1
00:00:10,390 --> 00:00:08,230
good afternoon we're live here at

2
00:00:12,470 --> 00:00:10,400
kennedy space center i'm felicia chao

3
00:00:14,709 --> 00:00:12,480
public affairs officer and we've got

4
00:00:16,870 --> 00:00:14,719
exciting panel for you today we're going

5
00:00:18,870 --> 00:00:16,880
to be talking about how asteroids relate

6
00:00:21,349 --> 00:00:18,880
to the origins of our solar system our

7
00:00:23,029 --> 00:00:21,359
search for life and what nasa is doing

8
00:00:24,550 --> 00:00:23,039
now i'm sure um there might be some

9
00:00:26,550 --> 00:00:24,560
overlap in what you've already heard

10
00:00:28,710 --> 00:00:26,560
before but i'm sure that's also going to

11
00:00:30,470 --> 00:00:28,720
be very very eye-opening at least what

12
00:00:33,510 --> 00:00:30,480
we're going to be covering in our panel

13
00:00:36,630 --> 00:00:33,520

so today our panelists are ellen stofan

14
00:00:38,950 --> 00:00:36,640
nasa chief scientist at headquarters

15
00:00:40,470 --> 00:00:38,960
michelle fowler deputy director of

16
00:00:42,150 --> 00:00:40,480
science communications also at

17
00:00:44,549 --> 00:00:42,160
headquarters

18
00:00:46,549 --> 00:00:44,559
alex young heliophysics associate

19
00:00:48,630 --> 00:00:46,559
director at the goddard space flight

20
00:00:51,029 --> 00:00:48,640
center in greenbelt maryland

21
00:00:52,790 --> 00:00:51,039
and lynley johnson planetary defense

22
00:00:54,069 --> 00:00:52,800
officer at headquarters

23
00:00:55,910 --> 00:00:54,079
and with that

24
00:00:57,430 --> 00:00:55,920
ellen can you start us off with how

25
00:00:59,270 --> 00:00:57,440
asteroids relate to the origins of our

26
00:01:01,830 --> 00:00:59,280
solar system

27
00:01:03,270 --> 00:01:01,840
sure it is um such a pleasure to be here

28
00:01:05,109 --> 00:01:03,280
today it was such a pleasure this

29
00:01:06,310 --> 00:01:05,119
morning to see that rocket roll out to

30
00:01:08,149 --> 00:01:06,320
the pad

31
00:01:10,550 --> 00:01:08,159
we're really going to an asteroid

32
00:01:12,230 --> 00:01:10,560
tomorrow this is incredibly exciting

33
00:01:13,429 --> 00:01:12,240
because if i can have the first video

34
00:01:16,149 --> 00:01:13,439
cued up

35
00:01:17,429 --> 00:01:16,159
you know asteroids like bennu the

36
00:01:19,749 --> 00:01:17,439
information we're going to gain from

37
00:01:21,590 --> 00:01:19,759
osiris-rex it's really going to help

38
00:01:23,749 --> 00:01:21,600

pull back the curtains on the origin of

39
00:01:25,190 --> 00:01:23,759
this planet on the origin of life itself

40
00:01:27,109 --> 00:01:25,200
and we're going to be talking about that

41
00:01:28,630 --> 00:01:27,119
here this morning

42
00:01:33,590 --> 00:01:28,640
now

43
00:01:35,990 --> 00:01:33,600
billion years ago

44
00:01:37,590 --> 00:01:36,000
when at this point shortly before the

45
00:01:40,390 --> 00:01:37,600
formation of the sun

46
00:01:42,870 --> 00:01:40,400
what you had was a cloud of basically

47
00:01:44,310 --> 00:01:42,880
gas and dust like you're seeing in this

48
00:01:46,710 --> 00:01:44,320
video

49
00:01:48,789 --> 00:01:46,720
so just think everything that you're

50
00:01:50,389 --> 00:01:48,799
made of your cat is made of this

51
00:01:52,710 --> 00:01:50,399
building is made of

52
00:01:55,109 --> 00:01:52,720
all of that a little over 4.6 billion

53
00:01:56,950 --> 00:01:55,119
years ago was just part of this cloud of

54
00:01:59,429 --> 00:01:56,960
gas and dust

55
00:02:01,830 --> 00:01:59,439
then probably there was a nearby star

56
00:02:03,190 --> 00:02:01,840
explosion the shock waves from that came

57
00:02:05,429 --> 00:02:03,200
in

58
00:02:06,630 --> 00:02:05,439
disrupted that material the material

59
00:02:08,389 --> 00:02:06,640
collapsed

60
00:02:10,550 --> 00:02:08,399
and the sun formed

61
00:02:11,510 --> 00:02:10,560
and around that early sun

62
00:02:13,910 --> 00:02:11,520
was a

63
00:02:16,229 --> 00:02:13,920

this cloud of now most of the mass from

64
00:02:18,070 --> 00:02:16,239
that collapse went into the sun but the

65
00:02:19,910 --> 00:02:18,080
material that was left formed basically

66
00:02:21,910 --> 00:02:19,920
a rotating disk

67
00:02:24,309 --> 00:02:21,920
around that early sun and that's called

68
00:02:26,949 --> 00:02:24,319
a proto-planetary disk

69
00:02:29,990 --> 00:02:26,959
if i can have the next video

70
00:02:31,910 --> 00:02:30,000
so again now think 4.6 billion years ago

71
00:02:33,990 --> 00:02:31,920
most of the mass has gone into the sun

72
00:02:35,509 --> 00:02:34,000
and how do we know all this well our we

73
00:02:38,470 --> 00:02:35,519
have telescopes like the hubble space

74
00:02:40,630 --> 00:02:38,480
telescope that's now able to look at all

75
00:02:42,470 --> 00:02:40,640
these different stages of solar system

76
00:02:45,030 --> 00:02:42,480
formation not our solar systems but

77
00:02:47,190 --> 00:02:45,040
other solar systems that are forming

78
00:02:50,550 --> 00:02:47,200
now that dust as it's in this

79
00:02:52,390 --> 00:02:50,560
protoplanetary disk it's it's colliding

80
00:02:54,309 --> 00:02:52,400
those collisions are now producing

81
00:02:56,309 --> 00:02:54,319
bigger and bigger grains

82
00:02:57,910 --> 00:02:56,319
than clumps of material

83
00:03:00,790 --> 00:02:57,920
and then ultimately forming

84
00:03:01,910 --> 00:03:00,800
planetesimals which collide and form

85
00:03:04,710 --> 00:03:01,920
planets

86
00:03:07,110 --> 00:03:04,720
and that's where the earth came from

87
00:03:09,430 --> 00:03:07,120
now but not all of that material got

88
00:03:10,949 --> 00:03:09,440

swept up into planets some of it was

89
00:03:13,750 --> 00:03:10,959
left over

90
00:03:16,470 --> 00:03:13,760
that's asteroids that's comets so

91
00:03:18,790 --> 00:03:16,480
studying these materials are incredibly

92
00:03:20,790 --> 00:03:18,800
important because it is this fundamental

93
00:03:22,869 --> 00:03:20,800
building block material

94
00:03:24,149 --> 00:03:22,879
that the rest of the solar system is

95
00:03:25,509 --> 00:03:24,159
made of

96
00:03:27,190 --> 00:03:25,519
and given that we really only have

97
00:03:29,350 --> 00:03:27,200
samples right now we have a few samples

98
00:03:30,789 --> 00:03:29,360
from mars we have a lot of samples from

99
00:03:33,270 --> 00:03:30,799
the earth we have samples from the moon

100
00:03:35,589 --> 00:03:33,280
but we really have sampled such a small

101
00:03:36,789 --> 00:03:35,599
amount of the material in this solar

102
00:03:39,110 --> 00:03:36,799
system

103
00:03:40,630 --> 00:03:39,120
if i can have the next slide now what

104
00:03:42,949 --> 00:03:40,640
we've been doing obviously is trying to

105
00:03:44,630 --> 00:03:42,959
understand what is this material that

106
00:03:46,390 --> 00:03:44,640
we're all made of we have meteorite

107
00:03:48,470 --> 00:03:46,400
collections to study and from that we've

108
00:03:51,509 --> 00:03:48,480
learned not all these materials are the

109
00:03:53,110 --> 00:03:51,519
same you've got stony meteorites you

110
00:03:55,110 --> 00:03:53,120
have irons you have carbonaceous

111
00:03:57,750 --> 00:03:55,120
chondrites like bennu

112
00:03:59,350 --> 00:03:57,760
this is the asteroid ida it's about 59

113
00:04:00,630 --> 00:03:59,360

kilometers across this is an image from

114
00:04:02,630 --> 00:04:00,640
galileo

115
00:04:05,270 --> 00:04:02,640
this is just one type of asteroid it's a

116
00:04:07,990 --> 00:04:05,280
stony asteroid it actually even has its

117
00:04:10,229 --> 00:04:08,000
own moon uh called dactyl

118
00:04:11,750 --> 00:04:10,239
and this cratered surface kind of potato

119
00:04:13,509 --> 00:04:11,760
shape is kind of how i think about

120
00:04:15,190 --> 00:04:13,519
asteroids when i think about what they

121
00:04:16,229 --> 00:04:15,200
look like

122
00:04:18,069 --> 00:04:16,239
but

123
00:04:21,590 --> 00:04:18,079
this is just one type of asteroid if i

124
00:04:25,909 --> 00:04:23,830
this is itakawa it was imaged by the

125
00:04:27,670 --> 00:04:25,919
hayabusa spacecraft

126
00:04:29,189 --> 00:04:27,680
and you can see it looks very different

127
00:04:30,790 --> 00:04:29,199
the materials aren't actually all that

128
00:04:32,950 --> 00:04:30,800
different but instead what you have here

129
00:04:36,550 --> 00:04:32,960
is basically a rubble pile you've got

130
00:04:39,030 --> 00:04:36,560
very loosely consolidated material

131
00:04:40,629 --> 00:04:39,040
that is extremely interesting in how it

132
00:04:42,870 --> 00:04:40,639
formed how it formed over time you also

133
00:04:44,390 --> 00:04:42,880
notice it has this very unusual shape

134
00:04:46,150 --> 00:04:44,400
it's what we sometimes refer to as a

135
00:04:47,990 --> 00:04:46,160
contact binary it looks like two

136
00:04:49,350 --> 00:04:48,000
different large pieces of material have

137
00:04:50,629 --> 00:04:49,360
come together

138
00:04:52,550 --> 00:04:50,639

and some of you might think it's very

139
00:04:53,749 --> 00:04:52,560
reminiscent in shape but also in

140
00:04:57,510 --> 00:04:53,759
appearance

141
00:05:01,110 --> 00:04:57,520
being has been studied for the last

142
00:05:02,950 --> 00:05:01,120
several years uh by the rosetta mission

143
00:05:04,870 --> 00:05:02,960
now again there's different types of

144
00:05:06,390 --> 00:05:04,880
materials that are occurring different

145
00:05:08,469 --> 00:05:06,400
types of rock

146
00:05:10,550 --> 00:05:08,479
but one thing we do know is that the

147
00:05:12,150 --> 00:05:10,560
rocky asteroids we used to think that a

148
00:05:13,909 --> 00:05:12,160
lot of the water on the earth was

149
00:05:15,590 --> 00:05:13,919
brought to the earth by comets but over

150
00:05:16,950 --> 00:05:15,600
time we've actually figured out that we

151
00:05:18,390 --> 00:05:16,960
think most of the water on earth was

152
00:05:19,590 --> 00:05:18,400
actually brought here by asteroids

153
00:05:21,430 --> 00:05:19,600
that's part of the reason we like to

154
00:05:22,790 --> 00:05:21,440
study them

155
00:05:24,150 --> 00:05:22,800
now most of the asteroids in the

156
00:05:26,150 --> 00:05:24,160
asteroid belt like the ones i've been

157
00:05:27,749 --> 00:05:26,160
showing you most of those are are fairly

158
00:05:29,029 --> 00:05:27,759
rocky materials if you go out to the

159
00:05:30,790 --> 00:05:29,039
kuiper belt

160
00:05:32,790 --> 00:05:30,800
everything is much icier just think

161
00:05:34,629 --> 00:05:32,800
about pluto the other kuiper belt

162
00:05:36,629 --> 00:05:34,639
objects are like that much more made of

163
00:05:38,230 --> 00:05:36,639

the ices and michelle's going to be

164
00:05:39,430 --> 00:05:38,240
talking a little bit about why there's

165
00:05:41,110 --> 00:05:39,440
this difference in competitive

166
00:05:42,310 --> 00:05:41,120
composition between

167
00:05:44,070 --> 00:05:42,320
the inner

168
00:05:45,990 --> 00:05:44,080
belt materials we have and the outer

169
00:05:48,390 --> 00:05:46,000
solar system materials

170
00:05:50,629 --> 00:05:48,400
the next slide

171
00:05:52,469 --> 00:05:50,639
but one of the most important things

172
00:05:54,070 --> 00:05:52,479
that we've been learning is that

173
00:05:55,830 --> 00:05:54,080
asteroids aren't only a key to the

174
00:05:57,749 --> 00:05:55,840
building blocks of what our planets are

175
00:05:59,270 --> 00:05:57,759
made of and then therefore they help us

176
00:06:02,070 --> 00:05:59,280
understand the very early history of the

177
00:06:04,830 --> 00:06:02,080
earth how the earth works

178
00:06:07,749 --> 00:06:04,840
we've also discovered organic

179
00:06:09,270 --> 00:06:07,759
material in asteroids and you can see in

180
00:06:11,909 --> 00:06:09,280
in this image

181
00:06:13,350 --> 00:06:11,919
there's things like adenine guanine if

182
00:06:15,830 --> 00:06:13,360
those of you don't know those what those

183
00:06:18,390 --> 00:06:15,840
are those are called nucleobases these

184
00:06:20,550 --> 00:06:18,400
are the letters that make up our dna

185
00:06:22,550 --> 00:06:20,560
that make up our rna

186
00:06:24,790 --> 00:06:22,560
but the really cool thing is we haven't

187
00:06:25,909 --> 00:06:24,800
just found the letters basically of our

188
00:06:27,510 --> 00:06:25,919

dna

189
00:06:30,790 --> 00:06:27,520
in meteorites

190
00:06:32,710 --> 00:06:30,800
we've found other letters that we

191
00:06:34,390 --> 00:06:32,720
that life here on earth doesn't actually

192
00:06:35,909 --> 00:06:34,400
utilize

193
00:06:38,150 --> 00:06:35,919
now that's really cool because again

194
00:06:40,070 --> 00:06:38,160
this material is being delivered

195
00:06:42,230 --> 00:06:40,080
not just around our solar system but

196
00:06:44,070 --> 00:06:42,240
around our galaxy and there's different

197
00:06:47,110 --> 00:06:44,080
letters out there so when we start

198
00:06:48,629 --> 00:06:47,120
thinking about life on other planets

199
00:06:50,629 --> 00:06:48,639
we really start wondering what could

200
00:06:52,629 --> 00:06:50,639
that life be like is it different than

201
00:06:54,390 --> 00:06:52,639
life here on earth could it be utilizing

202
00:06:56,469 --> 00:06:54,400
some of those other letters

203
00:06:57,990 --> 00:06:56,479
we don't know but that's what we're

204
00:06:59,749 --> 00:06:58,000
trying to figure out

205
00:07:02,230 --> 00:06:59,759
michelle

206
00:07:04,469 --> 00:07:02,240
well thank you yes the the context of

207
00:07:06,629 --> 00:07:04,479
asteroids is is just really incredible

208
00:07:08,469 --> 00:07:06,639
in fact i have a carbonaceous conduit

209
00:07:09,990 --> 00:07:08,479
here in my pocket which is probably not

210
00:07:11,990 --> 00:07:10,000
something you hear a lot of people say

211
00:07:13,990 --> 00:07:12,000
so um this uh

212
00:07:16,150 --> 00:07:14,000
this is a meteorite sample uh it's a

213
00:07:17,909 --> 00:07:16,160

sample of the very very primitive type

214
00:07:19,270 --> 00:07:17,919
primitive but by i mean it's hardly been

215
00:07:20,790 --> 00:07:19,280
processed at all

216
00:07:22,870 --> 00:07:20,800
this little sliver of something is

217
00:07:25,350 --> 00:07:22,880
actually a bit older than the sun

218
00:07:27,189 --> 00:07:25,360
and it has all sorts of stuff in it it

219
00:07:29,270 --> 00:07:27,199
has more different kinds of organic

220
00:07:31,430 --> 00:07:29,280
molecules than you find in my body it

221
00:07:32,629 --> 00:07:31,440
has more nucleobases than you find in my

222
00:07:34,629 --> 00:07:32,639
dna

223
00:07:36,309 --> 00:07:34,639
and if you want to okay you are going to

224
00:07:38,390 --> 00:07:36,319
promise to give this back right whoever

225
00:07:39,670 --> 00:07:38,400
gets this right if i pass it around so

226
00:07:41,830 --> 00:07:39,680
if you look at there's a little there's

227
00:07:44,550 --> 00:07:41,840
a little inclusion in here which is one

228
00:07:46,469 --> 00:07:44,560
of the first solid pieces of our solar

229
00:07:48,469 --> 00:07:46,479
system that's real right here so you can

230
00:07:49,909 --> 00:07:48,479
pass that around

231
00:07:51,670 --> 00:07:49,919
there you go all right so there's your

232
00:07:53,350 --> 00:07:51,680
carbonaceous chondrite so if i could

233
00:07:55,189 --> 00:07:53,360
have my first graphic

234
00:07:58,070 --> 00:07:55,199
um the the thing that's amazing to me

235
00:08:00,550 --> 00:07:58,080
okay why do we need the story of comets

236
00:08:02,869 --> 00:08:00,560
and asteroids to to really figure out

237
00:08:04,710 --> 00:08:02,879
why life started here on earth and this

238
00:08:06,309 --> 00:08:04,720

is something that at nasa you're hearing

239
00:08:08,950 --> 00:08:06,319
today from us about some of the large

240
00:08:10,629 --> 00:08:08,960
strategic priorities of nasa science

241
00:08:12,950 --> 00:08:10,639
and one of the things that i'm involved

242
00:08:14,550 --> 00:08:12,960
in is the study of exoplanets planets

243
00:08:15,589 --> 00:08:14,560
around other stars

244
00:08:17,430 --> 00:08:15,599
and

245
00:08:20,189 --> 00:08:17,440
as of today as of this morning because i

246
00:08:23,189 --> 00:08:20,199
actually went and checked there are 3

247
00:08:25,430 --> 00:08:23,199
375 confirmed exoplanets

248
00:08:26,950 --> 00:08:25,440
and we're following up on almost 5 000

249
00:08:28,950 --> 00:08:26,960
more candidates

250
00:08:31,189 --> 00:08:28,960
and all of a sudden now it's not just an

251
00:08:33,750 --> 00:08:31,199
example of one solar system we now have

252
00:08:35,029 --> 00:08:33,760
a statistical sample of how many solar

253
00:08:37,029 --> 00:08:35,039
systems evolve

254
00:08:39,110 --> 00:08:37,039
and one of the things that we see

255
00:08:41,990 --> 00:08:39,120
is that where the earth formed around

256
00:08:44,630 --> 00:08:42,000
the sun as close as we are to the sun

257
00:08:46,630 --> 00:08:44,640
you find very very little water

258
00:08:48,470 --> 00:08:46,640
very little of what we call the volatile

259
00:08:50,470 --> 00:08:48,480
elements or compounds things that are

260
00:08:52,630 --> 00:08:50,480
easily evaporated things that don't

261
00:08:54,790 --> 00:08:52,640
survive under warm conditions and this

262
00:08:57,590 --> 00:08:54,800
is an artist's conception of a young

263
00:08:59,829 --> 00:08:57,600

solar system where what you're seeing is

264
00:09:02,470 --> 00:08:59,839
that the young star has basically either

265
00:09:04,710 --> 00:09:02,480
blown away or heated up all the material

266
00:09:07,590 --> 00:09:04,720
close to it and you need to get out to a

267
00:09:09,350 --> 00:09:07,600
certain distance away where it's cooler

268
00:09:11,910 --> 00:09:09,360
in order for these ices to start

269
00:09:13,190 --> 00:09:11,920
condensing and astronomers call this the

270
00:09:15,430 --> 00:09:13,200
snow line

271
00:09:17,430 --> 00:09:15,440
and in our solar system you really don't

272
00:09:19,350 --> 00:09:17,440
reach the snow line until you get out

273
00:09:21,509 --> 00:09:19,360
towards the orbit of jupiter

274
00:09:24,790 --> 00:09:21,519
so where the earth formed things were

275
00:09:26,790 --> 00:09:24,800
very dry and the earth is a rocky solid

276
00:09:28,710 --> 00:09:26,800
body that formed largely from compounds

277
00:09:30,310 --> 00:09:28,720
that you would find in that place but

278
00:09:31,430 --> 00:09:30,320
where did all of the stuff that makes us

279
00:09:32,870 --> 00:09:31,440
up come from

280
00:09:35,190 --> 00:09:32,880
and and this is where the story of

281
00:09:37,670 --> 00:09:35,200
asteroids really comes to the fort if i

282
00:09:40,310 --> 00:09:37,680
could have my next graphic

283
00:09:42,070 --> 00:09:40,320
you may have heard that nowadays we're

284
00:09:44,389 --> 00:09:42,080
actually trying to piece together how

285
00:09:46,230 --> 00:09:44,399
the early solar system was affected by

286
00:09:48,710 --> 00:09:46,240
the formation of the planets and

287
00:09:50,790 --> 00:09:48,720
possibly even planets moving around

288
00:09:52,949 --> 00:09:50,800

there's a current hypothesis that

289
00:09:53,910 --> 00:09:52,959
jupiter may not have formed where it is

290
00:09:55,590 --> 00:09:53,920
right now

291
00:09:57,829 --> 00:09:55,600
it may have formed a little farther out

292
00:10:00,710 --> 00:09:57,839
in the solar system it may have moved in

293
00:10:02,389 --> 00:10:00,720
almost as far in as the orbit of mars

294
00:10:04,550 --> 00:10:02,399
currently we have the juno mission that

295
00:10:06,389 --> 00:10:04,560
has just arrived at jupiter and one of

296
00:10:08,389 --> 00:10:06,399
the scientific goals of the juno mission

297
00:10:10,389 --> 00:10:08,399
is to look at the chemistry of jupiter

298
00:10:12,949 --> 00:10:10,399
and look for clues as to where jupiter

299
00:10:15,670 --> 00:10:12,959
formed and where it may have migrated

300
00:10:18,470 --> 00:10:15,680
so jupiter moved in we think probably

301
00:10:20,630 --> 00:10:18,480
past where the asteroid belt is now and

302
00:10:22,790 --> 00:10:20,640
that probably disrupted anything that

303
00:10:24,230 --> 00:10:22,800
was there we believe that almost all the

304
00:10:26,230 --> 00:10:24,240
material that was originally in the

305
00:10:28,069 --> 00:10:26,240
asteroid belt has either been thrown

306
00:10:30,230 --> 00:10:28,079
into the inner solar system or thrown

307
00:10:32,389 --> 00:10:30,240
out of our solar system entirely

308
00:10:34,470 --> 00:10:32,399
and this amazing era was called the era

309
00:10:36,389 --> 00:10:34,480
of heavy bombardment it happened many

310
00:10:38,389 --> 00:10:36,399
billions of years ago but this is an

311
00:10:40,389 --> 00:10:38,399
artist's conception of the idea that

312
00:10:41,990 --> 00:10:40,399
throwing in these asteroids throwing in

313
00:10:44,150 --> 00:10:42,000

these comets

314
00:10:45,990 --> 00:10:44,160
possibly under the influence of jupiter

315
00:10:47,910 --> 00:10:46,000
actually made for the arrival of all of

316
00:10:49,269 --> 00:10:47,920
the water all of the organics that we

317
00:10:51,110 --> 00:10:49,279
use today

318
00:10:53,110 --> 00:10:51,120
next slide

319
00:10:54,790 --> 00:10:53,120
and and this there's a larger context to

320
00:10:56,790 --> 00:10:54,800
this as well uh this is an artist's

321
00:10:59,190 --> 00:10:56,800
conception of an asteroid belt we found

322
00:11:01,350 --> 00:10:59,200
around the star epsilon eridani

323
00:11:03,190 --> 00:11:01,360
and epsilon eridani is one of the

324
00:11:05,590 --> 00:11:03,200
nearest stars to us it's only about 10

325
00:11:07,590 --> 00:11:05,600
light years away and the spitzer space

326
00:11:09,590 --> 00:11:07,600
telescope is a telescope that sees in

327
00:11:11,110 --> 00:11:09,600
infrared light so instead of visible

328
00:11:11,990 --> 00:11:11,120
light it actually is sensitive to heat

329
00:11:14,310 --> 00:11:12,000
light

330
00:11:16,069 --> 00:11:14,320
and using these heat sensitive eyes we

331
00:11:19,269 --> 00:11:16,079
could see that there were debris belts

332
00:11:21,110 --> 00:11:19,279
areas of warm dust around this star

333
00:11:23,030 --> 00:11:21,120
and in the case of epsilon eridani there

334
00:11:25,269 --> 00:11:23,040
is an asteroid belt

335
00:11:27,430 --> 00:11:25,279
nearly about where the asteroid belt is

336
00:11:29,030 --> 00:11:27,440
here it's about three astronomical units

337
00:11:30,150 --> 00:11:29,040
three times the earth's distance away

338
00:11:32,550 --> 00:11:30,160

from the sun

339
00:11:34,630 --> 00:11:32,560
so already we know of other solar

340
00:11:36,790 --> 00:11:34,640
systems that have something like our

341
00:11:38,630 --> 00:11:36,800
asteroid belt and there's even a farther

342
00:11:40,150 --> 00:11:38,640
out belt around epsilon eridani that's

343
00:11:41,509 --> 00:11:40,160
more like our kuiper belt where we find

344
00:11:44,069 --> 00:11:41,519
comets

345
00:11:45,110 --> 00:11:44,079
so in our exoplanet program and in the

346
00:11:46,949 --> 00:11:45,120
program where we're going to start

347
00:11:48,550 --> 00:11:46,959
looking for signs of life

348
00:11:50,150 --> 00:11:48,560
not only in our solar system but even

349
00:11:51,430 --> 00:11:50,160
around other stars

350
00:11:53,030 --> 00:11:51,440
we're trying to piece together the

351
00:11:55,190 --> 00:11:53,040
equation of where would it be likely to

352
00:11:56,870 --> 00:11:55,200
find life and perhaps one of the things

353
00:11:58,710 --> 00:11:56,880
that's in the positive column you know a

354
00:12:00,949 --> 00:11:58,720
good place that where life might exist

355
00:12:03,430 --> 00:12:00,959
is a place with asteroids an asteroid

356
00:12:05,269 --> 00:12:03,440
belt could have delivered the water the

357
00:12:07,030 --> 00:12:05,279
organic molecules to the inner solar

358
00:12:09,350 --> 00:12:07,040
system and made the conditions right for

359
00:12:13,269 --> 00:12:11,350
thank you michelle um so alex why don't

360
00:12:15,350 --> 00:12:13,279
you tell us about how

361
00:12:17,590 --> 00:12:15,360
asteroids can give us the history of our

362
00:12:19,030 --> 00:12:17,600
solar system yeah so um one of the

363
00:12:21,190 --> 00:12:19,040

things that's really interesting is

364
00:12:23,430 --> 00:12:21,200
asteroids are traveling through space

365
00:12:24,470 --> 00:12:23,440
and space is incredibly

366
00:12:26,150 --> 00:12:24,480
dynamic

367
00:12:28,310 --> 00:12:26,160
and very hostile

368
00:12:30,389 --> 00:12:28,320
and the reason is because of the sun

369
00:12:33,750 --> 00:12:30,399
mostly the sun

370
00:12:35,750 --> 00:12:33,760
is uh putting off this constant stream

371
00:12:38,629 --> 00:12:35,760
of particles if we look at the uh the

372
00:12:41,110 --> 00:12:38,639
next video you can see the sun's outer

373
00:12:43,110 --> 00:12:41,120
atmosphere is incredibly hot millions

374
00:12:45,670 --> 00:12:43,120
and millions of degrees so hot that it

375
00:12:46,949 --> 00:12:45,680
streams away and it carries off

376
00:12:50,150 --> 00:12:46,959
particles

377
00:12:52,150 --> 00:12:50,160
it carries off electricity and magnetism

378
00:12:54,389 --> 00:12:52,160
and this is traveling through the solar

379
00:12:57,910 --> 00:12:54,399
system in something we call the solar

380
00:13:01,190 --> 00:12:57,920
wind and it's bathing all of the bodies

381
00:13:03,269 --> 00:13:01,200
within the solar system and these are as

382
00:13:05,430 --> 00:13:03,279
actually danny mentioned last time

383
00:13:07,110 --> 00:13:05,440
talking about ionizing radiation

384
00:13:10,389 --> 00:13:07,120
one of the things is this is ionizing

385
00:13:12,389 --> 00:13:10,399
radiation so this is radiation that

386
00:13:15,430 --> 00:13:12,399
penetrates

387
00:13:17,910 --> 00:13:15,440
much farther than just uv light and it's

388
00:13:19,670 --> 00:13:17,920

hitting planets it's leaving its mark

389
00:13:22,790 --> 00:13:19,680
wherever it goes

390
00:13:24,550 --> 00:13:22,800
we can see it here it's going to pass

391
00:13:26,949 --> 00:13:24,560
venus and you can see it hitting the

392
00:13:29,350 --> 00:13:26,959
surface of venus because it doesn't have

393
00:13:31,590 --> 00:13:29,360
a strong magnetic field and this is the

394
00:13:34,550 --> 00:13:31,600
same situation that we have with an

395
00:13:35,990 --> 00:13:34,560
asteroid so as an asteroid is traveling

396
00:13:38,629 --> 00:13:36,000
through this

397
00:13:39,590 --> 00:13:38,639
uh incredibly dynamic

398
00:13:41,990 --> 00:13:39,600
space

399
00:13:43,829 --> 00:13:42,000
it's being bombarded over billions and

400
00:13:46,629 --> 00:13:43,839
billions of years

401
00:13:48,949 --> 00:13:46,639
and it's leaving its mark basically

402
00:13:51,750 --> 00:13:48,959
recording the history as it travels

403
00:13:53,350 --> 00:13:51,760
through the solar system

404
00:13:55,350 --> 00:13:53,360
but the interesting thing is that

405
00:13:57,509 --> 00:13:55,360
there's a little more to it so that was

406
00:13:59,670 --> 00:13:57,519
the solar wind which is constantly

407
00:14:01,509 --> 00:13:59,680
streaming away but the sun

408
00:14:05,110 --> 00:14:01,519
also has

409
00:14:07,750 --> 00:14:05,120
this ebb and flow of activity going from

410
00:14:09,350 --> 00:14:07,760
periods where it's extremely active

411
00:14:12,069 --> 00:14:09,360
throwing off

412
00:14:14,829 --> 00:14:12,079
big blobs billions of tons of solar

413
00:14:18,470 --> 00:14:14,839

material huge blasts of

414
00:14:21,350 --> 00:14:18,480
radiation and this is happening on top

415
00:14:22,470 --> 00:14:21,360
of what's happening with the solar wind

416
00:14:25,350 --> 00:14:22,480
but then

417
00:14:28,230 --> 00:14:25,360
when the sun is not active this actually

418
00:14:30,230 --> 00:14:28,240
allows another form of space weather to

419
00:14:33,670 --> 00:14:30,240
come into the system something in the

420
00:14:36,069 --> 00:14:33,680
form of galactic cosmic rays so when the

421
00:14:38,629 --> 00:14:36,079
sun is active it pushes those cosmic

422
00:14:41,910 --> 00:14:38,639
rays out of the solar system

423
00:14:44,470 --> 00:14:41,920
but when it's calm it lets those in so

424
00:14:47,110 --> 00:14:44,480
then we have this other component of

425
00:14:50,150 --> 00:14:47,120
energetic particles of energy that is

426
00:14:53,430 --> 00:14:50,160
bombarding these asteroids and so over

427
00:14:56,150 --> 00:14:53,440
time we're seeing this history

428
00:14:58,470 --> 00:14:56,160
of the change in the solar system the

429
00:14:59,750 --> 00:14:58,480
change in solar activity the change in

430
00:15:02,069 --> 00:14:59,760
the environment

431
00:15:04,629 --> 00:15:02,079
and this is really important because

432
00:15:07,350 --> 00:15:04,639
understanding how the sun has changed

433
00:15:09,509 --> 00:15:07,360
over time or how other stars have

434
00:15:11,269 --> 00:15:09,519
changed over time is critical for

435
00:15:12,389 --> 00:15:11,279
understanding the formation of life

436
00:15:13,269 --> 00:15:12,399
because we believe

437
00:15:16,470 --> 00:15:13,279
that

438
00:15:19,110 --> 00:15:16,480

not just water but the activity of the

439
00:15:22,949 --> 00:15:19,120
parent star

440
00:15:25,910 --> 00:15:22,959
has a huge role in the evolution of life

441
00:15:29,749 --> 00:15:25,920
and the evolution of solar systems

442
00:15:32,629 --> 00:15:29,759
both here and throughout the universe

443
00:15:35,749 --> 00:15:32,639
well thanks well speaking of the sun

444
00:15:37,269 --> 00:15:35,759
how does the sun affect the trajectory

445
00:15:39,749 --> 00:15:37,279
of asteroids

446
00:15:42,710 --> 00:15:39,759
so the sun has another area where it

447
00:15:45,590 --> 00:15:42,720
causes a little bit of trouble

448
00:15:47,829 --> 00:15:45,600
when if we look at the next graphic

449
00:15:50,389 --> 00:15:47,839
when an asteroid is rotating just like a

450
00:15:51,749 --> 00:15:50,399
planet it has a day and a night

451
00:15:54,629 --> 00:15:51,759
and when it's

452
00:15:56,949 --> 00:15:54,639
experiencing the day side is is getting

453
00:16:00,389 --> 00:15:56,959
heated up from the sun

454
00:16:01,990 --> 00:16:00,399
and then as it rotates to the night side

455
00:16:04,230 --> 00:16:02,000
and cools

456
00:16:05,590 --> 00:16:04,240
that radiation that's leaving the

457
00:16:08,470 --> 00:16:05,600
asteroid

458
00:16:10,470 --> 00:16:08,480
creates a very small force and that

459
00:16:13,269 --> 00:16:10,480
force depending on how the asteroid is

460
00:16:15,749 --> 00:16:13,279
rotating can either

461
00:16:18,470 --> 00:16:15,759
speed it up or slow it down and for

462
00:16:21,269 --> 00:16:18,480
smaller asteroids this can have a huge

463
00:16:23,350 --> 00:16:21,279

impact over time on the trajectory so

464
00:16:25,189 --> 00:16:23,360
we've come to find that

465
00:16:27,749 --> 00:16:25,199
we can't just determine where the

466
00:16:31,189 --> 00:16:27,759
asteroid is going to go just by normal

467
00:16:33,590 --> 00:16:31,199
orbital dynamics we have to account for

468
00:16:35,509 --> 00:16:33,600
this irkowski effect

469
00:16:37,910 --> 00:16:35,519
which is due to the the heating and

470
00:16:40,069 --> 00:16:37,920
cooling from the sun

471
00:16:41,990 --> 00:16:40,079
so we've heard a lot about how the sun

472
00:16:43,910 --> 00:16:42,000
can affect the trajectory of asteroids

473
00:16:46,710 --> 00:16:43,920
so lindley why don't you tell us about

474
00:16:48,870 --> 00:16:46,720
what nasa is doing to track and study

475
00:16:51,990 --> 00:16:48,880
asteroids

476
00:16:53,509 --> 00:16:52,000
okay well you've heard all about uh

477
00:16:54,949 --> 00:16:53,519
formation of the solar system and all

478
00:16:56,230 --> 00:16:54,959
the material that's left over from the

479
00:16:57,990 --> 00:16:56,240
solar system

480
00:16:59,829 --> 00:16:58,000
and the planets uh including earth

481
00:17:01,749 --> 00:16:59,839
getting bombarded by this material and

482
00:17:03,269 --> 00:17:01,759
it being the creation and probably the

483
00:17:05,750 --> 00:17:03,279
creation of life

484
00:17:07,750 --> 00:17:05,760
so where is all this matter now

485
00:17:09,750 --> 00:17:07,760
and is there any hazard to the earth

486
00:17:12,069 --> 00:17:09,760
being hit in the future

487
00:17:14,630 --> 00:17:12,079
all that is the job of the planetary

488
00:17:17,669 --> 00:17:14,640

defense coordination office at nasa and

489
00:17:19,429 --> 00:17:17,679
the projects that we have for surveying

490
00:17:21,829 --> 00:17:19,439
the solar system and finding where the

491
00:17:24,309 --> 00:17:21,839
asteroids and comets are if i could have

492
00:17:26,309 --> 00:17:24,319
the first uh animation here

493
00:17:28,789 --> 00:17:26,319
one of our projects is the

494
00:17:29,909 --> 00:17:28,799
neo-wise it's a spacecraft that's in

495
00:17:30,710 --> 00:17:29,919
earth orbit

496
00:17:32,390 --> 00:17:30,720
and

497
00:17:35,510 --> 00:17:32,400
as a earth

498
00:17:38,710 --> 00:17:35,520
revolves around the sun it sweeps out

499
00:17:40,870 --> 00:17:38,720
uh the population of asteroids now you

500
00:17:42,230 --> 00:17:40,880
clearly see the main asteroid belt the

501
00:17:44,789 --> 00:17:42,240
gray dots

502
00:17:47,270 --> 00:17:44,799
uh beyond the orbit of mars and i need

503
00:17:49,510 --> 00:17:47,280
to say that

504
00:17:51,190 --> 00:17:49,520
objects in this animation are very very

505
00:17:52,950 --> 00:17:51,200
much smaller than they appear here on

506
00:17:54,870 --> 00:17:52,960
the animation in fact you wouldn't be

507
00:17:56,390 --> 00:17:54,880
able to see them at all

508
00:18:00,390 --> 00:17:56,400
if we had them

509
00:18:03,190 --> 00:18:00,400
the size uh relative to the orbits uh

510
00:18:05,350 --> 00:18:03,200
the depictions in the movies are just uh

511
00:18:08,150 --> 00:18:05,360
you know totally not correct uh

512
00:18:09,830 --> 00:18:08,160
but uh star wars and uh and star trek

513
00:18:12,310 --> 00:18:09,840

beyond they go into these asteroid

514
00:18:13,909 --> 00:18:12,320
fields and these asteroids are all

515
00:18:14,789 --> 00:18:13,919
around and bouncing off of each other

516
00:18:17,190 --> 00:18:14,799
well

517
00:18:19,590 --> 00:18:17,200
uh we've shown uh in

518
00:18:21,110 --> 00:18:19,600
the juno mission uh in the don mission

519
00:18:23,029 --> 00:18:21,120
has spent several years in the asteroid

520
00:18:25,350 --> 00:18:23,039
belt and you can go through the asteroid

521
00:18:27,669 --> 00:18:25,360
belt without seeing a single asteroid

522
00:18:29,590 --> 00:18:27,679
unless we direct you right to

523
00:18:31,909 --> 00:18:29,600
to that asteroid

524
00:18:33,830 --> 00:18:31,919
so you see here uh the main asteroid

525
00:18:35,110 --> 00:18:33,840
belt and then you see these objects that

526
00:18:36,310 --> 00:18:35,120
have entered the inner solar system

527
00:18:38,230 --> 00:18:36,320
there in the green these are the

528
00:18:40,630 --> 00:18:38,240
near-earth asteroids in which the

529
00:18:43,029 --> 00:18:40,640
asteroid bennu is one of them

530
00:18:45,270 --> 00:18:43,039
bennu as mentioned previously was

531
00:18:46,950 --> 00:18:45,280
discovered by one of our projects

532
00:18:49,029 --> 00:18:46,960
the linear project

533
00:18:51,110 --> 00:18:49,039
back in 1999.

534
00:18:53,830 --> 00:18:51,120
uh could i have a next graphic so we

535
00:18:56,710 --> 00:18:53,840
have several survey projects that are

536
00:18:59,830 --> 00:18:56,720
discovering tracking and characterizing

537
00:19:01,430 --> 00:18:59,840
the near-earth object population neowise

538
00:19:03,110 --> 00:19:01,440

there's our one spacecraft this is

539
00:19:04,390 --> 00:19:03,120
actually a repurposed spacecraft its

540
00:19:06,950 --> 00:19:04,400
original mission

541
00:19:08,549 --> 00:19:06,960
was for astrophysics in mapping the

542
00:19:11,110 --> 00:19:08,559
infrared sky

543
00:19:12,870 --> 00:19:11,120
but we saw as we compared image to image

544
00:19:14,870 --> 00:19:12,880
we could uh discover the asteroids

545
00:19:16,950 --> 00:19:14,880
moving through those fields and made a

546
00:19:19,029 --> 00:19:16,960
very good asteroid hunter so after it

547
00:19:21,350 --> 00:19:19,039
completed its astrophysics mission we

548
00:19:22,950 --> 00:19:21,360
recruited it as an asteroid hunter and

549
00:19:25,270 --> 00:19:22,960
we've been operating it for three years

550
00:19:26,789 --> 00:19:25,280
now in that mode

551
00:19:29,350 --> 00:19:26,799
also we have several ground-based

552
00:19:30,710 --> 00:19:29,360
observatories the pan-starrs

553
00:19:34,230 --> 00:19:30,720
observatory

554
00:19:36,310 --> 00:19:35,190
has

555
00:19:38,549 --> 00:19:36,320
discovered

556
00:19:40,789 --> 00:19:38,559
a good number of the population of near

557
00:19:41,590 --> 00:19:40,799
earth objects uh that we know about now

558
00:19:43,909 --> 00:19:41,600
we're

559
00:19:46,710 --> 00:19:43,919
about to uh by the end of the year we

560
00:19:48,070 --> 00:19:46,720
will have some 15 000 objects in our

561
00:19:51,029 --> 00:19:48,080
catalog

562
00:19:52,630 --> 00:19:51,039
the linear project there in the middle

563
00:19:55,029 --> 00:19:52,640

kind of a far away view but you kind of

564
00:19:56,870 --> 00:19:55,039
see the kinds of terrain that these

565
00:19:58,549 --> 00:19:56,880
observatories are on

566
00:20:00,710 --> 00:19:58,559
the linear project

567
00:20:03,669 --> 00:20:00,720
was the uh

568
00:20:05,110 --> 00:20:03,679
project that discovered bennu back in

569
00:20:07,110 --> 00:20:05,120
1999

570
00:20:08,310 --> 00:20:07,120
and the catalina sky survey there on the

571
00:20:09,669 --> 00:20:08,320
lower right

572
00:20:12,390 --> 00:20:09,679
has also done

573
00:20:13,590 --> 00:20:12,400
a lot of the discoveries in the catalog

574
00:20:16,870 --> 00:20:13,600
and in fact

575
00:20:18,549 --> 00:20:16,880
a catalina sky survey just early monday

576
00:20:21,909 --> 00:20:18,559
morning discovered

577
00:20:25,029 --> 00:20:21,919
an object that had not been seen before

578
00:20:27,990 --> 00:20:25,039
catalog 2016 rb1

579
00:20:30,310 --> 00:20:28,000
and just right about now it is on its uh

580
00:20:32,549 --> 00:20:30,320
closest approach to the earth

581
00:20:33,510 --> 00:20:32,559
passing underneath the earth at about 21

582
00:20:35,830 --> 00:20:33,520
000

583
00:20:37,990 --> 00:20:35,840
miles that's closer than

584
00:20:39,110 --> 00:20:38,000
uh communication satellites orbit the

585
00:20:41,270 --> 00:20:39,120
earth

586
00:20:43,430 --> 00:20:41,280
but it is uh passing underneath the

587
00:20:45,990 --> 00:20:43,440
earth so it's not

588
00:20:47,909 --> 00:20:46,000

a hazard to to any of the spacecraft and

589
00:20:48,789 --> 00:20:47,919
it's not a hazard of of hitting the

590
00:20:49,830 --> 00:20:48,799
earth

591
00:20:53,110 --> 00:20:49,840
but

592
00:20:54,870 --> 00:20:53,120
what observatories can see it

593
00:20:56,789 --> 00:20:54,880
actually before and after it passes

594
00:20:58,390 --> 00:20:56,799
underneath the earth because in the

595
00:21:00,549 --> 00:20:58,400
southern hemisphere we don't have too

596
00:21:03,430 --> 00:21:00,559
many observatories that work on this uh

597
00:21:05,190 --> 00:21:03,440
we're taking as much uh

598
00:21:07,270 --> 00:21:05,200
data on it as we can it's a very small

599
00:21:08,390 --> 00:21:07,280
asteroid it's only about 10 meters in

600
00:21:09,590 --> 00:21:08,400
size

601
00:21:11,669 --> 00:21:09,600
according to

602
00:21:13,430 --> 00:21:11,679
looking at its brightness so if it were

603
00:21:15,590 --> 00:21:13,440
to have impacted the earth it would have

604
00:21:17,029 --> 00:21:15,600
disintegrated in the atmosphere

605
00:21:17,990 --> 00:21:17,039
i could have the next

606
00:21:19,750 --> 00:21:18,000
graphic

607
00:21:21,029 --> 00:21:19,760
so we detect these objects that come

608
00:21:23,590 --> 00:21:21,039
close to the earth

609
00:21:25,190 --> 00:21:23,600
on a regular basis uh most of them

610
00:21:27,510 --> 00:21:25,200
will pass by harmlessly but we're

611
00:21:29,190 --> 00:21:27,520
looking for one that that might cause us

612
00:21:31,909 --> 00:21:29,200
more of a problem

613
00:21:35,110 --> 00:21:31,919

back in october of last year we

614
00:21:38,950 --> 00:21:35,120
the panstarrs project discovered object

615
00:21:41,270 --> 00:21:38,960
designated 2015 tb145

616
00:21:44,950 --> 00:21:41,280
which was a fairly sizable object turned

617
00:21:46,789 --> 00:21:44,960
out to be about 60 meters uh 600 meters

618
00:21:47,750 --> 00:21:46,799
i'm sorry 600 meters

619
00:21:49,510 --> 00:21:47,760
across

620
00:21:52,470 --> 00:21:49,520
and the first images that we got of it

621
00:21:54,870 --> 00:21:52,480
that you see up there on the left uh

622
00:21:56,950 --> 00:21:54,880
it was close a pat approach to the earth

623
00:21:58,390 --> 00:21:56,960
was on halloween day so seeing these

624
00:22:00,710 --> 00:21:58,400
images uh

625
00:22:02,070 --> 00:22:00,720
about halloween time uh kind of startled

626
00:22:03,510 --> 00:22:02,080
this a little bit there if you have a

627
00:22:04,950 --> 00:22:03,520
little bit of imagination you can kind

628
00:22:06,789 --> 00:22:04,960
of see a ghostly

629
00:22:09,350 --> 00:22:06,799
ghostly image there

630
00:22:12,470 --> 00:22:09,360
that was imaged by the arecibo

631
00:22:14,950 --> 00:22:12,480
radio telescope in in puerto rico

632
00:22:17,430 --> 00:22:14,960
we also got radar images

633
00:22:19,190 --> 00:22:17,440
using our goldstone

634
00:22:22,390 --> 00:22:19,200
deep space network telescope in

635
00:22:24,710 --> 00:22:22,400
california and also spectrometry

636
00:22:27,669 --> 00:22:24,720
from the infrared

637
00:22:30,230 --> 00:22:27,679
telescope facility uh in hawaii

638
00:22:32,549 --> 00:22:30,240

that determined that uh this object was

639
00:22:35,510 --> 00:22:32,559
probably actually the dead nucleus of

640
00:22:36,230 --> 00:22:35,520
the comet uh where all the volatiles had

641
00:22:42,149 --> 00:22:36,240
uh

642
00:22:43,990 --> 00:22:42,159
close of previous close passages

643
00:22:44,710 --> 00:22:44,000
in the inner solar system

644
00:22:47,590 --> 00:22:44,720
but

645
00:22:48,789 --> 00:22:47,600
we got more detailed images uh next

646
00:22:50,310 --> 00:22:48,799
graphic

647
00:22:52,710 --> 00:22:50,320
of the object

648
00:22:55,669 --> 00:22:52,720
using goldstone as a transmitter and the

649
00:22:57,830 --> 00:22:55,679
green bank radio telescope is a receiver

650
00:22:59,830 --> 00:22:57,840
we have detailed resolution down here to

651
00:23:01,590 --> 00:22:59,840
about four meters in size

652
00:23:06,070 --> 00:23:01,600
and you see these bright spots on the

653
00:23:08,230 --> 00:23:06,080
surface of the asteroid and these are

654
00:23:10,390 --> 00:23:08,240
determined to be uh these are boulders

655
00:23:12,230 --> 00:23:10,400
that are sitting on the surface of this

656
00:23:14,710 --> 00:23:12,240
object

657
00:23:16,070 --> 00:23:14,720
several meters in size

658
00:23:17,909 --> 00:23:16,080
uh so

659
00:23:20,230 --> 00:23:17,919
what might we do if an object were

660
00:23:21,990 --> 00:23:20,240
discovered on an impact uh trajectory

661
00:23:24,310 --> 00:23:22,000
with the earth that's another area

662
00:23:26,710 --> 00:23:24,320
research for the planetary defense

663
00:23:29,430 --> 00:23:26,720

coordination office if i could have the

664
00:23:31,430 --> 00:23:29,440
next graphic

665
00:23:33,830 --> 00:23:31,440
one of the projects that we are working

666
00:23:35,750 --> 00:23:33,840
on in collaboration with the european

667
00:23:38,230 --> 00:23:35,760
space agency

668
00:23:42,390 --> 00:23:38,240
this project has just completed its

669
00:23:44,789 --> 00:23:42,400
concept studies and is ready

670
00:23:47,430 --> 00:23:44,799
if the decision is made to go into

671
00:23:49,110 --> 00:23:47,440
further uh design

672
00:23:51,269 --> 00:23:49,120
the asteroid impact and deflection

673
00:23:53,110 --> 00:23:51,279
assessment mission

674
00:23:55,669 --> 00:23:53,120
where the european space agency would

675
00:23:58,070 --> 00:23:55,679
build the rendezvous spacecraft uh

676
00:23:59,510 --> 00:23:58,080
called the asteroid impact monitor that

677
00:24:01,269 --> 00:23:59,520
would go out to

678
00:24:03,590 --> 00:24:01,279
uh this uh

679
00:24:06,230 --> 00:24:03,600
candidate asteroid called ditamos and

680
00:24:09,029 --> 00:24:06,240
this is actually a binary uh asteroid

681
00:24:12,230 --> 00:24:09,039
system uh uh asteroid that's about about

682
00:24:15,029 --> 00:24:12,240
the size of banu a little bigger

683
00:24:16,789 --> 00:24:15,039
that has its own small moon of about 100

684
00:24:18,630 --> 00:24:16,799
meters across

685
00:24:20,710 --> 00:24:18,640
that orbits it

686
00:24:22,789 --> 00:24:20,720
the aim spacecraft for the europeans

687
00:24:24,630 --> 00:24:22,799
would characterize the system and those

688
00:24:26,390 --> 00:24:24,640

those two bodies

689
00:24:28,789 --> 00:24:26,400
and then the

690
00:24:30,310 --> 00:24:28,799
nasa and the us would

691
00:24:32,710 --> 00:24:30,320
launch the

692
00:24:34,870 --> 00:24:32,720
double asteroid redirection test this is

693
00:24:35,909 --> 00:24:34,880
a kinetic impactor that would impact the

694
00:24:37,909 --> 00:24:35,919
moon

695
00:24:39,669 --> 00:24:37,919
of didamos which we affectionately refer

696
00:24:41,669 --> 00:24:39,679
to as diddy moon

697
00:24:43,510 --> 00:24:41,679
and

698
00:24:46,470 --> 00:24:43,520
demonstrate

699
00:24:48,630 --> 00:24:46,480
how much energy could be imparted

700
00:24:51,110 --> 00:24:48,640
to that body

701
00:24:51,990 --> 00:24:51,120
and change the orbital period of the

702
00:24:53,590 --> 00:24:52,000
moon

703
00:24:55,750 --> 00:24:53,600
and this way we were able to test the

704
00:24:56,789 --> 00:24:55,760
effectiveness of this kinetic deflection

705
00:24:59,269 --> 00:24:56,799
technique

706
00:25:00,870 --> 00:24:59,279
that is thought to be one of the

707
00:25:02,710 --> 00:25:00,880
technologies that we could use to

708
00:25:04,870 --> 00:25:02,720
redirect an asteroid

709
00:25:08,070 --> 00:25:04,880
it were on an impact trajectory if we

710
00:25:10,470 --> 00:25:08,080
found it enough years in advance

711
00:25:12,950 --> 00:25:10,480
another concept that we're working with

712
00:25:14,950 --> 00:25:12,960
is with the asteroid redirect mission of

713
00:25:16,149 --> 00:25:14,960

the human exploration operations mission

714
00:25:19,350 --> 00:25:16,159
directorate

715
00:25:22,390 --> 00:25:19,360
they are working on technology that will

716
00:25:25,350 --> 00:25:22,400
take us to mars in the future

717
00:25:27,350 --> 00:25:25,360
particularly solar electric propulsion

718
00:25:28,870 --> 00:25:27,360
and the ability to move large masses

719
00:25:31,350 --> 00:25:28,880
around the inner solar system like

720
00:25:33,669 --> 00:25:31,360
habitat modules and cargo if i could

721
00:25:36,789 --> 00:25:33,679
have the next graphic

722
00:25:39,269 --> 00:25:36,799
the asteroid redirect mission is of

723
00:25:40,789 --> 00:25:39,279
three major components the identify

724
00:25:43,909 --> 00:25:40,799
component is

725
00:25:45,350 --> 00:25:43,919
done by the neo observation program

726
00:25:46,789 --> 00:25:45,360
the planetary defense coordination

727
00:25:48,070 --> 00:25:46,799
office and that's finding good

728
00:25:49,669 --> 00:25:48,080
candidates

729
00:25:51,590 --> 00:25:49,679
for this mission

730
00:25:55,430 --> 00:25:51,600
we have one that

731
00:25:58,789 --> 00:25:55,440
has been being used in the design of the

732
00:26:02,070 --> 00:25:58,799
asteroid redirect robotic spacecraft

733
00:26:03,990 --> 00:26:02,080
and so that redirect part of the mission

734
00:26:05,590 --> 00:26:04,000
would be done by this robotic spacecraft

735
00:26:06,630 --> 00:26:05,600
which will go

736
00:26:08,870 --> 00:26:06,640
to

737
00:26:10,789 --> 00:26:08,880
this candidate body

738
00:26:13,669 --> 00:26:10,799

2005.

739
00:26:15,269 --> 00:26:13,679
or 2008 i'm sorry ev5

740
00:26:16,789 --> 00:26:15,279
is the candidate we're working with

741
00:26:18,789 --> 00:26:16,799
right now but we're continuing to look

742
00:26:21,990 --> 00:26:18,799
we might find a better one before uh the

743
00:26:23,750 --> 00:26:22,000
mission is launched it will go and uh

744
00:26:25,669 --> 00:26:23,760
to the surface of the asteroid to

745
00:26:27,669 --> 00:26:25,679
collect a boulder and then the crude

746
00:26:29,830 --> 00:26:27,679
mission uh

747
00:26:32,070 --> 00:26:29,840
will bring that boulder back to lunar

748
00:26:33,110 --> 00:26:32,080
orbit and a crude mission will go up to

749
00:26:35,110 --> 00:26:33,120
sample it

750
00:26:35,830 --> 00:26:35,120
if i could have the video

751
00:26:38,549 --> 00:26:35,840
uh

752
00:26:41,430 --> 00:26:38,559
of the arm mission concept video this is

753
00:26:44,070 --> 00:26:41,440
the solar electric propulsion spacecraft

754
00:26:46,310 --> 00:26:44,080
going out to the

755
00:26:48,950 --> 00:26:46,320
parent asteroid

756
00:26:51,269 --> 00:26:48,960
it has these landing legs

757
00:26:52,390 --> 00:26:51,279
and these grappling arms

758
00:26:54,549 --> 00:26:52,400
which

759
00:26:56,630 --> 00:26:54,559
will go down to the surface but first of

760
00:26:58,470 --> 00:26:56,640
all it will survey the service

761
00:27:01,909 --> 00:26:58,480
for a period of several months to select

762
00:27:03,909 --> 00:27:01,919
the best candidate boulder to retrieve

763
00:27:06,470 --> 00:27:03,919

and then once the

764
00:27:08,870 --> 00:27:06,480
investigation team has decided

765
00:27:10,070 --> 00:27:08,880
which boulder

766
00:27:11,590 --> 00:27:10,080
is the best

767
00:27:13,830 --> 00:27:11,600
to retrieve for the mission and bring

768
00:27:16,070 --> 00:27:13,840
back to lunar orbit it will slowly

769
00:27:18,950 --> 00:27:16,080
approach the surface

770
00:27:24,310 --> 00:27:22,230
land down on those legs

771
00:27:25,830 --> 00:27:24,320
and if these grappling arms that have

772
00:27:27,990 --> 00:27:25,840
these uh

773
00:27:31,350 --> 00:27:28,000
appendages at the end that are very much

774
00:27:33,029 --> 00:27:31,360
like a bunch of cat claws or cut cats in

775
00:27:35,990 --> 00:27:33,039
this again

776
00:27:37,110 --> 00:27:36,000
that these tines they go down and grip

777
00:27:39,590 --> 00:27:37,120
the boulder

778
00:27:41,590 --> 00:27:39,600
and actually these two grappling arms

779
00:27:43,029 --> 00:27:41,600
will lift that boulder up

780
00:27:44,710 --> 00:27:43,039
and uh

781
00:27:46,549 --> 00:27:44,720
then the

782
00:27:49,029 --> 00:27:46,559
spacecraft will depart the surface of

783
00:27:50,710 --> 00:27:49,039
the asteroid but before it leaves and

784
00:27:52,230 --> 00:27:50,720
goes to lunar orbit it will do what we

785
00:27:54,230 --> 00:27:52,240
call an enhanced gravity tractor and

786
00:27:55,909 --> 00:27:54,240
this is another technique for

787
00:27:58,789 --> 00:27:55,919
diverting

788
00:28:01,110 --> 00:27:58,799

a asteroid from its natural orbit just

789
00:28:03,110 --> 00:28:01,120
the mass of the spacecraft and this

790
00:28:05,190 --> 00:28:03,120
several tens of ton boulder

791
00:28:06,549 --> 00:28:05,200
as you station keep to one side of the

792
00:28:10,230 --> 00:28:06,559
asteroid

793
00:28:11,830 --> 00:28:10,240
nature's natural gravity rope

794
00:28:14,310 --> 00:28:11,840
nature's uh

795
00:28:16,710 --> 00:28:14,320
natural tug rope i should say gravity

796
00:28:17,750 --> 00:28:16,720
will pull that asteroid off its natural

797
00:28:20,389 --> 00:28:17,760
orbit

798
00:28:22,310 --> 00:28:20,399
uh and then the uh spacecraft after

799
00:28:23,269 --> 00:28:22,320
we've demonstrated that we'll uh come

800
00:28:25,269 --> 00:28:23,279
back

801
00:28:26,789 --> 00:28:25,279
to lunar orbit and the astronauts will

802
00:28:28,710 --> 00:28:26,799
go up and

803
00:28:30,950 --> 00:28:28,720
retrieve samples and return them to

804
00:28:33,909 --> 00:28:30,960
earth so

805
00:28:36,950 --> 00:28:33,919
uh already we have two techniques uh

806
00:28:38,710 --> 00:28:36,960
that are in concept and uh an entering

807
00:28:40,470 --> 00:28:38,720
demonstration phase for viable

808
00:28:42,310 --> 00:28:40,480
techniques to divert

809
00:28:43,350 --> 00:28:42,320
hazardous asteroids

810
00:28:45,669 --> 00:28:43,360
felicia

811
00:28:47,190 --> 00:28:45,679
thanks lindley um so before we open it

812
00:28:49,909 --> 00:28:47,200
up for questions and i'm sure you guys

813
00:28:52,549 --> 00:28:49,919

are dying to ask questions um ellen do

814
00:28:55,510 --> 00:28:52,559
you have any closing remarks

815
00:28:57,430 --> 00:28:55,520
sure so obviously we're all here to see

816
00:28:59,350 --> 00:28:57,440
what we consider to be a planetary

817
00:29:00,950 --> 00:28:59,360
mission launching to an asteroid to

818
00:29:02,549 --> 00:29:00,960
understand that basic material what is

819
00:29:05,190 --> 00:29:02,559
the asteroid made of what can it tell us

820
00:29:07,190 --> 00:29:05,200
about our own origins

821
00:29:08,789 --> 00:29:07,200
but in talking here today you've been

822
00:29:10,950 --> 00:29:08,799
hearing how it's connected to everything

823
00:29:13,350 --> 00:29:10,960
that we do at nasa from helping us to

824
00:29:14,870 --> 00:29:13,360
understand the possibility for life on

825
00:29:17,110 --> 00:29:14,880
extrasolar planets for helping us

826
00:29:19,110 --> 00:29:17,120
understand what the conditions are in

827
00:29:21,110 --> 00:29:19,120
solar system formation that can lead to

828
00:29:22,630 --> 00:29:21,120
the habitability of a planet

829
00:29:23,909 --> 00:29:22,640
we've heard about how the sun is so

830
00:29:25,590 --> 00:29:23,919
critical to

831
00:29:27,830 --> 00:29:25,600
the formation of life the evolution of

832
00:29:29,909 --> 00:29:27,840
life and yet it also influences what

833
00:29:31,190 --> 00:29:29,919
materials we even have on the surfaces

834
00:29:32,950 --> 00:29:31,200
of bodies

835
00:29:35,110 --> 00:29:32,960
and then of course it's always the human

836
00:29:37,430 --> 00:29:35,120
consideration how do these how do these

837
00:29:40,870 --> 00:29:37,440
asteroids potentially affect this planet

838
00:29:42,710 --> 00:29:40,880

in the past and and in the future

839
00:29:45,029 --> 00:29:42,720
so while sometimes we think of nasa as

840
00:29:46,710 --> 00:29:45,039
being these different organizations out

841
00:29:48,310 --> 00:29:46,720
answering lots of different questions

842
00:29:50,470 --> 00:29:48,320
those of us within nasa really see the

843
00:29:53,269 --> 00:29:50,480
connections between what we do whether

844
00:29:56,470 --> 00:29:53,279
it's jeff williams uh landing last night

845
00:29:58,470 --> 00:29:56,480
after his a record amount of stay

846
00:30:00,950 --> 00:29:58,480
in space over his career

847
00:30:02,950 --> 00:30:00,960
he's getting us ready to go to mars by

848
00:30:05,669 --> 00:30:02,960
helping us understand

849
00:30:07,590 --> 00:30:05,679
how humans can survive for long duration

850
00:30:09,269 --> 00:30:07,600
in microgravity

851
00:30:10,950 --> 00:30:09,279
that's connected to everything you're

852
00:30:13,029 --> 00:30:10,960
hearing today because we want to send

853
00:30:15,990 --> 00:30:13,039
humans to mars because we want to go

854
00:30:18,389 --> 00:30:16,000
find out if life originated on another

855
00:30:20,630 --> 00:30:18,399
body in our own solar system

856
00:30:21,909 --> 00:30:20,640
so from osiris-rex to the work we do

857
00:30:23,830 --> 00:30:21,919
every day on the international space

858
00:30:25,750 --> 00:30:23,840
station to the curiosity rover to the

859
00:30:28,149 --> 00:30:25,760
hubble space telescope to our future

860
00:30:29,990 --> 00:30:28,159
telescopes like james webb we're really

861
00:30:30,950 --> 00:30:30,000
trying to answer this fundamental

862
00:30:32,789 --> 00:30:30,960
question

863
00:30:34,470 --> 00:30:32,799

where did we come from

864
00:30:36,789 --> 00:30:34,480
how did this planet form and how is it

865
00:30:39,029 --> 00:30:36,799
going to change over time

866
00:30:40,549 --> 00:30:39,039
and are we alone

867
00:30:47,750 --> 00:30:40,559
so thank you all and we're ready to

868
00:30:51,990 --> 00:30:49,350
thanks now we're going to open up to

869
00:30:54,149 --> 00:30:52,000
folks in the room um so for those who

870
00:30:55,750 --> 00:30:54,159
want to ask questions via social media

871
00:30:58,549 --> 00:30:55,760
please submit the questions using the

872
00:31:00,310 --> 00:30:58,559
hashtag asknasa

873
00:31:04,310 --> 00:31:00,320
now um let's see

874
00:31:09,990 --> 00:31:07,909
hi um this question is for dr young also

875
00:31:11,350 --> 00:31:10,000
awesome shoes by the way thank you those

876
00:31:13,110 --> 00:31:11,360
are great um

877
00:31:15,990 --> 00:31:13,120
so you said that the

878
00:31:17,909 --> 00:31:16,000
sun can influence the motions of uh

879
00:31:19,909 --> 00:31:17,919
asteroids like bennu through the

880
00:31:21,830 --> 00:31:19,919
yarkovsky effect which is heating and

881
00:31:24,310 --> 00:31:21,840
cooling can it also

882
00:31:26,630 --> 00:31:24,320
affect their emotions through uh its

883
00:31:27,830 --> 00:31:26,640
outbursts like solar storms cmes things

884
00:31:30,310 --> 00:31:27,840
like that i mean those are obviously

885
00:31:33,029 --> 00:31:30,320
much bigger events do they can they move

886
00:31:35,110 --> 00:31:33,039
the asteroids around more than likely no

887
00:31:37,590 --> 00:31:35,120
i mean we don't know for certain so i

888
00:31:39,350 --> 00:31:37,600

can't say exactly but one of the key

889
00:31:41,350 --> 00:31:39,360
issues is that

890
00:31:43,269 --> 00:31:41,360
basically what's coming off not thinking

891
00:31:46,070 --> 00:31:43,279
about the charged particles but thinking

892
00:31:47,909 --> 00:31:46,080
about the cmes coronal mass ejections

893
00:31:50,149 --> 00:31:47,919
those are electromagnetic phenomena

894
00:31:52,549 --> 00:31:50,159
mainly and so it's really something that

895
00:31:55,269 --> 00:31:52,559
has a magnetic field that it's going to

896
00:31:57,350 --> 00:31:55,279
have an impact on so we have seen

897
00:32:00,389 --> 00:31:57,360
cmes interact with comets we've seen

898
00:32:01,990 --> 00:32:00,399
them strip the tails off of comets we've

899
00:32:04,389 --> 00:32:02,000
seen what we think is a magnetic

900
00:32:06,950 --> 00:32:04,399
reconnection happen in a comet but we

901
00:32:08,710 --> 00:32:06,960
don't think asteroids have these kinds

902
00:32:10,149 --> 00:32:08,720
of magnetic fields they don't have the

903
00:32:11,190 --> 00:32:10,159
coma they don't have the plasma

904
00:32:12,870 --> 00:32:11,200
structure

905
00:32:15,190 --> 00:32:12,880
so more than likely that sort of

906
00:32:17,190 --> 00:32:15,200
interaction will not happen

907
00:32:19,350 --> 00:32:17,200
but we could be wrong

908
00:32:21,190 --> 00:32:19,360
and we'll have to wait and see but more

909
00:32:25,509 --> 00:32:21,200
than likely no

910
00:32:25,519 --> 00:32:34,070
don't be shy

911
00:32:39,990 --> 00:32:36,630
now i've never heard of any meteorites

912
00:32:41,590 --> 00:32:40,000
being radioactive but which seems

913
00:32:43,350 --> 00:32:41,600

strange to me

914
00:32:45,190 --> 00:32:43,360
that you haven't heard of that i haven't

915
00:32:47,430 --> 00:32:45,200
heard of any is there any concern that

916
00:32:49,990 --> 00:32:47,440
any of these asteroids would contain

917
00:32:55,350 --> 00:32:50,000
radionuclides that are more powerful

918
00:33:01,190 --> 00:32:59,190
um well there isn't uh any enhanced uh

919
00:33:04,710 --> 00:33:01,200
you know radiation background in

920
00:33:07,269 --> 00:33:04,720
meteorites uh everything uh though has a

921
00:33:09,110 --> 00:33:07,279
radioactive signature it's just uh how

922
00:33:11,269 --> 00:33:09,120
strong it is i don't know we have a

923
00:33:12,710 --> 00:33:11,279
beater right expert over here jeff

924
00:33:21,509 --> 00:33:12,720
grossman

925
00:33:26,470 --> 00:33:24,389
so meteorites sometimes are always

926
00:33:29,110 --> 00:33:26,480
contain a little bit of enhanced

927
00:33:31,350 --> 00:33:29,120
radioactivity from cosmo jet what we

928
00:33:33,509 --> 00:33:31,360
call cosmogenic nuclides these are

929
00:33:34,870 --> 00:33:33,519
caused by interactions of energetic

930
00:33:38,149 --> 00:33:34,880
particles with the surface of the

931
00:33:40,230 --> 00:33:38,159
meteorite in space but the levels of of

932
00:33:41,990 --> 00:33:40,240
radioactivity are so low

933
00:33:44,389 --> 00:33:42,000
that you need special equipment just to

934
00:33:50,149 --> 00:33:44,399
detect them so

935
00:33:54,710 --> 00:33:52,630
i've heard that multiple like meteorites

936
00:33:56,950 --> 00:33:54,720
hit earth every day uh i was just

937
00:33:59,590 --> 00:33:56,960
wondering do they ever collide with our

938
00:34:01,909 --> 00:33:59,600

own satellites that orbit around us and

939
00:34:03,750 --> 00:34:01,919
uh if so is that something that you all

940
00:34:05,830 --> 00:34:03,760
help track and handle

941
00:34:08,550 --> 00:34:05,840
well yes that's exactly right there is

942
00:34:10,069 --> 00:34:08,560
uh over 100 tons of

943
00:34:12,069 --> 00:34:10,079
material

944
00:34:15,750 --> 00:34:12,079
that falls into the to the earth every

945
00:34:19,270 --> 00:34:18,230
from space

946
00:34:20,389 --> 00:34:19,280
we do

947
00:34:25,990 --> 00:34:20,399
uh

948
00:34:27,829 --> 00:34:26,000
impacting spacecraft

949
00:34:29,990 --> 00:34:27,839
we have an office at marshall space

950
00:34:31,109 --> 00:34:30,000
center the meteor rights environments

951
00:34:32,550 --> 00:34:31,119
office

952
00:34:34,950 --> 00:34:32,560
that

953
00:34:36,069 --> 00:34:34,960
monitors the

954
00:34:37,909 --> 00:34:36,079
flux

955
00:34:39,589 --> 00:34:37,919
of meteoroids

956
00:34:41,669 --> 00:34:39,599
to the planet

957
00:34:43,669 --> 00:34:41,679
to determine if there's any enhancement

958
00:34:45,990 --> 00:34:43,679
of what we call the background flux you

959
00:34:48,550 --> 00:34:46,000
know the stuff that happens every day

960
00:34:50,310 --> 00:34:48,560
and during a large meteor storms like

961
00:34:52,550 --> 00:34:50,320
the leonids

962
00:34:54,550 --> 00:34:52,560
there is some concern that spacecraft

963
00:34:56,950 --> 00:34:54,560

could be hit there's

964
00:34:58,950 --> 00:34:56,960
several incidents over time where we

965
00:35:01,270 --> 00:34:58,960
believe the spacecraft

966
00:35:04,710 --> 00:35:01,280
may have gotten hit by a meteorite it's

967
00:35:10,790 --> 00:35:07,109
until you go up and look at it but we

968
00:35:15,670 --> 00:35:13,430
weathering i will call it of the space

969
00:35:17,430 --> 00:35:15,680
station for instance getting hit by

970
00:35:19,030 --> 00:35:17,440
small meteorites

971
00:35:20,069 --> 00:35:19,040
there's even some dings in the windows

972
00:35:21,589 --> 00:35:20,079
of the space station you have to

973
00:35:23,270 --> 00:35:21,599
remember even small pieces of dust

974
00:35:27,670 --> 00:35:23,280
traveling at really high velocity can

975
00:35:32,230 --> 00:35:29,829
no it was the space station was designed

976
00:35:33,910 --> 00:35:32,240
to withstand that you know obviously it

977
00:35:35,750 --> 00:35:33,920
can't withstand huge particles but it

978
00:35:38,150 --> 00:35:35,760
was definitely designed to withstand

979
00:35:39,589 --> 00:35:38,160
these very small dust impacts but we

980
00:35:41,670 --> 00:35:39,599
keep a close eye on it no matter we

981
00:35:44,230 --> 00:35:41,680
actually saw an impact on mms

982
00:35:47,349 --> 00:35:44,240
the boom the little tiny boom sticking

983
00:35:50,790 --> 00:35:49,589
so we're going to take one more question

984
00:35:52,310 --> 00:35:50,800
in the room and then we're going to go

985
00:35:54,790 --> 00:35:52,320
to social media and then we'll go back

986
00:35:56,069 --> 00:35:54,800
to taking questions in the room

987
00:35:58,230 --> 00:35:56,079
generally speaking do we know the

988
00:36:00,470 --> 00:35:58,240

composition of most asteroids or do you

989
00:36:01,670 --> 00:36:00,480
expect to find possibly new materials on

990
00:36:03,589 --> 00:36:01,680
there i mean we're not looking at like

991
00:36:05,030 --> 00:36:03,599
unobtainium kind of thing but do you

992
00:36:08,150 --> 00:36:05,040
expect to find

993
00:36:09,829 --> 00:36:08,160
new materials on it

994
00:36:12,390 --> 00:36:09,839
well i think that's the whole reason why

995
00:36:15,030 --> 00:36:12,400
we have missions like osiris-rex to go

996
00:36:16,870 --> 00:36:15,040
out and see what we really know about

997
00:36:20,630 --> 00:36:16,880
asteroids

998
00:36:22,310 --> 00:36:20,640
we see the meteorites on the ground we

999
00:36:23,589 --> 00:36:22,320
are reasonably certain they came from

1000
00:36:24,950 --> 00:36:23,599
asteroids

1001
00:36:27,349 --> 00:36:24,960
comets

1002
00:36:30,310 --> 00:36:27,359
that were in orbit

1003
00:36:33,349 --> 00:36:30,320
so we know what we see from meteorites

1004
00:36:35,589 --> 00:36:33,359
but is that totally representative of

1005
00:36:37,270 --> 00:36:35,599
the composition of these objects so

1006
00:36:39,910 --> 00:36:37,280
that's why we need these space missions

1007
00:36:42,710 --> 00:36:39,920
like osiris-rex to go out and sample and

1008
00:36:44,150 --> 00:36:42,720
determine what all is there

1009
00:36:45,829 --> 00:36:44,160
i can tell you as a geologist there's

1010
00:36:48,470 --> 00:36:45,839
nothing that makes me more uncomfortable

1011
00:36:50,470 --> 00:36:48,480
than a rock out of context and you know

1012
00:36:52,069 --> 00:36:50,480
that's why osiris-rex is such an

1013
00:36:54,230 --> 00:36:52,079

exciting mission because we don't know

1014
00:36:56,230 --> 00:36:54,240
what we don't know and so to actually be

1015
00:36:58,150 --> 00:36:56,240
able to understand here's the context

1016
00:36:59,349 --> 00:36:58,160
from which we got this rock we now

1017
00:37:02,950 --> 00:36:59,359
understand

1018
00:37:04,230 --> 00:37:02,960
is for a geologist everything

1019
00:37:06,230 --> 00:37:04,240
emily do we have questions from social

1020
00:37:08,230 --> 00:37:06,240
media yeah we have a couple from social

1021
00:37:10,310 --> 00:37:08,240
um this one this first one is asking

1022
00:37:12,710 --> 00:37:10,320
will the public be able to track uh

1023
00:37:14,069 --> 00:37:12,720
osiris-rex when it's in space and if so

1024
00:37:15,510 --> 00:37:14,079
how

1025
00:37:17,109 --> 00:37:15,520
jeff is this a question that you can

1026
00:37:18,230 --> 00:37:17,119
help cover eyes on the solar system i

1027
00:37:19,349 --> 00:37:18,240
was going to say eyes on the solar

1028
00:37:21,109 --> 00:37:19,359
system

1029
00:37:23,109 --> 00:37:21,119
there's a really really wonderful

1030
00:37:25,349 --> 00:37:23,119
program but it's called well it's called

1031
00:37:27,030 --> 00:37:25,359
nasa eyes and there are a number of

1032
00:37:28,870 --> 00:37:27,040
different uh it's a site that you can

1033
00:37:31,109 --> 00:37:28,880
look and see where all of our spacecraft

1034
00:37:33,190 --> 00:37:31,119
are in real time and the graphics are

1035
00:37:34,710 --> 00:37:33,200
really really lovely so it's actually

1036
00:37:36,550 --> 00:37:34,720
divided into sections there's eyes on

1037
00:37:38,310 --> 00:37:36,560
the solar system and eyes on the solar

1038
00:37:40,790 --> 00:37:38,320

system allows you to see exactly where

1039
00:37:42,710 --> 00:37:40,800
all of our solar system resources are

1040
00:37:44,390 --> 00:37:42,720
there's also eyes on earth where you can

1041
00:37:46,310 --> 00:37:44,400
see all of the different satellites and

1042
00:37:47,670 --> 00:37:46,320
there are something on the order of 30

1043
00:37:49,589 --> 00:37:47,680
different satellites that are orbiting

1044
00:37:51,829 --> 00:37:49,599
the earth and returning data and then

1045
00:37:53,430 --> 00:37:51,839
there's also eyes on exoplanets

1046
00:37:55,270 --> 00:37:53,440
and the eyes on exoplanets i mean

1047
00:37:57,030 --> 00:37:55,280
unfortunately we have no nasa spacecraft

1048
00:37:59,349 --> 00:37:57,040
out of exoplanets at the moment but what

1049
00:38:01,190 --> 00:37:59,359
you can actually do is download

1050
00:38:03,190 --> 00:38:01,200
an atlas of the sky

1051
00:38:05,270 --> 00:38:03,200
and you will see especially with the

1052
00:38:07,349 --> 00:38:05,280
kepler data from the kepler spacecraft

1053
00:38:09,190 --> 00:38:07,359
you will see exactly uh how many planets

1054
00:38:11,270 --> 00:38:09,200
we know of around each star and you'll

1055
00:38:13,109 --> 00:38:11,280
see their proper configuration the angle

1056
00:38:15,510 --> 00:38:13,119
of the the solar system and where those

1057
00:38:16,790 --> 00:38:15,520
planets are as far as we know so nasa

1058
00:38:18,790 --> 00:38:16,800
eyes is a way that you're going to be

1059
00:38:22,470 --> 00:38:18,800
able to tell minute by minute where

1060
00:38:24,710 --> 00:38:22,480
osiris-rex is and what it's doing

1061
00:38:26,310 --> 00:38:24,720
awesome thanks um this next one

1062
00:38:35,510 --> 00:38:26,320
asks what is the most critical thing

1063
00:38:40,069 --> 00:38:37,910

it's knowing where they are

1064
00:38:41,670 --> 00:38:40,079
we've got to find them first uh

1065
00:38:43,990 --> 00:38:41,680
before we can do anything about them

1066
00:38:46,470 --> 00:38:44,000
whether it be uh protecting the earth

1067
00:38:49,030 --> 00:38:46,480
from impacts or

1068
00:38:50,790 --> 00:38:49,040
utilizing them as a resource in the

1069
00:38:51,750 --> 00:38:50,800
future

1070
00:38:56,310 --> 00:38:51,760
the

1071
00:38:57,349 --> 00:38:56,320
asteroids that may be of some value at

1072
00:39:00,630 --> 00:38:57,359
least

1073
00:39:02,150 --> 00:39:00,640
for exploration of the solar system uh

1074
00:39:04,230 --> 00:39:02,160
is um

1075
00:39:05,990 --> 00:39:04,240
you know another area that that we work

1076
00:39:08,870 --> 00:39:06,000
with but you've got to know where those

1077
00:39:11,030 --> 00:39:08,880
objects are for so to me it is knowing

1078
00:39:12,790 --> 00:39:11,040
where they are doing the observations

1079
00:39:15,270 --> 00:39:12,800
to build up the catalog of where all the

1080
00:39:16,390 --> 00:39:15,280
objects are and where they're going

1081
00:39:17,910 --> 00:39:16,400
okay we're going to take one more

1082
00:39:18,950 --> 00:39:17,920
question for social media and then we're

1083
00:39:21,670 --> 00:39:18,960
going to go back to the room for

1084
00:39:24,950 --> 00:39:21,680
questions okay um this last one asks how

1085
00:39:26,790 --> 00:39:24,960
osiris rex specifically will help us for

1086
00:39:27,670 --> 00:39:26,800
future manned missions to an asteroid

1087
00:39:30,390 --> 00:39:27,680
before

1088
00:39:31,589 --> 00:39:30,400

mars missions

1089
00:39:33,829 --> 00:39:31,599
you know there's a number of different

1090
00:39:35,430 --> 00:39:33,839
ways but but one of the things i think

1091
00:39:37,750 --> 00:39:35,440
we certainly learned for example from

1092
00:39:40,069 --> 00:39:37,760
the rosetta mission is

1093
00:39:42,069 --> 00:39:40,079
proximity operations around small bodies

1094
00:39:44,470 --> 00:39:42,079
are interesting and nasa's gotten very

1095
00:39:45,670 --> 00:39:44,480
skilled at going to mars going to saturn

1096
00:39:47,829 --> 00:39:45,680
and doing you know with the cassini

1097
00:39:50,550 --> 00:39:47,839
spacecraft and doing really complex

1098
00:39:53,270 --> 00:39:50,560
maneuvering through a multi-body system

1099
00:39:56,710 --> 00:39:53,280
but proximity operations around a very

1100
00:39:58,390 --> 00:39:56,720
small body are are going to be fun and

1101
00:39:59,510 --> 00:39:58,400
interesting and i think that's one of

1102
00:40:01,510 --> 00:39:59,520
the things that we're really going to

1103
00:40:03,349 --> 00:40:01,520
learn from osiris-rex is how to do that

1104
00:40:05,910 --> 00:40:03,359
and if we want to eventually land say

1105
00:40:09,349 --> 00:40:05,920
humans on on an asteroid on one of the

1106
00:40:10,870 --> 00:40:09,359
moons of mars you know phobos or demos

1107
00:40:15,190 --> 00:40:10,880
these are things we need to learn and so

1108
00:40:19,270 --> 00:40:17,190
hey good afternoon um

1109
00:40:21,670 --> 00:40:19,280
so i recognize that nasa is more of a

1110
00:40:23,510 --> 00:40:21,680
research scientific body obviously but

1111
00:40:25,510 --> 00:40:23,520
i'm surprised we haven't heard

1112
00:40:26,710 --> 00:40:25,520
any of the potential

1113
00:40:29,349 --> 00:40:26,720

commercial

1114
00:40:30,950 --> 00:40:29,359
ramifications of

1115
00:40:33,270 --> 00:40:30,960
these are major leaps forward and things

1116
00:40:35,270 --> 00:40:33,280
like asteroid retrieval and bringing

1117
00:40:36,870 --> 00:40:35,280
planetary you know bodies into earth

1118
00:40:38,550 --> 00:40:36,880
orbit potentially or being able to move

1119
00:40:40,069 --> 00:40:38,560
them around that's seems like there'd be

1120
00:40:41,470 --> 00:40:40,079
some you know

1121
00:40:43,510 --> 00:40:41,480
interesting ramifications for

1122
00:40:44,630 --> 00:40:43,520
commercialization of space is there

1123
00:40:46,390 --> 00:40:44,640
anything you guys want to talk about

1124
00:40:47,910 --> 00:40:46,400
about that

1125
00:40:49,430 --> 00:40:47,920
well certainly there's a lot of interest

1126
00:40:51,270 --> 00:40:49,440
out there of

1127
00:40:53,430 --> 00:40:51,280
you know the earth is a finite place we

1128
00:40:55,030 --> 00:40:53,440
only have so much of you know rare earth

1129
00:40:57,349 --> 00:40:55,040
element minerals that you know there we

1130
00:40:59,190 --> 00:40:57,359
are constrained and obviously as a

1131
00:41:01,109 --> 00:40:59,200
society we're having to learn

1132
00:41:03,190 --> 00:41:01,119
that it's certainly important to

1133
00:41:05,670 --> 00:41:03,200
live sustainably and try to reuse and

1134
00:41:07,190 --> 00:41:05,680
recycle what we have so right now when

1135
00:41:08,630 --> 00:41:07,200
we say okay are we going to run out of

1136
00:41:11,030 --> 00:41:08,640
something would we need to go to our

1137
00:41:13,109 --> 00:41:11,040
moon would we need to go to asteroids

1138
00:41:16,230 --> 00:41:13,119

right now the economics just isn't there

1139
00:41:17,829 --> 00:41:16,240
but will it be in the future um and so

1140
00:41:19,349 --> 00:41:17,839
if we get to that point in the future

1141
00:41:21,190 --> 00:41:19,359
where we say okay we can't live without

1142
00:41:23,030 --> 00:41:21,200
a certain element it's been depleted on

1143
00:41:25,349 --> 00:41:23,040
the earth we need to go out

1144
00:41:26,950 --> 00:41:25,359
learning how to do proximity operations

1145
00:41:29,589 --> 00:41:26,960
around small bodies learning how to

1146
00:41:31,910 --> 00:41:29,599
bring them back closer to the earth

1147
00:41:33,589 --> 00:41:31,920
their ability potentially we've even

1148
00:41:35,190 --> 00:41:33,599
discussed you know as you move humans

1149
00:41:37,109 --> 00:41:35,200
further out into the solar system do you

1150
00:41:39,349 --> 00:41:37,119
bring everything from earth do you use

1151
00:41:41,270 --> 00:41:39,359
asteroids as a way to help resupply you

1152
00:41:43,349 --> 00:41:41,280
as you go these are huge questions we

1153
00:41:45,430 --> 00:41:43,359
have so the more we learn from missions

1154
00:41:47,430 --> 00:41:45,440
like osiris-rex it helps you sort of put

1155
00:41:49,030 --> 00:41:47,440
that into the trade space and say you

1156
00:41:51,349 --> 00:41:49,040
know money wise is

1157
00:41:53,589 --> 00:41:51,359
is this logical it might not be today

1158
00:41:57,190 --> 00:41:53,599
but 30 40 years from now it might be so

1159
00:42:03,990 --> 00:41:58,470
hi

1160
00:42:06,309 --> 00:42:04,000
actually retrieves a um

1161
00:42:09,430 --> 00:42:06,319
retrieves a boulder from an asteroid is

1162
00:42:13,030 --> 00:42:09,440
that the follow-on mission to osiris-rex

1163
00:42:14,390 --> 00:42:13,040

and is there a set timeline for that

1164
00:42:17,109 --> 00:42:14,400
well i wouldn't call it a follow-on

1165
00:42:19,190 --> 00:42:17,119
mission to osiris-rex as i said it's a

1166
00:42:21,430 --> 00:42:19,200
capabilities demonstration mission for

1167
00:42:24,150 --> 00:42:21,440
human exploration

1168
00:42:25,990 --> 00:42:24,160
and our journey to mars to develop the

1169
00:42:28,309 --> 00:42:26,000
solar electric propulsion

1170
00:42:30,630 --> 00:42:28,319
high power high thrust

1171
00:42:33,910 --> 00:42:30,640
technology to take uh

1172
00:42:37,349 --> 00:42:33,920
cargo and habitats uh to mars

1173
00:42:39,030 --> 00:42:37,359
uh it's uh so it's it's separate cyrus

1174
00:42:40,950 --> 00:42:39,040
rex is a science mission done by the

1175
00:42:41,910 --> 00:42:40,960
science mission director uh science

1176
00:42:42,829 --> 00:42:41,920
driven

1177
00:42:45,349 --> 00:42:42,839
uh

1178
00:42:47,510 --> 00:42:45,359
whereas arm is a

1179
00:42:51,349 --> 00:42:47,520
technology capabilities uh mission for

1180
00:42:53,670 --> 00:42:51,359
the future but uh it is on a

1181
00:42:54,790 --> 00:42:53,680
development path where it would launch

1182
00:42:59,109 --> 00:42:54,800
in uh

1183
00:43:01,910 --> 00:42:59,119
2021 december 2021 is the uh

1184
00:43:03,589 --> 00:43:01,920
date that is being planned to

1185
00:43:04,950 --> 00:43:03,599
rendezvous with the asteroid a couple of

1186
00:43:07,349 --> 00:43:04,960
years after that

1187
00:43:09,510 --> 00:43:07,359
uh spend about a year uh total at the

1188
00:43:12,150 --> 00:43:09,520

asteroid and then it takes about a year

1189
00:43:13,510 --> 00:43:12,160
and a half to bring the boulder back to

1190
00:43:15,589 --> 00:43:13,520
lunar orbit

1191
00:43:18,309 --> 00:43:15,599
and so the crude mission to go up and

1192
00:43:21,349 --> 00:43:18,319
sample the asteroid would be in the 2026

1193
00:43:24,950 --> 00:43:23,030
so it's fascinating to me that these

1194
00:43:27,109 --> 00:43:24,960
bases that form

1195
00:43:30,230 --> 00:43:27,119
really the basis for rna and dna are

1196
00:43:31,510 --> 00:43:30,240
found on on you know these asteroids and

1197
00:43:34,150 --> 00:43:31,520
comets

1198
00:43:36,710 --> 00:43:34,160
do we have a reason why the ones that we

1199
00:43:38,390 --> 00:43:36,720
use in our dna are

1200
00:43:39,270 --> 00:43:38,400
present are they the most frequently

1201
00:43:40,950 --> 00:43:39,280
found

1202
00:43:42,550 --> 00:43:40,960
ones on on the asteroids that we've

1203
00:43:46,470 --> 00:43:42,560
examined or

1204
00:43:49,349 --> 00:43:48,150
there's a little bit uh so you know one

1205
00:43:50,069 --> 00:43:49,359
of the things

1206
00:43:51,190 --> 00:43:50,079
is

1207
00:43:52,710 --> 00:43:51,200
does it say something about the

1208
00:43:54,069 --> 00:43:52,720
conditions of the early solar system

1209
00:43:55,910 --> 00:43:54,079
that some of these were selected and

1210
00:43:58,950 --> 00:43:55,920
some of these weren't uh in terms of

1211
00:44:00,390 --> 00:43:58,960
amino acids um i i think for those of

1212
00:44:02,150 --> 00:44:00,400
you that were in the last briefing you

1213
00:44:04,069 --> 00:44:02,160

heard danny glavin who i absolutely love

1214
00:44:06,069 --> 00:44:04,079
and danny was saying that actually only

1215
00:44:07,990 --> 00:44:06,079
a subset of our amino acids are common

1216
00:44:09,990 --> 00:44:08,000
on meteorites that there are meteor

1217
00:44:11,030 --> 00:44:10,000
their amino acids that are here on earth

1218
00:44:12,550 --> 00:44:11,040
that we think may have developed

1219
00:44:14,230 --> 00:44:12,560
afterwards so things that actually

1220
00:44:16,069 --> 00:44:14,240
chemically developed after the original

1221
00:44:17,750 --> 00:44:16,079
organics were brought so there may be

1222
00:44:18,950 --> 00:44:17,760
sort of amino acids that are older and

1223
00:44:20,870 --> 00:44:18,960
those that are younger which is kind of

1224
00:44:22,790 --> 00:44:20,880
fascinating its own right and then

1225
00:44:25,270 --> 00:44:22,800
there's the whole topic of chirality

1226
00:44:27,510 --> 00:44:25,280
because we only use we we immediately

1227
00:44:29,190 --> 00:44:27,520
cut off half the amount of amino acids

1228
00:44:30,710 --> 00:44:29,200
so i mean if you think about your hands

1229
00:44:32,309 --> 00:44:30,720
they're mirror images of each other and

1230
00:44:34,150 --> 00:44:32,319
there are molecules they're amino acids

1231
00:44:37,109 --> 00:44:34,160
that are also mirror images but we only

1232
00:44:39,670 --> 00:44:37,119
use the left-handed ones and

1233
00:44:40,870 --> 00:44:39,680
we actually there is some suggestion now

1234
00:44:42,390 --> 00:44:40,880
that there might be a slight over

1235
00:44:43,910 --> 00:44:42,400
abundance of left-handed immediate i

1236
00:44:45,430 --> 00:44:43,920
mean left-handed amino acids and

1237
00:44:47,109 --> 00:44:45,440
meteorites

1238
00:44:48,870 --> 00:44:47,119

why that would be

1239
00:44:51,270 --> 00:44:48,880
is something that has astrophysicists

1240
00:44:52,710 --> 00:44:51,280
very interested because we're wondering

1241
00:44:54,710 --> 00:44:52,720
if there might have been some kind of

1242
00:44:56,710 --> 00:44:54,720
strong magnetic field around the

1243
00:44:58,069 --> 00:44:56,720
formation of the early solar system is

1244
00:45:00,390 --> 00:44:58,079
it possible that we passed near a

1245
00:45:02,230 --> 00:45:00,400
neutron star or some object that was

1246
00:45:04,710 --> 00:45:02,240
very very strong magnetically and it

1247
00:45:07,589 --> 00:45:04,720
basically polarized the material that

1248
00:45:09,270 --> 00:45:07,599
was in the early solar uh nebula

1249
00:45:11,829 --> 00:45:09,280
this is conjecture right now but this is

1250
00:45:14,150 --> 00:45:11,839
why we're looking for more clues and as

1251
00:45:16,069 --> 00:45:14,160
to exactly which nuclear bases we chose

1252
00:45:18,390 --> 00:45:16,079
i'm i'm an astrophysicist i'm not

1253
00:45:20,630 --> 00:45:18,400
actually an astrobiologist but i'm

1254
00:45:21,910 --> 00:45:20,640
from an astrophysics perspective i think

1255
00:45:23,430 --> 00:45:21,920
there might be something really

1256
00:45:25,750 --> 00:45:23,440
interesting here about what happened to

1257
00:45:26,870 --> 00:45:25,760
our early solar system so does anybody

1258
00:45:28,630 --> 00:45:26,880
have this agency but the particular

1259
00:45:31,030 --> 00:45:28,640
nuclear bases i don't yeah i don't know

1260
00:45:32,870 --> 00:45:31,040
the abundances myself but um you yeah

1261
00:45:35,270 --> 00:45:32,880
the thing that really gets me right is

1262
00:45:36,309 --> 00:45:35,280
if we're trying to find life on mars

1263
00:45:37,750 --> 00:45:36,319

and we're trying to design these

1264
00:45:40,150 --> 00:45:37,760
experiments to look for organics and

1265
00:45:42,069 --> 00:45:40,160
look for organic processes what if it

1266
00:45:44,069 --> 00:45:42,079
uses entirely different nucleobases than

1267
00:45:46,309 --> 00:45:44,079
what we have and the amazing thing is

1268
00:45:47,510 --> 00:45:46,319
that at nasa we're trying to mimic that

1269
00:45:49,430 --> 00:45:47,520
in the lab we're trying to figure out

1270
00:45:51,109 --> 00:45:49,440
what's in these meteorites what sort of

1271
00:45:53,430 --> 00:45:51,119
chemical combinations they might

1272
00:45:54,710 --> 00:45:53,440
actually create and how you might

1273
00:45:56,230 --> 00:45:54,720
recognize

1274
00:45:57,670 --> 00:45:56,240
the whole process of light is the whole

1275
00:45:59,030 --> 00:45:57,680
process of life is limiting the

1276
00:46:01,270 --> 00:45:59,040
chemicals that you use that's really

1277
00:46:03,990 --> 00:46:01,280
fascinating so people like you met like

1278
00:46:06,230 --> 00:46:04,000
danny danny's one of my superheroes and

1279
00:46:08,230 --> 00:46:06,240
uh you know i mean he's somebody that

1280
00:46:09,270 --> 00:46:08,240
the the the careful chemistry these

1281
00:46:11,030 --> 00:46:09,280
people do

1282
00:46:12,150 --> 00:46:11,040
as well as the creativity about what

1283
00:46:13,750 --> 00:46:12,160
kind of life could you get with

1284
00:46:15,349 --> 00:46:13,760
different nuclear bases what might it

1285
00:46:16,630 --> 00:46:15,359
look chemically i think it's one of the

1286
00:46:20,550 --> 00:46:16,640
more exciting things that's happening at

1287
00:46:24,390 --> 00:46:21,750
because you're only getting like a

1288
00:46:26,950 --> 00:46:24,400

handful of material from osiris-rex how

1289
00:46:28,790 --> 00:46:26,960
much testing can really be done with

1290
00:46:30,790 --> 00:46:28,800
that amount of like

1291
00:46:32,390 --> 00:46:30,800
amino acids and different materials that

1292
00:46:33,910 --> 00:46:32,400
you pick up

1293
00:46:36,069 --> 00:46:33,920
you know

1294
00:46:37,589 --> 00:46:36,079
what what is exciting is the amount of

1295
00:46:39,430 --> 00:46:37,599
testing that you can do with material

1296
00:46:41,190 --> 00:46:39,440
that you bring back here to earth is so

1297
00:46:43,190 --> 00:46:41,200
much more than you can ever hope to do

1298
00:46:45,030 --> 00:46:43,200
with the spacecraft so

1299
00:46:47,190 --> 00:46:45,040
you know we have mass spectrometers that

1300
00:46:48,710 --> 00:46:47,200
we take into space that are

1301
00:46:50,870 --> 00:46:48,720
you know yay big

1302
00:46:52,790 --> 00:46:50,880
the ones here on earth are would fill

1303
00:46:55,190 --> 00:46:52,800
you know a quarter of this room and so

1304
00:46:57,750 --> 00:46:55,200
with very small amounts of material you

1305
00:47:00,230 --> 00:46:57,760
can do such precise analysis that that

1306
00:47:01,750 --> 00:47:00,240
we get amazing amounts of information so

1307
00:47:03,589 --> 00:47:01,760
we don't really feel we're inhibited

1308
00:47:05,430 --> 00:47:03,599
obviously geologists we always want more

1309
00:47:07,670 --> 00:47:05,440
rocks the better um

1310
00:47:09,430 --> 00:47:07,680
but but because our instruments here on

1311
00:47:11,190 --> 00:47:09,440
the earth are so sophisticated we'll be

1312
00:47:13,270 --> 00:47:11,200
able to really bring the science out of

1313
00:47:14,630 --> 00:47:13,280

that material yeah i mean if they get as

1314
00:47:16,550 --> 00:47:14,640
much as they plan they're only going to

1315
00:47:18,710 --> 00:47:16,560
use 20 of it and they're going to put

1316
00:47:25,109 --> 00:47:18,720
the rest of it away and keep it for the

1317
00:47:29,510 --> 00:47:27,670
okay um and that's all the time we have

1318
00:47:31,990 --> 00:47:29,520
for today's panel i hope you guys

1319
00:47:33,750 --> 00:47:32,000
learned as much as i did um for those

1320
00:47:35,829 --> 00:47:33,760
who still have questions please feel

1321
00:47:37,510 --> 00:47:35,839
free to stay after and talk to some of

1322
00:47:40,230 --> 00:47:37,520
the folks or

1323
00:47:42,230 --> 00:47:40,240
send them in using the hashtag asknasa

1324
00:47:46,230 --> 00:47:42,240
for more information on all the stuff we

1325
00:47:46,240 --> 00:47:52,790
thank you