00:30:59,029 --> 00:30:57,720
know all of us who studied science and

793
00:31:00,350 --> 00:30:59,039
pursued careers in science and

794
00:31:01,970 --> 00:31:00,360
engineering have things that make us

795
00:31:03,350 --> 00:31:01,980
very human

796
00:31:04,730 --> 00:31:03,360
um I do really want to get to our

797
00:31:06,710 --> 00:31:04,740
audience questions I see a lot of them

798
00:31:08,570 --> 00:31:06,720
flowing in already from our YouTube

799
00:31:10,490 --> 00:31:08,580
audience and from Twitter

800
00:31:13,310 --> 00:31:10,500
um before that though we have our faster

801
00:31:15,590 --> 00:31:13,320
than light segment some fun rapid fire

802
00:31:17,930 --> 00:31:15,600
questions just to hear a bit more about

803
00:31:19,190 --> 00:31:17,940
your interest in astrobiology but as

804
00:31:21,470 --> 00:31:19,200
well as other things that have

805
00:31:23,690 --> 00:31:21,480
interested you in your career

806
00:31:26,389 --> 00:31:23,700
um so first off what is your favorite

807
00:31:28,690 --> 00:31:26,399
answer to fermi's question where are

808
00:31:35,870 --> 00:31:31,730
so I

809
00:31:36,830 --> 00:31:35,880
um I think it's a an intriguing question

810
00:31:38,630 --> 00:31:36,840
um

811
00:31:41,269 --> 00:31:38,640
you know from the perspective of of

812
00:31:42,769 --> 00:31:41,279
trying to understand our place in the

813
00:31:46,549 --> 00:31:42,779

you know in the universe and where we

814
00:31:48,289 --> 00:31:46,559
fit in I think that it's that there are

815
00:31:49,490 --> 00:31:48,299
a lot of aspects I think it's telling us

816
00:31:50,690 --> 00:31:49,500
there are a lot of things we don't know

817
00:31:52,970 --> 00:31:50,700
yet

818
00:31:54,889 --> 00:31:52,980
um and so a lot of the a lot of the

819
00:31:57,649 --> 00:31:54,899
answers get at you know what what

820
00:32:00,289 --> 00:31:57,659
aspects of the the universe of the

821
00:32:03,169 --> 00:32:00,299
development of Life Etc don't we know

822
00:32:05,830 --> 00:32:03,179
and I I think uh I think it really helps

823
00:32:09,350 --> 00:32:05,840
to helps us to kind of

824
00:32:11,029 --> 00:32:09,360
uh compile that uh you know a set of

825
00:32:14,810 --> 00:32:11,039
things we we still need to learn about

826
00:32:16,190 --> 00:32:14,820
uh and and use as a as a guide to uh uh

827
00:32:18,409 --> 00:32:16,200
to look for answers to some of those

828
00:32:20,090 --> 00:32:18,419
unknown factors

829
00:32:22,730 --> 00:32:20,100
wonderful

830
00:32:24,769 --> 00:32:22,740
um what stories be they novels and

831
00:32:26,510 --> 00:32:24,779
television shows whatever what stories

832
00:32:28,970 --> 00:32:26,520
have inspired you to want to learn more

833
00:32:31,490 --> 00:32:28,980
about the universe

834
00:32:33,889 --> 00:32:31,500
uh most of the stories I think that have

835
00:32:35,690 --> 00:32:33,899
really have really deep really inspired

836
00:32:38,810 --> 00:32:35,700
me or the or the

837
00:32:41,149 --> 00:32:38,820
um uh are the the real ones of our of

838
00:32:42,529 --> 00:32:41,159

our you know exploration of space so so

839
00:32:45,230 --> 00:32:42,539
far

840
00:32:47,389 --> 00:32:45,240
um in terms of watching as you know

841
00:32:48,889 --> 00:32:47,399
getting to watch as we you know saw the

842
00:32:50,570 --> 00:32:48,899
voyagers go further and further out

843
00:32:53,330 --> 00:32:50,580
through the the solar system and

844
00:32:55,250 --> 00:32:53,340
discover things uh that were new

845
00:32:57,110 --> 00:32:55,260
um I took a class as an undergraduate

846
00:33:00,470 --> 00:32:57,120
about what we were going to learn at the

847
00:33:03,110 --> 00:33:00,480
Neptune uh flyby by Voyage or based on

848
00:33:05,930 --> 00:33:03,120
what we knew so far and when we had the

849
00:33:07,010 --> 00:33:05,940
Neptune fly by six months later so many

850
00:33:08,630 --> 00:33:07,020
of the things we thought we were going

851
00:33:11,930 --> 00:33:08,640
to learn we learned very different

852
00:33:13,549 --> 00:33:11,940
things and so that uh those constant

853
00:33:16,130 --> 00:33:13,559
surprises and the fact that the solar

854
00:33:17,990 --> 00:33:16,140
system and the you know beyond uh has a

855
00:33:20,450 --> 00:33:18,000
better imagination than we sometimes do

856
00:33:22,430 --> 00:33:20,460
uh is one of the things that uh that

857
00:33:24,049 --> 00:33:22,440
really you know inspires me to to keep

858
00:33:25,370 --> 00:33:24,059
looking outward and and looking beyond

859
00:33:27,409 --> 00:33:25,380
the next Horizon

860
00:33:29,389 --> 00:33:27,419
wow fantastic yeah there's so much

861
00:33:31,549 --> 00:33:29,399
Serendipity in some of our exploration

862
00:33:34,009 --> 00:33:31,559
you know from from you know plumes out

863
00:33:35,210 --> 00:33:34,019

of Enceladus the surface of Titan you

864
00:33:36,409 --> 00:33:35,220
know all these discoveries and things

865
00:33:38,210 --> 00:33:36,419
you know we always think we're gonna

866
00:33:39,289 --> 00:33:38,220
find it one way and then it's completely

867
00:33:42,409 --> 00:33:39,299
different

868
00:33:44,930 --> 00:33:42,419
um there's so much for us to learn

869
00:33:47,149 --> 00:33:44,940
um so another question if you could go

870
00:33:49,310 --> 00:33:47,159
back in time and visit yourself at the

871
00:33:52,909 --> 00:33:49,320
very beginning of your career what

872
00:34:00,230 --> 00:33:56,509
it's okay if it's not easy

873
00:34:03,529 --> 00:34:00,240
right it's often we look at at people in

874
00:34:05,450 --> 00:34:03,539
careers uh and and think that um because

875
00:34:07,009 --> 00:34:05,460
they are you know because of where they

876
00:34:08,450 --> 00:34:07,019
are that it must have been easy for them

877
00:34:11,690 --> 00:34:08,460
to get there

878
00:34:14,089 --> 00:34:11,700
um and and uh it's not it's not always

879
00:34:16,609 --> 00:34:14,099
easy and that's okay if something takes

880
00:34:18,290 --> 00:34:16,619
multiple times to get it it's you know

881
00:34:20,629 --> 00:34:18,300
can be really worth putting the effort

882
00:34:21,829 --> 00:34:20,639
in to keep trying to get there

883
00:34:23,510 --> 00:34:21,839
um but just because something doesn't

884
00:34:26,270 --> 00:34:23,520
come easily the first time you try it

885
00:34:28,730 --> 00:34:26,280
doesn't mean you can't do it uh and and

886
00:34:29,990 --> 00:34:28,740
it doesn't mean that by persevering and

887
00:34:32,089 --> 00:34:30,000
pushing through that you won't be able

888
00:34:34,129 --> 00:34:32,099

to do it even better

889
00:34:35,329 --> 00:34:34,139
um as you uh as you move ahead so I

890
00:34:39,109 --> 00:34:35,339
think that would be the the biggest

891
00:34:40,730 --> 00:34:39,119
thing um that uh it's not things don't

892
00:34:43,070 --> 00:34:40,740
always come easy and that's that's okay

893
00:34:44,149 --> 00:34:43,080
uh it's it's okay to keep trying when

894
00:34:46,070 --> 00:34:44,159
they don't

895
00:34:48,230 --> 00:34:46,080
that's wonderful

896
00:34:52,270 --> 00:34:48,240
um what is something that excites you I

897
00:34:54,589 --> 00:34:52,280
mean Beyond dragonfly about the future

898
00:34:57,170 --> 00:34:54,599
I'm really excited about a lot of the

899
00:34:59,990 --> 00:34:57,180
the upcoming exploration we're doing uh

900
00:35:01,490 --> 00:35:00,000
and the next generation of explorers and

901
00:35:04,910 --> 00:35:01,500
uh what people are going to think about

902
00:35:07,730 --> 00:35:04,920
uh I think about next we have been we

903
00:35:11,270 --> 00:35:07,740
are so fortunate in our solar system

904
00:35:13,609 --> 00:35:11,280
um in terms of the variety of uh of

905
00:35:16,069 --> 00:35:13,619
destinations and the complementarity of

906
00:35:18,770 --> 00:35:16,079
the destinations right uh the different

907
00:35:22,190 --> 00:35:18,780
things that we will be able to learn at

908
00:35:24,410 --> 00:35:22,200
uh at Europa and Titan and Enceladus and

909
00:35:26,150 --> 00:35:24,420
the Iranian satellites right each of

910
00:35:29,270 --> 00:35:26,160
these give us a different story a

911
00:35:32,210 --> 00:35:29,280
different history and a picture into the

912
00:35:34,190 --> 00:35:32,220
realm of possible uh scenarios for uh

913
00:35:36,109 --> 00:35:34,200

you know for for planetary histories for

914
00:35:37,670 --> 00:35:36,119
the histories of Worlds and I just can't

915
00:35:38,630 --> 00:35:37,680
wait to to learn about all of them

916
00:35:41,109 --> 00:35:38,640
frankly

917
00:35:44,030 --> 00:35:41,119
I love that one more question from me

918
00:35:46,910 --> 00:35:44,040
what's an unbelievable science fact that

919
00:35:48,650 --> 00:35:46,920
still blows your mind

920
00:35:50,329 --> 00:35:48,660
um

921
00:36:07,069 --> 00:35:50,339
the

922
00:36:08,930 --> 00:36:07,079
in many worlds uh is uh that I I still

923
00:36:10,970 --> 00:36:08,940
just find that uh just find that

924
00:36:12,230 --> 00:36:10,980
incredible and I I can't wait till we

925
00:36:13,910 --> 00:36:12,240
get to explore them

926
00:36:15,410 --> 00:36:13,920
absolutely

927
00:36:16,730 --> 00:36:15,420
um thank you so much for that we are

928
00:36:18,589 --> 00:36:16,740
going to open it now to our audience

929
00:36:20,150 --> 00:36:18,599
questions so for those watching right

930
00:36:21,890 --> 00:36:20,160
now live in the YouTube chat please ask

931
00:36:23,150 --> 00:36:21,900
your questions if you are watching the

932
00:36:25,250 --> 00:36:23,160
recording later of course we can't

933
00:36:26,569 --> 00:36:25,260
answer those questions now but um I will

934
00:36:28,190 --> 00:36:26,579
try my best to get to them in the

935
00:36:30,230 --> 00:36:28,200
comments later

936
00:36:32,950 --> 00:36:30,240
um so let's go uh first off with a

937
00:36:36,050 --> 00:36:32,960
question from Jim pass who is at

938
00:36:37,670 --> 00:36:36,060

astrosociology on Twitter uh Jim wants

939
00:36:39,950 --> 00:36:37,680
to know how the dragonfly mission to

940
00:36:42,050 --> 00:36:39,960
Titan is going to compare to the

941
00:36:43,910 --> 00:36:42,060
Ingenuity Mission uh which we of course

942
00:36:46,130 --> 00:36:43,920
have now seen you know flying as a small

943
00:36:49,010 --> 00:36:46,140
drone on the surface of Mars

944
00:36:51,349 --> 00:36:49,020
yeah Ingenuity has been spectacular uh

945
00:36:53,390 --> 00:36:51,359
it's really it's so exciting to see you

946
00:36:55,670 --> 00:36:53,400
know to see flight on another on another

947
00:36:58,190 --> 00:36:55,680
world in our solar system

948
00:37:00,710 --> 00:36:58,200
um so uh there are a number of ways in

949
00:37:03,349 --> 00:37:00,720
in in which uh exploration at Titan is

950
00:37:06,349 --> 00:37:03,359
different uh from the the uh Exploration

951
00:37:07,730 --> 00:37:06,359
with Ingenuity at uh at Mars uh one is

952
00:37:11,030 --> 00:37:07,740
the scale

953
00:37:13,490 --> 00:37:11,040
um The Martian atmosphere is very is

954
00:37:15,589 --> 00:37:13,500
very thin uh and Mars has higher gravity

955
00:37:17,870 --> 00:37:15,599
is a little larger than Titan so at

956
00:37:20,030 --> 00:37:17,880
Titan we have an atmosphere that's four

957
00:37:22,430 --> 00:37:20,040
times as dense as Earth's atmosphere and

958
00:37:24,950 --> 00:37:22,440
that has one seventh and Titan has one

959
00:37:26,750 --> 00:37:24,960
seventh of gravity of uh of Earth so

960
00:37:28,490 --> 00:37:26,760
it's actually physically easier to fly

961
00:37:31,010 --> 00:37:28,500
on Titan like a person could put Wings

962
00:37:32,990 --> 00:37:31,020
on and soar over the over the surface

963
00:37:34,910 --> 00:37:33,000

which would be a really excellent future

964
00:37:39,829 --> 00:37:34,920
mission to Titan

965
00:37:42,290 --> 00:37:39,839
um so on Titan the dragonfly octocopter

966
00:37:44,870 --> 00:37:42,300
is about the size of the perseverance

967
00:37:46,970 --> 00:37:44,880
Rover as opposed to the the you know

968
00:37:48,530 --> 00:37:46,980
Ingenuity which which is you know has to

969
00:37:50,510 --> 00:37:48,540
be much smaller simply because of the

970
00:37:52,910 --> 00:37:50,520
Dynamics of flight in the in the Martian

971
00:37:54,770 --> 00:37:52,920
atmosphere on Titan we can actually take

972
00:37:57,470 --> 00:37:54,780
something the size of perseverance and

973
00:37:58,910 --> 00:37:57,480
fly from place to place uh which allows

974
00:38:00,770 --> 00:37:58,920
us to take you know a very capable

975
00:38:02,690 --> 00:38:00,780
payload um the same way we've been

976
00:38:04,069 --> 00:38:02,700
exploring on Mars with uh with the

977
00:38:07,190 --> 00:38:04,079
Rovers

978
00:38:09,650 --> 00:38:07,200
um another uh difference is

979
00:38:11,870 --> 00:38:09,660
um that the um

980
00:38:15,109 --> 00:38:11,880
uh that we don't have a fleet of

981
00:38:17,750 --> 00:38:15,119
orbiters at Titan yet sadly

982
00:38:19,970 --> 00:38:17,760
um and so dragonfly has to do direct to

983
00:38:22,310 --> 00:38:19,980
Earth communication from the surface of

984
00:38:23,990 --> 00:38:22,320
Titan uh so all of the data will come

985
00:38:25,910 --> 00:38:24,000
directly from the surface of Titan as

986
00:38:27,710 --> 00:38:25,920
opposed to being relayed through you

987
00:38:30,589 --> 00:38:27,720
know satellites as we're able to do at

988
00:38:32,150 --> 00:38:30,599

Mars uh but uh uh one of the areas

989
00:38:33,710 --> 00:38:32,160
that's similar is that even though Mars

990
00:38:36,890 --> 00:38:33,720
is much closer and the light time is

991
00:38:39,109 --> 00:38:36,900
much shorter uh but Ingenuity has to fly

992
00:38:40,730 --> 00:38:39,119
completely autonomously on the surface

993
00:38:43,069 --> 00:38:40,740
of Mars and so we have that experience

994
00:38:45,589 --> 00:38:43,079
on Mars already and dragonfly will be

995
00:38:48,170 --> 00:38:45,599
also flying completely anonymously uh at

996
00:38:49,130 --> 00:38:48,180
Titan that's fantastic

997
00:38:50,510 --> 00:38:49,140
um and so you mentioned you know all

998
00:38:52,010 --> 00:38:50,520
these orbiters we have at Mars where we

999
00:38:54,109 --> 00:38:52,020
can you know send data links through

1000
00:38:55,609 --> 00:38:54,119
orbiters back to Earth and so we have to

1001
00:38:57,290 --> 00:38:55,619
communicate directly but we also have a

1002
00:38:59,150 --> 00:38:57,300
lot more imaging

1003
00:39:01,730 --> 00:38:59,160
um a question from at science unders

1004
00:39:03,770 --> 00:39:01,740
underscore sponge on Twitter

1005
00:39:05,390 --> 00:39:03,780
um is is there possibility of having

1006
00:39:08,150 --> 00:39:05,400
cameras doing high high definition

1007
00:39:09,770 --> 00:39:08,160
images of Titan like we have for Mars

1008
00:39:11,450 --> 00:39:09,780
and I guess the question is you know

1009
00:39:13,390 --> 00:39:11,460
what level what resolution will images

1010
00:39:17,270 --> 00:39:13,400
be taken from dragonfly

1011
00:39:19,550 --> 00:39:17,280
right so uh so we have a global mapping

1012
00:39:21,589 --> 00:39:19,560
from uh from Cassini at very different

1013
00:39:23,870 --> 00:39:21,599

wavelengths uh we have radar mapping at

1014
00:39:27,470 --> 00:39:23,880
2.2 centimeters down to you know near

1015
00:39:29,690 --> 00:39:27,480
infrared Imaging uh on these uh the

1016
00:39:31,910 --> 00:39:29,700
resolutions of those uh are at the 100

1017
00:39:33,530 --> 00:39:31,920
meter scale so we can use that Global

1018
00:39:35,270 --> 00:39:33,540
mapping we know where we want to go we

1019
00:39:38,089 --> 00:39:35,280
know aspects of the surface to be able

1020
00:39:40,490 --> 00:39:38,099
to play in dragonfly but we don't have

1021
00:39:42,589 --> 00:39:40,500
you know high rise in orbit at uh at

1022
00:39:45,890 --> 00:39:42,599
Titan and so dragonfly will actually

1023
00:39:46,730 --> 00:39:45,900
scout out it scout out its own sites in

1024
00:39:48,710 --> 00:39:46,740
advance

1025
00:39:51,410 --> 00:39:48,720
um and by virtue because we're able to

1026
00:39:53,569 --> 00:39:51,420
fly we can actually use dragonfly to do

1027
00:39:56,390 --> 00:39:53,579
our own scouting uh and so we'll fly out

1028
00:39:58,730 --> 00:39:56,400
take images of the the surface uh come

1029
00:40:01,069 --> 00:39:58,740
back to our Landing site and then uh you

1030
00:40:03,470 --> 00:40:01,079
know play those images back to Earth uh

1031
00:40:05,510 --> 00:40:03,480
to uh to decide where we where we want

1032
00:40:08,750 --> 00:40:05,520
to go next and we use dragonfly to to do

1033
00:40:11,450 --> 00:40:08,760
its own scouting uh we'll have images uh

1034
00:40:14,690 --> 00:40:11,460
at resolutions ranging from you know

1035
00:40:19,010 --> 00:40:14,700
from meter scale uh down down to very

1036
00:40:21,470 --> 00:40:19,020
very high resolution imaging of our of

1037
00:40:23,390 --> 00:40:21,480
our sampling of the sampling site uh

1038
00:40:25,190 --> 00:40:23,400

where we where we do drilling to to

1039
00:40:26,870 --> 00:40:25,200
break up the surface material to bring

1040
00:40:28,790 --> 00:40:26,880
into the mass spectrometer and there

1041
00:40:30,950 --> 00:40:28,800
will be Imaging at the scale of grains

1042
00:40:33,650 --> 00:40:30,960
so that we can really understand the the

1043
00:40:35,210 --> 00:40:33,660
details of the the surface at the the

1044
00:40:38,630 --> 00:40:35,220
sampling site so we'll have this whole

1045
00:40:40,970 --> 00:40:38,640
range of kind of nested uh Imaging

1046
00:40:44,990 --> 00:40:40,980
um at different scales

1047
00:40:46,490 --> 00:40:45,000
wonderful our next question from AC is

1048
00:40:48,109 --> 00:40:46,500
about the surface temperature of Titan

1049
00:40:50,270 --> 00:40:48,119
being just slightly warmer than liquid

1050
00:40:52,069 --> 00:40:50,280
nitrogen would we expect the metabolism

1051
00:40:53,690 --> 00:40:52,079
for Life as we know it and I think I'll

1052
00:40:55,849 --> 00:40:53,700
start off there that you know dragonfly

1053
00:40:58,069 --> 00:40:55,859
is not an astrobiology Mission directly

1054
00:41:00,770 --> 00:40:58,079
it's not it's directly looking for signs

1055
00:41:02,270 --> 00:41:00,780
of life because yes it is very cold on

1056
00:41:04,010 --> 00:41:02,280
the surface of Titan as you've mentioned

1057
00:41:05,210 --> 00:41:04,020
but as you mentioned as well like we're

1058
00:41:06,770 --> 00:41:05,220
exploring this realm where there has

1059
00:41:09,290 --> 00:41:06,780
been an impact crater and there could be

1060
00:41:10,670 --> 00:41:09,300
different energetic systems what do you

1061
00:41:13,190 --> 00:41:10,680
think is kind of the vision what could

1062
00:41:15,650 --> 00:41:13,200
we discover with dragonfly in that Realm

1063
00:41:17,630 --> 00:41:15,660

right so so as you say dragonfly is

1064
00:41:19,730 --> 00:41:17,640
primarily a chemistry Mission we want to

1065
00:41:23,510 --> 00:41:19,740
understand the chemical steps that occur

1066
00:41:25,370 --> 00:41:23,520
before biology uh and how far how how

1067
00:41:27,170 --> 00:41:25,380
far that chemistry can have progressed

1068
00:41:29,089 --> 00:41:27,180
in this extraterrestrial environment in

1069
00:41:31,010 --> 00:41:29,099
the outer solar system right we can't

1070
00:41:32,270 --> 00:41:31,020
easily study the chemistry that occurred

1071
00:41:34,069 --> 00:41:32,280
before life here on Earth because

1072
00:41:36,170 --> 00:41:34,079
because we've got you know biology on

1073
00:41:39,950 --> 00:41:36,180
top of it everywhere uh and so that's

1074
00:41:42,890 --> 00:41:39,960
really what we're what we're looking for

1075
00:41:45,170 --> 00:41:42,900
um we do because we're making uh

1076
00:41:48,050 --> 00:41:45,180
detailed measurements of aspects of

1077
00:41:52,370 --> 00:41:48,060
Titans uh you know composition and

1078
00:41:57,349 --> 00:41:52,380
chemistry we do have the capability to

1079
00:42:00,410 --> 00:41:57,359
uh to identify a variety of chemical

1080
00:42:02,450 --> 00:42:00,420
biosignatures if chemistry on Titan in

1081
00:42:05,690 --> 00:42:02,460
at some point in the past did take the

1082
00:42:08,690 --> 00:42:05,700
the leap to biology 94 Kelvin certainly

1083
00:42:09,530 --> 00:42:08,700
isn't conducive to uh to Life as we know

1084
00:42:13,670 --> 00:42:09,540
it

1085
00:42:15,410 --> 00:42:13,680
protected

1086
00:42:17,329 --> 00:42:15,420
um there's an atmosphere that protects

1087
00:42:19,370 --> 00:42:17,339
the surface from radiation for example

1088
00:42:22,910 --> 00:42:19,380

and so if there are molecules that you

1089
00:42:24,770 --> 00:42:22,920
know uh were created very long ago you

1090
00:42:26,210 --> 00:42:24,780
know geologically speaking they they

1091
00:42:27,710 --> 00:42:26,220
won't break down at the same kind of

1092
00:42:29,810 --> 00:42:27,720
rate that we're used to on other on

1093
00:42:31,790 --> 00:42:29,820
other targets and so we'll be able to to

1094
00:42:34,609 --> 00:42:31,800
make those measurements

1095
00:42:37,010 --> 00:42:34,619
um to understand uh you know we'll be

1096
00:42:38,810 --> 00:42:37,020
able to to measure that uh that uh

1097
00:42:41,630 --> 00:42:38,820
chemistry because it it's an environment

1098
00:42:43,490 --> 00:42:41,640
that will preserve preserve those uh the

1099
00:42:44,990 --> 00:42:43,500
chemical products uh but yeah

1100
00:42:46,550 --> 00:42:45,000
fundamentally we're we're trying to

1101
00:42:48,530 --> 00:42:46,560
understand the chemistry that occurred

1102
00:42:50,510 --> 00:42:48,540
before before biology

1103
00:42:51,829 --> 00:42:50,520
yeah and that chemistry is really

1104
00:42:54,290 --> 00:42:51,839
important I recall when I was in

1105
00:42:56,030 --> 00:42:54,300
graduate school I took an environmental

1106
00:42:57,710 --> 00:42:56,040
organic chemistry course but the

1107
00:42:59,750 --> 00:42:57,720
professor allowed me to do a project for

1108
00:43:01,670 --> 00:42:59,760
the course focusing on Titan atmospheric

1109
00:43:03,290 --> 00:43:01,680
chemistry that we knew of and at that

1110
00:43:05,329 --> 00:43:03,300
point you know it was really you know we

1111
00:43:07,069 --> 00:43:05,339
did have measurements from Huygens we

1112
00:43:09,230 --> 00:43:07,079
had some knowledge from Cassini but a

1113
00:43:10,730 --> 00:43:09,240

lot of it was basically modeling trying

1114
00:43:12,770 --> 00:43:10,740
to figure out based on known

1115
00:43:14,990 --> 00:43:12,780
photochemistry and you know the ethane

1116
00:43:17,270 --> 00:43:15,000
methane precursors nitrogen precursors

1117
00:43:19,069 --> 00:43:17,280
what is possible within the realm of

1118
00:43:21,349 --> 00:43:19,079
energetics and and the chemistry

1119
00:43:23,930 --> 00:43:21,359
available we have a question from

1120
00:43:25,130 --> 00:43:23,940
upgrade me BB on YouTube

1121
00:43:27,589 --> 00:43:25,140
um they want to know if we're using

1122
00:43:29,569 --> 00:43:27,599
something like artificial intelligence

1123
00:43:32,270 --> 00:43:29,579
um to generate models to kind of

1124
00:43:34,490 --> 00:43:32,280
simulate potential uh chemicals we might

1125
00:43:38,569 --> 00:43:34,500
find with dragonfly at the surface or

1126
00:43:42,290 --> 00:43:38,579
the atmosphere uh we we are doing

1127
00:43:43,849 --> 00:43:42,300
um work in terms of uh modeling uh the

1128
00:43:47,270 --> 00:43:43,859
and in in fact

1129
00:43:49,790 --> 00:43:47,280
generating literally producing uh the

1130
00:43:52,370 --> 00:43:49,800
kinds of of molecules that we might find

1131
00:43:55,309 --> 00:43:52,380
on the surface uh in the laboratory we

1132
00:43:57,530 --> 00:43:55,319
want to have uh kind of a library to be

1133
00:44:00,349 --> 00:43:57,540
able to compare the measurements that we

1134
00:44:02,150 --> 00:44:00,359
that we make at Titan 2 so that we can

1135
00:44:04,370 --> 00:44:02,160
interpret that

1136
00:44:06,710 --> 00:44:04,380
um so yeah so we can do that through

1137
00:44:08,210 --> 00:44:06,720
through modeling but there's also uh you

1138
00:44:10,250 --> 00:44:08,220

know you can also generate a lot of

1139
00:44:11,630 --> 00:44:10,260
these materials in small quantities in

1140
00:44:13,910 --> 00:44:11,640
the laboratory and one of our team

1141
00:44:16,130 --> 00:44:13,920
members uh Dr Sarah Hurst at Johns

1142
00:44:19,430 --> 00:44:16,140
Hopkins University has uh you know has a

1143
00:44:21,589 --> 00:44:19,440
laboratory where she can build the uh

1144
00:44:24,650 --> 00:44:21,599
you know some of these uh carbon-rich

1145
00:44:26,089 --> 00:44:24,660
tollens that uh we expect to be on the

1146
00:44:27,770 --> 00:44:26,099
surface of Titan so that'll be a

1147
00:44:29,329 --> 00:44:27,780
fascinating comparison to see if what we

1148
00:44:32,630 --> 00:44:29,339
build in the laboratory or what we model

1149
00:44:34,670 --> 00:44:32,640
is what Titan is producing or if once

1150
00:44:37,069 --> 00:44:34,680
again Titan surprises us completely and

1151
00:44:38,990 --> 00:44:37,079
has gone off and and uh you know and and

1152
00:44:41,510 --> 00:44:39,000
developed things in a in a in a

1153
00:44:44,030 --> 00:44:41,520
different way than uh than we predict

1154
00:44:47,750 --> 00:44:44,040
oh fantastic a question coming in from

1155
00:44:48,829 --> 00:44:47,760
Valentin uh at Valu underscore 66 000 on

1156
00:44:50,329 --> 00:44:48,839
Twitter

1157
00:44:52,370 --> 00:44:50,339
um they want to know if dragonfly is

1158
00:44:54,710 --> 00:44:52,380
going to actually study any of the Lakes

1159
00:44:56,510 --> 00:44:54,720
at the surface of Titan Titan has these

1160
00:44:58,430 --> 00:44:56,520
hydrocarbon Lakes at the surface and

1161
00:45:00,290 --> 00:44:58,440
specifically Valentin says they would

1162
00:45:03,950 --> 00:45:00,300
love to see photos of these Lakes up

1163
00:45:08,750 --> 00:45:03,960

close that would be spectacular

1164
00:45:11,210 --> 00:45:08,760
um so Titans uh sees and most of the

1165
00:45:13,490 --> 00:45:11,220
lakes are near the North Pole are at

1166
00:45:16,370 --> 00:45:13,500
very high Northern latitudes and the

1167
00:45:17,870 --> 00:45:16,380
time scale for the for the new frontier

1168
00:45:20,450 --> 00:45:17,880
for our for our mission in the New

1169
00:45:24,470 --> 00:45:20,460
Frontiers program uh is such that we

1170
00:45:27,530 --> 00:45:24,480
arrive in uh uh by 2034. uh this is

1171
00:45:28,970 --> 00:45:27,540
about One Titan year after the arrival

1172
00:45:30,530 --> 00:45:28,980
of the Huygens probe and so that's

1173
00:45:31,910 --> 00:45:30,540
actually very fortuitous in that we

1174
00:45:33,890 --> 00:45:31,920
actually have measurements of the

1175
00:45:35,329 --> 00:45:33,900
atmosphere from Boykins

1176
00:45:37,430 --> 00:45:35,339
um you know and we know what the weather

1177
00:45:39,770 --> 00:45:37,440
was like in the Titan system from

1178
00:45:42,770 --> 00:45:39,780
Cassini observations when uh when

1179
00:45:44,450 --> 00:45:42,780
Cassini arrived at uh at Saturn Titan uh

1180
00:45:47,809 --> 00:45:44,460
so that's excellent

1181
00:45:49,910 --> 00:45:47,819
um but that time in Titan's year is

1182
00:45:52,370 --> 00:45:49,920
Northern winter Titan has Seasons like

1183
00:45:55,010 --> 00:45:52,380
ours the the saturnian system is tilted

1184
00:45:57,410 --> 00:45:55,020
of a little more than than the uh tilt

1185
00:45:59,089 --> 00:45:57,420
of the Earth Moon system uh and so the

1186
00:46:01,069 --> 00:45:59,099
seasons it has Seasons just like ours

1187
00:46:03,950 --> 00:46:01,079
except they're you know several years

1188
00:46:06,290 --> 00:46:03,960

instead of a few months long uh and so

1189
00:46:08,630 --> 00:46:06,300
when we arrive it will be late Northern

1190
00:46:10,910 --> 00:46:08,640
winter and the northern latitudes will

1191
00:46:12,609 --> 00:46:10,920
still be in Northern darkness that that

1192
00:46:15,349 --> 00:46:12,619
means that not only is there not

1193
00:46:17,030 --> 00:46:15,359
illumination for Imaging but because we

1194
00:46:20,870 --> 00:46:17,040
are doing direct to Earth communication

1195
00:46:22,309 --> 00:46:20,880
from the surface if uh you know if the

1196
00:46:25,190 --> 00:46:22,319
the sun isn't up in the sky the Earth

1197
00:46:26,809 --> 00:46:25,200
isn't up in the sky and so it wasn't uh

1198
00:46:29,210 --> 00:46:26,819
you know it wasn't possible in this time

1199
00:46:31,190 --> 00:46:29,220
frame uh to explore the the high

1200
00:46:34,130 --> 00:46:31,200
Northern latitude simply because of the

1201
00:46:36,109 --> 00:46:34,140
of the Season uh so we have chosen to go

1202
00:46:39,170 --> 00:46:36,119
to uh uh you know a target of

1203
00:46:42,170 --> 00:46:39,180
astrobiological Interest where uh liquid

1204
00:46:43,870 --> 00:46:42,180
water and uh carbon material may have

1205
00:46:46,490 --> 00:46:43,880
been able to mix at the site of a

1206
00:46:48,290 --> 00:46:46,500
equatorial or near equatorial impact

1207
00:46:49,910 --> 00:46:48,300
crater for this Mission

1208
00:46:52,609 --> 00:46:49,920
um but unfortunately we won't be able to

1209
00:46:54,349 --> 00:46:52,619
uh to get to the the lakes and seas this

1210
00:46:56,150 --> 00:46:54,359
time although I agree it would be

1211
00:46:58,550 --> 00:46:56,160
spectacular to get images of those

1212
00:47:00,050 --> 00:46:58,560
shorelines well it's a little saddening

1213
00:47:02,030 --> 00:47:00,060

but I imagine just like everything in

1214
00:47:04,309 --> 00:47:02,040
our Planetary Exploration we'll discover

1215
00:47:06,470 --> 00:47:04,319
all new things with dragonfly that will

1216
00:47:09,349 --> 00:47:06,480
be remarkable and give us yet another

1217
00:47:10,910 --> 00:47:09,359
reason to go back and explore some more

1218
00:47:12,890 --> 00:47:10,920
we have a question coming in from

1219
00:47:15,349 --> 00:47:12,900
rendering reality 3D animations on

1220
00:47:17,089 --> 00:47:15,359
YouTube they want to know um if we can

1221
00:47:19,849 --> 00:47:17,099
describe how dragonfly will study

1222
00:47:21,230 --> 00:47:19,859
atmospheric differences with altitude

1223
00:47:23,990 --> 00:47:21,240
um specifically in like boundary layers

1224
00:47:25,790 --> 00:47:24,000
in the in the atmosphere changes over a

1225
00:47:28,849 --> 00:47:25,800
diurnal cycle if there is one for us to

1226
00:47:30,230 --> 00:47:28,859
explore during uh dragonfly's Mission

1227
00:47:32,569 --> 00:47:30,240
um while we're looking for the chemistry

1228
00:47:35,089 --> 00:47:32,579
of the surface and atmosphere of Titan

1229
00:47:36,950 --> 00:47:35,099
yeah so we want to be able to put the

1230
00:47:39,410 --> 00:47:36,960
measurements we make of the you know the

1231
00:47:41,510 --> 00:47:39,420
detailed chemical composition of

1232
00:47:43,790 --> 00:47:41,520
different materials on the surface of

1233
00:47:45,710 --> 00:47:43,800
Titan into the context of the Titan

1234
00:47:47,809 --> 00:47:45,720
environment to understand the

1235
00:47:49,730 --> 00:47:47,819
environment itself uh and that the

1236
00:47:53,270 --> 00:47:49,740
habitability how things vary from from

1237
00:47:55,609 --> 00:47:53,280
location to location so we have you know

1238
00:47:58,430 --> 00:47:55,619

the the Imaging we have the geophysical

1239
00:48:00,829 --> 00:47:58,440
measurements and we have a suite of

1240
00:48:03,349 --> 00:48:00,839
meteorological sensors to uh to measure

1241
00:48:05,870 --> 00:48:03,359
aspects of the atmosphere uh you know

1242
00:48:07,550 --> 00:48:05,880
pressure temperature uh wind speed wind

1243
00:48:09,290 --> 00:48:07,560
direction Etc

1244
00:48:12,109 --> 00:48:09,300
um and we will make we will be

1245
00:48:14,270 --> 00:48:12,119
monitoring through the Titan day

1246
00:48:15,770 --> 00:48:14,280
um uh the monitoring the conditions

1247
00:48:17,809 --> 00:48:15,780
through the Titan day the Titan

1248
00:48:20,150 --> 00:48:17,819
atmosphere actually doesn't change a lot

1249
00:48:23,030 --> 00:48:20,160
with a dense atmosphere it's quite

1250
00:48:25,970 --> 00:48:23,040
sluggish uh and so the the surface

1251
00:48:28,370 --> 00:48:25,980
temperature is you know day to night uh

1252
00:48:30,170 --> 00:48:28,380
you know winter to summer uh is it

1253
00:48:32,270 --> 00:48:30,180
really only changes about by about a

1254
00:48:35,210 --> 00:48:32,280
Kelvin but will certainly be certainly

1255
00:48:37,730 --> 00:48:35,220
be be measuring that uh to understand

1256
00:48:39,829 --> 00:48:37,740
the uh to understand the atmosphere and

1257
00:48:42,530 --> 00:48:39,839
its variability we'll be able to do some

1258
00:48:45,170 --> 00:48:42,540
measurements with with low altitude we

1259
00:48:47,870 --> 00:48:45,180
don't need to fly terribly High uh in

1260
00:48:50,150 --> 00:48:47,880
our mission operations plan to Traverse

1261
00:48:52,250 --> 00:48:50,160
from place to place across the surface

1262
00:48:55,609 --> 00:48:52,260
we'll probably only apply at an altitude

1263
00:48:57,170 --> 00:48:55,619

of a few hundred meters but we uh we do

1264
00:48:59,809 --> 00:48:57,180
have some measurements planned during

1265
00:49:02,390 --> 00:48:59,819
the last stages of our initial descent

1266
00:49:04,550 --> 00:49:02,400
through Titan's atmosphere and we may be

1267
00:49:06,589 --> 00:49:04,560
able to fly to do atmospheric profiles

1268
00:49:08,329 --> 00:49:06,599
to slightly higher altitude but not up

1269
00:49:09,770 --> 00:49:08,339
to like the you know the tropopause or

1270
00:49:11,390 --> 00:49:09,780
something like that just in the very

1271
00:49:12,109 --> 00:49:11,400
lowest part of the atmosphere for this

1272
00:49:14,030 --> 00:49:12,119
mission

1273
00:49:15,950 --> 00:49:14,040
yeah very cool and Titan has a very

1274
00:49:17,750 --> 00:49:15,960
thick atmosphere

1275
00:49:19,849 --> 00:49:17,760
um we did mention earlier this idea of

1276
00:49:21,890 --> 00:49:19,859
sampling from the surface while one of

1277
00:49:24,109 --> 00:49:21,900
our users AC on YouTube wants to know if

1278
00:49:26,030 --> 00:49:24,119
the RTG will be used for melting ice or

1279
00:49:29,510 --> 00:49:26,040
or what kind of drilling process we're

1280
00:49:31,910 --> 00:49:29,520
using on dragonfly to sample the surface

1281
00:49:34,309 --> 00:49:31,920
yeah we uh have a

1282
00:49:36,109 --> 00:49:34,319
rotary percussion of drill so this

1283
00:49:37,609 --> 00:49:36,119
breaks up the surface and then we can

1284
00:49:39,829 --> 00:49:37,619
actually use pneumatic transport because

1285
00:49:41,329 --> 00:49:39,839
we've got this great atmosphere uh to

1286
00:49:44,450 --> 00:49:41,339
just like a vacuum cleaner you just suck

1287
00:49:46,430 --> 00:49:44,460
the the material right into the um into

1288
00:49:48,410 --> 00:49:46,440

the mass spectrometer and the fact that

1289
00:49:50,690 --> 00:49:48,420
the atmosphere is so cold allows us to

1290
00:49:52,430 --> 00:49:50,700
keep those materials cold until we get

1291
00:49:54,109 --> 00:49:52,440
them into the mass spectrometer to make

1292
00:49:57,349 --> 00:49:54,119
measurements which is really which is

1293
00:49:58,790 --> 00:49:57,359
very very important as well uh the mmrtg

1294
00:50:00,650 --> 00:49:58,800
the multi-mission radioisotope

1295
00:50:02,690 --> 00:50:00,660
thermoelectric generator that we used

1296
00:50:04,609 --> 00:50:02,700
for that we use for power we use that to

1297
00:50:06,349 --> 00:50:04,619
charge a battery

1298
00:50:08,930 --> 00:50:06,359
um there's a lot of what's typically

1299
00:50:12,170 --> 00:50:08,940
referred to as waste heat that comes off

1300
00:50:14,870 --> 00:50:12,180
of off of the mmrtg we use every bit of

1301
00:50:17,210 --> 00:50:14,880
that to keep the interior of the Lander

1302
00:50:19,190 --> 00:50:17,220
warm so the exterior of the Lander will

1303
00:50:21,710 --> 00:50:19,200
be basically the temperature of of

1304
00:50:24,290 --> 00:50:21,720
titano be equilibrated with uh with the

1305
00:50:27,170 --> 00:50:24,300
Titan environment uh and we have a thick

1306
00:50:30,230 --> 00:50:27,180
layer of insulation uh around the around

1307
00:50:33,230 --> 00:50:30,240
the the Lander so that we keep all of

1308
00:50:35,089 --> 00:50:33,240
that all of that heat inside uh to keep

1309
00:50:36,829 --> 00:50:35,099
the uh to keep the you know the

1310
00:50:38,630 --> 00:50:36,839
instruments functioning

1311
00:50:40,370 --> 00:50:38,640
Etc so there won't be any heating of the

1312
00:50:43,010 --> 00:50:40,380
environment by by dragonfly in that

1313
00:50:44,390 --> 00:50:43,020

sense am I fantastic I I love these

1314
00:50:45,770 --> 00:50:44,400
conversations so much because they

1315
00:50:48,109 --> 00:50:45,780
always like bring things to my mind

1316
00:50:50,030 --> 00:50:48,119
imagery of the you know this this you

1317
00:50:52,730 --> 00:50:50,040
know rotorcraft Lander now the outside

1318
00:50:53,870 --> 00:50:52,740
is like so freezing cold you know and it

1319
00:50:55,010 --> 00:50:53,880
kind of just like brings this Vision to

1320
00:50:56,569 --> 00:50:55,020
my mind of the outside metal being

1321
00:50:58,970 --> 00:50:56,579
freezing cold but the inside having this

1322
00:51:01,130 --> 00:50:58,980
loving heat from from us giving it the

1323
00:51:02,750 --> 00:51:01,140
RTG to heat it up inside

1324
00:51:04,190 --> 00:51:02,760
um and that kind of is a fun way to jump

1325
00:51:06,650 --> 00:51:04,200
into this next question which I really

1326
00:51:09,349 --> 00:51:06,660
appreciate from Tasha on YouTube

1327
00:51:11,030 --> 00:51:09,359
Tasha wants to know uh what is something

1328
00:51:13,190 --> 00:51:11,040
about Titan that you would love to see

1329
00:51:16,190 --> 00:51:13,200
represented more or maybe represented

1330
00:51:23,750 --> 00:51:16,200
better in our artists impressions of

1331
00:51:29,089 --> 00:51:26,569
different geological environments and

1332
00:51:32,210 --> 00:51:29,099
just how how familiar they are sometimes

1333
00:51:34,490 --> 00:51:32,220
you know sometimes when when uh we think

1334
00:51:37,130 --> 00:51:34,500
of extraterrestrial worlds we think of

1335
00:51:38,329 --> 00:51:37,140
you know very alien environments and I

1336
00:51:41,270 --> 00:51:38,339
think one of the things that's that

1337
00:51:44,030 --> 00:51:41,280
struck me about Titan is is in some

1338
00:51:46,430 --> 00:51:44,040

senses just how how Earth-like it is and

1339
00:51:49,309 --> 00:51:46,440
how familiar it is I still I still

1340
00:51:51,349 --> 00:51:49,319
remember uh the images that came back

1341
00:51:54,589 --> 00:51:51,359
from the huygensburg the first time I

1342
00:51:56,930 --> 00:51:54,599
saw one of those images uh from uh from

1343
00:51:59,690 --> 00:51:56,940
The Descent images showing the channeled

1344
00:52:02,630 --> 00:51:59,700
landscape on Titan and it was instantly

1345
00:52:05,150 --> 00:52:02,640
so recognizable and so familiar and here

1346
00:52:06,890 --> 00:52:05,160
we are on this icy satellite out in the

1347
00:52:08,329 --> 00:52:06,900
outer solar system with all of these

1348
00:52:10,490 --> 00:52:08,339
different materials and very different

1349
00:52:12,589 --> 00:52:10,500
conditions and yet we're seeing

1350
00:52:14,569 --> 00:52:12,599
something that you you don't you you

1351
00:52:16,849 --> 00:52:14,579
immediately know what it is when you

1352
00:52:19,910 --> 00:52:16,859
look at uh and so that that kind of

1353
00:52:22,309 --> 00:52:19,920
balance of familiarity and uh you know

1354
00:52:25,190 --> 00:52:22,319
in this uh In This Very on this very

1355
00:52:27,589 --> 00:52:25,200
different world uh is is something that

1356
00:52:30,109 --> 00:52:27,599
uh that always strikes me and I'd like

1357
00:52:31,490 --> 00:52:30,119
be happy to see that uh that kind of

1358
00:52:34,010 --> 00:52:31,500
balance struck

1359
00:52:36,770 --> 00:52:34,020
um and a number of artists do a good job

1360
00:52:38,210 --> 00:52:36,780
of that wonderful well maybe we have

1361
00:52:40,250 --> 00:52:38,220
some artists watching right now who want

1362
00:52:41,690 --> 00:52:40,260
to take on that task and and create some

1363
00:52:43,670 --> 00:52:41,700

cool Impressions and visuals and

1364
00:52:45,349 --> 00:52:43,680
graphics for us to see

1365
00:52:48,290 --> 00:52:45,359
um one thing we've not really discussed

1366
00:52:50,870 --> 00:52:48,300
is how Titan became such a methane and

1367
00:52:53,030 --> 00:52:50,880
ethane-rich world what we know uh user

1368
00:52:55,609 --> 00:52:53,040
arunov upadar um who is one of our past

1369
00:52:57,130 --> 00:52:55,619
young scientist program participants at

1370
00:52:59,870 --> 00:52:57,140
Blue Marble space Institute of science

1371
00:53:01,849 --> 00:52:59,880
arunova wants to know how dragonfly

1372
00:53:03,890 --> 00:53:01,859
might help us understanding the origin

1373
00:53:06,049 --> 00:53:03,900
and history of the methane and ethane

1374
00:53:08,690 --> 00:53:06,059
and chemical inventory of Titan

1375
00:53:12,290 --> 00:53:08,700
right so one of the things we want to do

1376
00:53:15,230 --> 00:53:12,300
is understand uh what the role of the

1377
00:53:18,950 --> 00:53:15,240
equatorial regions are in the broader

1378
00:53:20,089 --> 00:53:18,960
you know hydrological cycle on on Titan

1379
00:53:22,849 --> 00:53:20,099
um there are a lot of outstanding

1380
00:53:24,770 --> 00:53:22,859
questions about Titan's hydrology given

1381
00:53:26,569 --> 00:53:24,780
the the Dune the nature of the Dune

1382
00:53:29,510 --> 00:53:26,579
fields at Titan's equator it seems like

1383
00:53:31,430 --> 00:53:29,520
in general it must be an arid place

1384
00:53:34,309 --> 00:53:31,440
um on the other hand Cassini did observe

1385
00:53:36,650 --> 00:53:34,319
some rainfall at some Seasons uh at low

1386
00:53:39,589 --> 00:53:36,660
latitudes and so understanding that uh

1387
00:53:42,170 --> 00:53:39,599
that hydrology whether there are near

1388
00:53:44,630 --> 00:53:42,180

surface uh

1389
00:53:46,309 --> 00:53:44,640
um reservoirs of of liquid is going to

1390
00:53:47,930 --> 00:53:46,319
be is going to be very important to

1391
00:53:50,210 --> 00:53:47,940
understand

1392
00:53:52,849 --> 00:53:50,220
um the the Huygens probe uh potentially

1393
00:53:54,650 --> 00:53:52,859
detected you know that the surface the

1394
00:53:56,990 --> 00:53:54,660
surface there may have been damp and so

1395
00:53:58,670 --> 00:53:57,000
uh so that kind of measurement the

1396
00:54:00,530 --> 00:53:58,680
measurements it'll allow us to get at

1397
00:54:02,750 --> 00:54:00,540
just the very it's very shallow surface

1398
00:54:04,730 --> 00:54:02,760
uh but that kind of that kind of

1399
00:54:07,309 --> 00:54:04,740
measurement is going to be important uh

1400
00:54:11,450 --> 00:54:07,319
we also uh have the mass spectrometer

1401
00:54:13,609 --> 00:54:11,460
also uh has the capability to measure

1402
00:54:15,710 --> 00:54:13,619
um uh

1403
00:54:17,750 --> 00:54:15,720
um noble gases uh some of the noble

1404
00:54:19,730 --> 00:54:17,760
gases and that on the you know kind of

1405
00:54:23,270 --> 00:54:19,740
stepping back to the big picture will

1406
00:54:25,549 --> 00:54:23,280
help us understand uh the nature of the

1407
00:54:28,069 --> 00:54:25,559
the atmosphere and provide some uh

1408
00:54:29,870 --> 00:54:28,079
information about the uh the atmospheric

1409
00:54:31,010 --> 00:54:29,880
history which of course they're you know

1410
00:54:32,450 --> 00:54:31,020
they're still outstanding very

1411
00:54:35,150 --> 00:54:32,460
fundamental questions about about

1412
00:54:37,190 --> 00:54:35,160
Titan's unique atmosphere absolutely and

1413
00:54:38,690 --> 00:54:37,200

it is a very thick and dense atmosphere

1414
00:54:40,190 --> 00:54:38,700
it's one and a half times the pressure

1415
00:54:42,470 --> 00:54:40,200
at the surface and we have here at sea

1416
00:54:44,150 --> 00:54:42,480
level and it's a very thick atmosphere I

1417
00:54:45,410 --> 00:54:44,160
love pointing out for students that like

1418
00:54:46,670 --> 00:54:45,420
the International Space Station where

1419
00:54:49,910 --> 00:54:46,680
it's orbiting the Earth would very much

1420
00:54:51,710 --> 00:54:49,920
still be in that very thick hazy layer

1421
00:54:53,630 --> 00:54:51,720
um our user miles fully on YouTube

1422
00:54:56,150 --> 00:54:53,640
wanted to know if we could see a Saturn

1423
00:54:57,470 --> 00:54:56,160
rise photo from dragonfly looking up but

1424
00:55:00,230 --> 00:54:57,480
again it's a it's a very thick

1425
00:55:01,970 --> 00:55:00,240
atmosphere and so maybe not I'll let you

1426
00:55:03,410 --> 00:55:01,980
answer that question but what do you

1427
00:55:04,849 --> 00:55:03,420
think we'll see if we look up with

1428
00:55:07,790 --> 00:55:04,859
dragonfly

1429
00:55:09,710 --> 00:55:07,800
uh right so they're um so Titans

1430
00:55:11,450 --> 00:55:09,720
atmosphere is thick we are Imaging with

1431
00:55:14,510 --> 00:55:11,460
dragonfly is that

1432
00:55:16,609 --> 00:55:14,520
um is that uh visible wavelengths mostly

1433
00:55:19,069 --> 00:55:16,619
visible just just into the near infrared

1434
00:55:21,049 --> 00:55:19,079
uh the visibility of the atmosphere in

1435
00:55:22,970 --> 00:55:21,059
terms of of the you know the methane

1436
00:55:25,549 --> 00:55:22,980
transmission spectrum is much better out

1437
00:55:27,410 --> 00:55:25,559
into the infrared uh but because we're

1438
00:55:29,390 --> 00:55:27,420

down within the atmosphere at the you

1439
00:55:32,089 --> 00:55:29,400
know the base of the atmosphere uh you

1440
00:55:33,290 --> 00:55:32,099
know we can see fine too to explore the

1441
00:55:35,510 --> 00:55:33,300
surface

1442
00:55:37,370 --> 00:55:35,520
um looking up what we would see is the

1443
00:55:40,250 --> 00:55:37,380
you know is the kind of orange the

1444
00:55:42,410 --> 00:55:40,260
orange Sky uh so we wouldn't be able to

1445
00:55:44,990 --> 00:55:42,420
see Saturn in the sky for a couple

1446
00:55:47,390 --> 00:55:45,000
reasons one is because of the uh the

1447
00:55:48,410 --> 00:55:47,400
opacity of the the atmosphere

1448
00:55:50,210 --> 00:55:48,420
um you know when you're looking through

1449
00:55:52,309 --> 00:55:50,220
the full Optical depth of the atmosphere

1450
00:55:55,430 --> 00:55:52,319
but the other is that Titan is tidally

1451
00:55:57,230 --> 00:55:55,440
locked to uh to Saturn uh so the same

1452
00:55:59,210 --> 00:55:57,240
just like our moon the same side of

1453
00:56:01,430 --> 00:55:59,220
Titan always faces Saturn and we're

1454
00:56:03,589 --> 00:56:01,440
landing on the opposite side from where

1455
00:56:05,089 --> 00:56:03,599
Saturn is so even if we were able to

1456
00:56:08,030 --> 00:56:05,099
observe at a wavelength where you could

1457
00:56:11,030 --> 00:56:08,040
see Saturn uh it's it won't be up in the

1458
00:56:12,349 --> 00:56:11,040
up in the sky above above dragonfly so

1459
00:56:14,030 --> 00:56:12,359
we'll have to we'll have to look for a

1460
00:56:15,890 --> 00:56:14,040
future opportunity for that uh that

1461
00:56:17,630 --> 00:56:15,900
picture which would be spectacular

1462
00:56:19,190 --> 00:56:17,640
it would be pretty spectacular again

1463
00:56:22,609 --> 00:56:19,200

another reason we'll have to eventually

1464
00:56:23,930 --> 00:56:22,619
go back again and do even more work

1465
00:56:25,190 --> 00:56:23,940
um and that now in my mind I can't help

1466
00:56:27,109 --> 00:56:25,200
but like visualize the titanium

1467
00:56:29,510 --> 00:56:27,119
atmospheres like this orange Haze above

1468
00:56:32,210 --> 00:56:29,520
this beautiful Frozen on the outside uh

1469
00:56:33,589 --> 00:56:32,220
dragonfly if it chooses to look up

1470
00:56:34,790 --> 00:56:33,599
um you know again that's part of the fun

1471
00:56:36,710 --> 00:56:34,800
of these conversations it's just to

1472
00:56:38,809 --> 00:56:36,720
think of what's going to happen what's

1473
00:56:42,170 --> 00:56:38,819
likely what we would see ourselves and

1474
00:56:44,990 --> 00:56:42,180
and maybe even to personify uh dragonfly

1475
00:56:46,970 --> 00:56:45,000
a little bit I we did note our team um

1476
00:56:48,890 --> 00:56:46,980
that in the current iteration of the

1477
00:56:50,329 --> 00:56:48,900
design that we're at now that it does

1478
00:56:52,309 --> 00:56:50,339
look a little bit cuter it's like a

1479
00:56:54,950 --> 00:56:52,319
little button nose on the front of it uh

1480
00:56:56,630 --> 00:56:54,960
can you explain what that change was oh

1481
00:56:58,849 --> 00:56:56,640
there have been a number of of changes

1482
00:57:00,170 --> 00:56:58,859
in the in the design as we've gone you

1483
00:57:02,809 --> 00:57:00,180
know gone through our our design

1484
00:57:06,230 --> 00:57:02,819
iteration uh in the preliminary design

1485
00:57:09,589 --> 00:57:06,240
phase coming up to our our review uh

1486
00:57:12,109 --> 00:57:09,599
just the uh the end of last month

1487
00:57:13,670 --> 00:57:12,119
um a lot of this has been

1488
00:57:17,030 --> 00:57:13,680

um a lot of the design changes have been

1489
00:57:19,010 --> 00:57:17,040
focused on uh we want to make sure that

1490
00:57:20,630 --> 00:57:19,020
we're as aerodynamic as possible it's

1491
00:57:22,069 --> 00:57:20,640
not you know the most aerodynamic shape

1492
00:57:25,190 --> 00:57:22,079
but it's definitely more aerodynamic

1493
00:57:28,250 --> 00:57:25,200
than it was to be able to really uh you

1494
00:57:29,809 --> 00:57:28,260
know buy uh simplify flight enable our

1495
00:57:32,690 --> 00:57:29,819
our flight or better enable our flight

1496
00:57:35,030 --> 00:57:32,700
uh we're also reducing you know keeping

1497
00:57:37,250 --> 00:57:35,040
our mass as low as possible

1498
00:57:40,730 --> 00:57:37,260
um so a lot of the the work we've done

1499
00:57:42,710 --> 00:57:40,740
is to uh is to simplify aspects of the

1500
00:57:44,990 --> 00:57:42,720
design to

1501
00:57:46,970 --> 00:57:45,000
um reduce risk as much as possible as we

1502
00:57:48,650 --> 00:57:46,980
can through design and and some of those

1503
00:57:51,170 --> 00:57:48,660
things are showing up in the in the new

1504
00:57:53,210 --> 00:57:51,180
design in terms of uh the streamlining

1505
00:57:56,569 --> 00:57:53,220
uh and the simplification of the

1506
00:57:58,549 --> 00:57:56,579
exterior as well I love that so much we

1507
00:58:00,349 --> 00:57:58,559
do have more questions unfortunately for

1508
00:58:01,490 --> 00:58:00,359
our audience and for me

1509
00:58:03,589 --> 00:58:01,500
um we're running out of time to have you

1510
00:58:05,630 --> 00:58:03,599
on the show with us here uh for the

1511
00:58:07,970 --> 00:58:05,640
audience there is a remarkable website

1512
00:58:10,849 --> 00:58:07,980
for dragonfly you can check out lots of

1513
00:58:12,829 --> 00:58:10,859

really incredible Mission information a

1514
00:58:14,870 --> 00:58:12,839
really wonderful gallery of images and

1515
00:58:16,790 --> 00:58:14,880
such for for understanding this Mission

1516
00:58:19,549 --> 00:58:16,800
a bit better I hope you're as excited

1517
00:58:21,230 --> 00:58:19,559
for it as I am Dr zubby turtle thank you

1518
00:58:22,609 --> 00:58:21,240
so much for joining us for ask an

1519
00:58:24,470 --> 00:58:22,619
astrobiologist

1520
00:58:26,870 --> 00:58:24,480
thank you it's been so fun to talk to

1521
00:58:28,190 --> 00:58:26,880
you today about dragonfly yeah that's

1522
00:58:29,930 --> 00:58:28,200
such an incredible Mission I'm looking

1523
00:58:31,370 --> 00:58:29,940
forward to it uh for those of you

1524
00:58:33,290 --> 00:58:31,380
watching if you'd like to learn more

1525
00:58:35,390 --> 00:58:33,300
about our upcoming episodes you can

1526
00:58:37,789 --> 00:58:35,400
always tune in on Twitter at Nasa

1527
00:58:40,370 --> 00:58:37,799
astrobio uh you can check me out at

1528
00:58:41,809 --> 00:58:40,380
cosmobiologist we also have a sign up

1529
00:58:44,030 --> 00:58:41,819
for the mailing list for the NASA

1530
00:58:46,069 --> 00:58:44,040
astrobiology program of course we're

1531
00:58:47,589 --> 00:58:46,079
also brought to you by segnet.org you

1532
00:58:50,329 --> 00:58:47,599
can find out more information about

1533
00:58:52,849 --> 00:58:50,339
resources and upcoming articles about

1534
00:58:54,650 --> 00:58:52,859
astrobiology there as well so thank you

1535
00:58:57,109 --> 00:58:54,660
all for tuning in and joining us and

1536
00:58:58,730 --> 00:58:57,119
learning a bit more about Dr zubby

1537
00:59:01,309 --> 00:58:58,740
turtle and about the dragonfly Mission

1538
00:59:03,470 --> 00:59:01,319

that's coming up on its way to Titan so

1539
00:59:04,810 --> 00:59:03,480
as always remember until next time too

1540
00:59:11,569 --> 00:59:04,820
stay curious

1541
00:59:23,000 --> 00:59:12,820
ha

1542
00:59:24,310 --> 00:59:23,010
[Music]

1543
00:59:25,180 --> 00:59:24,320
[Applause]