Ask An Astrobiologist

Episode 41: May 19th, 2021

OSIRIS-REx Panel

NASA Astrobiology Program

1
00:00:00,680 --> 00:00:29,750
[Music]

2
00:00:33,510 --> 00:00:31,189
greetings friends and

3
00:00:35,030 --> 00:00:33,520
fellow fans of sample return missions

4
00:00:37,910 --> 00:00:35,040
from our solar system

5
00:00:39,830 --> 00:00:37,920
this is ask an astrobiologist the show

6
00:00:42,310 --> 00:00:39,840
that celebrates the science

7
00:00:44,630 --> 00:00:42,320
and celebrates the scientists involved

8
00:00:46,389 --> 00:00:44,640
in our quest to understand the nature of

9
00:00:49,830 --> 00:00:46,399
life in the cosmos

10
00:00:52,470 --> 00:00:49,840
our origins evolution the distribution

11
00:00:54,150 --> 00:00:52,480
of life throughout the universe i'm dr

12
00:00:57,189 --> 00:00:54,160
graham lau your host

13
00:00:59,510 --> 00:00:57,199

also known online as the cosmobiologist

14
00:01:02,389 --> 00:00:59,520
and we're brought to you by saganet.org

15
00:01:04,390 --> 00:01:02,399
and the nasa astrobiology program

16
00:01:05,509 --> 00:01:04,400
now this month's special feature episode

17
00:01:07,350 --> 00:01:05,519
is going to be so

18
00:01:08,710 --> 00:01:07,360
awesome i actually feel some nervousness

19
00:01:09,590 --> 00:01:08,720
of my own right now just thinking about

20
00:01:11,590 --> 00:01:09,600
how cool

21
00:01:13,510 --> 00:01:11,600
this is going to be we're going to talk

22
00:01:16,469 --> 00:01:13,520
with some researchers who are involved

23
00:01:17,109 --> 00:01:16,479
in the osiris-rex mission team for those

24
00:01:19,830 --> 00:01:17,119
who don't know

25
00:01:22,310 --> 00:01:19,840
osiris-rex is a spacecraft that just

26
00:01:24,710 --> 00:01:22,320
recently left the asteroid bennu

27
00:01:25,590 --> 00:01:24,720
with a sample in hand to bring it back

28
00:01:28,469 --> 00:01:25,600
to earth

29
00:01:28,950 --> 00:01:28,479
for further study but before we get to

30
00:01:30,870 --> 00:01:28,960
that

31
00:01:33,109 --> 00:01:30,880
i want to introduce our ambassadors of

32
00:01:33,590 --> 00:01:33,119
the month those who've done the work of

33
00:01:36,390 --> 00:01:33,600
going

34
00:01:37,510 --> 00:01:36,400
online on twitter and other places to

35
00:01:40,550 --> 00:01:37,520
share their love

36
00:01:41,590 --> 00:01:40,560
for ask an astrobiologist this month's

37
00:01:45,350 --> 00:01:41,600
winners

38
00:01:46,710 --> 00:01:45,360

joe landon denise and amarut mohanty

39
00:01:48,469 --> 00:01:46,720
who shared their love for ask an

40
00:01:50,149 --> 00:01:48,479
astrobiologist on twitter

41
00:01:52,950 --> 00:01:50,159
thank you very much to all of you for

42
00:01:55,190 --> 00:01:52,960
being big supporters of our show

43
00:01:57,109 --> 00:01:55,200
so thank you everyone for tuning in and

44
00:01:58,950 --> 00:01:57,119
i think we can get this started

45
00:02:00,389 --> 00:01:58,960
i'm going to start off by introducing dr

46
00:02:02,069 --> 00:02:00,399
scott sanford

47
00:02:03,429 --> 00:02:02,079
dr sanford is a member of the

48
00:02:05,350 --> 00:02:03,439
astrochemical

49
00:02:07,109 --> 00:02:05,360
astrochemistry laboratory at nasa ames

50
00:02:08,469 --> 00:02:07,119
research center investigator for

51
00:02:09,910 --> 00:02:08,479
osiris-rex

52
00:02:12,070 --> 00:02:09,920
dr sanford has also been a

53
00:02:12,869 --> 00:02:12,080
co-investigator on jax's hayabusa

54
00:02:16,229 --> 00:02:12,879
mission

55
00:02:18,070 --> 00:02:16,239
sanford

56
00:02:19,670 --> 00:02:18,080
welcome to ask an astrobiologist and

57
00:02:20,790 --> 00:02:19,680
thank you for joining us well thanks for

58
00:02:23,190 --> 00:02:20,800
having me on i've been looking forward

59
00:02:24,790 --> 00:02:23,200
to this yeah it's so great i mean i'm so

60
00:02:26,229 --> 00:02:24,800
excited for the whole group here

61
00:02:28,550 --> 00:02:26,239
um before we introduce the rest of the

62
00:02:30,070 --> 00:02:28,560
panel i kind of wonder if you can just

63
00:02:32,390 --> 00:02:30,080

kind of briefly give us

64
00:02:33,430 --> 00:02:32,400
a little background on the trajectory of

65
00:02:35,350 --> 00:02:33,440
your research

66
00:02:37,110 --> 00:02:35,360
in all these different sample return

67
00:02:38,869 --> 00:02:37,120
missions all these different missions

68
00:02:40,150 --> 00:02:38,879
and what you think kind of the grand

69
00:02:43,509 --> 00:02:40,160
scheme is for

70
00:02:45,110 --> 00:02:43,519
sample return in the future as well

71
00:02:46,710 --> 00:02:45,120
okay i've been fortunate to be on a

72
00:02:48,390 --> 00:02:46,720
number of sample return missions

73
00:02:50,309 --> 00:02:48,400
uh starting with the stardust which

74
00:02:53,350 --> 00:02:50,319
brought back samples of comet

75
00:02:54,550 --> 00:02:53,360
thus from comet build 2 and

76
00:02:55,589 --> 00:02:54,560
sample return missions are a very

77
00:02:57,030 --> 00:02:55,599
special kind of mission they're

78
00:02:58,710 --> 00:02:57,040
difficult because you not

79
00:03:00,630 --> 00:02:58,720
only need to get to some object in space

80
00:03:03,110 --> 00:03:00,640
but you have to get back

81
00:03:03,990 --> 00:03:03,120
and that increases the complexity but

82
00:03:06,149 --> 00:03:04,000
the advantage of bringing

83
00:03:07,110 --> 00:03:06,159
a sample back is that you can do things

84
00:03:09,030 --> 00:03:07,120
that you couldn't do

85
00:03:11,030 --> 00:03:09,040
otherwise i mean most missions go to an

86
00:03:13,430 --> 00:03:11,040
object they do remote observations as

87
00:03:15,830 --> 00:03:13,440
they fly by or perhaps rendezvous

88
00:03:17,670 --> 00:03:15,840

and then you're sort of done whereas

89
00:03:19,430 --> 00:03:17,680
when you have a sample return mission

90
00:03:21,110 --> 00:03:19,440
you can do all those remote observations

91
00:03:22,710 --> 00:03:21,120
but then you get to sample back

92
00:03:24,390 --> 00:03:22,720
and you can study it on the earth and at

93
00:03:25,750 --> 00:03:24,400
that point your spacecraft's payload

94
00:03:28,229 --> 00:03:25,760
effectively becomes

95
00:03:30,229 --> 00:03:28,239
all the analytical devices on the planet

96
00:03:33,509 --> 00:03:30,239
earth so you can simply do things that

97
00:03:35,509 --> 00:03:33,519
you could never do remotely and so

98
00:03:37,430 --> 00:03:35,519
this is a just a tremendous power for

99
00:03:37,670 --> 00:03:37,440
sample return missions of all types and

100
00:03:41,430 --> 00:03:37,680
i

101
00:03:42,789 --> 00:03:41,440
know more of these

102
00:03:43,910 --> 00:03:42,799
yeah absolutely i remember from my

103
00:03:45,030 --> 00:03:43,920
graduate work i was working with

104
00:03:46,789 --> 00:03:45,040
synchrotrons

105
00:03:48,630 --> 00:03:46,799
uh doing x-ray spectroscopy and i always

106
00:03:50,710 --> 00:03:48,640
thought i got i can't take a synchrotron

107
00:03:51,990 --> 00:03:50,720
to mars or to an asteroid

108
00:03:54,229 --> 00:03:52,000
that's an instrument that's not only

109
00:03:55,670 --> 00:03:54,239
bigger than the osiris-rex spacecraft

110
00:03:57,270 --> 00:03:55,680
i think it's probably bigger than the

111
00:03:58,149 --> 00:03:57,280
launch pad from which the spacecraft

112
00:04:01,190 --> 00:03:58,159
left so

113
00:04:04,550 --> 00:04:02,949

you can bring the comet or the asteroid

114
00:04:06,149 --> 00:04:04,560
back to the synchrotron

115
00:04:07,429 --> 00:04:06,159
absolutely yeah so we have those samples

116
00:04:08,070 --> 00:04:07,439
we can bring them back and study them

117
00:04:10,390 --> 00:04:08,080
here

118
00:04:12,630 --> 00:04:10,400
um that's fantastic uh our second

119
00:04:13,670 --> 00:04:12,640
panelist to introduce is dr jason

120
00:04:17,990 --> 00:04:13,680
dworkin

121
00:04:20,390 --> 00:04:18,000
project scientist working from

122
00:04:22,310 --> 00:04:20,400
nasa's goddard space flight center his

123
00:04:24,629 --> 00:04:22,320
work is focused on assessing the organic

124
00:04:27,430 --> 00:04:24,639
species available for the origins and

125
00:04:28,070 --> 00:04:27,440
early evolution of life with a focus on

126
00:04:30,150 --> 00:04:28,080
understanding

127
00:04:31,510 --> 00:04:30,160
extraterrestrial sources and molecules

128
00:04:33,189 --> 00:04:31,520
relevant for life

129
00:04:34,550 --> 00:04:33,199
dr dworkin directs the research

130
00:04:36,550 --> 00:04:34,560
astrobiological

131
00:04:38,790 --> 00:04:36,560
analytical laboratory at nasa goddard

132
00:04:41,030 --> 00:04:38,800
and has taken scientific leadership

133
00:04:43,670 --> 00:04:41,040
roles in nasa sample return and in situ

134
00:04:45,430 --> 00:04:43,680
missions uh so dr dworkin welcome to ask

135
00:04:47,909 --> 00:04:45,440
an astro biologist

136
00:04:49,749 --> 00:04:47,919
thank you i'm excited to be here today

137
00:04:50,950 --> 00:04:49,759
uh i'm wondering uh before we introduce

138
00:04:53,270 --> 00:04:50,960

our third panelist

139
00:04:54,390 --> 00:04:53,280
if you can give us kind of just a

140
00:04:56,230 --> 00:04:54,400
general scheme

141
00:04:57,909 --> 00:04:56,240
of what the objectives what the mission

142
00:05:00,469 --> 00:04:57,919
goals have been

143
00:05:02,710 --> 00:05:00,479
with osiris-rex both at bennu and with

144
00:05:06,070 --> 00:05:02,720
sample return

145
00:05:07,830 --> 00:05:06,080
so osiris-rex is of course an acronym uh

146
00:05:09,110 --> 00:05:07,840
and the acronym in this case a lot of

147
00:05:11,670 --> 00:05:09,120
the mission objectives

148
00:05:13,990 --> 00:05:11,680
origins to study the origins of the

149
00:05:16,629 --> 00:05:14,000
solar system the origins of life

150
00:05:17,830 --> 00:05:16,639
by looking at the sample spectral

151
00:05:21,110 --> 00:05:17,840
interpretation to look

152
00:05:23,110 --> 00:05:21,120
at at this asteroid spectroscopically

153
00:05:24,550 --> 00:05:23,120
and apply what we learned to other

154
00:05:25,510 --> 00:05:24,560
asteroids because there's a million

155
00:05:28,469 --> 00:05:25,520
asteroids

156
00:05:30,550 --> 00:05:28,479
but not a million missions to visit them

157
00:05:33,670 --> 00:05:30,560
resource investigation

158
00:05:34,710 --> 00:05:33,680
to understand how to perhaps someday

159
00:05:37,350 --> 00:05:34,720
mine asteroids

160
00:05:38,150 --> 00:05:37,360
and navigate around such small objects

161
00:05:40,469 --> 00:05:38,160
security

162
00:05:41,590 --> 00:05:40,479
to understand how to track and

163
00:05:43,830 --> 00:05:41,600

potentially deflect

164
00:05:46,310 --> 00:05:43,840
asteroids and regulate explorer to look

165
00:05:47,990 --> 00:05:46,320
at the at this asteroid and find detail

166
00:05:49,590 --> 00:05:48,000
both on the surface and of course in our

167
00:05:51,350 --> 00:05:49,600
laboratories

168
00:05:53,110 --> 00:05:51,360
now that's so many different parts of

169
00:05:54,710 --> 00:05:53,120
this mission that are crucial and

170
00:05:56,550 --> 00:05:54,720
honestly i didn't actually think that

171
00:05:58,150 --> 00:05:56,560
much about the security fact this idea

172
00:05:59,029 --> 00:05:58,160
that we might actually need to track

173
00:06:00,390 --> 00:05:59,039
these things

174
00:06:02,150 --> 00:06:00,400
and be prepared for them as well which

175
00:06:03,189 --> 00:06:02,160
is like a whole other thing besides just

176
00:06:06,230 --> 00:06:03,199
the science of

177
00:06:09,029 --> 00:06:06,240
studying ben now indeed

178
00:06:10,070 --> 00:06:09,039
um a bennu is a potentially hazardous

179
00:06:12,550 --> 00:06:10,080
object

180
00:06:13,510 --> 00:06:12,560
with a 1 2 700 chance of hitting the

181
00:06:16,070 --> 00:06:13,520
earth

182
00:06:17,110 --> 00:06:16,080
in the late 22nd century so a long time

183
00:06:18,870 --> 00:06:17,120
from now

184
00:06:20,390 --> 00:06:18,880
but the data that we get from this

185
00:06:24,309 --> 00:06:20,400
mission will enable

186
00:06:25,830 --> 00:06:24,319
future scientists and engineers in 2135

187
00:06:26,550 --> 00:06:25,840
when the asteroid does a close approach

188
00:06:28,309 --> 00:06:26,560

with earth

189
00:06:29,749 --> 00:06:28,319
to make decisions about if we need to

190
00:06:32,550 --> 00:06:29,759
deflect it and if so

191
00:06:34,150 --> 00:06:32,560
how have this wealth of data on the

192
00:06:36,550 --> 00:06:34,160
topography of the asteroid

193
00:06:37,510 --> 00:06:36,560
and how it responds to when a spacecraft

194
00:06:39,590 --> 00:06:37,520
touches it

195
00:06:41,350 --> 00:06:39,600
and details on the sample chemistry so

196
00:06:43,029 --> 00:06:41,360
we can actually design how to

197
00:06:44,550 --> 00:06:43,039
how to deflect it and of course apply

198
00:06:46,550 --> 00:06:44,560
that to other asteroids as they

199
00:06:47,909 --> 00:06:46,560
potentially pose threats

200
00:06:50,230 --> 00:06:47,919
that's wonderful yeah i just read a

201
00:06:51,670 --> 00:06:50,240
roman chrisnerics book the good ancestor

202
00:06:54,070 --> 00:06:51,680
and that just makes me think a lot about

203
00:06:55,909 --> 00:06:54,080
you know how our nasa missions today

204
00:06:57,110 --> 00:06:55,919
are making us good ancestors for future

205
00:06:58,870 --> 00:06:57,120
generations by

206
00:07:00,070 --> 00:06:58,880
preparing for some of that needed work

207
00:07:00,710 --> 00:07:00,080
that they'll have to do so it's very

208
00:07:03,189 --> 00:07:00,720
cool that

209
00:07:05,270 --> 00:07:03,199
osiris-rex is involved in that to

210
00:07:08,070 --> 00:07:05,280
introduce our third panelist

211
00:07:10,309 --> 00:07:08,080
we have dr eve berger joining us dr

212
00:07:12,550 --> 00:07:10,319
berger is a senior research scientist at

213
00:07:14,309 --> 00:07:12,560

nasa's johnson space flight center

214
00:07:16,390 --> 00:07:14,319
her current research includes exploring

215
00:07:17,029 --> 00:07:16,400
the effects of impact processes on the

216
00:07:19,510 --> 00:07:17,039
formation

217
00:07:21,430 --> 00:07:19,520
and evolution of amino acids as well as

218
00:07:22,230 --> 00:07:21,440
looking at extraterrestrial amino acid

219
00:07:25,029 --> 00:07:22,240
abundances

220
00:07:26,550 --> 00:07:25,039
in meteorite samples dr berger is a

221
00:07:29,510 --> 00:07:26,560
collaborator with the osiris

222
00:07:30,950 --> 00:07:29,520
osiris-rex mission and also a mars 2020

223
00:07:32,150 --> 00:07:30,960
science team member working with the

224
00:07:34,070 --> 00:07:32,160
sherlock team

225
00:07:35,909 --> 00:07:34,080
uh so dr berger thank you for joining us

226
00:07:38,710 --> 00:07:35,919
for ask an astrobiologist

227
00:07:39,189 --> 00:07:38,720
thanks fran i'm glad to be here uh i

228
00:07:41,510 --> 00:07:39,199
think

229
00:07:43,029 --> 00:07:41,520
for a first question for you if i can so

230
00:07:44,390 --> 00:07:43,039
you've had a background i understand

231
00:07:45,909 --> 00:07:44,400
that when you were a graduate student

232
00:07:46,309 --> 00:07:45,919
you were working on some samples from

233
00:07:48,710 --> 00:07:46,319
vilt

234
00:07:50,309 --> 00:07:48,720
ii you've had a background kind of using

235
00:07:52,309 --> 00:07:50,319
instrumentation to

236
00:07:54,790 --> 00:07:52,319
study amino acid abundances in these

237
00:07:56,869 --> 00:07:54,800
materials cometary asteroidal and

238
00:07:58,070 --> 00:07:56,879

in meteoritics i'm wondering if you can

239
00:07:59,990 --> 00:07:58,080
kind of speak to us

240
00:08:01,270 --> 00:08:00,000
about this this work that you've done

241
00:08:02,950 --> 00:08:01,280
through your career now

242
00:08:04,790 --> 00:08:02,960
advancing to the point of becoming part

243
00:08:08,070 --> 00:08:04,800
of the osiris-rex team

244
00:08:10,629 --> 00:08:08,080
sure um so early on in my career um

245
00:08:12,629 --> 00:08:10,639
during my graduate work i did mostly uh

246
00:08:14,950 --> 00:08:12,639
electron microscopy works using

247
00:08:17,749 --> 00:08:14,960
transmission electron microscope that

248
00:08:20,710 --> 00:08:17,759
allows us to see

249
00:08:21,749 --> 00:08:20,720
crystal structure and identify minerals

250
00:08:23,270 --> 00:08:21,759
and the

251
00:08:25,029 --> 00:08:23,280
the relationships they have to one

252
00:08:27,029 --> 00:08:25,039
another which tell us about how they

253
00:08:28,790 --> 00:08:27,039
formed or where they formed or what

254
00:08:31,670 --> 00:08:28,800
under what conditions they formed

255
00:08:32,790 --> 00:08:31,680
and so i carried on doing that kind of

256
00:08:35,670 --> 00:08:32,800
work on

257
00:08:36,550 --> 00:08:35,680
build two and also chondritic samples

258
00:08:38,790 --> 00:08:36,560
and then

259
00:08:41,190 --> 00:08:38,800
a few years ago i started working with

260
00:08:42,310 --> 00:08:41,200
another organic geochemist at johnson

261
00:08:43,829 --> 00:08:42,320
space center and

262
00:08:45,910 --> 00:08:43,839
we started looking and we were looking

263
00:08:47,829 --> 00:08:45,920

at amino acids kind of continuing on the

264
00:08:51,509 --> 00:08:47,839
work that he had started

265
00:08:51,910 --> 00:08:51,519
and so we look at what organic compounds

266
00:08:54,550 --> 00:08:51,920
are

267
00:08:55,509 --> 00:08:54,560
in meteorites and what i've done uh with

268
00:08:57,750 --> 00:08:55,519
him in the next step

269
00:08:59,590 --> 00:08:57,760
is to sort of look at what happens when

270
00:09:01,750 --> 00:08:59,600
those amino acids are delivered

271
00:09:03,269 --> 00:09:01,760
to the earth how do they go from what we

272
00:09:05,590 --> 00:09:03,279
see in the meteorite

273
00:09:07,110 --> 00:09:05,600
to well the life that we see in each

274
00:09:08,070 --> 00:09:07,120
other's eyes as we're looking at the

275
00:09:11,110 --> 00:09:08,080
screens today

276
00:09:13,509 --> 00:09:11,120
and so i like to cook so i sort of

277
00:09:14,790 --> 00:09:13,519
sort of use a cooking analogy so have

278
00:09:16,550 --> 00:09:14,800
you ever been out if you've ever been

279
00:09:19,110 --> 00:09:16,560
out for a good meal and at the end

280
00:09:20,949 --> 00:09:19,120
someone hands you a dessert that is just

281
00:09:22,230 --> 00:09:20,959
fantastic you could continue eating it

282
00:09:22,949 --> 00:09:22,240
for the rest of your life when you think

283
00:09:24,949 --> 00:09:22,959
to yourself

284
00:09:26,230 --> 00:09:24,959
i could make that at home no problem

285
00:09:27,030 --> 00:09:26,240
there's a little bit of chocolate in

286
00:09:30,230 --> 00:09:27,040
there

287
00:09:31,829 --> 00:09:30,240
i'm detecting a note of some some ginger

288
00:09:33,590 --> 00:09:31,839

and maybe a little bit of cinnamon but

289
00:09:34,070 --> 00:09:33,600
you get home and you realize you don't

290
00:09:36,550 --> 00:09:34,080
know

291
00:09:38,150 --> 00:09:36,560
exactly what ingredients were used and

292
00:09:39,190 --> 00:09:38,160
you don't know exactly how they were

293
00:09:42,550 --> 00:09:39,200
mixed together

294
00:09:44,470 --> 00:09:42,560
was it pan fried was it baked was it

295
00:09:46,310 --> 00:09:44,480
air chilled all those kinds of things

296
00:09:48,150 --> 00:09:46,320
and so when we're looking at how do we

297
00:09:50,150 --> 00:09:48,160
go from

298
00:09:52,150 --> 00:09:50,160
organic materials delivered to the

299
00:09:55,030 --> 00:09:52,160
surface of the earth to life

300
00:09:57,190 --> 00:09:55,040
we need to know both the process and the

301
00:10:00,310 --> 00:09:57,200
starting materials and so

302
00:10:02,230 --> 00:10:00,320
i can simulate asteroidal impacts in my

303
00:10:04,310 --> 00:10:02,240
lab and see if the energy from that

304
00:10:07,590 --> 00:10:04,320
impact is enough to

305
00:10:09,750 --> 00:10:07,600
uh promote polymerization or the joining

306
00:10:10,790 --> 00:10:09,760
of two amino acids together to form a

307
00:10:12,790 --> 00:10:10,800
peptide

308
00:10:14,310 --> 00:10:12,800
or is it too much energy and they get

309
00:10:16,829 --> 00:10:14,320
destroyed and that's not the way that

310
00:10:19,670 --> 00:10:16,839
things progressed on the early earth

311
00:10:21,910 --> 00:10:19,680
um in general

312
00:10:23,350 --> 00:10:21,920
we don't know the process but we can get

313
00:10:24,949 --> 00:10:23,360

a much better answer on the starting

314
00:10:26,790 --> 00:10:24,959
materials from osiris-rex

315
00:10:28,550 --> 00:10:26,800
so this will be the first sample that we

316
00:10:29,509 --> 00:10:28,560
have from an asteroid that's completely

317
00:10:31,750 --> 00:10:29,519
pristine

318
00:10:32,870 --> 00:10:31,760
no terrestrial contamination at all so

319
00:10:35,269 --> 00:10:32,880
it gives us

320
00:10:36,949 --> 00:10:35,279
sort of our starting recipe um which is

321
00:10:38,150 --> 00:10:36,959
great for someone who does experimental

322
00:10:40,949 --> 00:10:38,160
work because i know that

323
00:10:42,949 --> 00:10:40,959
i'm then more closely approximating uh

324
00:10:44,790 --> 00:10:42,959
what happened on the early earth

325
00:10:46,870 --> 00:10:44,800
and i love that i love the analogy to

326
00:10:48,389 --> 00:10:46,880
cooking since i love to cook myself and

327
00:10:50,150 --> 00:10:48,399
trying to reverse engineered dishes can

328
00:10:51,590 --> 00:10:50,160
be very hard so having some knowledge of

329
00:10:53,750 --> 00:10:51,600
your starting ingredients and

330
00:10:55,670 --> 00:10:53,760
some of the process is is really helpful

331
00:10:56,949 --> 00:10:55,680
right um i really love that i think it's

332
00:10:58,470 --> 00:10:56,959
good for our audience too especially

333
00:10:59,829 --> 00:10:58,480
some of the younger ones who might

334
00:11:01,269 --> 00:10:59,839
want to get involved in this research

335
00:11:03,430 --> 00:11:01,279
themselves one day to remember that you

336
00:11:04,710 --> 00:11:03,440
know how they're framing their thinking

337
00:11:06,710 --> 00:11:04,720
about being involved in this kind of

338
00:11:08,310 --> 00:11:06,720

work and also i have a bunch of

339
00:11:10,069 --> 00:11:08,320
meteorites in my own collection and one

340
00:11:11,990 --> 00:11:10,079
of my favorites is murchison which has

341
00:11:13,509 --> 00:11:12,000
an abundance of amino acids in it

342
00:11:15,430 --> 00:11:13,519
and it's always cool to just like share

343
00:11:16,790 --> 00:11:15,440
that with other people and and tell them

344
00:11:18,150 --> 00:11:16,800
you know we're learning so much about

345
00:11:20,230 --> 00:11:18,160
organic chemistry

346
00:11:21,750 --> 00:11:20,240
in the cosmos beyond our own planet by

347
00:11:24,069 --> 00:11:21,760
having these materials

348
00:11:25,509 --> 00:11:24,079
to study and so that sample return gives

349
00:11:28,870 --> 00:11:25,519
us even better material

350
00:11:31,190 --> 00:11:28,880
to study which is really cool absolutely

351
00:11:33,110 --> 00:11:31,200
i'd like to transfer over to scott now

352
00:11:35,670 --> 00:11:33,120
if you wouldn't mind telling us

353
00:11:37,509 --> 00:11:35,680
what is it about asteroid bennu in

354
00:11:39,509 --> 00:11:37,519
particular that makes this asteroid

355
00:11:41,829 --> 00:11:39,519
interesting for studying with this

356
00:11:43,750 --> 00:11:41,839
mission and for bringing samples home

357
00:11:45,750 --> 00:11:43,760
well actually i think a number of things

358
00:11:47,750 --> 00:11:45,760
make it interesting jason going over the

359
00:11:50,470 --> 00:11:47,760
acronym makes it clear that there's

360
00:11:50,870 --> 00:11:50,480
actually different um good reasons to

361
00:11:52,949 --> 00:11:50,880
study

362
00:11:53,990 --> 00:11:52,959
this object on you know the security one

363
00:11:56,230 --> 00:11:54,000

being one

364
00:11:57,190 --> 00:11:56,240
um i since uh the three people you have

365
00:11:59,430 --> 00:11:57,200
on this panel are

366
00:12:01,030 --> 00:11:59,440
are into sample analysis i mean

367
00:12:01,829 --> 00:12:01,040
obviously one of our answers is going to

368
00:12:04,069 --> 00:12:01,839
be

369
00:12:05,430 --> 00:12:04,079
uh that we think venue will provide

370
00:12:07,590 --> 00:12:05,440
samples that will be very

371
00:12:09,350 --> 00:12:07,600
interesting to study and in particular

372
00:12:11,590 --> 00:12:09,360
we believe these samples

373
00:12:13,190 --> 00:12:11,600
are likely to contain organic compounds

374
00:12:15,269 --> 00:12:13,200
so in terms of this

375
00:12:17,670 --> 00:12:15,279
aspen astrobiologist angle i mean this

376
00:12:19,110 --> 00:12:17,680
makes that much more interesting i'm

377
00:12:20,949 --> 00:12:19,120
i would i would probably still be

378
00:12:22,310 --> 00:12:20,959
excited to study samples from an iron

379
00:12:24,629 --> 00:12:22,320
asteroid but not as

380
00:12:25,910 --> 00:12:24,639
as excited as i'll be to get samples

381
00:12:28,949 --> 00:12:25,920
from venue because we

382
00:12:30,949 --> 00:12:28,959
fully expect the venue samples to

383
00:12:32,629 --> 00:12:30,959
show a great deal of complexity in both

384
00:12:33,509 --> 00:12:32,639
the minerals and the organics and that

385
00:12:36,389 --> 00:12:33,519
these

386
00:12:38,870 --> 00:12:36,399
we ought to be able to tease out a lot

387
00:12:40,870 --> 00:12:38,880
of information about the ingredients for

388
00:12:43,110 --> 00:12:40,880

the cooking but also

389
00:12:44,069 --> 00:12:43,120
the processes that have already they've

390
00:12:48,230 --> 00:12:44,079
already experienced

391
00:12:50,629 --> 00:12:48,240
i mean since we think menu is similar to

392
00:12:52,389 --> 00:12:50,639
carbonaceous chondrites

393
00:12:54,230 --> 00:12:52,399
we have an expectation that the samples

394
00:12:57,269 --> 00:12:54,240
we bring back will show

395
00:12:59,190 --> 00:12:57,279
parts of the materials history not just

396
00:13:00,949 --> 00:12:59,200
to the life of the asteroid but back

397
00:13:02,870 --> 00:13:00,959
into the original solar nebula from

398
00:13:05,350 --> 00:13:02,880
which the asteroid formed and frankly

399
00:13:06,949 --> 00:13:05,360
we would expect there to be components

400
00:13:08,629 --> 00:13:06,959
within the return samples that actually

401
00:13:10,230 --> 00:13:08,639
predate the solar system that were

402
00:13:12,150 --> 00:13:10,240
grains that existed

403
00:13:13,990 --> 00:13:12,160
in the dense molecular cloud that

404
00:13:16,150 --> 00:13:14,000
ultimately started to have a portion

405
00:13:18,790 --> 00:13:16,160
collapse and make our solar system so

406
00:13:20,069 --> 00:13:18,800
it gives us insights to a huge range of

407
00:13:22,230 --> 00:13:20,079
the pre-history

408
00:13:23,829 --> 00:13:22,240
of the materials will be returning to

409
00:13:25,590 --> 00:13:23,839
earth

410
00:13:27,590 --> 00:13:25,600
absolutely i think a lot of people are

411
00:13:28,069 --> 00:13:27,600
unaware of things like pre-solar grains

412
00:13:29,750 --> 00:13:28,079
and

413
00:13:31,750 --> 00:13:29,760

other materials that do predate our

414
00:13:33,190 --> 00:13:31,760
solar system and when we use this term

415
00:13:33,990 --> 00:13:33,200
primitive we're talking about some of

416
00:13:36,629 --> 00:13:34,000
the earliest

417
00:13:37,110 --> 00:13:36,639
solid materials to form in our solar

418
00:13:39,750 --> 00:13:37,120
system

419
00:13:41,750 --> 00:13:39,760
yeah we know from meteorites that we

420
00:13:45,829 --> 00:13:41,760
have grains that come from supernova

421
00:13:47,829 --> 00:13:45,839
from nova from all kinds of dying stars

422
00:13:49,670 --> 00:13:47,839
we have materials that actually form

423
00:13:51,110 --> 00:13:49,680
themselves in space and the dense

424
00:13:53,110 --> 00:13:51,120
molecular clouds so we have

425
00:13:54,230 --> 00:13:53,120
astro chemistry that isn't even

426
00:13:57,030 --> 00:13:54,240
associated um

427
00:13:58,310 --> 00:13:57,040
with the star and the kind of detail you

428
00:13:59,829 --> 00:13:58,320
can get from this just kind of blows

429
00:14:01,910 --> 00:13:59,839
your mind i mean i think we know from

430
00:14:03,590 --> 00:14:01,920
the basis of like titanium isotopes and

431
00:14:05,910 --> 00:14:03,600
a certain kind of grain

432
00:14:07,829 --> 00:14:05,920
that we have materials in the solar

433
00:14:11,189 --> 00:14:07,839
system that came from at least seven

434
00:14:13,269 --> 00:14:11,199
different um stars so

435
00:14:14,870 --> 00:14:13,279
um so you can you know once you can

436
00:14:16,310 --> 00:14:14,880
start picking the atoms apart and this

437
00:14:17,990 --> 00:14:16,320
is one of the advantages of sample

438
00:14:19,670 --> 00:14:18,000

return you can

439
00:14:21,829 --> 00:14:19,680
look at things at a level of detail it's

440
00:14:23,350 --> 00:14:21,839
just kind of mind-boggling

441
00:14:24,550 --> 00:14:23,360
absolutely that's incredible i actually

442
00:14:25,030 --> 00:14:24,560
hadn't heard that number before i have

443
00:14:26,389 --> 00:14:25,040
to go

444
00:14:27,750 --> 00:14:26,399
look into that more that's that's really

445
00:14:28,470 --> 00:14:27,760
wonderful to know that we're piecing

446
00:14:29,990 --> 00:14:28,480
together

447
00:14:32,069 --> 00:14:30,000
our solar system's history from these

448
00:14:32,949 --> 00:14:32,079
materials as well the birth of our solar

449
00:14:35,829 --> 00:14:32,959
system

450
00:14:37,350 --> 00:14:35,839
uh jason if i can kick it to you now um

451
00:14:39,829 --> 00:14:37,360
you know with this a really incredible

452
00:14:41,910 --> 00:14:39,839
mission getting osiris-rex to bennu

453
00:14:43,189 --> 00:14:41,920
all the research we've done already i

454
00:14:44,949 --> 00:14:43,199
wonder if you could speak though a bit

455
00:14:46,550 --> 00:14:44,959
about this process now of getting the

456
00:14:47,990 --> 00:14:46,560
sample back to earth

457
00:14:50,310 --> 00:14:48,000
what's going to happen what is the

458
00:14:51,430 --> 00:14:50,320
process for you as researchers to get

459
00:14:53,350 --> 00:14:51,440
your hands

460
00:14:54,870 --> 00:14:53,360
on sample material and like how does it

461
00:14:56,389 --> 00:14:54,880
go down the line of who gets who gets

462
00:14:58,230 --> 00:14:56,399
this material to work on and

463
00:15:00,230 --> 00:14:58,240

what what what key objectives get get

464
00:15:01,829 --> 00:15:00,240
addressed first basically i guess is my

465
00:15:05,430 --> 00:15:01,839
question

466
00:15:06,629 --> 00:15:05,440
so on um uh may 10th the spacecraft did

467
00:15:08,629 --> 00:15:06,639
a departure burn

468
00:15:10,949 --> 00:15:08,639
to leave the proximity of bennu and

469
00:15:12,949 --> 00:15:10,959
began its long journey back to earth

470
00:15:14,629 --> 00:15:12,959
takes a long time because it's a low

471
00:15:17,030 --> 00:15:14,639
energy trajectory so we've gotta

472
00:15:19,030 --> 00:15:17,040
obey gravitational forces and orbit the

473
00:15:21,590 --> 00:15:19,040
sun twice to make it to earth

474
00:15:22,949 --> 00:15:21,600
uh four hours before the spacecraft

475
00:15:25,509 --> 00:15:22,959
comes

476
00:15:27,269 --> 00:15:25,519
would come to earth it ejects the sample

477
00:15:30,710 --> 00:15:27,279
return canada that's the uh

478
00:15:32,790 --> 00:15:30,720
about this about this big um uh

479
00:15:34,230 --> 00:15:32,800
quite huggable device as scott likes to

480
00:15:35,990 --> 00:15:34,240
describe it

481
00:15:38,870 --> 00:15:36,000
that holds the sample and then that

482
00:15:40,949 --> 00:15:38,880
spins uh to keep it in a straight path

483
00:15:42,949 --> 00:15:40,959
descends into the atmosphere at the same

484
00:15:43,590 --> 00:15:42,959
time the spacecraft doesn't revert burn

485
00:15:47,269 --> 00:15:43,600
to leave

486
00:15:50,629 --> 00:15:47,279
earth and so it can be used for whatever

487
00:15:53,829 --> 00:15:50,639
nasa chooses to use it for the space the

488
00:15:54,949 --> 00:15:53,839

temperature capsule employs a drove

489
00:15:58,150 --> 00:15:54,959
shooting a parachute

490
00:16:00,310 --> 00:15:58,160
and lands the test and training range uh

491
00:16:02,230 --> 00:16:00,320
outside salt lake city on uh uh

492
00:16:04,150 --> 00:16:02,240
september 24th 2023

493
00:16:06,470 --> 00:16:04,160
a little bit before nine in the morning

494
00:16:08,790 --> 00:16:06,480
uh the location is mostly dependent on

495
00:16:11,030 --> 00:16:08,800
the winds and weather of that day

496
00:16:11,910 --> 00:16:11,040
because the uh orbital mechanics are so

497
00:16:14,870 --> 00:16:11,920
well understood

498
00:16:15,509 --> 00:16:14,880
it's really remarkable uh the the sample

499
00:16:17,829 --> 00:16:15,519
canister

500
00:16:19,430 --> 00:16:17,839
is the src is picked up put under

501
00:16:22,550 --> 00:16:19,440
nitrogen purge

502
00:16:25,590 --> 00:16:22,560
and the simple return canister is

503
00:16:26,949 --> 00:16:25,600
partly disassembled in utah uh removing

504
00:16:27,749 --> 00:16:26,959
the batteries and the pyro things of

505
00:16:30,470 --> 00:16:27,759
that sort

506
00:16:31,189 --> 00:16:30,480
and all transported to uh to eve's

507
00:16:34,150 --> 00:16:31,199
building

508
00:16:36,069 --> 00:16:34,160
at johnson space center in houston where

509
00:16:39,509 --> 00:16:36,079
the very next day it's opened up

510
00:16:41,430 --> 00:16:39,519
and uh the uh curators begin

511
00:16:43,269 --> 00:16:41,440
cataloging uh the material that's

512
00:16:45,189 --> 00:16:43,279
present weighing as we actually know how

513
00:16:48,629 --> 00:16:45,199

much we we really got

514
00:16:52,069 --> 00:16:48,639
um pulling apart uh material for

515
00:16:55,189 --> 00:16:52,079
our japanese and canadian

516
00:16:57,749 --> 00:16:55,199
partners so that they get their sample

517
00:16:59,590 --> 00:16:57,759
and the sample team will begin begin

518
00:17:01,110 --> 00:16:59,600
their analysis to test our over 50

519
00:17:04,150 --> 00:17:01,120
different hypotheses

520
00:17:07,189 --> 00:17:04,160
about uh the original solar system

521
00:17:08,309 --> 00:17:07,199
uh what uh all the way up to what the

522
00:17:11,669 --> 00:17:08,319
spacecraft did

523
00:17:13,750 --> 00:17:11,679
to bennu and vice versa um

524
00:17:15,270 --> 00:17:13,760
to prepare for this we we will be doing

525
00:17:18,309 --> 00:17:15,280
rehearsals starting

526
00:17:20,069 --> 00:17:18,319
uh next summer uh to make sure that

527
00:17:21,590 --> 00:17:20,079
our all of our laboratories are in

528
00:17:24,710 --> 00:17:21,600
tip-top shape

529
00:17:25,110 --> 00:17:24,720
and that we have uh uh executed all of

530
00:17:31,590 --> 00:17:25,120
our

531
00:17:33,110 --> 00:17:31,600
sharing uh from labs lab to make sure

532
00:17:34,950 --> 00:17:33,120
that we work out all the kinks

533
00:17:38,710 --> 00:17:34,960
before the precious sample from bennu

534
00:17:40,070 --> 00:17:38,720
comes so that we're 100 ready

535
00:17:42,710 --> 00:17:40,080
that's awesome i know in a video

536
00:17:44,789 --> 00:17:42,720
produced by nasa astrobiology last year

537
00:17:45,909 --> 00:17:44,799
you said that 60 grams which is roughly

538
00:17:46,390 --> 00:17:45,919

the amount of sample we're bringing back

539
00:17:48,630 --> 00:17:46,400
that

540
00:17:49,430 --> 00:17:48,640
60 grams is a bounty of a sample could

541
00:17:51,990 --> 00:17:49,440
you speak to why

542
00:17:54,549 --> 00:17:52,000
why you why you said that so well first

543
00:17:57,029 --> 00:17:54,559
of all 60 grams is our requirement

544
00:17:57,669 --> 00:17:57,039
uh you should remember the sample return

545
00:18:00,070 --> 00:17:57,679
the

546
00:18:01,510 --> 00:18:00,080
sample collection device uh when we did

547
00:18:04,630 --> 00:18:01,520
the tag in october

548
00:18:06,150 --> 00:18:04,640
was literally overflowing with material

549
00:18:08,070 --> 00:18:06,160
so much so that we couldn't actually

550
00:18:09,990 --> 00:18:08,080
weigh it in space in our our spin

551
00:18:12,150 --> 00:18:10,000
maneuver that we had planned

552
00:18:13,909 --> 00:18:12,160
uh so there's no way to know exactly how

553
00:18:15,270 --> 00:18:13,919
much we have it's well more than 60

554
00:18:18,870 --> 00:18:15,280
grams

555
00:18:20,470 --> 00:18:18,880
saw stuff leaking out so we won't really

556
00:18:23,590 --> 00:18:20,480
know until we get back to earth

557
00:18:26,150 --> 00:18:23,600
but um as scott described

558
00:18:27,270 --> 00:18:26,160
you can dissect atom by atom and get a

559
00:18:30,070 --> 00:18:27,280
lot of information

560
00:18:31,430 --> 00:18:30,080
from a single tiny grain and that that

561
00:18:32,230 --> 00:18:31,440
gives you information about that one

562
00:18:33,750 --> 00:18:32,240
grain but

563
00:18:35,350 --> 00:18:33,760

there's a diversity of materials there's

564
00:18:37,990 --> 00:18:35,360
at least two lithologies

565
00:18:38,870 --> 00:18:38,000
we've detected from our spectrometers on

566
00:18:41,350 --> 00:18:38,880
bennu

567
00:18:42,310 --> 00:18:41,360
in addition uh you can the more mature

568
00:18:44,549 --> 00:18:42,320
you have

569
00:18:45,830 --> 00:18:44,559
the more subtle tests you can do you can

570
00:18:50,310 --> 00:18:45,840
look for

571
00:18:51,909 --> 00:18:50,320
uh uh remarkably uh uh rare species

572
00:18:53,590 --> 00:18:51,919
and get even more information you can

573
00:18:55,270 --> 00:18:53,600
with with big ones

574
00:18:57,830 --> 00:18:55,280
so like i'm interested in amino acids

575
00:19:00,310 --> 00:18:57,840
just like eve is but we can look for the

576
00:19:01,029 --> 00:19:00,320
really rare amino acids observe the

577
00:19:03,510 --> 00:19:01,039
chirality

578
00:19:05,110 --> 00:19:03,520
observe the isotopic ratios of each

579
00:19:07,110 --> 00:19:05,120
different compound

580
00:19:09,669 --> 00:19:07,120
and look at the precursors so more

581
00:19:12,710 --> 00:19:09,679
sample means means more analyses

582
00:19:15,110 --> 00:19:12,720
but the most um i know i'm

583
00:19:17,430 --> 00:19:15,120
talking too much but the uh this is the

584
00:19:20,870 --> 00:19:17,440
part that excites me the absolute most

585
00:19:24,630 --> 00:19:20,880
is that 75 of the sample or so

586
00:19:28,150 --> 00:19:24,640
is archived for the future and so

587
00:19:30,549 --> 00:19:28,160
um once we have this catalog it'll be

588
00:19:31,830 --> 00:19:30,559

released and people can propose to look

589
00:19:34,870 --> 00:19:31,840
at that sample

590
00:19:36,549 --> 00:19:34,880
so members of your audience or their

591
00:19:39,190 --> 00:19:36,559
children or grandchildren or people not

592
00:19:42,150 --> 00:19:39,200
yet born can request samples

593
00:19:43,029 --> 00:19:42,160
to analyze them with instruments not yet

594
00:19:44,630 --> 00:19:43,039
invented to ask

595
00:19:46,390 --> 00:19:44,640
questions we don't know how to phrase

596
00:19:48,549 --> 00:19:46,400
now so it

597
00:19:49,750 --> 00:19:48,559
self-returned just like apollo and all

598
00:19:51,590 --> 00:19:49,760
these other things

599
00:19:53,750 --> 00:19:51,600
are the the gift that keeps on giving

600
00:19:55,750 --> 00:19:53,760
for literally generations

601
00:19:56,950 --> 00:19:55,760
uh i i love that part too and actually i

602
00:19:58,390 --> 00:19:56,960
wonder if you could speak to that for us

603
00:20:00,390 --> 00:19:58,400
for a moment as well

604
00:20:02,630 --> 00:20:00,400
um you know i know that you joined the

605
00:20:04,149 --> 00:20:02,640
osiris-rex team fairly recently

606
00:20:05,750 --> 00:20:04,159
uh and i think some sometimes you know

607
00:20:07,669 --> 00:20:05,760
some of our younger members maybe

608
00:20:09,430 --> 00:20:07,679
undergraduate students are unaware

609
00:20:11,270 --> 00:20:09,440
what it's like to be a scientist to have

610
00:20:12,630 --> 00:20:11,280
a chance to join these teams

611
00:20:13,909 --> 00:20:12,640
and you don't actually have to be there

612
00:20:14,630 --> 00:20:13,919
at the very beginning you can kind of

613
00:20:16,390 --> 00:20:14,640

join

614
00:20:18,149 --> 00:20:16,400
at certain periods and then you can also

615
00:20:19,430 --> 00:20:18,159
look to the future like jason just

616
00:20:21,110 --> 00:20:19,440
mentioned with future generations

617
00:20:22,390 --> 00:20:21,120
working on these samples

618
00:20:24,149 --> 00:20:22,400
i wonder if you could speak to what it's

619
00:20:25,750 --> 00:20:24,159
like to be a researcher who's now

620
00:20:27,590 --> 00:20:25,760
joining osiris-rex

621
00:20:29,029 --> 00:20:27,600
and looking forward to those samples and

622
00:20:32,230 --> 00:20:29,039
what kinds of work you see

623
00:20:34,070 --> 00:20:32,240
down the road as well sure um so i will

624
00:20:35,830 --> 00:20:34,080
say just being given the opportunity

625
00:20:37,590 --> 00:20:35,840
to join the team as a collaborator is

626
00:20:40,710 --> 00:20:37,600
just so exciting i

627
00:20:42,310 --> 00:20:40,720
i'm just i'm really excited i was

628
00:20:44,230 --> 00:20:42,320
at university of arizona when you're

629
00:20:46,149 --> 00:20:44,240
writing the proposal so you know 10

630
00:20:46,950 --> 00:20:46,159
years later to be a part of it it's just

631
00:20:49,430 --> 00:20:46,960
amazing

632
00:20:51,510 --> 00:20:49,440
um it's also really overwhelming because

633
00:20:52,710 --> 00:20:51,520
the wealth of data that has come out of

634
00:20:55,909 --> 00:20:52,720
the mission so far

635
00:20:56,470 --> 00:20:55,919
is incredible so trying to catch up and

636
00:20:58,149 --> 00:20:56,480
sort of

637
00:20:59,669 --> 00:20:58,159
be on top of where things are i'm still

638
00:21:02,149 --> 00:20:59,679

working on that part of it

639
00:21:03,270 --> 00:21:02,159
um but i'm just going to add something

640
00:21:06,870 --> 00:21:03,280
to what jason said

641
00:21:08,950 --> 00:21:06,880
um it really is very small like if you

642
00:21:10,710 --> 00:21:08,960
look for something specific if you find

643
00:21:11,750 --> 00:21:10,720
a mineral that tells you something you

644
00:21:14,830 --> 00:21:11,760
don't need a lot of it

645
00:21:17,270 --> 00:21:14,840
to give you an answer um so i wrote my

646
00:21:20,070 --> 00:21:17,280
dissertation based

647
00:21:22,149 --> 00:21:20,080
mainly on a 200 nanometer grain that

648
00:21:24,549 --> 00:21:22,159
that village 2 returned that had

649
00:21:26,630 --> 00:21:24,559
some really cool properties you know

650
00:21:28,310 --> 00:21:26,640
where it changes form at a particular

651
00:21:30,230 --> 00:21:28,320
temperature and doesn't go back

652
00:21:32,070 --> 00:21:30,240
and it tells us something about aqueous

653
00:21:33,669 --> 00:21:32,080
alteration and so

654
00:21:35,750 --> 00:21:33,679
i was able to write an entire

655
00:21:37,430 --> 00:21:35,760
dissertation positing what i thought

656
00:21:39,029 --> 00:21:37,440
might have happened to that grain in the

657
00:21:42,470 --> 00:21:39,039
history of its life

658
00:21:45,590 --> 00:21:42,480
um from start to finish you know across

659
00:21:47,430 --> 00:21:45,600
millions of years and to be able to do

660
00:21:49,270 --> 00:21:47,440
that from a tiny brain is amazing and

661
00:21:49,830 --> 00:21:49,280
people often ask me well what if you're

662
00:21:52,149 --> 00:21:49,840
wrong

663
00:21:53,750 --> 00:21:52,159

and i say that's great if somebody goes

664
00:21:56,870 --> 00:21:53,760
back if something that i do

665
00:21:58,789 --> 00:21:56,880
on an o-rex sample inspires someone 10

666
00:22:01,029 --> 00:21:58,799
years from now to say

667
00:22:02,549 --> 00:22:01,039
yeah eve that was a really nice idea but

668
00:22:04,789 --> 00:22:02,559
i'm not entirely sure

669
00:22:06,070 --> 00:22:04,799
because today we can measure x y and z

670
00:22:07,590 --> 00:22:06,080
that you couldn't measure

671
00:22:09,909 --> 00:22:07,600
and they go back and look at the clean

672
00:22:11,350 --> 00:22:09,919
sample or something similar

673
00:22:13,110 --> 00:22:11,360
that just forwards the research i mean

674
00:22:16,549 --> 00:22:13,120
that's what science is all about

675
00:22:18,310 --> 00:22:16,559
making hypotheses about science and the

676
00:22:20,070 --> 00:22:18,320
history of our universe based on the

677
00:22:22,549 --> 00:22:20,080
available information that you have

678
00:22:23,669 --> 00:22:22,559
and so seeing that move forward and

679
00:22:27,110 --> 00:22:23,679
these samples

680
00:22:29,190 --> 00:22:27,120
coming back to be able to measure um

681
00:22:31,510 --> 00:22:29,200
amino acid abundances and jason

682
00:22:33,270 --> 00:22:31,520
mentioned chirality a minute ago

683
00:22:35,270 --> 00:22:33,280
so for folks who are watching that maybe

684
00:22:37,909 --> 00:22:35,280
aren't familiar with that term

685
00:22:39,909 --> 00:22:37,919
uh chiral molecules are ones that are

686
00:22:41,590 --> 00:22:39,919
mirror images of one another so sort of

687
00:22:42,630 --> 00:22:41,600
like your hands your left and right

688
00:22:44,470 --> 00:22:42,640

hands

689
00:22:46,070 --> 00:22:44,480
mirror image but no matter what you do

690
00:22:49,110 --> 00:22:46,080
you can't superimpose them

691
00:22:51,270 --> 00:22:49,120
on one another identically and so

692
00:22:53,750 --> 00:22:51,280
meteorites derivative amino acids in

693
00:22:54,230 --> 00:22:53,760
both right-handed and left-handed forms

694
00:22:56,070 --> 00:22:54,240
in fact

695
00:22:57,590 --> 00:22:56,080
most of the meteorites come back we see

696
00:22:59,510 --> 00:22:57,600
racemic mixtures

697
00:23:00,789 --> 00:22:59,520
which means equal amounts of right and

698
00:23:03,750 --> 00:23:00,799
left-handedness

699
00:23:05,430 --> 00:23:03,760
but life only uses left-handed so going

700
00:23:06,549 --> 00:23:05,440
back to my research that's sort of what

701
00:23:10,070 --> 00:23:06,559
inspires me how to

702
00:23:12,310 --> 00:23:10,080
go from equal amounts to just this one

703
00:23:14,950 --> 00:23:12,320
uh in life and so

704
00:23:16,950 --> 00:23:14,960
these worry about contamination right

705
00:23:18,710 --> 00:23:16,960
because we have amino acids on earth but

706
00:23:19,669 --> 00:23:18,720
these samples we don't have to worry

707
00:23:21,750 --> 00:23:19,679
about that so

708
00:23:23,909 --> 00:23:21,760
really just again ground truth data

709
00:23:25,430 --> 00:23:23,919
point for us

710
00:23:27,510 --> 00:23:25,440
that's awesome and there's so much about

711
00:23:29,110 --> 00:23:27,520
characterizing life and understanding

712
00:23:30,549 --> 00:23:29,120
what life is as we know it and as it

713
00:23:31,909 --> 00:23:30,559

might be elsewhere and so

714
00:23:33,909 --> 00:23:31,919
those are really important things i

715
00:23:35,750 --> 00:23:33,919
think for us to talk about

716
00:23:37,510 --> 00:23:35,760
i have so many more questions but i've

717
00:23:38,710 --> 00:23:37,520
realized that i also want to get to our

718
00:23:39,909 --> 00:23:38,720
audience questions we have a bunch

719
00:23:41,510 --> 00:23:39,919
pouring in right now and

720
00:23:43,029 --> 00:23:41,520
for those watching please remember to

721
00:23:44,230 --> 00:23:43,039
ask your questions in the chat on

722
00:23:46,230 --> 00:23:44,240
sagatnet or

723
00:23:47,430 --> 00:23:46,240
on facebook on the nasa astrobiology

724
00:23:48,630 --> 00:23:47,440
facebook page

725
00:23:50,310 --> 00:23:48,640
we'll try our best to get through as

726
00:23:51,830 --> 00:23:50,320
many as we can but i see there's a bunch

727
00:23:53,190 --> 00:23:51,840
pouring in already

728
00:23:54,549 --> 00:23:53,200
i'd like to ask at least one more

729
00:23:55,990 --> 00:23:54,559
question of my own for each of you and

730
00:23:56,950 --> 00:23:56,000
then i'll try to get into the audience

731
00:23:59,350 --> 00:23:56,960
questions

732
00:24:01,669 --> 00:23:59,360
um scott starting off with you to change

733
00:24:03,190 --> 00:24:01,679
things a little bit from osiris-rex

734
00:24:05,430 --> 00:24:03,200
uh you've done a lot of work in your

735
00:24:07,110 --> 00:24:05,440
career not just in sample return

736
00:24:09,029 --> 00:24:07,120
and in studying things like in the

737
00:24:11,430 --> 00:24:09,039
interstellar medium

738
00:24:12,950 --> 00:24:11,440

but also in meteoritics and i understand

739
00:24:13,750 --> 00:24:12,960
that you've traveled to antarctica and

740
00:24:16,310 --> 00:24:13,760
have collected

741
00:24:17,110 --> 00:24:16,320
a large number of meteorites and i read

742
00:24:19,110 --> 00:24:17,120
in your bio

743
00:24:22,230 --> 00:24:19,120
that you collected the allen hills

744
00:24:23,510 --> 00:24:22,240
meteorite at alh 84001

745
00:24:25,830 --> 00:24:23,520
i'm wondering if you could just speak to

746
00:24:27,430 --> 00:24:25,840
us about how well the experience

747
00:24:29,669 --> 00:24:27,440
of being in antarctica and picking up

748
00:24:31,830 --> 00:24:29,679
those rocks and let alone the one of one

749
00:24:33,669 --> 00:24:31,840
of the most interesting ones of all time

750
00:24:34,070 --> 00:24:33,679
well let me begin by just correcting one

751
00:24:37,190 --> 00:24:34,080
thing

752
00:24:38,630 --> 00:24:37,200
um with very few exceptions i never say

753
00:24:40,390 --> 00:24:38,640
i found a meteorite because there's a

754
00:24:41,029 --> 00:24:40,400
team down there and we work together

755
00:24:42,149 --> 00:24:41,039
it's i mean

756
00:24:44,230 --> 00:24:42,159
you have to work together just to

757
00:24:47,029 --> 00:24:44,240
survive much less find meteorites and so

758
00:24:48,310 --> 00:24:47,039
i was on the team that found the uh the

759
00:24:50,630 --> 00:24:48,320
martian meteorite

760
00:24:51,909 --> 00:24:50,640
uh there is one meteorite i say i found

761
00:24:53,190 --> 00:24:51,919
because i had to fight the rest of the

762
00:24:53,590 --> 00:24:53,200
team to bring it back and that was

763
00:24:55,110 --> 00:24:53,600

actually

764
00:24:56,950 --> 00:24:55,120
ended up being a large sample of the

765
00:24:58,230 --> 00:24:56,960
moon but um anyways

766
00:25:00,310 --> 00:24:58,240
yeah i've been down i've been fortunate

767
00:25:01,750 --> 00:25:00,320
to go down three times uh

768
00:25:04,310 --> 00:25:01,760
there's a program called anzmet

769
00:25:07,510 --> 00:25:04,320
antarctic search for meteorites which

770
00:25:09,190 --> 00:25:07,520
nasa is one of the partners on and they

771
00:25:11,510 --> 00:25:09,200
try to send a team down to antarctica

772
00:25:13,430 --> 00:25:11,520
every hospital summer

773
00:25:14,710 --> 00:25:13,440
that then goes into a remote field site

774
00:25:18,149 --> 00:25:14,720
they live in tents for

775
00:25:20,310 --> 00:25:18,159
roughly six weeks or so and search

776
00:25:21,669 --> 00:25:20,320
bare ice patches for meteorites and i

777
00:25:23,110 --> 00:25:21,679
won't go into all the details but there

778
00:25:24,470 --> 00:25:23,120
are a number of reasons why antarctica

779
00:25:25,990 --> 00:25:24,480
is a really good place to find

780
00:25:28,630 --> 00:25:26,000
meteorites um

781
00:25:29,350 --> 00:25:28,640
they they're frozen in so they last a

782
00:25:30,710 --> 00:25:29,360
long time

783
00:25:33,909 --> 00:25:30,720
you don't have to be very bright to

784
00:25:35,830 --> 00:25:33,919
recognize a black rock on blue ice uh so

785
00:25:37,350 --> 00:25:35,840
training is minimalistic um so the

786
00:25:39,430 --> 00:25:37,360
biggest problem is just the logistics of

787
00:25:41,990 --> 00:25:39,440
getting in and surviving

788
00:25:43,269 --> 00:25:42,000

um and this program has brought back uh

789
00:25:44,310 --> 00:25:43,279
you know literally thousands of

790
00:25:46,070 --> 00:25:44,320
meteorites

791
00:25:48,549 --> 00:25:46,080
to the scientific community and these

792
00:25:51,430 --> 00:25:48,559
are curated in much the same way

793
00:25:52,950 --> 00:25:51,440
uh the osiris-rex stamps samples will be

794
00:25:55,029 --> 00:25:52,960
curated that

795
00:25:56,390 --> 00:25:55,039
uh they're cataloged and a certain

796
00:25:57,590 --> 00:25:56,400
amount of minimal work is done to make

797
00:25:59,510 --> 00:25:57,600
sure we understand what kind of a

798
00:26:01,510 --> 00:25:59,520
meteorite it is and then they're

799
00:26:03,350 --> 00:26:01,520
posted as available for people to

800
00:26:05,669 --> 00:26:03,360
request and study so they become a

801
00:26:08,149 --> 00:26:05,679
resource for the entire world's

802
00:26:09,830 --> 00:26:08,159
scientific community so when you go down

803
00:26:11,190 --> 00:26:09,840
on the antarctic expeditions it's it's

804
00:26:12,870 --> 00:26:11,200
kind of an adventure and you find the

805
00:26:13,750 --> 00:26:12,880
meteorites you don't do any much of the

806
00:26:16,549 --> 00:26:13,760
science

807
00:26:18,310 --> 00:26:16,559
with trying to figure out why the

808
00:26:21,190 --> 00:26:18,320
meteorites ended up where you found them

809
00:26:22,870 --> 00:26:21,200
but um but they become available to

810
00:26:24,630 --> 00:26:22,880
everyone else so it's a really important

811
00:26:28,149 --> 00:26:24,640
community service that gets

812
00:26:31,269 --> 00:26:28,159
done most years and provides us with an

813
00:26:32,950 --> 00:26:31,279

enormous scientific resource

814
00:26:34,230 --> 00:26:32,960
yeah that's incredible i know a large

815
00:26:34,789 --> 00:26:34,240
number of our meteorites have come from

816
00:26:36,630 --> 00:26:34,799
anzmed

817
00:26:38,070 --> 00:26:36,640
and i'd love to go down sometime i think

818
00:26:39,990 --> 00:26:38,080
it sounds really cool to be involved

819
00:26:41,110 --> 00:26:40,000
in these missions to collect so many

820
00:26:43,510 --> 00:26:41,120
samples

821
00:26:45,190 --> 00:26:43,520
i would go again in a shot if i if i had

822
00:26:46,070 --> 00:26:45,200
an opportunity it's a lot of fun it's

823
00:26:48,149 --> 00:26:46,080
hard work too

824
00:26:49,190 --> 00:26:48,159
um they're very long days and you're

825
00:26:52,230 --> 00:26:49,200
never warm but

826
00:26:53,830 --> 00:26:52,240
um but it's pretty cool that's awesome

827
00:26:55,029 --> 00:26:53,840
um i love that so much you're making me

828
00:26:58,149 --> 00:26:55,039
super jealous

829
00:26:59,750 --> 00:26:58,159
um i do want to ask jason as well uh

830
00:27:02,390 --> 00:26:59,760
outside of osiris-rex you've done a lot

831
00:27:04,470 --> 00:27:02,400
of work on organic chemistry kind of

832
00:27:05,669 --> 00:27:04,480
the the inventory of organic molecules

833
00:27:08,230 --> 00:27:05,679
that could be important

834
00:27:09,750 --> 00:27:08,240
for origins for their origin of life or

835
00:27:11,510 --> 00:27:09,760
for things here on earth i wonder if you

836
00:27:12,549 --> 00:27:11,520
could speak to our audience about the

837
00:27:14,789 --> 00:27:12,559
importance

838
00:27:17,990 --> 00:27:14,799

of understanding cometary and asteroidal

839
00:27:20,230 --> 00:27:18,000
materials when it comes to origins

840
00:27:21,590 --> 00:27:20,240
yes so i actually started out my

841
00:27:23,830 --> 00:27:21,600
research career studying

842
00:27:24,950 --> 00:27:23,840
traditional origins of life chemistry uh

843
00:27:27,510 --> 00:27:24,960
prebiotic uh

844
00:27:29,669 --> 00:27:27,520
earlier simulations and then i actually

845
00:27:32,149 --> 00:27:29,679
was a postdoc for scott

846
00:27:33,029 --> 00:27:32,159
at ames where we were studying ices and

847
00:27:35,830 --> 00:27:33,039
that was a

848
00:27:36,950 --> 00:27:35,840
further restriction of of the of the

849
00:27:40,149 --> 00:27:36,960
phase space

850
00:27:41,669 --> 00:27:40,159
instead of studying uh things based on

851
00:27:43,110 --> 00:27:41,679
the models we have the early earth which

852
00:27:44,710 --> 00:27:43,120
are not very well constrained they're

853
00:27:46,470 --> 00:27:44,720
based on the models we have of the

854
00:27:49,269 --> 00:27:46,480
interstellar medium which constrained by

855
00:27:51,909 --> 00:27:49,279
telescopic observations then i had the

856
00:27:53,190 --> 00:27:51,919
opportunity to to get hired at goddard

857
00:27:55,510 --> 00:27:53,200
and start a laboratory studying

858
00:27:57,190 --> 00:27:55,520
meteorites uh which are even more

859
00:27:59,750 --> 00:27:57,200
constrained because these are actually

860
00:28:00,870 --> 00:27:59,760
samples that were in space and you can

861
00:28:02,870 --> 00:28:00,880
look at close up

862
00:28:04,630 --> 00:28:02,880
and then of course srx is the natural

863
00:28:05,669 --> 00:28:04,640

extension of that from a specific

864
00:28:08,389 --> 00:28:05,679
asteroid

865
00:28:10,870 --> 00:28:08,399
and so uh my strategy is to look for

866
00:28:13,909 --> 00:28:10,880
compounds of interest to

867
00:28:17,750 --> 00:28:13,919
uh prebiotic chemistry like amino acids

868
00:28:19,909 --> 00:28:17,760
cyanide um amines

869
00:28:20,950 --> 00:28:19,919
things of that sort but what i'd like to

870
00:28:22,630 --> 00:28:20,960
do is instead of doing

871
00:28:24,389 --> 00:28:22,640
an inventory of every single amino acid

872
00:28:26,549 --> 00:28:24,399
we can get in a meteorite i like to

873
00:28:27,909 --> 00:28:26,559
focus on a suite of them and look at

874
00:28:29,110 --> 00:28:27,919
them across different kinds of

875
00:28:31,830 --> 00:28:29,120
meteorites

876
00:28:32,470 --> 00:28:31,840
to understand uh instead of just making

877
00:28:34,310 --> 00:28:32,480
a menu

878
00:28:36,310 --> 00:28:34,320
trying to understand that the cosmo

879
00:28:38,310 --> 00:28:36,320
chemistry of that was happening

880
00:28:40,310 --> 00:28:38,320
uh that could have influenced the origin

881
00:28:42,830 --> 00:28:40,320
of life on earth or

882
00:28:45,029 --> 00:28:42,840
mars europa enceladus your favorite

883
00:28:46,950 --> 00:28:45,039
object that's awesome yeah and

884
00:28:48,230 --> 00:28:46,960
i think a lot of us in the audience have

885
00:28:49,590 --> 00:28:48,240
their own favorite objects throughout

886
00:28:50,950 --> 00:28:49,600
the solar system to talk about for

887
00:28:53,430 --> 00:28:50,960
astrobiology so

888
00:28:55,830 --> 00:28:53,440

i'm glad you mentioned that um eve if i

889
00:28:56,870 --> 00:28:55,840
may also kind of outside of osiris-rex

890
00:28:58,950 --> 00:28:56,880
you've done a lot of work in

891
00:29:01,269 --> 00:28:58,960
instrumentation and understanding

892
00:29:03,110 --> 00:29:01,279
um you know these sources the evolution

893
00:29:05,110 --> 00:29:03,120
changes and amino acids but you've

894
00:29:06,789 --> 00:29:05,120
you've done a lot in kind of modeling

895
00:29:07,510 --> 00:29:06,799
these impact processes and how they

896
00:29:09,669 --> 00:29:07,520
affect

897
00:29:11,590 --> 00:29:09,679
organics specifically amino acids and

898
00:29:13,269 --> 00:29:11,600
that's also relevant for life

899
00:29:14,950 --> 00:29:13,279
i'm wondering for our audience if you

900
00:29:15,350 --> 00:29:14,960
could just give kind of your vision of

901
00:29:17,269 --> 00:29:15,360
the

902
00:29:18,710 --> 00:29:17,279
importance of understanding impact

903
00:29:21,029 --> 00:29:18,720
processes

904
00:29:23,510 --> 00:29:21,039
for the origins and evolution of life on

905
00:29:26,789 --> 00:29:23,520
earth and maybe even elsewhere

906
00:29:28,710 --> 00:29:26,799
sure so the hypothesis that we were

907
00:29:30,549 --> 00:29:28,720
working with was

908
00:29:32,149 --> 00:29:30,559
we know that there are amino acids in

909
00:29:33,669 --> 00:29:32,159
meteorites and in asteroids and they're

910
00:29:36,470 --> 00:29:33,679
being delivered to multiple

911
00:29:38,389 --> 00:29:36,480
planetary bodies not just earth and we

912
00:29:38,870 --> 00:29:38,399
also know that there has to be an energy

913
00:29:41,909 --> 00:29:38,880

source

914
00:29:44,230 --> 00:29:41,919
in order to give them what they need to

915
00:29:45,190 --> 00:29:44,240
polymerize so we go from amino acid to

916
00:29:48,149 --> 00:29:45,200
peptides

917
00:29:50,149 --> 00:29:48,159
to protein to dna and rna which

918
00:29:52,310 --> 00:29:50,159
eventually leads to life and i

919
00:29:53,990 --> 00:29:52,320
i really am really interested in that

920
00:29:56,789 --> 00:29:54,000
part of astrobiology too although

921
00:29:57,750 --> 00:29:56,799
i'm definitely an amateur i just watched

922
00:30:00,549 --> 00:29:57,760
that happen

923
00:30:01,750 --> 00:30:00,559
but we had there haven't been a lot of

924
00:30:05,029 --> 00:30:01,760
experiments done

925
00:30:07,830 --> 00:30:05,039
looking at uh systematically across

926
00:30:09,110 --> 00:30:07,840
different sizes of amino acids or

927
00:30:11,990 --> 00:30:09,120
different handedness

928
00:30:12,789 --> 00:30:12,000
of amino acids so we were trying to fill

929
00:30:14,789 --> 00:30:12,799
that gap

930
00:30:16,149 --> 00:30:14,799
and we've been a little bit derailed by

931
00:30:18,230 --> 00:30:16,159
the pandemic but

932
00:30:20,070 --> 00:30:18,240
i do have some samples that we've run

933
00:30:22,149 --> 00:30:20,080
but haven't analyzed yet using mass

934
00:30:24,389 --> 00:30:22,159
spectrometry and when we get back in the

935
00:30:27,669 --> 00:30:24,399
lab hopefully soon we'll be

936
00:30:29,510 --> 00:30:27,679
doing impacts and at johnson space

937
00:30:32,950 --> 00:30:29,520
center we have an experimental impact

938
00:30:34,950 --> 00:30:32,960

lab that allows us to simulate

939
00:30:36,710 --> 00:30:34,960
a specific shock pressure so that's a

940
00:30:39,430 --> 00:30:36,720
flat plate accelerator

941
00:30:41,590 --> 00:30:39,440
and then we also have two impact

942
00:30:44,630 --> 00:30:41,600
apparatuses that

943
00:30:46,549 --> 00:30:44,640
simulate a more open so

944
00:30:48,310 --> 00:30:46,559
instead of having our sample encased

945
00:30:50,549 --> 00:30:48,320
inside of stainless steel

946
00:30:51,510 --> 00:30:50,559
it's a more open container so it's more

947
00:30:53,510 --> 00:30:51,520
natural so

948
00:30:55,110 --> 00:30:53,520
our impactor hits and we have ejecta

949
00:30:57,909 --> 00:30:55,120
coming out and we have a

950
00:30:59,350 --> 00:30:57,919
range of pressures over which those uh

951
00:31:01,909 --> 00:30:59,360
organics that we've put into our

952
00:31:03,990 --> 00:31:01,919
starting material are exposed and then

953
00:31:04,950 --> 00:31:04,000
we take those and and we look and see

954
00:31:07,350 --> 00:31:04,960
what we've gotten

955
00:31:09,029 --> 00:31:07,360
uh you know and compared to what we

956
00:31:11,750 --> 00:31:09,039
started with and so

957
00:31:13,350 --> 00:31:11,760
i guess for me i've always enjoyed

958
00:31:15,029 --> 00:31:13,360
looking at a sample

959
00:31:17,750 --> 00:31:15,039
a meteoritic sample or something brought

960
00:31:19,750 --> 00:31:17,760
back by orex or from build two

961
00:31:21,830 --> 00:31:19,760
and then also trying to simulate that in

962
00:31:23,990 --> 00:31:21,840
the lab so doing experiments

963
00:31:24,870 --> 00:31:24,000

and then also sort of the third leg of

964
00:31:26,950 --> 00:31:24,880
that is looking

965
00:31:28,710 --> 00:31:26,960
theoretically and trying to put that all

966
00:31:30,789 --> 00:31:28,720
together because i think we need all of

967
00:31:32,789 --> 00:31:30,799
those pieces in order to

968
00:31:34,870 --> 00:31:32,799
let us know how life started on earth

969
00:31:36,230 --> 00:31:34,880
and if we can untangle what happened

970
00:31:40,070 --> 00:31:36,240
here

971
00:31:42,149 --> 00:31:40,080
might be able to better predict

972
00:31:44,070 --> 00:31:42,159
where we would find life somewhere else

973
00:31:45,990 --> 00:31:44,080
like what are the necessary components

974
00:31:48,470 --> 00:31:46,000
not just starting materials but energy

975
00:31:49,430 --> 00:31:48,480
sources as well i hope that answered

976
00:31:51,509 --> 00:31:49,440
your question

977
00:31:52,950 --> 00:31:51,519
absolutely that was great and thanks for

978
00:31:54,230 --> 00:31:52,960
talking about all these different pieces

979
00:31:56,070 --> 00:31:54,240
astrobiology you know

980
00:31:57,990 --> 00:31:56,080
as a large field of people coming

981
00:31:59,430 --> 00:31:58,000
together from different disciplines and

982
00:32:01,350 --> 00:31:59,440
bringing all these different pieces

983
00:32:03,350 --> 00:32:01,360
together to try to understand

984
00:32:04,549 --> 00:32:03,360
our origins and and what life in the

985
00:32:07,029 --> 00:32:04,559
cosmos really is

986
00:32:08,310 --> 00:32:07,039
i really love that a lot uh i do

987
00:32:09,990 --> 00:32:08,320
apologize to our audience i'm going to

988
00:32:11,029 --> 00:32:10,000

start audience questions here very soon

989
00:32:12,950 --> 00:32:11,039
i promise

990
00:32:14,389 --> 00:32:12,960
first off we do want to announce our

991
00:32:16,710 --> 00:32:14,399
twitter poll

992
00:32:18,470 --> 00:32:16,720
this is the very first time where we

993
00:32:20,789 --> 00:32:18,480
polled the audience on twitter

994
00:32:21,669 --> 00:32:20,799
a question about the mission or the

995
00:32:25,029 --> 00:32:21,679
topic

996
00:32:26,710 --> 00:32:25,039
and most people got it wrong so

997
00:32:29,830 --> 00:32:26,720
our question on twitter from nasa

998
00:32:33,190 --> 00:32:29,840
astrobiology or at nasa astrobio

999
00:32:35,909 --> 00:32:33,200
was now that osiris-rex is heading home

1000
00:32:36,950 --> 00:32:35,919
how far does the spacecraft itself have

1001
00:32:39,669 --> 00:32:36,960
to travel

1002
00:32:39,990 --> 00:32:39,679
to get back to earth uh and so we had

1003
00:32:43,029 --> 00:32:40,000
the

1004
00:32:48,870 --> 00:32:43,039
miles

1005
00:32:51,190 --> 00:32:48,880
and it was actually the largest of those

1006
00:32:53,990 --> 00:32:51,200
three 1.4 billion miles

1007
00:32:54,630 --> 00:32:54,000
the spacecraft has to go around the sun

1008
00:32:57,750 --> 00:32:54,640
twice

1009
00:33:00,070 --> 00:32:57,760
on its way back home by 2023 it has

1010
00:33:01,750 --> 00:33:00,080
quite a long journey ahead of it

1011
00:33:03,830 --> 00:33:01,760
but many congratulations to those who

1012
00:33:05,509 --> 00:33:03,840
got it right but there is a lot ahead

1013
00:33:07,269 --> 00:33:05,519

yet for this spacecraft

1014
00:33:10,470 --> 00:33:07,279
for those samples to come back as jason

1015
00:33:12,310 --> 00:33:10,480
mentioned landing in utah in 2023

1016
00:33:13,590 --> 00:33:12,320
uh so now i think we will jump to the

1017
00:33:15,430 --> 00:33:13,600
audience questions and

1018
00:33:17,110 --> 00:33:15,440
the first question i actually already

1019
00:33:17,909 --> 00:33:17,120
knew because it came in before the show

1020
00:33:19,909 --> 00:33:17,919
started

1021
00:33:21,909 --> 00:33:19,919
and i know that jason has an exact

1022
00:33:24,230 --> 00:33:21,919
answer for it because we talked about it

1023
00:33:26,549 --> 00:33:24,240
before the episode started uh the first

1024
00:33:29,909 --> 00:33:26,559
question comes from uh rudy von reap

1025
00:33:30,549 --> 00:33:29,919
on facebook uh rudy asks where is osiris

1026
00:33:34,230 --> 00:33:30,559
rex

1027
00:33:38,230 --> 00:33:34,240
now uh right now

1028
00:33:41,830 --> 00:33:38,240
uh assassin rex is has departed bennu it

1029
00:33:44,950 --> 00:33:41,840
is um 202

1030
00:33:47,350 --> 00:33:44,960
000 kilometers from bennu

1031
00:33:48,789 --> 00:33:47,360
and it is uh the other side of the solar

1032
00:33:50,630 --> 00:33:48,799
system from the earth so it's basically

1033
00:33:54,149 --> 00:33:50,640
in earth's orbit

1034
00:33:57,430 --> 00:33:54,159
uh it is 0.9 a u from the sun

1035
00:33:59,430 --> 00:33:57,440
and 1.9 a u from earth

1036
00:34:03,269 --> 00:33:59,440
so that gives you a one one way light

1037
00:34:04,789 --> 00:34:03,279
time of 15.885 minutes

1038
00:34:06,310 --> 00:34:04,799

lovely yeah it's great to have the data

1039
00:34:07,990 --> 00:34:06,320
we can actually say exactly where it's

1040
00:34:08,710 --> 00:34:08,000
at right now because we do track these

1041
00:34:09,829 --> 00:34:08,720
things

1042
00:34:11,990 --> 00:34:09,839
uh and as you mentioned we'll be

1043
00:34:12,550 --> 00:34:12,000
tracking this into the distant future as

1044
00:34:13,909 --> 00:34:12,560
well

1045
00:34:15,750 --> 00:34:13,919
for future generations they'll be

1046
00:34:17,430 --> 00:34:15,760
tracking venue and other asteroids in

1047
00:34:19,510 --> 00:34:17,440
our solar system

1048
00:34:21,030 --> 00:34:19,520
and if we can jump in you can look at

1049
00:34:22,869 --> 00:34:21,040
nasa eyes

1050
00:34:25,349 --> 00:34:22,879
it's a website where the deep state deep

1051
00:34:26,869 --> 00:34:25,359
space network updates in real time where

1052
00:34:27,990 --> 00:34:26,879
all these spacecraft are

1053
00:34:30,230 --> 00:34:28,000
so if you don't believe me you can look

1054
00:34:31,990 --> 00:34:30,240
yourself look for yourself and find out

1055
00:34:33,750 --> 00:34:32,000
awesome that's a great idea i've used

1056
00:34:34,310 --> 00:34:33,760
that website myself many times to see

1057
00:34:36,069 --> 00:34:34,320
where

1058
00:34:37,909 --> 00:34:36,079
various spacecraft on their way to mars

1059
00:34:39,190 --> 00:34:37,919
and other worlds are at and what's going

1060
00:34:41,909 --> 00:34:39,200
on with them currently

1061
00:34:43,109 --> 00:34:41,919
it's a great site our next question

1062
00:34:46,230 --> 00:34:43,119
comes from twitter

1063
00:34:48,190 --> 00:34:46,240

from jorge cristobal jorge wants to know

1064
00:34:49,589 --> 00:34:48,200
could there potentially be a dangerous

1065
00:34:51,430 --> 00:34:49,599
microorganism

1066
00:34:53,829 --> 00:34:51,440
within this sample coming back from

1067
00:34:55,430 --> 00:34:53,839
bennu and how do we control for a

1068
00:34:56,869 --> 00:34:55,440
potential biohazard and

1069
00:35:00,790 --> 00:34:56,879
i'll open that up to any of you who'd

1070
00:35:04,710 --> 00:35:04,069
i'll start i'll just uh my short answer

1071
00:35:08,310 --> 00:35:04,720
to that

1072
00:35:09,030 --> 00:35:08,320
is we have tons of material falling onto

1073
00:35:12,550 --> 00:35:09,040
the earth

1074
00:35:15,270 --> 00:35:12,560
every year um meteorites landing on

1075
00:35:17,430 --> 00:35:15,280
well everywhere and interplanetary dust

1076
00:35:20,069 --> 00:35:17,440
particles um scott or jason might have a

1077
00:35:22,950 --> 00:35:20,079
better accurate number on how much but

1078
00:35:24,870 --> 00:35:22,960
um so we have been exposed to asteroidal

1079
00:35:28,069 --> 00:35:24,880
materials our entire lives

1080
00:35:29,430 --> 00:35:28,079
um that's yeah there are a variety of

1081
00:35:29,990 --> 00:35:29,440
estimates but i think it's something

1082
00:35:33,430 --> 00:35:30,000
like 12

1083
00:35:36,310 --> 00:35:33,440
tons a day falls in um

1084
00:35:37,109 --> 00:35:36,320
even this was the smaller it brings um

1085
00:35:38,630 --> 00:35:37,119
and uh

1086
00:35:40,150 --> 00:35:38,640
so we're exposed to the stuff all the

1087
00:35:41,510 --> 00:35:40,160
time there's some in the room with you

1088
00:35:44,150 --> 00:35:41,520

right now

1089
00:35:45,990 --> 00:35:44,160
the small dust grains uh like the ones

1090
00:35:47,670 --> 00:35:46,000
we collected and built too

1091
00:35:49,109 --> 00:35:47,680
slow down in the upper atmosphere and

1092
00:35:50,790 --> 00:35:49,119
take you know anywhere from

1093
00:35:52,150 --> 00:35:50,800
a couple of days to a couple of weeks to

1094
00:35:52,470 --> 00:35:52,160
settle out to the ground and then they

1095
00:35:53,829 --> 00:35:52,480
just

1096
00:35:56,069 --> 00:35:53,839
you know get down on the ground and mix

1097
00:35:56,950 --> 00:35:56,079
up all the cat hair and dandruff and

1098
00:35:58,069 --> 00:35:56,960
everything else so

1099
00:35:59,670 --> 00:35:58,079
you've got you know you've probably got

1100
00:36:00,710 --> 00:35:59,680
some common dust in your hair right now

1101
00:36:03,349 --> 00:36:00,720
it's quite possible

1102
00:36:03,750 --> 00:36:03,359
um so uh so for these particular kinds

1103
00:36:05,750 --> 00:36:03,760
of

1104
00:36:07,109 --> 00:36:05,760
materials there's you know no real

1105
00:36:09,349 --> 00:36:07,119
biohazard

1106
00:36:11,030 --> 00:36:09,359
in fact since this has been going on for

1107
00:36:14,150 --> 00:36:11,040
the entire life of the earth maybe it's

1108
00:36:14,870 --> 00:36:14,160
good for us so i can expand on that even

1109
00:36:17,109 --> 00:36:14,880
further

1110
00:36:18,710 --> 00:36:17,119
so in the case of bennu it's a very

1111
00:36:22,230 --> 00:36:18,720
small asteroid only

1112
00:36:22,630 --> 00:36:22,240
uh 500 yards across uh which means that

1113
00:36:26,790 --> 00:36:22,640

it

1114
00:36:31,829 --> 00:36:26,800
water

1115
00:36:34,310 --> 00:36:31,839
to form

1116
00:36:35,589 --> 00:36:34,320
it's been irradiated by galactic cosmic

1117
00:36:37,990 --> 00:36:35,599
rays for

1118
00:36:39,190 --> 00:36:38,000
eons so any life that could have formed

1119
00:36:40,230 --> 00:36:39,200
which it couldn't have would have been

1120
00:36:43,030 --> 00:36:40,240
sterilized

1121
00:36:44,550 --> 00:36:43,040
the surface is very hot uh so anything

1122
00:36:45,190 --> 00:36:44,560
that was that could have formed but

1123
00:36:46,550 --> 00:36:45,200
couldn't have

1124
00:36:48,310 --> 00:36:46,560
would have been sterilized would have

1125
00:36:50,790 --> 00:36:48,320
been killed uh

1126
00:36:51,990 --> 00:36:50,800
and furthermore uh we now know that

1127
00:36:55,430 --> 00:36:52,000
bennu is ejecting

1128
00:36:57,589 --> 00:36:55,440
rocks all the time um centimeter-sized

1129
00:36:59,430 --> 00:36:57,599
pebbles are coming off of bennu bennu

1130
00:37:01,990 --> 00:36:59,440
does cross earth's orbit

1131
00:37:03,750 --> 00:37:02,000
so we we would expect there to be a

1132
00:37:05,430 --> 00:37:03,760
bennu meteor shower

1133
00:37:06,870 --> 00:37:05,440
uh every september in the southern

1134
00:37:09,990 --> 00:37:06,880
hemisphere uh

1135
00:37:11,030 --> 00:37:10,000
and so those generic uh asteroid rocks

1136
00:37:12,550 --> 00:37:11,040
that hit the earth

1137
00:37:14,390 --> 00:37:12,560
actually some of them are coming from

1138
00:37:14,790 --> 00:37:14,400

bennu we just have no way of identifying

1139
00:37:16,950 --> 00:37:14,800
them

1140
00:37:18,630 --> 00:37:16,960
hopefully until we get the sample i mean

1141
00:37:20,069 --> 00:37:18,640
it's entirely possible we have a sample

1142
00:37:23,430 --> 00:37:20,079
of bennu in that inventory

1143
00:37:25,030 --> 00:37:23,440
from antarctica we just don't know it um

1144
00:37:26,630 --> 00:37:25,040
but when we get the venue sample back

1145
00:37:28,230 --> 00:37:26,640
we'll be able to compare against

1146
00:37:31,430 --> 00:37:28,240
the rest of the data set and boost the

1147
00:37:33,589 --> 00:37:31,440
detail and maybe we'll find out

1148
00:37:35,190 --> 00:37:33,599
how we can prove that this has happened

1149
00:37:36,230 --> 00:37:35,200
yeah that's a really good point i think

1150
00:37:38,150 --> 00:37:36,240
a lot of folks you know

1151
00:37:39,829 --> 00:37:38,160
we have mars meteorites that we can we

1152
00:37:42,230 --> 00:37:39,839
can show came from mars because of the

1153
00:37:44,390 --> 00:37:42,240
atmospheric analyses we done on mars but

1154
00:37:45,990 --> 00:37:44,400
we certainly have meteorites from other

1155
00:37:46,710 --> 00:37:46,000
bodies in our solar system that we just

1156
00:37:48,069 --> 00:37:46,720
can't

1157
00:37:49,910 --> 00:37:48,079
pair them up so that's one one thing

1158
00:37:51,430 --> 00:37:49,920
with sample return too we actually then

1159
00:37:53,270 --> 00:37:51,440
can do the inventory and actually

1160
00:37:54,470 --> 00:37:53,280
compare those to other data

1161
00:37:56,470 --> 00:37:54,480
that's a really really good point i

1162
00:37:58,069 --> 00:37:56,480
think for our audience true

1163
00:37:59,829 --> 00:37:58,079

it's also possible that the rocks and

1164
00:38:02,550 --> 00:37:59,839
from bennu are so crumbly

1165
00:38:03,190 --> 00:38:02,560
as we saw from the tag event the the tag

1166
00:38:06,069 --> 00:38:03,200
uh

1167
00:38:06,710 --> 00:38:06,079
arm sank into bennu by perhaps half a

1168
00:38:08,790 --> 00:38:06,720
meter

1169
00:38:11,109 --> 00:38:08,800
that maybe the rocks are so crumbly that

1170
00:38:12,710 --> 00:38:11,119
they don't survive long on earth

1171
00:38:14,950 --> 00:38:12,720
that they don't pass through the

1172
00:38:16,630 --> 00:38:14,960
atmosphere without breaking up into dust

1173
00:38:17,990 --> 00:38:16,640
and if they land on the earth maybe they

1174
00:38:21,349 --> 00:38:18,000
they dissolve within

1175
00:38:22,310 --> 00:38:21,359
uh days or hours and so uh they may be

1176
00:38:25,510 --> 00:38:22,320
on earth and we just

1177
00:38:27,109 --> 00:38:25,520
never have seen them and you just you

1178
00:38:28,870 --> 00:38:27,119
just mentioned that the tag event um

1179
00:38:30,310 --> 00:38:28,880
we have another question from anna rupa

1180
00:38:31,030 --> 00:38:30,320
hunty one of our ambassadors of the

1181
00:38:33,589 --> 00:38:31,040
month

1182
00:38:34,310 --> 00:38:33,599
uh who asks uh the mars parachutes were

1183
00:38:36,390 --> 00:38:34,320
tested

1184
00:38:37,510 --> 00:38:36,400
in wind tunnels at nasa wallops and and

1185
00:38:40,230 --> 00:38:37,520
nasa ames

1186
00:38:41,349 --> 00:38:40,240
uh he wants to know if uh if and where

1187
00:38:44,550 --> 00:38:41,359
the osiris-rex

1188
00:38:46,550 --> 00:38:44,560

boop was tested was was the tag

1189
00:38:49,109 --> 00:38:46,560
process tested anywhere and and what was

1190
00:38:52,630 --> 00:38:49,119
that test like

1191
00:38:54,390 --> 00:38:52,640
it was tested so much um

1192
00:38:56,310 --> 00:38:54,400
it was the technology developed by our

1193
00:38:57,190 --> 00:38:56,320
partners at lockheed martin uh space

1194
00:38:59,829 --> 00:38:57,200
systems

1195
00:39:01,750 --> 00:38:59,839
and they uh they tested it in uh under

1196
00:39:03,430 --> 00:39:01,760
vacuum chambers on earth

1197
00:39:05,270 --> 00:39:03,440
with a var with a whole range of

1198
00:39:08,310 --> 00:39:05,280
materials in range of orientations

1199
00:39:08,950 --> 00:39:08,320
they tested it on the um the vomit comet

1200
00:39:11,349 --> 00:39:08,960
that this

1201
00:39:12,630 --> 00:39:11,359
the parabolic airplane to check it under

1202
00:39:14,550 --> 00:39:12,640
microgravity

1203
00:39:15,750 --> 00:39:14,560
uh it's difficult to enter full vacuum

1204
00:39:17,589 --> 00:39:15,760
and microgravity at the same time but

1205
00:39:20,710 --> 00:39:17,599
they did extrapolations

1206
00:39:22,069 --> 00:39:20,720
um so it's been tested

1207
00:39:24,950 --> 00:39:22,079
an enormous amount under various

1208
00:39:27,670 --> 00:39:24,960
different designs to then optimize it

1209
00:39:28,069 --> 00:39:27,680
for example we optimize the amount of

1210
00:39:35,670 --> 00:39:28,079
gas

1211
00:39:37,670 --> 00:39:35,680
we also discovered that you can also

1212
00:39:39,829 --> 00:39:37,680
uh pop up off the surface if there's too

1213
00:39:42,230 --> 00:39:39,839

much gas acts like a thruster

1214
00:39:44,069 --> 00:39:42,240
and so we we had to tailor that based on

1215
00:39:46,470 --> 00:39:44,079
the dynamics of the spacecraft

1216
00:39:48,310 --> 00:39:46,480
touching the asteroid uh based on our

1217
00:39:50,310 --> 00:39:48,320
understanding of the asteroid in

1218
00:39:51,910 --> 00:39:50,320
you know before launch which would

1219
00:39:53,510 --> 00:39:51,920
change somewhat when we got there

1220
00:39:55,190 --> 00:39:53,520
so it's been tested enormous amount we

1221
00:39:58,230 --> 00:39:55,200
also tested the parachutes of course

1222
00:40:00,310 --> 00:39:58,240
by dropping things from helicopters yeah

1223
00:40:02,710 --> 00:40:00,320
i point out that the the sample return

1224
00:40:06,150 --> 00:40:02,720
capsule for osiris-rex is

1225
00:40:07,589 --> 00:40:06,160
based on the stardust uh capsule and so

1226
00:40:09,430 --> 00:40:07,599
it also got lots of

1227
00:40:11,829 --> 00:40:09,440
testing that was dropped in the desert

1228
00:40:14,150 --> 00:40:11,839
and

1229
00:40:14,870 --> 00:40:14,160
before so there was a already a data set

1230
00:40:18,470 --> 00:40:14,880
available

1231
00:40:21,190 --> 00:40:18,480
for osiris-rex to begin from indeed

1232
00:40:23,349 --> 00:40:21,200
i i would just add that i the tag sam is

1233
00:40:25,589 --> 00:40:23,359
one of my favorite parts of this mission

1234
00:40:28,069 --> 00:40:25,599
and a few years ago as part of my job i

1235
00:40:30,470 --> 00:40:28,079
was able to work with a program

1236
00:40:32,230 --> 00:40:30,480
with engineers so partly getting

1237
00:40:34,309 --> 00:40:32,240
engineers and scientists to learn how to

1238
00:40:37,190 --> 00:40:34,319

work together but they were designing

1239
00:40:38,390 --> 00:40:37,200
sample return missions using a little

1240
00:40:40,309 --> 00:40:38,400
helicopters

1241
00:40:42,069 --> 00:40:40,319
and they had to actually design a way

1242
00:40:45,190 --> 00:40:42,079
and successfully pick up

1243
00:40:48,069 --> 00:40:45,200
samples from a you know a mars yard

1244
00:40:49,829 --> 00:40:48,079
um at johnson space center and so

1245
00:40:52,150 --> 00:40:49,839
working with them and finding ways not

1246
00:40:53,910 --> 00:40:52,160
only to collect successfully but collect

1247
00:40:56,470 --> 00:40:53,920
cleanly making sure that you're not

1248
00:40:58,950 --> 00:40:56,480
adding anything to the sample and so

1249
00:41:00,790 --> 00:40:58,960
tag sam to me is just an engineering

1250
00:41:03,589 --> 00:41:00,800
marvel and it's amazing

1251
00:41:04,950 --> 00:41:03,599
um yeah i think everyone loves it too

1252
00:41:06,069 --> 00:41:04,960
like the idea that there's this cosmic

1253
00:41:07,270 --> 00:41:06,079
boop right

1254
00:41:09,430 --> 00:41:07,280
i think i think everyone really loved

1255
00:41:11,030 --> 00:41:09,440
that um scott i'd like to direct the

1256
00:41:13,829 --> 00:41:11,040
next question to you

1257
00:41:15,670 --> 00:41:13,839
this comes from jim pass he's at astro

1258
00:41:17,910 --> 00:41:15,680
sociology on twitter

1259
00:41:18,790 --> 00:41:17,920
jim wants to know what can analyzing

1260
00:41:20,309 --> 00:41:18,800
this sample

1261
00:41:22,390 --> 00:41:20,319
from bennu and really what does this

1262
00:41:24,069 --> 00:41:22,400
work reveal to us

1263
00:41:26,069 --> 00:41:24,079

as a society that really benefits the

1264
00:41:28,069 --> 00:41:26,079
future of humanity

1265
00:41:29,910 --> 00:41:28,079
well i think i'll go back to yet again

1266
00:41:31,670 --> 00:41:29,920
to jason describing our acronym

1267
00:41:34,230 --> 00:41:31,680
there's actually not one answer to this

1268
00:41:35,910 --> 00:41:34,240
um uh you know just

1269
00:41:38,710 --> 00:41:35,920
let's just pick a really big scale one

1270
00:41:40,630 --> 00:41:38,720
since bennu is in fact one of the larger

1271
00:41:42,069 --> 00:41:40,640
potential hazards for an impact with the

1272
00:41:44,870 --> 00:41:42,079
earth uh

1273
00:41:45,990 --> 00:41:44,880
if it did that the destructive uh nature

1274
00:41:49,270 --> 00:41:46,000
of that event would be

1275
00:41:51,109 --> 00:41:49,280
pretty serious and um so our

1276
00:41:52,790 --> 00:41:51,119
our understanding this object and

1277
00:41:54,230 --> 00:41:52,800
understanding the dynamics of such

1278
00:41:55,750 --> 00:41:54,240
objects and being able to

1279
00:41:57,430 --> 00:41:55,760
understand the material from which this

1280
00:41:59,109 --> 00:41:57,440
project was made

1281
00:42:01,829 --> 00:41:59,119
how that might affect how you could get

1282
00:42:03,670 --> 00:42:01,839
manipulated

1283
00:42:05,030 --> 00:42:03,680
play a major role in you know literally

1284
00:42:06,230 --> 00:42:05,040
saving millions of people from the

1285
00:42:08,550 --> 00:42:06,240
future so

1286
00:42:09,430 --> 00:42:08,560
so there's so there's a big scale one um

1287
00:42:13,670 --> 00:42:09,440
uh

1288
00:42:15,670 --> 00:42:13,680

point maybe i put more

1289
00:42:16,870 --> 00:42:15,680
emphasis on this than maybe your average

1290
00:42:18,790 --> 00:42:16,880
person does but

1291
00:42:20,470 --> 00:42:18,800
um you know the solar system is our

1292
00:42:22,069 --> 00:42:20,480
neighborhood and i like to understand

1293
00:42:23,990 --> 00:42:22,079
our neighborhood and so just the raw

1294
00:42:27,829 --> 00:42:24,000
science the raw understanding

1295
00:42:30,230 --> 00:42:27,839
of what's going on around us i think

1296
00:42:33,510 --> 00:42:30,240
enriches our lives uh which is our

1297
00:42:36,309 --> 00:42:33,520
understanding of the universe we live in

1298
00:42:37,750 --> 00:42:36,319
uh and so i see i personally see that as

1299
00:42:39,589 --> 00:42:37,760
as a big value as well

1300
00:42:41,670 --> 00:42:39,599
and um there are others but maybe i'll

1301
00:42:45,349 --> 00:42:41,680
shut up and let one of the other two

1302
00:42:48,710 --> 00:42:45,359
weigh in on this

1303
00:42:51,829 --> 00:42:48,720
go ahead jason oh i mean so

1304
00:42:53,750 --> 00:42:51,839
let me first um uh clarify scott

1305
00:42:54,950 --> 00:42:53,760
said if i want to make sure it's stuck

1306
00:42:57,589 --> 00:42:54,960
in everyone's mind

1307
00:42:59,589 --> 00:42:57,599
the potential for bennu impact is in

1308
00:43:01,910 --> 00:42:59,599
over 150 years

1309
00:43:03,270 --> 00:43:01,920
so there's lots and lots of time to to

1310
00:43:06,230 --> 00:43:03,280
to worry about that

1311
00:43:07,750 --> 00:43:06,240
uh there are many there are more many

1312
00:43:09,910 --> 00:43:07,760
more present dangers

1313
00:43:12,230 --> 00:43:09,920

uh you can focus on rather than worrying

1314
00:43:14,069 --> 00:43:12,240
about about this asteroid impact um

1315
00:43:16,230 --> 00:43:14,079
and it's not a it would be a local

1316
00:43:18,150 --> 00:43:16,240
catastrophe but

1317
00:43:19,589 --> 00:43:18,160
we we have enough information to prevent

1318
00:43:22,390 --> 00:43:19,599
it so that's great

1319
00:43:23,990 --> 00:43:22,400
uh we also have learned how to navigate

1320
00:43:25,670 --> 00:43:24,000
around a small object

1321
00:43:27,030 --> 00:43:25,680
something this small that has

1322
00:43:29,109 --> 00:43:27,040
microgravity

1323
00:43:30,150 --> 00:43:29,119
so that would be useful for say future

1324
00:43:32,069 --> 00:43:30,160
asteroid mining

1325
00:43:33,829 --> 00:43:32,079
future exploration of the solar system

1326
00:43:37,349 --> 00:43:33,839
either robotically or with

1327
00:43:38,950 --> 00:43:37,359
or with humans um and of course uh we're

1328
00:43:39,990 --> 00:43:38,960
all here for astrobiology and that's

1329
00:43:43,190 --> 00:43:40,000
that's my favorite part

1330
00:43:45,190 --> 00:43:43,200
is the origins aspect

1331
00:43:47,030 --> 00:43:45,200
i would agree that the origins aspect is

1332
00:43:48,309 --> 00:43:47,040
also my favorite part but one of the

1333
00:43:50,550 --> 00:43:48,319
things that i hope comes

1334
00:43:53,270 --> 00:43:50,560
from the mission is that future

1335
00:43:53,990 --> 00:43:53,280
engineers and future scientists are so

1336
00:43:56,150 --> 00:43:54,000
inspired

1337
00:43:58,470 --> 00:43:56,160
by what they saw and all of the records

1338
00:44:02,150 --> 00:43:58,480

that osiris-rex has

1339
00:44:05,030 --> 00:44:02,160
met and exceeded on its own um that it

1340
00:44:06,550 --> 00:44:05,040
gets their imaginations going and they

1341
00:44:08,710 --> 00:44:06,560
start planning

1342
00:44:10,390 --> 00:44:08,720
you know missions for the future and so

1343
00:44:12,390 --> 00:44:10,400
i think

1344
00:44:13,510 --> 00:44:12,400
even without all the scientific data

1345
00:44:13,910 --> 00:44:13,520
that we're going to get which is going

1346
00:44:15,750 --> 00:44:13,920
to be

1347
00:44:19,109 --> 00:44:15,760
fantastic the things we're going to

1348
00:44:22,470 --> 00:44:19,119
learn i think we're also going to

1349
00:44:23,670 --> 00:44:22,480
promote future scientists and engineers

1350
00:44:25,430 --> 00:44:23,680
i already said that

1351
00:44:27,270 --> 00:44:25,440
but that's that's sort of what i think a

1352
00:44:30,710 --> 00:44:27,280
big picture um

1353
00:44:32,390 --> 00:44:30,720
beyond the mission uh effect i love that

1354
00:44:34,230 --> 00:44:32,400
so much i know we have students watching

1355
00:44:35,670 --> 00:44:34,240
this show who might be interested in

1356
00:44:37,750 --> 00:44:35,680
being those future scientists and

1357
00:44:39,030 --> 00:44:37,760
engineers who are taking part in that

1358
00:44:40,390 --> 00:44:39,040
and actually there's another question

1359
00:44:41,990 --> 00:44:40,400
kind of along that line that i'd like to

1360
00:44:44,710 --> 00:44:42,000
start off with with you eve

1361
00:44:45,109 --> 00:44:44,720
uh aaron francis on facebook wants to

1362
00:44:47,270 --> 00:44:45,119
know

1363
00:44:48,470 --> 00:44:47,280

if there are any emerging techniques or

1364
00:44:50,390 --> 00:44:48,480
technologies

1365
00:44:52,309 --> 00:44:50,400
um that you're most excited about being

1366
00:44:54,150 --> 00:44:52,319
applied to bennu or potentially being

1367
00:44:58,230 --> 00:44:54,160
applied to these samples from bennu

1368
00:45:00,069 --> 00:44:58,240
oh gosh um

1369
00:45:02,790 --> 00:45:00,079
you know that's a really great question

1370
00:45:05,030 --> 00:45:02,800
and i i'm so stuck in my own little

1371
00:45:07,990 --> 00:45:05,040
world these days but what i will say

1372
00:45:09,510 --> 00:45:08,000
is i know that for liquid chromatography

1373
00:45:12,390 --> 00:45:09,520
mass spectrometry

1374
00:45:13,510 --> 00:45:12,400
new capabilities are being developed by

1375
00:45:16,870 --> 00:45:13,520
companies every day

1376
00:45:18,870 --> 00:45:16,880
a new uh one of the companies just came

1377
00:45:20,550 --> 00:45:18,880
out with a new way or a new material to

1378
00:45:22,309 --> 00:45:20,560
build things with so that more of the

1379
00:45:24,470 --> 00:45:22,319
material goes through the system and

1380
00:45:25,030 --> 00:45:24,480
gets analyzed so things like that are

1381
00:45:27,270 --> 00:45:25,040
happening

1382
00:45:30,230 --> 00:45:27,280
i know transmission electron micro

1383
00:45:33,670 --> 00:45:30,240
microscopes are getting more and more

1384
00:45:35,430 --> 00:45:33,680
accurate and can measure

1385
00:45:36,950 --> 00:45:35,440
to higher and higher degrees so all of

1386
00:45:39,589 --> 00:45:36,960
those little changes

1387
00:45:40,630 --> 00:45:39,599
will add up um i apologize that i don't

1388
00:45:42,630 --> 00:45:40,640

have a specific

1389
00:45:44,870 --> 00:45:42,640
really big one right now but i will say

1390
00:45:46,069 --> 00:45:44,880
just you see small incremental changes

1391
00:45:49,109 --> 00:45:46,079
in the instrumentation

1392
00:45:52,309 --> 00:45:49,119
over time um are amazing

1393
00:45:53,990 --> 00:45:52,319
yeah i'd add that

1394
00:45:55,430 --> 00:45:54,000
you know we're going to be studying

1395
00:45:57,349 --> 00:45:55,440
these samples using techniques that

1396
00:45:58,870 --> 00:45:57,359
probably didn't exist when osiris-rex

1397
00:46:01,750 --> 00:45:58,880
launched

1398
00:46:02,790 --> 00:46:01,760
when we flew stardust i um and got back

1399
00:46:04,390 --> 00:46:02,800
and did the analysis

1400
00:46:05,750 --> 00:46:04,400
the initial analysis of the samples i

1401
00:46:07,190 --> 00:46:05,760
went and looked at all the techniques we

1402
00:46:07,990 --> 00:46:07,200
used and then compared to the list of

1403
00:46:09,990 --> 00:46:08,000
techniques

1404
00:46:11,589 --> 00:46:10,000
we told nasa we would try to use on the

1405
00:46:13,670 --> 00:46:11,599
samples when they came back

1406
00:46:14,630 --> 00:46:13,680
and the overlap wasn't all that big

1407
00:46:18,390 --> 00:46:14,640
actually um

1408
00:46:19,829 --> 00:46:18,400
that uh techniques had developed so much

1409
00:46:20,390 --> 00:46:19,839
over the course of the flight of the

1410
00:46:22,470 --> 00:46:20,400
mission

1411
00:46:24,150 --> 00:46:22,480
um that we were doing things to the

1412
00:46:27,430 --> 00:46:24,160
samples that we hadn't even imagined

1413
00:46:27,990 --> 00:46:27,440

when we first started and there's no

1414
00:46:30,150 --> 00:46:28,000
reason to believe

1415
00:46:31,990 --> 00:46:30,160
this will stop um and and uh the fact

1416
00:46:34,950 --> 00:46:32,000
that the samples by the territorial

1417
00:46:36,630 --> 00:46:34,960
facility will they'll be available for

1418
00:46:39,670 --> 00:46:36,640
you know decades to come just means that

1419
00:46:42,150 --> 00:46:39,680
we'll just keep happening

1420
00:46:44,150 --> 00:46:42,160
and to combine those two answers uh when

1421
00:46:44,870 --> 00:46:44,160
we first wrote the osophosaurus rex we

1422
00:46:46,870 --> 00:46:44,880
hadn't

1423
00:46:48,069 --> 00:46:46,880
included ultra high resolution mass

1424
00:46:49,349 --> 00:46:48,079
spectrometry

1425
00:46:51,349 --> 00:46:49,359
which is one of the techniques that's

1426
00:46:53,030 --> 00:46:51,359
being applied to

1427
00:46:55,030 --> 00:46:53,040
liquid chromatography and other

1428
00:46:57,990 --> 00:46:55,040
techniques which is now

1429
00:46:59,750 --> 00:46:58,000
which had been which had existed but was

1430
00:47:01,589 --> 00:46:59,760
really out of the reach of these sorts

1431
00:47:03,910 --> 00:47:01,599
of samples and now they are

1432
00:47:05,750 --> 00:47:03,920
almost routine and they they will shed

1433
00:47:07,510 --> 00:47:05,760
tremendous amounts of information

1434
00:47:09,430 --> 00:47:07,520
and our sample analysis plan now

1435
00:47:09,990 --> 00:47:09,440
includes several different approaches

1436
00:47:11,990 --> 00:47:10,000
with different

1437
00:47:13,750 --> 00:47:12,000
kinds of ultra high resolution mass

1438
00:47:15,750 --> 00:47:13,760

spectrometry

1439
00:47:17,190 --> 00:47:15,760
um yeah there's too much and you know it

1440
00:47:17,670 --> 00:47:17,200
is hard to predict the future who knows

1441
00:47:19,030 --> 00:47:17,680
what

1442
00:47:20,790 --> 00:47:19,040
the great techniques of the future will

1443
00:47:21,270 --> 00:47:20,800
be but yeah we're very much in that kind

1444
00:47:24,630 --> 00:47:21,280
of

1445
00:47:26,630 --> 00:47:24,640
learning and using new things

1446
00:47:28,230 --> 00:47:26,640
it's like the galileo spacecraft used a

1447
00:47:29,750 --> 00:47:28,240
much different camera system than

1448
00:47:31,670 --> 00:47:29,760
we would have sent by the time it

1449
00:47:32,950 --> 00:47:31,680
actually got to the jovian system

1450
00:47:34,390 --> 00:47:32,960
and these things happened in space

1451
00:47:35,910 --> 00:47:34,400
exploration so i'm very glad you pointed

1452
00:47:38,549 --> 00:47:35,920
that out scott

1453
00:47:39,589 --> 00:47:38,559
our next question comes from tom caruso

1454
00:47:41,190 --> 00:47:39,599
on facebook

1455
00:47:42,710 --> 00:47:41,200
uh tom has been watching this show for

1456
00:47:44,069 --> 00:47:42,720
quite some time and i happen to know

1457
00:47:47,030 --> 00:47:44,079
that tom loves

1458
00:47:48,870 --> 00:47:47,040
the icy ocean worlds of our solar system

1459
00:47:49,670 --> 00:47:48,880
and so his question isn't too surprising

1460
00:47:51,190 --> 00:47:49,680
to me

1461
00:47:53,190 --> 00:47:51,200
uh he does thank all three of you for

1462
00:47:54,150 --> 00:47:53,200
your time and then he wants to know if

1463
00:47:56,870 --> 00:47:54,160

you can describe

1464
00:47:58,150 --> 00:47:56,880
what we've learned so far from bennu and

1465
00:48:00,950 --> 00:47:58,160
whether that will possibly

1466
00:48:04,829 --> 00:48:00,960
tell us anything about the rocky cores

1467
00:48:10,390 --> 00:48:07,510
system

1468
00:48:12,470 --> 00:48:10,400
that's a really great question i'm going

1469
00:48:12,790 --> 00:48:12,480
to be the first to say that that is so

1470
00:48:15,030 --> 00:48:12,800
far

1471
00:48:16,470 --> 00:48:15,040
outside of the realm of my expertise

1472
00:48:21,990 --> 00:48:16,480
that i would be

1473
00:48:26,150 --> 00:48:24,069
um yeah well you know i don't know much

1474
00:48:29,510 --> 00:48:26,160
about the course of these objects myself

1475
00:48:32,630 --> 00:48:29,520
um but i we do i think believe that

1476
00:48:34,309 --> 00:48:32,640
objects like bennu are quite primitive

1477
00:48:36,150 --> 00:48:34,319
in the sense that they have they've been

1478
00:48:37,829 --> 00:48:36,160
altered since they first formed but they

1479
00:48:39,109 --> 00:48:37,839
haven't been altered to the extent for

1480
00:48:43,030 --> 00:48:39,119
example the earth

1481
00:48:45,109 --> 00:48:43,040
or these kinds of satellites have

1482
00:48:47,270 --> 00:48:45,119
and so studying objects like bennu at

1483
00:48:49,990 --> 00:48:47,280
least gives you a better understanding

1484
00:48:51,430 --> 00:48:50,000
of kind of where you started from

1485
00:48:53,670 --> 00:48:51,440
so the cores of these satellites have

1486
00:48:55,750 --> 00:48:53,680
really had a very specific history

1487
00:48:57,589 --> 00:48:55,760
unique to themselves

1488
00:48:59,589 --> 00:48:57,599

but they were initially made from

1489
00:49:00,230 --> 00:48:59,599
materials that spent time in the solar

1490
00:49:03,270 --> 00:49:00,240
nebula

1491
00:49:06,069 --> 00:49:03,280
and went through those processes and so

1492
00:49:07,510 --> 00:49:06,079
i don't know that bennu can use to

1493
00:49:08,950 --> 00:49:07,520
directly address the nature of the

1494
00:49:10,470 --> 00:49:08,960
course of these satellites but it

1495
00:49:11,349 --> 00:49:10,480
certainly gives us a hint of the kinds

1496
00:49:12,870 --> 00:49:11,359
of things

1497
00:49:14,470 --> 00:49:12,880
that would have been in the ingredients

1498
00:49:15,910 --> 00:49:14,480
list for the cooking for you know that's

1499
00:49:17,270 --> 00:49:15,920
a very different recipe to make one of

1500
00:49:19,670 --> 00:49:17,280
these satellites and to make

1501
00:49:21,270 --> 00:49:19,680
bennu you know or the earth but at least

1502
00:49:24,390 --> 00:49:21,280
some of the ingredients may have

1503
00:49:27,910 --> 00:49:24,400
been similar indeed

1504
00:49:30,230 --> 00:49:27,920
um the other thing you're both correct

1505
00:49:32,790 --> 00:49:30,240
it's very hard to say something specific

1506
00:49:33,349 --> 00:49:32,800
um we look at the sandwich we might we

1507
00:49:36,069 --> 00:49:33,359
have

1508
00:49:37,109 --> 00:49:36,079
learned more about uh perhaps how

1509
00:49:41,829 --> 00:49:37,119
impacts form

1510
00:49:45,030 --> 00:49:41,839
on uh on uh very loose rocks that might

1511
00:49:46,870 --> 00:49:45,040
perhaps melt intercourse and

1512
00:49:49,109 --> 00:49:46,880
that maybe that that helps maybe it

1513
00:49:52,150 --> 00:49:49,119

doesn't but we also have learned that

1514
00:49:53,589 --> 00:49:52,160
we have evidence of uh rocks on the

1515
00:49:55,990 --> 00:49:53,599
surface of bennu from

1516
00:49:57,430 --> 00:49:56,000
perhaps vesta and so that tells us

1517
00:50:00,470 --> 00:49:57,440
something about how

1518
00:50:01,670 --> 00:50:00,480
these um these bodies can exchange

1519
00:50:02,790 --> 00:50:01,680
material which is something that hadn't

1520
00:50:05,750 --> 00:50:02,800
really been thought about

1521
00:50:07,349 --> 00:50:05,760
so much and so perhaps we'll get a piece

1522
00:50:09,910 --> 00:50:07,359
of the of this festoid uh

1523
00:50:11,349 --> 00:50:09,920
back and if festa then well maybe series

1524
00:50:12,870 --> 00:50:11,359
two

1525
00:50:14,950 --> 00:50:12,880
that's incredible to think about i think

1526
00:50:16,710 --> 00:50:14,960
a lot of people are kind of unaware that

1527
00:50:18,790 --> 00:50:16,720
in the very early solar system there

1528
00:50:20,630 --> 00:50:18,800
were so many worldlets

1529
00:50:22,150 --> 00:50:20,640
just flying around and crashing into

1530
00:50:24,069 --> 00:50:22,160
each other and that's how we get things

1531
00:50:25,510 --> 00:50:24,079
like vesta and ceres and some of these

1532
00:50:27,270 --> 00:50:25,520
other bodies we see now

1533
00:50:29,109 --> 00:50:27,280
it wasn't all just formed where it is

1534
00:50:31,030 --> 00:50:29,119
now there's a lot of change in the

1535
00:50:32,390 --> 00:50:31,040
early solar system so that makes me

1536
00:50:33,910 --> 00:50:32,400
wonder a lot about the samples we might

1537
00:50:35,190 --> 00:50:33,920
get back now and if there is some

1538
00:50:37,349 --> 00:50:35,200

vestoid material and

1539
00:50:38,549 --> 00:50:37,359
i love that term too jason oh we know

1540
00:50:40,150 --> 00:50:38,559
from the returned

1541
00:50:41,750 --> 00:50:40,160
you know meteorites meteorites or

1542
00:50:44,950 --> 00:50:41,760
britches they actually are

1543
00:50:46,470 --> 00:50:44,960
ensembles of rock rocks they clearly

1544
00:50:47,510 --> 00:50:46,480
have very different histories that got

1545
00:50:49,030 --> 00:50:47,520
together

1546
00:50:50,950 --> 00:50:49,040
on a parent body and then ultimately

1547
00:50:53,030 --> 00:50:50,960
made it to us and so it's quite clear

1548
00:50:54,470 --> 00:50:53,040
these objects do in fact swap materials

1549
00:50:56,309 --> 00:50:54,480
back and forth and

1550
00:50:58,630 --> 00:50:56,319
we definitely did it and probably did it

1551
00:51:00,630 --> 00:50:58,640
at a very high rate in the early solar

1552
00:51:02,230 --> 00:51:00,640
nebula we've even observed enormous

1553
00:51:04,549 --> 00:51:02,240
stretches on bennu uh

1554
00:51:05,270 --> 00:51:04,559
meters across that brushes so the

1555
00:51:07,670 --> 00:51:05,280
brushes

1556
00:51:09,109 --> 00:51:07,680
we now know are both fine scale in the

1557
00:51:11,030 --> 00:51:09,119
the micron across

1558
00:51:13,270 --> 00:51:11,040
all the way up to meter-sized branches

1559
00:51:15,190 --> 00:51:13,280
so uh this this tells us something about

1560
00:51:16,950 --> 00:51:15,200
how planetesimals form

1561
00:51:19,030 --> 00:51:16,960
and i'm sure someone smarter than me

1562
00:51:21,430 --> 00:51:19,040
could apply that to the cores of

1563
00:51:23,750 --> 00:51:21,440

of ocean worlds love it yeah again

1564
00:51:24,230 --> 00:51:23,760
astrobiology and planetary science we

1565
00:51:26,069 --> 00:51:24,240
are

1566
00:51:27,510 --> 00:51:26,079
these large fields bringing together all

1567
00:51:28,870 --> 00:51:27,520
these different studies so that

1568
00:51:30,710 --> 00:51:28,880
the work you're doing right now in

1569
00:51:32,710 --> 00:51:30,720
organic chemistry and understanding

1570
00:51:33,990 --> 00:51:32,720
these materials forming on bennu

1571
00:51:35,990 --> 00:51:34,000
and the samples we're returning can

1572
00:51:37,750 --> 00:51:36,000
teach us about these other worlds

1573
00:51:39,910 --> 00:51:37,760
the expertise of other scientists as

1574
00:51:41,829 --> 00:51:39,920
well and i really love that

1575
00:51:43,589 --> 00:51:41,839
our next question comes from sanjoy

1576
00:51:45,670 --> 00:51:43,599
psalm using second net

1577
00:51:47,750 --> 00:51:45,680
but i want to alter his question just a

1578
00:51:49,510 --> 00:51:47,760
little bit uh he wants to know what all

1579
00:51:50,790 --> 00:51:49,520
of your favorite solar system objects

1580
00:51:53,109 --> 00:51:50,800
are

1581
00:51:54,309 --> 00:51:53,119
i'd like to alter that just a little bit

1582
00:51:57,670 --> 00:51:54,319
and say

1583
00:51:59,430 --> 00:51:57,680
if funding wasn't an issue and you could

1584
00:52:02,230 --> 00:51:59,440
choose whichever mission you want to

1585
00:52:04,150 --> 00:52:02,240
create to go to some solar system body

1586
00:52:05,510 --> 00:52:04,160
what would be the mission or the body

1587
00:52:07,349 --> 00:52:05,520
and why

1588
00:52:09,589 --> 00:52:07,359

i can't narrow it down to one object i

1589
00:52:11,510 --> 00:52:09,599
mean uh i'm you know professionally my

1590
00:52:12,950 --> 00:52:11,520
interest is in small primitive bodies so

1591
00:52:14,230 --> 00:52:12,960
asteroids and comets

1592
00:52:16,150 --> 00:52:14,240
i have to say i do have a sort of

1593
00:52:20,230 --> 00:52:16,160
special soft spot

1594
00:52:22,230 --> 00:52:20,240
for jupiter's moon io uh back in my

1595
00:52:24,150 --> 00:52:22,240
postdoc days i actually got telescopic

1596
00:52:25,829 --> 00:52:24,160
data bio that allowed us to identify the

1597
00:52:28,069 --> 00:52:25,839
molecule so2

1598
00:52:30,309 --> 00:52:28,079
on the surface and figure out that um

1599
00:52:32,230 --> 00:52:30,319
many of the ices on i o must be

1600
00:52:33,750 --> 00:52:32,240
large you know giant sort of like ice

1601
00:52:34,950 --> 00:52:33,760
cube type things as opposed to just

1602
00:52:36,790 --> 00:52:34,960
frosts

1603
00:52:38,069 --> 00:52:36,800
um so that's a pretty cool object but

1604
00:52:40,950 --> 00:52:38,079
that's a pretty far

1605
00:52:44,829 --> 00:52:40,960
stretch from astrobiology so it's more

1606
00:52:50,630 --> 00:52:47,030
favorite

1607
00:52:52,390 --> 00:52:50,640
that's where we know that there's life

1608
00:52:53,670 --> 00:52:52,400
and that's where my house is and i keep

1609
00:52:55,829 --> 00:52:53,680
my stuff

1610
00:52:57,030 --> 00:52:55,839
but if i had to get a sample from

1611
00:53:00,470 --> 00:52:57,040
somewhere i'd choose

1612
00:53:00,790 --> 00:53:00,480
arakoth if that's how you say it uh that

1613
00:53:03,750 --> 00:53:00,800

is

1614
00:53:04,390 --> 00:53:03,760
a truly primitive object that's never

1615
00:53:07,510 --> 00:53:04,400
melted

1616
00:53:09,990 --> 00:53:07,520
this is the thing discovered by um uh

1617
00:53:11,670 --> 00:53:10,000
new horizons it's out past pluto and

1618
00:53:13,430 --> 00:53:11,680
having a sample of that back in earth

1619
00:53:16,390 --> 00:53:13,440
would be just amazing

1620
00:53:18,630 --> 00:53:16,400
uh and a technological miracle we don't

1621
00:53:20,309 --> 00:53:18,640
have that ability right now but you know

1622
00:53:21,829 --> 00:53:20,319
if i had my fantasy that would be a

1623
00:53:25,910 --> 00:53:21,839
piece of that

1624
00:53:26,630 --> 00:53:25,920
i love it so like jason i am fond of the

1625
00:53:30,390 --> 00:53:26,640
earth

1626
00:53:33,109 --> 00:53:30,400
um i also have a fondness for titan

1627
00:53:33,829 --> 00:53:33,119
but if i if money were not an object and

1628
00:53:37,030 --> 00:53:33,839
i had

1629
00:53:39,510 --> 00:53:37,040
the engineering skills like scott

1630
00:53:41,990 --> 00:53:39,520
i am a sucker for the primitive material

1631
00:53:44,069 --> 00:53:42,000
so i really want comets and asteroids so

1632
00:53:47,750 --> 00:53:44,079
if i could send something out

1633
00:53:50,470 --> 00:53:47,760
sample stove sample stow and have it hop

1634
00:53:52,150 --> 00:53:50,480
from asteroid to asteroid and maybe pick

1635
00:53:54,390 --> 00:53:52,160
up a little bit of comet tail

1636
00:53:55,670 --> 00:53:54,400
and a little coma material as it flies

1637
00:53:57,510 --> 00:53:55,680
through then

1638
00:53:59,829 --> 00:53:57,520

you know why not that that is what

1639
00:54:01,829 --> 00:53:59,839
that's where my my money would go

1640
00:54:03,990 --> 00:54:01,839
ah see that audience those paying

1641
00:54:05,910 --> 00:54:04,000
attention the primitive asteroid hopper

1642
00:54:08,230 --> 00:54:05,920
is the mission you need to build for eve

1643
00:54:10,470 --> 00:54:08,240
for her future research

1644
00:54:12,309 --> 00:54:10,480
future missions i also second jason's

1645
00:54:13,670 --> 00:54:12,319
thing about ice i mean you know when i'm

1646
00:54:15,109 --> 00:54:13,680
not doing sample return missions my

1647
00:54:16,630 --> 00:54:15,119
laboratory work is largely trying to

1648
00:54:18,950 --> 00:54:16,640
understand the

1649
00:54:19,910 --> 00:54:18,960
molecular formation of molecular

1650
00:54:22,870 --> 00:54:19,920
complexity from

1651
00:54:23,990 --> 00:54:22,880
processing ices um and there are a lot

1652
00:54:25,990 --> 00:54:24,000
of ices out there

1653
00:54:27,109 --> 00:54:26,000
on not only in the outer solar system

1654
00:54:28,549 --> 00:54:27,119
but also in the

1655
00:54:30,390 --> 00:54:28,559
dense molecular cloud from which our

1656
00:54:32,870 --> 00:54:30,400
solar system formed

1657
00:54:33,910 --> 00:54:32,880
and uh so getting a sample of ice would

1658
00:54:36,470 --> 00:54:33,920
be great that's

1659
00:54:40,710 --> 00:54:36,480
technologically a real challenge but you

1660
00:54:44,789 --> 00:54:42,230
let's let's give ourselves a couple

1661
00:54:47,670 --> 00:54:44,799
meter core for stratigraphy too

1662
00:54:49,430 --> 00:54:47,680
sure why not i think i want to ask one

1663
00:54:50,150 --> 00:54:49,440

more question before we wrap the episode

1664
00:54:52,470 --> 00:54:50,160
here

1665
00:54:54,230 --> 00:54:52,480
um this one comes from kashish gupta

1666
00:54:56,309 --> 00:54:54,240
she's on facebook today

1667
00:54:57,910 --> 00:54:56,319
and kosh wants to know um as

1668
00:54:59,349 --> 00:54:57,920
astrobiologists not just

1669
00:55:01,190 --> 00:54:59,359
for osiris-rex and studying those

1670
00:55:02,150 --> 00:55:01,200
samples but but in general in your

1671
00:55:04,309 --> 00:55:02,160
research

1672
00:55:06,950 --> 00:55:04,319
what is your favorite piece of equipment

1673
00:55:09,109 --> 00:55:06,960
uh instrument or laboratory technique

1674
00:55:11,109 --> 00:55:09,119
and at what stage of your career did you

1675
00:55:13,990 --> 00:55:11,119
really get into that that that technique

1676
00:55:20,309 --> 00:55:17,190
i can start on this one if you like so

1677
00:55:21,670 --> 00:55:20,319
i really love uh the transmission

1678
00:55:24,789 --> 00:55:21,680
electron microscope

1679
00:55:26,230 --> 00:55:24,799
but i love it in conjunction with

1680
00:55:28,069 --> 00:55:26,240
liquid chromatography and mass

1681
00:55:30,630 --> 00:55:28,079
spectrometry because if i

1682
00:55:31,589 --> 00:55:30,640
take my sample and i extract my organic

1683
00:55:33,510 --> 00:55:31,599
materials

1684
00:55:35,430 --> 00:55:33,520
i can find out all the details about the

1685
00:55:36,230 --> 00:55:35,440
amino acids and other organics that are

1686
00:55:39,190 --> 00:55:36,240
in there

1687
00:55:40,069 --> 00:55:39,200
and then i can take the residual rock i

1688
00:55:42,150 --> 00:55:40,079

can prep it

1689
00:55:43,750 --> 00:55:42,160
for transmission electron microscopy and

1690
00:55:45,349 --> 00:55:43,760
i can tell you about the rock

1691
00:55:47,510 --> 00:55:45,359
those amino acids might have been

1692
00:55:48,549 --> 00:55:47,520
associated with i can tell you about its

1693
00:55:50,710 --> 00:55:48,559
mineralogy

1694
00:55:51,670 --> 00:55:50,720
and the interconnectedness of the

1695
00:55:53,430 --> 00:55:51,680
minerals

1696
00:55:55,510 --> 00:55:53,440
but really as much as i love

1697
00:55:57,109 --> 00:55:55,520
instrumentation anything that allows me

1698
00:56:00,230 --> 00:55:57,119
to get my hands dirty

1699
00:56:03,510 --> 00:56:00,240
in a lab is always going to trump um

1700
00:56:05,910 --> 00:56:03,520
analytical i love mixing together

1701
00:56:09,109 --> 00:56:05,920
you know commentary stimulant or making

1702
00:56:11,270 --> 00:56:09,119
fake asteroid for impacts or

1703
00:56:13,270 --> 00:56:11,280
simulating you know tidal pool

1704
00:56:15,510 --> 00:56:13,280
evaporation and recondensation on the

1705
00:56:17,349 --> 00:56:15,520
earth in a tiny little reactor

1706
00:56:19,430 --> 00:56:17,359
those are the things that i i enjoy the

1707
00:56:21,589 --> 00:56:19,440
most but taken as a whole

1708
00:56:23,589 --> 00:56:21,599
and i think the other part was when did

1709
00:56:27,030 --> 00:56:23,599
i start doing that in my career

1710
00:56:29,349 --> 00:56:27,040
um early on so in

1711
00:56:31,589 --> 00:56:29,359
uh really as an undergraduate when i was

1712
00:56:31,990 --> 00:56:31,599
doing my degree in chemistry i started

1713
00:56:34,789 --> 00:56:32,000

doing

1714
00:56:35,910 --> 00:56:34,799
experimental work and and also looking

1715
00:56:43,270 --> 00:56:35,920
at

1716
00:56:45,270 --> 00:56:43,280
as i went on for schooling and in jobs

1717
00:56:48,630 --> 00:56:45,280
to make sure that i was choosing careers

1718
00:56:51,309 --> 00:56:48,640
and places that would allow me to

1719
00:56:55,349 --> 00:56:51,319
exploit all of my interests

1720
00:56:59,270 --> 00:56:57,430
groovy scott or jason either of you have

1721
00:57:02,470 --> 00:56:59,280
a favorite technique

1722
00:57:03,750 --> 00:57:02,480
uh well i don't have um any technique

1723
00:57:05,349 --> 00:57:03,760
that will let me figure out things i'm

1724
00:57:07,589 --> 00:57:05,359
trying to figure out is a good one for

1725
00:57:09,910 --> 00:57:07,599
me i have a real fascination with these

1726
00:57:11,910 --> 00:57:09,920
isotopes and what they can tell us but i

1727
00:57:13,430 --> 00:57:11,920
guess if i had one technique that's been

1728
00:57:14,390 --> 00:57:13,440
with me the longest would be infrared

1729
00:57:17,190 --> 00:57:14,400
spectroscopy

1730
00:57:18,710 --> 00:57:17,200
i did my thesis work taking an infrared

1731
00:57:21,109 --> 00:57:18,720
spectra of comet dust

1732
00:57:22,789 --> 00:57:21,119
and asteroid dust upper stratosphere

1733
00:57:24,390 --> 00:57:22,799
using the il2 u2

1734
00:57:26,069 --> 00:57:24,400
aircraft that nasa was flying and

1735
00:57:28,870 --> 00:57:26,079
collecting uh

1736
00:57:30,789 --> 00:57:28,880
and then um also took our specter of

1737
00:57:32,470 --> 00:57:30,799
meteorites and then when i came to

1738
00:57:34,150 --> 00:57:32,480

work at ames i flew on the kuiper

1739
00:57:36,710 --> 00:57:34,160
airborne observatory and took

1740
00:57:37,349 --> 00:57:36,720
telescopic data objects throughout the

1741
00:57:41,109 --> 00:57:37,359
universe

1742
00:57:41,990 --> 00:57:41,119
uh in the infrared and then use that to

1743
00:57:43,270 --> 00:57:42,000
compare against

1744
00:57:45,109 --> 00:57:43,280
samples that i make in the

1745
00:57:46,390 --> 00:57:45,119
astrochemistry laboratory where i take

1746
00:57:48,710 --> 00:57:46,400
ices and irradiate them

1747
00:57:50,549 --> 00:57:48,720
and break down molecules make new ones

1748
00:57:51,990 --> 00:57:50,559
and infrared spectroscopy is at least

1749
00:57:53,829 --> 00:57:52,000
one of the techniques we can use while

1750
00:57:54,470 --> 00:57:53,839
we're looking at the isis and this issue

1751
00:57:56,549 --> 00:57:54,480
so

1752
00:57:58,150 --> 00:57:56,559
it's been a real workhorse and

1753
00:57:58,870 --> 00:57:58,160
particularly for someone like me who's

1754
00:58:00,309 --> 00:57:58,880
interested in

1755
00:58:01,910 --> 00:58:00,319
understanding all these materials take

1756
00:58:03,670 --> 00:58:01,920
their history back

1757
00:58:05,109 --> 00:58:03,680
into the interstellar medium we're never

1758
00:58:06,230 --> 00:58:05,119
going to go to a dense molecular cloud

1759
00:58:07,670 --> 00:58:06,240
at least not until someone

1760
00:58:09,270 --> 00:58:07,680
invents a warp drive we're not going to

1761
00:58:11,910 --> 00:58:09,280
go to a

1762
00:58:13,990 --> 00:58:11,920
dense molecular cloud and get sample so

1763
00:58:16,630 --> 00:58:14,000

simulation is kind of the only way to go

1764
00:58:18,069 --> 00:58:16,640
and the only way we can know what to

1765
00:58:18,950 --> 00:58:18,079
simulate what the ingredients in the

1766
00:58:20,710 --> 00:58:18,960
recipe are

1767
00:58:23,349 --> 00:58:20,720
is to take remote sensing with

1768
00:58:25,990 --> 00:58:23,359
telescopes and infrared spectroscopy is

1769
00:58:26,630 --> 00:58:26,000
very powerful for measuring molecular

1770
00:58:31,190 --> 00:58:26,640
bonds

1771
00:58:34,950 --> 00:58:33,750
yeah and my answer is i'm afraid similar

1772
00:58:37,910 --> 00:58:34,960
to eaves

1773
00:58:39,270 --> 00:58:37,920
i started using uh liquid chromatography

1774
00:58:42,549 --> 00:58:39,280
when i was a high school intern

1775
00:58:44,470 --> 00:58:42,559
so it's been a very long time uh and

1776
00:58:45,750 --> 00:58:44,480
coupling that with mass spectrometry

1777
00:58:47,829 --> 00:58:45,760
which i believe that

1778
00:58:49,190 --> 00:58:47,839
uh that our lab at goddard is the first

1779
00:58:50,950 --> 00:58:49,200
one to use

1780
00:58:53,030 --> 00:58:50,960
uh liquid chromatography mass

1781
00:58:53,750 --> 00:58:53,040
spectrometry to study meteoritic amino

1782
00:58:56,150 --> 00:58:53,760
acids

1783
00:58:57,510 --> 00:58:56,160
and so that that work pioneered as has

1784
00:58:59,910 --> 00:58:57,520
led on to new things

1785
00:59:01,750 --> 00:58:59,920
but also say that as great as as it is

1786
00:59:04,549 --> 00:59:01,760
take this technique to pull apart

1787
00:59:05,829 --> 00:59:04,559
complex mixtures it's also really sad

1788
00:59:07,589 --> 00:59:05,839

because it comes at the expense of

1789
00:59:09,270 --> 00:59:07,599
destroying the sample

1790
00:59:10,789 --> 00:59:09,280
and so i'm hoping that someone can come

1791
00:59:14,150 --> 00:59:10,799
up with a way to

1792
00:59:14,710 --> 00:59:14,160
look at the sample in situ uh it as a

1793
00:59:16,230 --> 00:59:14,720
rock

1794
00:59:18,470 --> 00:59:16,240
and pull apart all the individual

1795
00:59:19,990 --> 00:59:18,480
compounds in the mixture

1796
00:59:21,670 --> 00:59:20,000
without having to destroy the rock as

1797
00:59:22,470 --> 00:59:21,680
well but that technology doesn't really

1798
00:59:24,390 --> 00:59:22,480
exist yet

1799
00:59:26,230 --> 00:59:24,400
for at least the ways that the kind of

1800
00:59:28,150 --> 00:59:26,240
information i want

1801
00:59:29,589 --> 00:59:28,160
so there you go again viewers there's

1802
00:59:31,349 --> 00:59:29,599
another future way that you can be

1803
00:59:32,309 --> 00:59:31,359
involved and change the future of this

1804
00:59:34,870 --> 00:59:32,319
research

1805
00:59:36,710 --> 00:59:34,880
uh drzberger sanford and dwarken thank

1806
00:59:37,990 --> 00:59:36,720
you so much for joining us today for ask

1807
00:59:40,309 --> 00:59:38,000
an astrobiologist

1808
00:59:41,109 --> 00:59:40,319
it's been a true pleasure having you on

1809
00:59:43,910 --> 00:59:41,119
fun thank you

1810
00:59:44,870 --> 00:59:43,920
thank you and for all of our viewers who

1811
00:59:47,030 --> 00:59:44,880
are watching

1812
00:59:48,589 --> 00:59:47,040
uh maybe for your own entertainment go

1813
00:59:52,069 --> 00:59:48,599

on twitter use the hashtag

1814
00:59:53,670 --> 00:59:52,079
askastrobio tag at saginorg or tag at

1815
00:59:55,589 --> 00:59:53,680
nasa astrobio

1816
00:59:57,190 --> 00:59:55,599
and just let us know where you would

1817
00:59:59,589 --> 00:59:57,200
want to collect samples from

1818
01:00:01,109 --> 00:59:59,599
in our solar system to bring back to

1819
01:00:02,549 --> 01:00:01,119
earth to study

1820
01:00:04,630 --> 01:00:02,559
and if any of you want to know more

1821
01:00:06,789 --> 01:00:04,640
about the osiris-rex mission

1822
01:00:07,990 --> 01:00:06,799
uh what's been done so far and what lies

1823
01:00:10,870 --> 01:00:08,000
ahead for the future

1824
01:00:12,870 --> 01:00:10,880
you can go to asteroidmission.org to

1825
01:00:13,349 --> 01:00:12,880
find out a whole bunch more about the

1826
01:00:15,270 --> 01:00:13,359
theme

1827
01:00:16,870 --> 01:00:15,280
the mission the science and lots more

1828
01:00:17,990 --> 01:00:16,880
about osiris-rex

1829
01:00:19,990 --> 01:00:18,000
and for those who want to stay in the

1830
01:00:21,349 --> 01:00:20,000
loop for upcoming episodes of ask an

1831
01:00:23,589 --> 01:00:21,359
astrobiologist

1832
01:00:24,549 --> 01:00:23,599
or get more information about

1833
01:00:27,349 --> 01:00:24,559
opportunities

1834
01:00:27,990 --> 01:00:27,359
and news in astrobiology you can sign up

1835
01:00:30,950 --> 01:00:28,000
right now

1836
01:00:32,710 --> 01:00:30,960
for the nasa astrobiology newsletter uh

1837
01:00:35,430 --> 01:00:32,720
that goes out through email and

1838
01:00:36,950 --> 01:00:35,440

announces big things like our show uh

1839
01:00:38,870 --> 01:00:36,960
like when we have a tag

1840
01:00:40,309 --> 01:00:38,880
event and other cool things going on in

1841
01:00:42,069 --> 01:00:40,319
astrobiology for

1842
01:00:43,670 --> 01:00:42,079
all of you to stay up to par with what's

1843
01:00:46,309 --> 01:00:43,680
going on in this realm

1844
01:00:48,150 --> 01:00:46,319
of learning about life in the cosmos so

1845
01:00:49,670 --> 01:00:48,160
a huge thanks again to our panel for

1846
01:00:50,630 --> 01:00:49,680
joining us thanks to everyone for

1847
01:00:56,960 --> 01:00:50,640
watching