1
00:00:09,190 --> 00:00:07,190
good afternoon

2
00:00:11,270 --> 00:00:09,200
welcome to nasa headquarters in

3
00:00:13,669 --> 00:00:11,280
washington d.c my name is dwayne brown

4
00:00:15,589 --> 00:00:13,679
from the office of communications

5
00:00:18,310 --> 00:00:15,599
today we're going to take a trip to the

6
00:00:20,070 --> 00:00:18,320
solar system and beyond

7
00:00:21,910 --> 00:00:20,080
recent news headlines around the world

8
00:00:25,509 --> 00:00:21,920
have reported nasa findings of large

9
00:00:27,750 --> 00:00:25,519
amounts of water long ago on mars but

10
00:00:29,589 --> 00:00:27,760
present today on other bodies in our

11
00:00:31,589 --> 00:00:29,599
solar system

12
00:00:33,670 --> 00:00:31,599
we know this because at nasa in the

13
00:00:35,510 --> 00:00:33,680

solar system and beyond

14
00:00:37,190 --> 00:00:35,520
we're out there

15
00:00:38,549 --> 00:00:37,200
the news of water is not only intriguing

16
00:00:41,110 --> 00:00:38,559
to scientists

17
00:00:44,069 --> 00:00:41,120
but could humankind perhaps be

18
00:00:46,229 --> 00:00:44,079
getting even closer to answering where

19
00:00:47,830 --> 00:00:46,239
do we come from

20
00:00:49,830 --> 00:00:47,840
where are we going

21
00:00:51,750 --> 00:00:49,840
are we alone

22
00:00:52,709 --> 00:00:51,760
today you hear what the experts have to

23
00:00:53,990 --> 00:00:52,719
say

24
00:00:56,150 --> 00:00:54,000
we'll have brief remarks and

25
00:00:58,790 --> 00:00:56,160
presentations and then we'll open it up

26
00:01:00,389 --> 00:00:58,800
to questions here in our audience

27
00:01:01,990 --> 00:01:00,399
our phone lines

28
00:01:03,990 --> 00:01:02,000
and social media

29
00:01:05,030 --> 00:01:04,000
and there is a lot of buzz on social

30
00:01:07,030 --> 00:01:05,040
media

31
00:01:09,750 --> 00:01:07,040
on this subject

32
00:01:12,550 --> 00:01:09,760
send in your questions to hashtag

33
00:01:14,149 --> 00:01:12,560
ask nasa

34
00:01:15,350 --> 00:01:14,159
before we get started let me introduce

35
00:01:17,510 --> 00:01:15,360
you to

36
00:01:20,310 --> 00:01:17,520
our unique

37
00:01:22,550 --> 00:01:20,320
folks here on the stage first up

38
00:01:24,630 --> 00:01:22,560

dr john grunsfeld

39
00:01:27,270 --> 00:01:24,640
five-time space shuttle astronaut and

40
00:01:28,390 --> 00:01:27,280
associate administrator for the science

41
00:01:30,870 --> 00:01:28,400
mission director here at nasa

42
00:01:33,190 --> 00:01:30,880
headquarters and let me add that

43
00:01:34,870 --> 00:01:33,200
out of those five flights three times dr

44
00:01:37,429 --> 00:01:34,880
gruntsville service the hubble space

45
00:01:39,749 --> 00:01:37,439
telescope and this month humankind

46
00:01:41,830 --> 00:01:39,759
celebrates 25 years

47
00:01:43,910 --> 00:01:41,840
of the hubble in operations in space i

48
00:01:52,630 --> 00:01:43,920
think that deserves a round of applause

49
00:01:59,109 --> 00:01:56,149
following dr grunsfeld is dr jim green

50
00:02:02,950 --> 00:01:59,119
director of planetary science

51
00:02:06,630 --> 00:02:04,709
dr jeffrey newmark

52
00:02:08,550 --> 00:02:06,640
interim director

53
00:02:11,750 --> 00:02:08,560
of heliophysics

54
00:02:17,030 --> 00:02:13,990
and dr paul hertz

55
00:02:19,830 --> 00:02:17,040
director of astrophysics

56
00:02:23,830 --> 00:02:19,840
at nasa headquarters

57
00:02:25,670 --> 00:02:23,840
and dr ellen stofan nasa's chief

58
00:02:27,430 --> 00:02:25,680
scientist

59
00:02:29,910 --> 00:02:27,440
fasten your seat belts

60
00:02:32,710 --> 00:02:29,920
let's go to the solar system and beyond

61
00:02:34,550 --> 00:02:32,720
over to you dr gruntsfield

62
00:02:36,710 --> 00:02:34,560
thank you very much as you know our job

63
00:02:37,830 --> 00:02:36,720

here at nasa is to innovate

64
00:02:40,070 --> 00:02:37,840
explore

65
00:02:42,309 --> 00:02:40,080
discover and inspire

66
00:02:45,589 --> 00:02:42,319
and i believe the science program really

67
00:02:47,430 --> 00:02:45,599
epitomizes that that mantra

68
00:02:49,350 --> 00:02:47,440
we try and answer fundamental questions

69
00:02:50,869 --> 00:02:49,360
as you heard dwayne say

70
00:02:53,030 --> 00:02:50,879
where did we come from where did the

71
00:02:54,470 --> 00:02:53,040
bits that we're made out of come from

72
00:02:57,190 --> 00:02:54,480
where are we going what's the fate of

73
00:03:00,550 --> 00:02:57,200
the universe and are we alone

74
00:03:02,710 --> 00:03:00,560
on the question of you know other other

75
00:03:05,110 --> 00:03:02,720
beings out there of any kind

76
00:03:07,030 --> 00:03:05,120
science right now at nasa is exploring

77
00:03:08,710 --> 00:03:07,040
the sun in great detail

78
00:03:11,670 --> 00:03:08,720
uh from mercury with the messenger

79
00:03:14,390 --> 00:03:11,680
spacecraft still orbiting mercury

80
00:03:16,309 --> 00:03:14,400
uh out all the way to pluto new horizons

81
00:03:19,110 --> 00:03:16,319
will reach uh spacecraft will reach

82
00:03:21,670 --> 00:03:19,120
pluto this summer and beyond with

83
00:03:23,670 --> 00:03:21,680
voyager and of course we have maven that

84
00:03:26,309 --> 00:03:23,680
just recently arrived at mars studying

85
00:03:28,789 --> 00:03:26,319
the the atmosphere and current

86
00:03:31,350 --> 00:03:28,799
loss of the atmosphere at mars dawn has

87
00:03:32,390 --> 00:03:31,360
just arrived at ceres cassini is still

88
00:03:34,390 --> 00:03:32,400

studying

89
00:03:36,309 --> 00:03:34,400
saturn and the moons of saturn

90
00:03:38,630 --> 00:03:36,319
it's really an amazing exploration of

91
00:03:40,390 --> 00:03:38,640
our solar system and much more

92
00:03:43,430 --> 00:03:40,400
beyond we have hubble celebrating the

93
00:03:44,789 --> 00:03:43,440
25th anniversary of time on orbit and

94
00:03:47,110 --> 00:03:44,799
it's kind of neat to think about all of

95
00:03:49,190 --> 00:03:47,120
our students today in in grade school

96
00:03:50,949 --> 00:03:49,200
and high school and college who have

97
00:03:53,990 --> 00:03:50,959
lived in a world

98
00:03:56,229 --> 00:03:54,000
and have always known hubble

99
00:03:58,309 --> 00:03:56,239
kepler has told us that we live in a

100
00:04:00,390 --> 00:03:58,319
galaxy and in fact a universe that's

101
00:04:03,270 --> 00:04:00,400
filled with solar systems

102
00:04:05,429 --> 00:04:03,280
and many planets that may resemble earth

103
00:04:07,270 --> 00:04:05,439
in being a rocky planet in a potentially

104
00:04:08,789 --> 00:04:07,280
habitable zone

105
00:04:10,390 --> 00:04:08,799
hubble and spitzer have allowed us

106
00:04:12,550 --> 00:04:10,400
already to follow up by studying the

107
00:04:14,470 --> 00:04:12,560
atmospheres of some of those planets and

108
00:04:16,949 --> 00:04:14,480
the james webb space telescope which

109
00:04:19,270 --> 00:04:16,959
we'll launch in october of 2018 will

110
00:04:21,030 --> 00:04:19,280
allow us to explore uh in much more

111
00:04:23,350 --> 00:04:21,040
detail the atmospheres of planets around

112
00:04:25,909 --> 00:04:23,360
nearby stars

113
00:04:30,150 --> 00:04:25,919

here on earth we live on a water planet

114
00:04:30,160 --> 00:04:33,749
some cases literally everywhere

115
00:04:36,629 --> 00:04:35,590
and water is critical for our life on

116
00:04:39,909 --> 00:04:36,639
earth

117
00:04:41,350 --> 00:04:39,919
observing

118
00:04:44,230 --> 00:04:41,360
constellation

119
00:04:45,030 --> 00:04:44,240
that you know the propagation of earth

120
00:04:47,430 --> 00:04:45,040
our

121
00:04:48,950 --> 00:04:47,440
water cycle is a very critical thing to

122
00:04:50,550 --> 00:04:48,960
understand that we can only understand

123
00:04:52,469 --> 00:04:50,560
from space we just launched the soil

124
00:04:54,230 --> 00:04:52,479
moisture active passive mission to look

125
00:04:55,909 --> 00:04:54,240
at that tiny amount of moisture in the

126
00:04:57,510 --> 00:04:55,919
soil and we know from the current

127
00:04:59,830 --> 00:04:57,520
drought situation in california and our

128
00:05:01,749 --> 00:04:59,840
american west how critical that is but

129
00:05:02,790 --> 00:05:01,759
water is everywhere in our solar system

130
00:05:04,390 --> 00:05:02,800
as well

131
00:05:06,070 --> 00:05:04,400
and we're seeing that through our

132
00:05:07,110 --> 00:05:06,080
various missions and you'll hear hear

133
00:05:08,790 --> 00:05:07,120
about that

134
00:05:10,390 --> 00:05:08,800
in our quest to answer the question of

135
00:05:12,629 --> 00:05:10,400
are we alone in the universe we're

136
00:05:14,870 --> 00:05:12,639
looking for other habitable environments

137
00:05:16,710 --> 00:05:14,880
besides here on earth of course

138
00:05:18,310 --> 00:05:16,720

and we're seeing that environment in

139
00:05:19,909 --> 00:05:18,320
many different places

140
00:05:21,430 --> 00:05:19,919
you'll hear a little bit about our mars

141
00:05:23,909 --> 00:05:21,440
rovers that have established that mars

142
00:05:25,110 --> 00:05:23,919
was once habitable and mars has water

143
00:05:26,469 --> 00:05:25,120
today

144
00:05:28,950 --> 00:05:26,479
it had

145
00:05:31,270 --> 00:05:28,960
freshwater lakes and its own water cycle

146
00:05:33,590 --> 00:05:31,280
but it also has organics

147
00:05:35,430 --> 00:05:33,600
we've seen a methane signal we know that

148
00:05:36,469 --> 00:05:35,440
there are nitrates in the martian

149
00:05:38,550 --> 00:05:36,479
surface

150
00:05:39,909 --> 00:05:38,560
it's currently a habitable environment

151
00:05:43,270 --> 00:05:39,919
but we don't know

152
00:05:44,710 --> 00:05:43,280
whether there's was or is life on mars

153
00:05:46,310 --> 00:05:44,720
and we're seeing in some of the icy

154
00:05:49,110 --> 00:05:46,320
moons the

155
00:05:50,390 --> 00:05:49,120
tantalizing possibility that there are

156
00:05:51,909 --> 00:05:50,400
oceans that have been around for

157
00:05:55,270 --> 00:05:51,919
billions of years that would also

158
00:05:56,950 --> 00:05:55,280
provide a habitat for primitive life and

159
00:05:59,110 --> 00:05:56,960
we're very happy this year to be able to

160
00:06:01,909 --> 00:05:59,120
say that we're starting a mission to go

161
00:06:04,629 --> 00:06:01,919
study the moon of jupiter europa to see

162
00:06:07,270 --> 00:06:04,639
if it perhaps has signs of habitable

163
00:06:09,110 --> 00:06:07,280

environments or perhaps even life

164
00:06:10,790 --> 00:06:09,120
this is just a grand time to be

165
00:06:12,790 --> 00:06:10,800
exploring science to be exploring our

166
00:06:15,430 --> 00:06:12,800
solar system and beyond

167
00:06:18,150 --> 00:06:15,440
and i look forward to all your questions

168
00:06:20,309 --> 00:06:18,160
jim green thank you very much john

169
00:06:22,150 --> 00:06:20,319
what i'd like to do today is to talk a

170
00:06:24,390 --> 00:06:22,160
little bit about some of the fabulous

171
00:06:26,070 --> 00:06:24,400
observations that john mentioned and a

172
00:06:27,670 --> 00:06:26,080
number of others and we'll start of

173
00:06:29,830 --> 00:06:27,680
course with mars

174
00:06:32,469 --> 00:06:29,840
mars like earth is in what we call the

175
00:06:34,870 --> 00:06:32,479
habitable zone the region that extends

176
00:06:37,909 --> 00:06:34,880
around the sun for which the sun's light

177
00:06:40,469 --> 00:06:37,919
on a body about like the earth

178
00:06:43,029 --> 00:06:40,479
is such that water can exist in three

179
00:06:45,270 --> 00:06:43,039
phases liquid phase

180
00:06:47,590 --> 00:06:45,280
solid and vapor

181
00:06:50,150 --> 00:06:47,600
now today mars although it's in the

182
00:06:52,950 --> 00:06:50,160
habitable zone is a very arid planet and

183
00:06:55,029 --> 00:06:52,960
if i can have my first video

184
00:06:56,150 --> 00:06:55,039
what we've discovered using our assets

185
00:06:58,070 --> 00:06:56,160
at mars

186
00:07:01,189 --> 00:06:58,080
looking at the terrain and our ground

187
00:07:03,670 --> 00:07:01,199
truth observations from all our rovers

188
00:07:06,070 --> 00:07:03,680

is that mars in its past had a

189
00:07:08,790 --> 00:07:06,080
significant amount of water

190
00:07:10,870 --> 00:07:08,800
in fact as john mentioned it had a a

191
00:07:13,909 --> 00:07:10,880
habitable environment curiosity is in a

192
00:07:17,029 --> 00:07:13,919
region where water flowed pretty rapidly

193
00:07:19,510 --> 00:07:17,039
so when we think of mars in its past we

194
00:07:22,550 --> 00:07:19,520
recognize that it was a

195
00:07:25,430 --> 00:07:22,560
water world much like the earth it had

196
00:07:27,830 --> 00:07:25,440
clouds it had oceans uh and in a

197
00:07:29,749 --> 00:07:27,840
hydrological cycle

198
00:07:32,230 --> 00:07:29,759
but the most recent observations that

199
00:07:34,150 --> 00:07:32,240
are really tantalizing are those that

200
00:07:36,710 --> 00:07:34,160
were made with ground-based telescopes

201
00:07:40,629 --> 00:07:36,720
in the infrared these telescopes were

202
00:07:41,430 --> 00:07:40,639
looking at the north polar cap of mars

203
00:07:43,589 --> 00:07:41,440
for

204
00:07:46,550 --> 00:07:43,599
what's called the deuterium to hydrogen

205
00:07:48,790 --> 00:07:46,560
ratio this is called the d to h ratio

206
00:07:50,950 --> 00:07:48,800
and once we make those measurements and

207
00:07:54,070 --> 00:07:50,960
we compare them with earth we then can

208
00:07:56,309 --> 00:07:54,080
extrapolate back in time how much water

209
00:07:58,309 --> 00:07:56,319
really existed on the surface of mars

210
00:08:00,469 --> 00:07:58,319
now i mean water i don't mean ice and i

211
00:08:02,230 --> 00:08:00,479
don't mean the vapor and what we find

212
00:08:03,670 --> 00:08:02,240
out is really illustrated in the next

213
00:08:05,189 --> 00:08:03,680

video

214
00:08:07,589 --> 00:08:05,199
here we see

215
00:08:09,670 --> 00:08:07,599
mars as it was in the past but now we're

216
00:08:11,189 --> 00:08:09,680
going to paint the oceans we're going to

217
00:08:13,270 --> 00:08:11,199
strip away the clouds we're going to

218
00:08:14,230 --> 00:08:13,280
look through the atmosphere and what we

219
00:08:17,430 --> 00:08:14,240
find

220
00:08:20,950 --> 00:08:17,440
is that about 50 percent of the northern

221
00:08:23,189 --> 00:08:20,960
hemisphere of mars had water and it had

222
00:08:25,350 --> 00:08:23,199
it for a very long period of time

223
00:08:27,749 --> 00:08:25,360
perhaps more than a billion years

224
00:08:28,869 --> 00:08:27,759
current thinking is about 1.2 billion

225
00:08:30,869 --> 00:08:28,879
years

226
00:08:33,029 --> 00:08:30,879
now in fact some of this ocean was as

227
00:08:36,230 --> 00:08:33,039
much as a mile deep

228
00:08:38,389 --> 00:08:36,240
now curiosity is sitting in a crater not

229
00:08:40,469 --> 00:08:38,399
on the ancient shore

230
00:08:42,870 --> 00:08:40,479
line of where this ocean would be but a

231
00:08:45,269 --> 00:08:42,880
little inland but what we do know and

232
00:08:47,829 --> 00:08:45,279
what we have found out is that water

233
00:08:50,310 --> 00:08:47,839
cycle on mars was such that it popped

234
00:08:52,630 --> 00:08:50,320
over the crater wall flowed down into

235
00:08:55,269 --> 00:08:52,640
the crater and in fact did this

236
00:08:57,829 --> 00:08:55,279
repeatedly over perhaps millions and

237
00:08:59,910 --> 00:08:57,839
millions of years and actually built up

238
00:09:03,110 --> 00:08:59,920

that large mountain called mount sharp

239
00:09:06,070 --> 00:09:03,120
in the center of uh of gale crater

240
00:09:09,509 --> 00:09:06,080
so mars was much more earth-like in a

241
00:09:11,990 --> 00:09:09,519
habitable zone for a very long period of

242
00:09:14,150 --> 00:09:12,000
time than we ever imagined this is

243
00:09:17,430 --> 00:09:14,160
really an exciting time

244
00:09:19,829 --> 00:09:17,440
now just beyond mars is a region called

245
00:09:22,949 --> 00:09:19,839
the asteroid belt but it's also a

246
00:09:25,829 --> 00:09:22,959
location for which the solar energy is

247
00:09:27,269 --> 00:09:25,839
such that beyond a certain location we

248
00:09:29,430 --> 00:09:27,279
call the snow line

249
00:09:30,550 --> 00:09:29,440
further out than the snow line

250
00:09:33,190 --> 00:09:30,560
we find

251
00:09:34,790 --> 00:09:33,200
water should be only in one phase only

252
00:09:36,870 --> 00:09:34,800
in the solid phase

253
00:09:38,310 --> 00:09:36,880
but what we're finding is that's not

254
00:09:40,550 --> 00:09:38,320
true either

255
00:09:42,230 --> 00:09:40,560
if we look at the next uh my first

256
00:09:45,190 --> 00:09:42,240
graphic

257
00:09:47,269 --> 00:09:45,200
here we see what galileo saw you know

258
00:09:49,990 --> 00:09:47,279
400 plus years ago the galilean

259
00:09:52,150 --> 00:09:50,000
satellites the moons of jupiter io

260
00:09:54,230 --> 00:09:52,160
europa ganymede and callisto and as you

261
00:09:57,750 --> 00:09:54,240
can see they're ordered in such a way

262
00:09:59,829 --> 00:09:57,760
with io close to jupiter and the gravity

263
00:10:03,110 --> 00:09:59,839

interaction between jupiter and the moon

264
00:10:05,430 --> 00:10:03,120
io as such with tidal forces that it

265
00:10:07,750 --> 00:10:05,440
literally heats the inside of io it

266
00:10:10,230 --> 00:10:07,760
turns it inside out

267
00:10:12,230 --> 00:10:10,240
iowa is a very volcanic world don't

268
00:10:14,470 --> 00:10:12,240
expect any water there

269
00:10:17,269 --> 00:10:14,480
however the next one europa we're

270
00:10:19,829 --> 00:10:17,279
finding at much different location

271
00:10:22,949 --> 00:10:19,839
it's far enough out that the tidal

272
00:10:24,150 --> 00:10:22,959
forces don't dissipate its eye shell but

273
00:10:25,269 --> 00:10:24,160
retain

274
00:10:28,870 --> 00:10:25,279
enough

275
00:10:30,790 --> 00:10:28,880
water in liquid form below an ice crust

276
00:10:33,910 --> 00:10:30,800
to really make it an exciting place to

277
00:10:36,790 --> 00:10:33,920
look at so if i can have the next slide

278
00:10:39,110 --> 00:10:36,800
most recent observations from hubble

279
00:10:40,630 --> 00:10:39,120
have really tantalized us

280
00:10:42,710 --> 00:10:40,640
in going to

281
00:10:45,269 --> 00:10:42,720
to europa

282
00:10:47,269 --> 00:10:45,279
as our future mission here we see

283
00:10:51,670 --> 00:10:47,279
potential

284
00:10:52,949 --> 00:10:51,680
plumes of material ice water ice flowing

285
00:10:54,710 --> 00:10:52,959
out from

286
00:10:57,190 --> 00:10:54,720
cracks perhaps

287
00:10:59,110 --> 00:10:57,200
in europe in the southern hemisphere and

288
00:11:01,030 --> 00:10:59,120

recoating the surface

289
00:11:04,069 --> 00:11:01,040
this is must be what was happening

290
00:11:05,430 --> 00:11:04,079
because the surface of of europa is very

291
00:11:07,110 --> 00:11:05,440
little cratered

292
00:11:10,150 --> 00:11:07,120
this is just a tremendous set of

293
00:11:12,069 --> 00:11:10,160
observations but even more recently were

294
00:11:14,870 --> 00:11:12,079
those in my next slide

295
00:11:18,630 --> 00:11:14,880
of humble observations of aurora

296
00:11:21,030 --> 00:11:18,640
on ganymede now ganymede is a huge body

297
00:11:23,590 --> 00:11:21,040
it is the largest moon in the solar

298
00:11:25,829 --> 00:11:23,600
system larger than our own moon

299
00:11:28,949 --> 00:11:25,839
it has a magnetic field which is also a

300
00:11:30,069 --> 00:11:28,959
very bizarre thing for a moon to have

301
00:11:32,230 --> 00:11:30,079
but

302
00:11:34,150 --> 00:11:32,240
that magnetic field as it interacts with

303
00:11:36,230 --> 00:11:34,160
jupiter's magnetic field allows

304
00:11:38,790 --> 00:11:36,240
particles to be exchanged between the

305
00:11:41,750 --> 00:11:38,800
two planets or the planet and the moon

306
00:11:43,990 --> 00:11:41,760
ganymede and this produces aurora now

307
00:11:45,829 --> 00:11:44,000
that's great we can observe this aurora

308
00:11:48,230 --> 00:11:45,839
we've seen the aurora many times but

309
00:11:50,550 --> 00:11:48,240
when we do a detailed analysis of the

310
00:11:51,670 --> 00:11:50,560
aurora we find out something very

311
00:11:53,430 --> 00:11:51,680
important

312
00:11:56,790 --> 00:11:53,440
now the magnetic field of jupiter

313
00:11:58,870 --> 00:11:56,800

actually is is is pretty twisted and by

314
00:12:00,389 --> 00:11:58,880
the time it gets out to ganymede it can

315
00:12:02,550 --> 00:12:00,399
really rock

316
00:12:04,470 --> 00:12:02,560
back and forth as ganymede moves through

317
00:12:06,470 --> 00:12:04,480
the magnetosphere of jupiter we

318
00:12:09,269 --> 00:12:06,480
therefore expected the aurora to rock

319
00:12:11,910 --> 00:12:09,279
back and forth but it doesn't it rocks

320
00:12:14,470 --> 00:12:11,920
very little now this means that some

321
00:12:15,829 --> 00:12:14,480
sort of current arises underneath that

322
00:12:18,550 --> 00:12:15,839
ice crust

323
00:12:21,350 --> 00:12:18,560
generating another magnetic field that

324
00:12:24,069 --> 00:12:21,360
then stabilizes this aurora such that we

325
00:12:25,910 --> 00:12:24,079
see it in a particular place from those

326
00:12:29,269 --> 00:12:25,920
data we now know

327
00:12:30,389 --> 00:12:29,279
that indeed ganymede has an undercrossed

328
00:12:32,550 --> 00:12:30,399
ocean

329
00:12:35,269 --> 00:12:32,560
now we only are just getting tantalizing

330
00:12:38,310 --> 00:12:35,279
glimpses of that how deep it is you know

331
00:12:40,310 --> 00:12:38,320
but but it must be a vast body of water

332
00:12:43,110 --> 00:12:40,320
this changes our perspective of where

333
00:12:44,230 --> 00:12:43,120
habitable zones are completely my next

334
00:12:46,310 --> 00:12:44,240
slide

335
00:12:47,430 --> 00:12:46,320
here we see those galilean satellites

336
00:12:50,629 --> 00:12:47,440
once again

337
00:12:52,949 --> 00:12:50,639
io's closest to jupiter but it's a

338
00:12:55,750 --> 00:12:52,959

volcanic world it's not

339
00:12:57,829 --> 00:12:55,760
uh an icy world but we know now that

340
00:12:59,829 --> 00:12:57,839
europa and ganymede have a significant

341
00:13:01,910 --> 00:12:59,839
amount of water underneath their ice

342
00:13:05,670 --> 00:13:01,920
crust and in fact we now believe europa

343
00:13:07,750 --> 00:13:05,680
has perhaps twice the amount of water

344
00:13:09,670 --> 00:13:07,760
underneath that ice crust that the earth

345
00:13:11,509 --> 00:13:09,680
has on its surface

346
00:13:13,350 --> 00:13:11,519
with the latest hubble observations

347
00:13:15,190 --> 00:13:13,360
we're going to include ganymede now in

348
00:13:17,430 --> 00:13:15,200
that habitable zone because water is

349
00:13:19,110 --> 00:13:17,440
incredibly important now there's some

350
00:13:21,509 --> 00:13:19,120
ideas that there may be water and

351
00:13:23,670 --> 00:13:21,519
callisto but we haven't confirmed that

352
00:13:25,190 --> 00:13:23,680
but at least now we recognize that

353
00:13:26,310 --> 00:13:25,200
habitable zones

354
00:13:28,710 --> 00:13:26,320
aren't just

355
00:13:30,710 --> 00:13:28,720
around stars but they can indeed be

356
00:13:33,269 --> 00:13:30,720
around our giant planets

357
00:13:36,470 --> 00:13:33,279
what we're finding out is that the solar

358
00:13:38,470 --> 00:13:36,480
system is really a soggy place

359
00:13:40,150 --> 00:13:38,480
now all these bodies of course are

360
00:13:42,790 --> 00:13:40,160
sitting in the solar wind

361
00:13:44,870 --> 00:13:42,800
and that changes the dynamics of the

362
00:13:47,030 --> 00:13:44,880
water and the atmosphere as they

363
00:13:48,790 --> 00:13:47,040

interact with the solar wind and for

364
00:13:49,750 --> 00:13:48,800
that i'm going to turn to jeff to

365
00:13:51,189 --> 00:13:49,760
explain

366
00:13:53,189 --> 00:13:51,199
thank you jim

367
00:13:55,189 --> 00:13:53,199
indeed all the planets and moons that

368
00:13:57,269 --> 00:13:55,199
jim just talked about are actually

369
00:13:59,509 --> 00:13:57,279
embedded in the solar atmosphere the

370
00:14:01,590 --> 00:13:59,519
extended atmosphere of our sun

371
00:14:04,150 --> 00:14:01,600
what we're trying to do is understand

372
00:14:05,750 --> 00:14:04,160
how the sun interacts with the planets

373
00:14:09,110 --> 00:14:05,760
the moons

374
00:14:11,750 --> 00:14:09,120
and this as a connected system

375
00:14:14,069 --> 00:14:11,760
you can please run my first video

376
00:14:16,069 --> 00:14:14,079
what we see here is a model of the inner

377
00:14:18,310 --> 00:14:16,079
solar system you see the planets and

378
00:14:21,110 --> 00:14:18,320
what we want to do is understand how the

379
00:14:23,189 --> 00:14:21,120
sun what is varying what is driving the

380
00:14:25,590 --> 00:14:23,199
solar wind that jim mentioned

381
00:14:26,389 --> 00:14:25,600
and how it interacts with planets here

382
00:14:28,069 --> 00:14:26,399
and

383
00:14:30,069 --> 00:14:28,079
in fact planets elsewhere how other

384
00:14:32,790 --> 00:14:30,079
stars how their winds interact with

385
00:14:34,629 --> 00:14:32,800
planets throughout the universe

386
00:14:37,110 --> 00:14:34,639
well as we'll see this interaction

387
00:14:39,189 --> 00:14:37,120
actually also involves the distribution

388
00:14:41,189 --> 00:14:39,199

of water throughout our solar system and

389
00:14:42,389 --> 00:14:41,199
indeed throughout other planetary

390
00:14:44,710 --> 00:14:42,399
systems

391
00:14:46,470 --> 00:14:44,720
in this model here what we see is a

392
00:14:49,509 --> 00:14:46,480
series of solar storms we call them

393
00:14:52,870 --> 00:14:49,519
coronal mass ejections or cmes this is a

394
00:14:54,949 --> 00:14:52,880
model of a series of events from 2012

395
00:14:56,389 --> 00:14:54,959
and you see these large scale events

396
00:14:58,069 --> 00:14:56,399
leave nothing in our solar system

397
00:15:00,550 --> 00:14:58,079
untouched these these are tremendous

398
00:15:02,550 --> 00:15:00,560
events with tremendous amount of energy

399
00:15:04,230 --> 00:15:02,560
this is billions of tons of material

400
00:15:06,710 --> 00:15:04,240
traveling millions of miles an hour

401
00:15:08,550 --> 00:15:06,720
throughout interplanetary space

402
00:15:10,629 --> 00:15:08,560
and indeed understanding how these

403
00:15:13,910 --> 00:15:10,639
interact with our planets

404
00:15:16,470 --> 00:15:13,920
is crucial for our understanding of the

405
00:15:18,870 --> 00:15:16,480
life cycle of water on these planets and

406
00:15:20,470 --> 00:15:18,880
indeed for habitability throughout the

407
00:15:22,470 --> 00:15:20,480
universe

408
00:15:24,629 --> 00:15:22,480
the constant streaming of the solar wind

409
00:15:26,870 --> 00:15:24,639
and the solar storms

410
00:15:28,790 --> 00:15:26,880
impacts the ways that our planets and

411
00:15:30,470 --> 00:15:28,800
other bodies of solar system in a wide

412
00:15:32,230 --> 00:15:30,480
variety of ways

413
00:15:34,069 --> 00:15:32,240

as jim described

414
00:15:35,350 --> 00:15:34,079
mars was covered by water three to four

415
00:15:37,910 --> 00:15:35,360
billion years ago

416
00:15:40,470 --> 00:15:37,920
however as we know today it is drier

417
00:15:42,470 --> 00:15:40,480
what may have caused this change and

418
00:15:44,150 --> 00:15:42,480
what role did the solar wind and the sun

419
00:15:45,590 --> 00:15:44,160
have to play in this

420
00:15:48,069 --> 00:15:45,600
it is thought that some three and a half

421
00:15:50,069 --> 00:15:48,079
billion years ago extreme interplanetary

422
00:15:52,870 --> 00:15:50,079
conditions caused by the sun may have

423
00:15:54,470 --> 00:15:52,880
caused a much larger rate of water loss

424
00:15:57,749 --> 00:15:54,480
in the martian atmosphere

425
00:16:00,629 --> 00:15:57,759
you can run my next video

426
00:16:02,470 --> 00:16:00,639
we see the changes in mars

427
00:16:05,110 --> 00:16:02,480
however how did these changes come from

428
00:16:06,150 --> 00:16:05,120
the solar wind well the and why did they

429
00:16:08,550 --> 00:16:06,160
affect the earth what are the

430
00:16:11,189 --> 00:16:08,560
differences the earth in fact is

431
00:16:12,710 --> 00:16:11,199
protected by a magnetic cocoon we call

432
00:16:14,550 --> 00:16:12,720
the magnetosphere

433
00:16:16,069 --> 00:16:14,560
however mars

434
00:16:18,870 --> 00:16:16,079
does not have a significant magnetic

435
00:16:21,030 --> 00:16:18,880
field so this absence of the protection

436
00:16:23,509 --> 00:16:21,040
allows the supersonic solar wind to

437
00:16:24,710 --> 00:16:23,519
interact directly with the martian upper

438
00:16:28,470 --> 00:16:24,720

atmosphere

439
00:16:30,550 --> 00:16:28,480
water from the planet as you see here in

440
00:16:32,470 --> 00:16:30,560
this model based on new observations

441
00:16:34,949 --> 00:16:32,480
from maven in fact

442
00:16:37,030 --> 00:16:34,959
and so we see that the interaction of

443
00:16:38,949 --> 00:16:37,040
solar wind directly affects the life

444
00:16:40,470 --> 00:16:38,959
cycle of water

445
00:16:41,590 --> 00:16:40,480
you can

446
00:16:43,749 --> 00:16:41,600
comets

447
00:16:46,629 --> 00:16:43,759
the next part of distributing water from

448
00:16:48,629 --> 00:16:46,639
our solar system these carry ingredients

449
00:16:50,550 --> 00:16:48,639
vital to life as we know it

450
00:16:52,150 --> 00:16:50,560
as the sun heats comets the water and

451
00:16:54,470 --> 00:16:52,160
dust and the chemicals

452
00:16:56,550 --> 00:16:54,480
scatter and are distributed to the water

453
00:16:58,550 --> 00:16:56,560
throughout our solar system

454
00:17:01,910 --> 00:16:58,560
certainly this occurs through distant

455
00:17:04,150 --> 00:17:01,920
stars and planets around other systems

456
00:17:06,069 --> 00:17:04,160
in my next video

457
00:17:07,990 --> 00:17:06,079
we see actual observations from our

458
00:17:10,789 --> 00:17:08,000
stereo spacecraft

459
00:17:12,710 --> 00:17:10,799
uh this shows the solar wind interacting

460
00:17:15,429 --> 00:17:12,720
with two there's actually two comets in

461
00:17:18,789 --> 00:17:15,439
this uh video one comet ison and the

462
00:17:21,270 --> 00:17:18,799
other comet enki and we see their

463
00:17:23,350 --> 00:17:21,280

tails being distributed again blowing

464
00:17:24,309 --> 00:17:23,360
water and dust throughout the solar

465
00:17:26,150 --> 00:17:24,319
system

466
00:17:28,069 --> 00:17:26,160
in this video actually the sun is off to

467
00:17:29,510 --> 00:17:28,079
the right and you get a very interesting

468
00:17:31,510 --> 00:17:29,520
perspective of

469
00:17:33,590 --> 00:17:31,520
relative positions of mercury mercury

470
00:17:35,510 --> 00:17:33,600
and earth in fact because stereo

471
00:17:37,750 --> 00:17:35,520
spacecraft are on the far side of the

472
00:17:40,150 --> 00:17:37,760
sun from us looking back

473
00:17:41,830 --> 00:17:40,160
at this

474
00:17:43,110 --> 00:17:41,840
so we've talked about the solar wind

475
00:17:44,390 --> 00:17:43,120
where does this come from we know it

476
00:17:47,029 --> 00:17:44,400
comes from the sun but how is it

477
00:17:50,710 --> 00:17:47,039
accelerated how is it driven

478
00:17:52,870 --> 00:17:50,720
where did the cme start in my next video

479
00:17:55,029 --> 00:17:52,880
you'll see in 2018

480
00:17:56,150 --> 00:17:55,039
nasa will launch the solar pro plus

481
00:17:59,110 --> 00:17:56,160
mission

482
00:18:01,029 --> 00:17:59,120
this will for the first time fly into

483
00:18:03,270 --> 00:18:01,039
the sun's

484
00:18:05,590 --> 00:18:03,280
direct lower atmosphere

485
00:18:07,350 --> 00:18:05,600
traveling closer than four million miles

486
00:18:10,390 --> 00:18:07,360
within the solar surface

487
00:18:12,830 --> 00:18:10,400
this historic mission will revolutionize

488
00:18:15,270 --> 00:18:12,840

our understanding of the sun's

489
00:18:17,510 --> 00:18:15,280
atmosphere and how it's heated and how

490
00:18:18,710 --> 00:18:17,520
the solar wind is accelerated

491
00:18:20,470 --> 00:18:18,720
um

492
00:18:22,470 --> 00:18:20,480
in the video you see that the solar

493
00:18:25,190 --> 00:18:22,480
probe plus spacecraft and its orbit

494
00:18:27,430 --> 00:18:25,200
through the inner part of the solar wind

495
00:18:29,590 --> 00:18:27,440
where it's being accelerated

496
00:18:31,110 --> 00:18:29,600
close to the sun

497
00:18:33,430 --> 00:18:31,120
here we'll understand the magnetic

498
00:18:35,110 --> 00:18:33,440
fields the particles how they're

499
00:18:37,110 --> 00:18:35,120
accelerated and

500
00:18:39,029 --> 00:18:37,120
again what drives this process of

501
00:18:40,470 --> 00:18:39,039
distributing water throughout the solar

502
00:18:42,390 --> 00:18:40,480
system

503
00:18:44,870 --> 00:18:42,400
once we do this this will help us

504
00:18:47,590 --> 00:18:44,880
understand our star what powers these

505
00:18:48,950 --> 00:18:47,600
storms and again looking at

506
00:18:52,870 --> 00:18:48,960
as an analog

507
00:18:54,470 --> 00:18:52,880
for solar systems throughout our galaxy

508
00:18:57,909 --> 00:18:54,480
in my last video

509
00:18:58,789 --> 00:18:57,919
you'll see a large exoplanet

510
00:19:00,390 --> 00:18:58,799
here

511
00:19:03,110 --> 00:19:00,400
this is weathering the impacts of a

512
00:19:05,669 --> 00:19:03,120
stellar storm these are car these storms

513
00:19:07,270 --> 00:19:05,679

occur through stars everywhere

514
00:19:08,390 --> 00:19:07,280
in this animation which is actually

515
00:19:09,750 --> 00:19:08,400
based on

516
00:19:11,190 --> 00:19:09,760
observations

517
00:19:12,630 --> 00:19:11,200
we see the

518
00:19:14,870 --> 00:19:12,640
material from the planet's upper

519
00:19:17,590 --> 00:19:14,880
atmosphere being driven away from this

520
00:19:21,110 --> 00:19:17,600
solar stellar storm

521
00:19:22,390 --> 00:19:21,120
exceeds exceeding 300 000 miles per hour

522
00:19:24,230 --> 00:19:22,400
and now

523
00:19:25,830 --> 00:19:24,240
to paul will provide details of these

524
00:19:28,549 --> 00:19:25,840
other stars and the habitability of

525
00:19:30,470 --> 00:19:28,559
planets elsewhere thanks

526
00:19:32,549 --> 00:19:30,480
so jim and jeff have told you about

527
00:19:34,070 --> 00:19:32,559
habitability and water in our own solar

528
00:19:36,950 --> 00:19:34,080
system and the impact on the

529
00:19:38,549 --> 00:19:36,960
habitability of planets from the sun

530
00:19:41,510 --> 00:19:38,559
and so i'm going to talk to you about

531
00:19:43,990 --> 00:19:41,520
habitability in the rest of the galaxy

532
00:19:46,470 --> 00:19:44,000
looking beyond our solar system we see

533
00:19:47,510 --> 00:19:46,480
lots of water the galaxy is also a soggy

534
00:19:49,510 --> 00:19:47,520
place

535
00:19:51,510 --> 00:19:49,520
we can see water in the interstellar

536
00:19:54,549 --> 00:19:51,520
clouds from which planetary systems and

537
00:19:56,230 --> 00:19:54,559
stellar systems form we can see water in

538
00:19:57,909 --> 00:19:56,240

the disks of debris that are going to

539
00:20:00,710 --> 00:19:57,919
become planetary systems around other

540
00:20:03,350 --> 00:20:00,720
stars and we can even see comets being

541
00:20:05,909 --> 00:20:03,360
dissipated in other solar systems as the

542
00:20:07,430 --> 00:20:05,919
thoughts as that star evaporates them

543
00:20:10,230 --> 00:20:07,440
but the place that we're most interested

544
00:20:12,870 --> 00:20:10,240
in looking is in at worlds in the

545
00:20:15,350 --> 00:20:12,880
habitable zones around pla stars other

546
00:20:16,710 --> 00:20:15,360
than our sun so my first graphic is a

547
00:20:18,630 --> 00:20:16,720
little illustration of what the

548
00:20:20,310 --> 00:20:18,640
habitable zone means

549
00:20:22,710 --> 00:20:20,320
uh it's

550
00:20:25,270 --> 00:20:22,720
excuse me planets which are too close to

551
00:20:26,950 --> 00:20:25,280
the star are too hot for liquid water to

552
00:20:29,590 --> 00:20:26,960
exist on the surface

553
00:20:31,830 --> 00:20:29,600
and planets which are beyond the snow

554
00:20:34,310 --> 00:20:31,840
line are too cold for liquid water to

555
00:20:37,029 --> 00:20:34,320
exist on the surface but planets in this

556
00:20:38,470 --> 00:20:37,039
habitable zone uh have water that can

557
00:20:40,149 --> 00:20:38,480
exist liquid on the surface we're

558
00:20:42,630 --> 00:20:40,159
looking for rocky planets that have

559
00:20:44,149 --> 00:20:42,640
surfaces that could hold water this

560
00:20:46,950 --> 00:20:44,159
would be the habitable zone and the only

561
00:20:49,909 --> 00:20:46,960
place we know of where life like life on

562
00:20:55,270 --> 00:20:53,029
20 years ago this year the first planet

563
00:20:57,270 --> 00:20:55,280

around another star or exoplanet was

564
00:21:01,350 --> 00:20:57,280
discovered a planet was discovered

565
00:21:04,149 --> 00:21:01,360
around the star 51 pegasi in 1995

566
00:21:06,789 --> 00:21:04,159
thanks to nasa's kepler space telescope

567
00:21:09,750 --> 00:21:06,799
which was launched six years ago we now

568
00:21:11,430 --> 00:21:09,760
know of over 5 000 worlds around other

569
00:21:14,070 --> 00:21:11,440
stars

570
00:21:17,029 --> 00:21:14,080
we now know that just about every star

571
00:21:20,549 --> 00:21:17,039
in the galaxy has planets around them

572
00:21:22,789 --> 00:21:20,559
probably multiple planets around them

573
00:21:25,350 --> 00:21:22,799
the most common size planets that we've

574
00:21:27,510 --> 00:21:25,360
seen around other stars are planets that

575
00:21:29,990 --> 00:21:27,520
are between the size of the earth and

576
00:21:32,630 --> 00:21:30,000
neptune in our own solar system now the

577
00:21:36,149 --> 00:21:32,640
earth has a rock is a rocky planet and

578
00:21:38,390 --> 00:21:36,159
neptune is a uh icy giant without a

579
00:21:40,789 --> 00:21:38,400
solid surface and the dividing line

580
00:21:43,110 --> 00:21:40,799
between them is uh somewhere around

581
00:21:45,590 --> 00:21:43,120
twice the size of the earth so we're

582
00:21:47,270 --> 00:21:45,600
very interested in finding planets that

583
00:21:49,029 --> 00:21:47,280
are between one and two times the size

584
00:21:50,710 --> 00:21:49,039
of the earth around other stars in the

585
00:21:53,750 --> 00:21:50,720
habitable zone

586
00:21:56,070 --> 00:21:53,760
in my next graphic i show you the very

587
00:21:58,390 --> 00:21:56,080
few that we've discovered so far using

588
00:22:00,710 --> 00:21:58,400

the kepler space telescope

589
00:22:02,230 --> 00:22:00,720
about a half a dozen or more rocky

590
00:22:03,270 --> 00:22:02,240
planets in the habitable zone of their

591
00:22:05,909 --> 00:22:03,280
stars

592
00:22:08,470 --> 00:22:05,919
and planets like these are the prime

593
00:22:10,310 --> 00:22:08,480
locations where we would like to be able

594
00:22:13,430 --> 00:22:10,320
someday to look for evidence of

595
00:22:15,270 --> 00:22:13,440
habitability on these planets

596
00:22:16,950 --> 00:22:15,280
the question is how do we look for the

597
00:22:17,909 --> 00:22:16,960
oh one more thing before i move on to

598
00:22:21,270 --> 00:22:17,919
that

599
00:22:23,190 --> 00:22:21,280
in the year 2017 nasa will be launching

600
00:22:24,950 --> 00:22:23,200
the transiting exoplanet survey

601
00:22:27,350 --> 00:22:24,960
satellite or tess

602
00:22:29,750 --> 00:22:27,360
and tess is going to find

603
00:22:32,149 --> 00:22:29,760
rocky planets in the habitable zones

604
00:22:34,310 --> 00:22:32,159
around the nearest stars to the earth

605
00:22:36,870 --> 00:22:34,320
nearest stars to the sun

606
00:22:38,789 --> 00:22:36,880
it will be finding many dozens of these

607
00:22:41,350 --> 00:22:38,799
and because these will be planets around

608
00:22:43,510 --> 00:22:41,360
the nearest stars they will be the prime

609
00:22:45,990 --> 00:22:43,520
planets that will want to follow up and

610
00:22:47,350 --> 00:22:46,000
look for signs of habitability but but

611
00:22:50,149 --> 00:22:47,360
how do we look for those signs of

612
00:22:52,789 --> 00:22:50,159
habitability well right now

613
00:22:54,950 --> 00:22:52,799

what we do is we wait until the planet

614
00:22:57,510 --> 00:22:54,960
passes in front of the star

615
00:22:59,669 --> 00:22:57,520
and watch the star's light filter

616
00:23:01,190 --> 00:22:59,679
through the planet's atmosphere

617
00:23:03,909 --> 00:23:01,200
this method is called transit

618
00:23:06,230 --> 00:23:03,919
spectroscopy and when the starlight

619
00:23:09,590 --> 00:23:06,240
filters through the planet's atmosphere

620
00:23:11,110 --> 00:23:09,600
the atmosphere absorbs some of the light

621
00:23:14,310 --> 00:23:11,120
and the different molecules in the

622
00:23:15,990 --> 00:23:14,320
atmosphere absorb different uh colors of

623
00:23:17,750 --> 00:23:16,000
light from the star

624
00:23:20,070 --> 00:23:17,760
and this these fingerprints have

625
00:23:21,990 --> 00:23:20,080
absorbed light are the indicators of

626
00:23:24,310 --> 00:23:22,000
exactly what kind of molecule is in the

627
00:23:27,669 --> 00:23:24,320
planet's atmosphere so we could detect

628
00:23:32,390 --> 00:23:27,679
water carbon dioxide methane and other

629
00:23:35,669 --> 00:23:34,070
so if you look at my next graphic these

630
00:23:37,750 --> 00:23:35,679
are some of the kinds of planets that

631
00:23:39,750 --> 00:23:37,760
we're trying to use this transit

632
00:23:41,750 --> 00:23:39,760
spectroscopy on

633
00:23:42,710 --> 00:23:41,760
we've been successful at using this

634
00:23:44,950 --> 00:23:42,720
method

635
00:23:47,029 --> 00:23:44,960
with two of nasa's space telescopes as

636
00:23:48,710 --> 00:23:47,039
john mentioned the hubble space

637
00:23:51,269 --> 00:23:48,720
telescope and the spitzer space

638
00:23:54,390 --> 00:23:51,279

telescope have both been able to use

639
00:23:57,190 --> 00:23:54,400
transit spectroscopy to look at the

640
00:23:59,990 --> 00:23:57,200
atmospheres of gas giant planets that

641
00:24:02,549 --> 00:24:00,000
are very close to their stars in the hot

642
00:24:04,470 --> 00:24:02,559
zone of their stars because these are

643
00:24:06,789 --> 00:24:04,480
the planets that have the most light

644
00:24:08,789 --> 00:24:06,799
filtering through them and also are the

645
00:24:10,470 --> 00:24:08,799
bright and around the brightest stars so

646
00:24:12,470 --> 00:24:10,480
we get enough signal

647
00:24:14,630 --> 00:24:12,480
it'll take the next generation of space

648
00:24:17,110 --> 00:24:14,640
telescopes for us to be able to extend

649
00:24:19,350 --> 00:24:17,120
this methodology to ocean planets

650
00:24:21,750 --> 00:24:19,360
smaller than the gas giants

651
00:24:24,470 --> 00:24:21,760
and in uh 2018 we'll be launching the

652
00:24:26,870 --> 00:24:24,480
james webb space telescope and one of

653
00:24:29,430 --> 00:24:26,880
the scientific investigations that it

654
00:24:31,590 --> 00:24:29,440
will be capable of uh of doing for us

655
00:24:34,230 --> 00:24:31,600
will be doing transit spectroscopy

656
00:24:38,789 --> 00:24:34,240
investigating the atmospheres of some of

657
00:24:44,070 --> 00:24:41,669
around the nearby plant stars the

658
00:24:46,549 --> 00:24:44,080
planets that tess discovers and looking

659
00:24:47,350 --> 00:24:46,559
for the signatures of

660
00:24:51,430 --> 00:24:47,360
of

661
00:24:53,909 --> 00:24:51,440
habitability gases in those atmospheres

662
00:24:57,350 --> 00:24:53,919
but eventually we need to develop new

663
00:24:59,590 --> 00:24:57,360

techniques for studying the atmospheres

664
00:25:02,549 --> 00:24:59,600
of rocky planets in the habitable zones

665
00:25:04,950 --> 00:25:02,559
of their stars now these planets are

666
00:25:06,789 --> 00:25:04,960
going to be smaller

667
00:25:08,470 --> 00:25:06,799
than the ones we're studying so far

668
00:25:10,470 --> 00:25:08,480
which makes them fainter but they're

669
00:25:12,149 --> 00:25:10,480
also going to be further away from the

670
00:25:14,149 --> 00:25:12,159
star because they have to be in the

671
00:25:15,669 --> 00:25:14,159
cooler habitable zone than the hot zones

672
00:25:17,110 --> 00:25:15,679
we're looking at now that means they're

673
00:25:19,269 --> 00:25:17,120
very very faint

674
00:25:20,470 --> 00:25:19,279
and we're going to have to use a new

675
00:25:22,870 --> 00:25:20,480
technique

676
00:25:25,269 --> 00:25:22,880
direct imaging in order to be able to

677
00:25:27,510 --> 00:25:25,279
measure their atmospheres so my next

678
00:25:30,630 --> 00:25:27,520
graphic is a simulation of what's such

679
00:25:32,789 --> 00:25:30,640
an image might look like through a

680
00:25:34,789 --> 00:25:32,799
future space telescope one that nasa is

681
00:25:37,669 --> 00:25:34,799
currently studying called the wide field

682
00:25:39,510 --> 00:25:37,679
infrared survey telescope or wfirst

683
00:25:41,269 --> 00:25:39,520
equipped with a special kind of camera

684
00:25:42,950 --> 00:25:41,279
called a coronagraph

685
00:25:45,909 --> 00:25:42,960
the coronagraph

686
00:25:48,630 --> 00:25:45,919
has a is capable of blocking out the

687
00:25:50,470 --> 00:25:48,640
star the light from the star and

688
00:25:52,549 --> 00:25:50,480

revealing the light from the planets

689
00:25:54,310 --> 00:25:52,559
surrounding that star these planets are

690
00:25:56,789 --> 00:25:54,320
over a billion times fainter than the

691
00:25:59,350 --> 00:25:56,799
star so this is a very tricky optical

692
00:26:01,350 --> 00:25:59,360
problem but in this simulation the

693
00:26:03,669 --> 00:26:01,360
star's light has been constrained to

694
00:26:05,350 --> 00:26:03,679
inside the red circle and it's been

695
00:26:07,830 --> 00:26:05,360
blocked out and you'll see that in the

696
00:26:09,909 --> 00:26:07,840
upper left a planet has been revealed

697
00:26:12,310 --> 00:26:09,919
which would be a large jupiter-sized gas

698
00:26:15,029 --> 00:26:12,320
giant and in the lower right just

699
00:26:17,029 --> 00:26:15,039
outside the red circle you can see a

700
00:26:18,549 --> 00:26:17,039
earth-sized planet has been revealed in

701
00:26:20,789 --> 00:26:18,559
this simulation

702
00:26:22,310 --> 00:26:20,799
and if this telescope works correctly

703
00:26:25,110 --> 00:26:22,320
and the right planets are around the

704
00:26:27,990 --> 00:26:25,120
nearby stars we would be able to look at

705
00:26:29,830 --> 00:26:28,000
the light directly from these planets

706
00:26:31,590 --> 00:26:29,840
and investigate

707
00:26:33,590 --> 00:26:31,600
what kind of gases are in their

708
00:26:36,950 --> 00:26:33,600
atmospheres and are giving us the

709
00:26:38,470 --> 00:26:36,960
spectra we look at so not only is nasa

710
00:26:40,310 --> 00:26:38,480
studying

711
00:26:42,630 --> 00:26:40,320
water and habitability in our solar

712
00:26:44,470 --> 00:26:42,640
system but we're also starting to look

713
00:26:46,630 --> 00:26:44,480

for water and habitability

714
00:26:48,950 --> 00:26:46,640
on planets around other stars

715
00:26:50,789 --> 00:26:48,960
and we're building the capabilities

716
00:26:53,669 --> 00:26:50,799
we'll need to be able to look for actual

717
00:26:55,350 --> 00:26:53,679
habitable rocky worlds around stars

718
00:26:57,750 --> 00:26:55,360
other than our own sun

719
00:26:58,710 --> 00:26:57,760
ellen

720
00:27:01,350 --> 00:26:58,720
you know obviously what we've been

721
00:27:03,190 --> 00:27:01,360
talking about here today is water why is

722
00:27:05,269 --> 00:27:03,200
water so important we're looking for

723
00:27:07,110 --> 00:27:05,279
water i want to bring you back to the

724
00:27:09,269 --> 00:27:07,120
earth for a minute now think about the

725
00:27:10,470 --> 00:27:09,279
fact the earth formed about 4.6 billion

726
00:27:16,149 --> 00:27:10,480
years ago

727
00:27:18,470 --> 00:27:16,159
evolved here on earth in the oceans and

728
00:27:19,669 --> 00:27:18,480
for billions of years it remained in the

729
00:27:21,269 --> 00:27:19,679
oceans

730
00:27:23,590 --> 00:27:21,279
so that's certainly one of the things

731
00:27:25,669 --> 00:27:23,600
that really drives us to look for these

732
00:27:28,230 --> 00:27:25,679
watery worlds either in our own solar

733
00:27:29,830 --> 00:27:28,240
system or beyond our solar system but

734
00:27:31,590 --> 00:27:29,840
you know it's even more than it's just

735
00:27:33,269 --> 00:27:31,600
the experience of what we understand

736
00:27:34,950 --> 00:27:33,279
here from the earth it's the fact that

737
00:27:37,510 --> 00:27:34,960
water the water molecule has these

738
00:27:39,990 --> 00:27:37,520

really unique properties we think it's a

739
00:27:41,750 --> 00:27:40,000
solvent it moves things around it has

740
00:27:43,350 --> 00:27:41,760
really unique properties that we think

741
00:27:45,990 --> 00:27:43,360
are really critical to the formation of

742
00:27:48,789 --> 00:27:46,000
life not just here on earth but on other

743
00:27:50,070 --> 00:27:48,799
bodies in the solar system now when you

744
00:27:52,070 --> 00:27:50,080
look at the bodies that we've been

745
00:27:53,590 --> 00:27:52,080
talking about here that jim green and

746
00:27:55,510 --> 00:27:53,600
jeff and and paul hertz were talking

747
00:27:57,590 --> 00:27:55,520
about that you see in this graphic you

748
00:28:00,549 --> 00:27:57,600
know mars there in the in the top center

749
00:28:02,310 --> 00:28:00,559
so critical we think to to the fact to

750
00:28:03,990 --> 00:28:02,320
the search for life because of the fact

751
00:28:06,310 --> 00:28:04,000
that water was stable

752
00:28:07,990 --> 00:28:06,320
as jim was saying for possibly a billion

753
00:28:09,590 --> 00:28:08,000
years on the surface

754
00:28:11,269 --> 00:28:09,600
so again that goes back to what we know

755
00:28:13,510 --> 00:28:11,279
from our experience here on earth we

756
00:28:15,669 --> 00:28:13,520
think that long period of time is

757
00:28:17,190 --> 00:28:15,679
necessary for life to maybe get more

758
00:28:18,789 --> 00:28:17,200
complex

759
00:28:22,149 --> 00:28:18,799
so when we talk about trying to find

760
00:28:23,990 --> 00:28:22,159
life on mars or maybe life on europa or

761
00:28:25,590 --> 00:28:24,000
on other moons of the solar system like

762
00:28:28,630 --> 00:28:25,600
enceladus that was at the bottom of the

763
00:28:30,630 --> 00:28:28,640

graphic that i showed a minute ago

764
00:28:33,350 --> 00:28:30,640
we're not talking about little green men

765
00:28:34,710 --> 00:28:33,360
we're more talking about little microbes

766
00:28:36,870 --> 00:28:34,720
so this is going to be life that's going

767
00:28:39,110 --> 00:28:36,880
to be a little bit hard to find

768
00:28:40,630 --> 00:28:39,120
in our own solar system

769
00:28:42,149 --> 00:28:40,640
and so when we think about that we start

770
00:28:43,750 --> 00:28:42,159
thinking how are we going to find it

771
00:28:45,430 --> 00:28:43,760
let's think about mars we've been

772
00:28:47,350 --> 00:28:45,440
sending these spacecraft they have very

773
00:28:49,669 --> 00:28:47,360
sophisticated instruments so what do we

774
00:28:51,750 --> 00:28:49,679
look for we look for the building blocks

775
00:28:54,149 --> 00:28:51,760
of life we look for organic molecules

776
00:28:55,909 --> 00:28:54,159
that might tell us that some process is

777
00:28:58,230 --> 00:28:55,919
going on we look for something

778
00:29:00,149 --> 00:28:58,240
scientists call disequilibrium we look

779
00:29:02,230 --> 00:29:00,159
for things out of balance is there

780
00:29:04,070 --> 00:29:02,240
something that seems to be consuming

781
00:29:05,430 --> 00:29:04,080
something and giving something else off

782
00:29:07,190 --> 00:29:05,440
so those are the things we look for

783
00:29:09,909 --> 00:29:07,200
scientifically

784
00:29:11,990 --> 00:29:09,919
but ultimately i'm a field geologist i

785
00:29:14,230 --> 00:29:12,000
go out and break open rocks and look for

786
00:29:16,230 --> 00:29:14,240
fossils those are hard to find

787
00:29:18,389 --> 00:29:16,240
so i have a bias that it's eventually

788
00:29:20,789 --> 00:29:18,399

going to take humans on the surface of

789
00:29:21,909 --> 00:29:20,799
mars field geologists astrobiologists

790
00:29:24,149 --> 00:29:21,919
chemists

791
00:29:26,070 --> 00:29:24,159
actually out there looking for that good

792
00:29:27,909 --> 00:29:26,080
evidence of life that we can bring back

793
00:29:30,470 --> 00:29:27,919
to earth for all the scientists to argue

794
00:29:32,470 --> 00:29:30,480
about and say is this life is it not how

795
00:29:33,430 --> 00:29:32,480
do those cells compare to cells here on

796
00:29:35,669 --> 00:29:33,440
earth

797
00:29:38,230 --> 00:29:35,679
do these microbes that formed on another

798
00:29:39,669 --> 00:29:38,240
planet do they have rna or dna like life

799
00:29:41,830 --> 00:29:39,679
has here on earth these are the

800
00:29:43,990 --> 00:29:41,840
questions that ultimately i think it's

801
00:29:46,230 --> 00:29:44,000
going to take our astrobiologists on the

802
00:29:48,310 --> 00:29:46,240
surface of mars to answer

803
00:29:49,990 --> 00:29:48,320
so that's why nasa is so focused on our

804
00:29:51,990 --> 00:29:50,000
journey to mars

805
00:29:54,389 --> 00:29:52,000
and what are we doing to accomplish that

806
00:29:55,510 --> 00:29:54,399
well for one thing uh as john and jim

807
00:29:57,350 --> 00:29:55,520
green were talking about we have a

808
00:29:59,750 --> 00:29:57,360
healthy program of studying the surface

809
00:30:03,269 --> 00:29:59,760
of mars right now with spacecraft like

810
00:30:04,950 --> 00:30:03,279
maven with our curiosity rover in 2020

811
00:30:06,389 --> 00:30:04,960
we're going to send a new rover to mars

812
00:30:08,310 --> 00:30:06,399
that's going to move us even further

813
00:30:10,710 --> 00:30:08,320

forward towards understanding mars's

814
00:30:12,310 --> 00:30:10,720
habitability and performing some initial

815
00:30:13,830 --> 00:30:12,320
experiments to get us ready to send

816
00:30:15,269 --> 00:30:13,840
humans to mars

817
00:30:16,950 --> 00:30:15,279
we're working every day up on the

818
00:30:19,110 --> 00:30:16,960
international space station with our

819
00:30:20,789 --> 00:30:19,120
astronauts to understand the long-term

820
00:30:23,350 --> 00:30:20,799
effects of space flight on human health

821
00:30:24,870 --> 00:30:23,360
so we can get astronauts to mars safely

822
00:30:26,870 --> 00:30:24,880
and return them back here to earth

823
00:30:28,470 --> 00:30:26,880
safely and that's what the one-year

824
00:30:30,389 --> 00:30:28,480
increment what scott kelly and mikhail

825
00:30:32,149 --> 00:30:30,399
kornienko is all about

826
00:30:33,990 --> 00:30:32,159
and the twin study that we just started

827
00:30:35,430 --> 00:30:34,000
uh conducting a few weeks ago with the

828
00:30:37,510 --> 00:30:35,440
successful launch up to the

829
00:30:38,789 --> 00:30:37,520
international space station it's why

830
00:30:40,789 --> 00:30:38,799
we're doing commercial crew in

831
00:30:42,549 --> 00:30:40,799
commercial cargo it's why we're

832
00:30:44,470 --> 00:30:42,559
developing the space launch system our

833
00:30:46,389 --> 00:30:44,480
new rocket that will move humans out

834
00:30:47,750 --> 00:30:46,399
beyond low earth orbit and the orion

835
00:30:49,590 --> 00:30:47,760
capsule which we just tested

836
00:30:51,669 --> 00:30:49,600
successfully in december

837
00:30:53,590 --> 00:30:51,679
so we have a whole program to move us

838
00:30:55,590 --> 00:30:53,600

forward on this journey to mars because

839
00:30:57,990 --> 00:30:55,600
again if we come back to the scientific

840
00:30:59,590 --> 00:30:58,000
question are we alone

841
00:31:02,310 --> 00:30:59,600
getting astronauts to the surface of

842
00:31:04,230 --> 00:31:02,320
mars to help answer that question

843
00:31:06,950 --> 00:31:04,240
understanding the sun and its behavior

844
00:31:09,029 --> 00:31:06,960
and its effects on life here on earth

845
00:31:11,110 --> 00:31:09,039
but also helping us use that information

846
00:31:13,110 --> 00:31:11,120
to understand the potential for life on

847
00:31:15,830 --> 00:31:13,120
worlds around other planets

848
00:31:18,149 --> 00:31:15,840
using our great telescopes uh like

849
00:31:20,710 --> 00:31:18,159
hubble and in the future james the james

850
00:31:22,149 --> 00:31:20,720
webb space telescope to start using the

851
00:31:24,310 --> 00:31:22,159
information we're gaining from

852
00:31:26,630 --> 00:31:24,320
understanding life here in our own solar

853
00:31:28,549 --> 00:31:26,640
system to understand

854
00:31:30,149 --> 00:31:28,559
beyond our solar system

855
00:31:33,590 --> 00:31:30,159
thank you

856
00:31:35,990 --> 00:31:33,600
something a little different here

857
00:31:37,430 --> 00:31:36,000
normally i'm up here and we're doing a

858
00:31:39,110 --> 00:31:37,440
press conference and the science mission

859
00:31:40,470 --> 00:31:39,120
directorate is always doing press

860
00:31:41,909 --> 00:31:40,480
conference because they always are

861
00:31:45,190 --> 00:31:41,919
making great news

862
00:31:47,590 --> 00:31:45,200
um we're gonna obviously go to the media

863
00:31:50,310 --> 00:31:47,600

ask questions here and on the phone line

864
00:31:51,430 --> 00:31:50,320
and social media there's a lot of buzz

865
00:31:54,070 --> 00:31:51,440
out there

866
00:31:56,870 --> 00:31:54,080
send in your questions to hashtag ask

867
00:31:59,269 --> 00:31:56,880
nasa but i see a lot of folks we have a

868
00:32:01,990 --> 00:31:59,279
very diverse audience here

869
00:32:04,789 --> 00:32:02,000
this subject affects every one of you in

870
00:32:06,870 --> 00:32:04,799
this room the folks hearing my voice

871
00:32:08,870 --> 00:32:06,880
watching nasa television

872
00:32:11,190 --> 00:32:08,880
and on our website and of course social

873
00:32:12,470 --> 00:32:11,200
media so we're going to transition if

874
00:32:14,310 --> 00:32:12,480
you have a question just wait for the

875
00:32:15,909 --> 00:32:14,320
mic we're going to start here we're

876
00:32:19,029 --> 00:32:15,919
going to go to the phone lines and we're

877
00:32:20,789 --> 00:32:19,039
going to go to social media so

878
00:32:25,190 --> 00:32:20,799
you can if we can get this gentleman and

879
00:32:28,950 --> 00:32:27,430
hi randy shostak reporter with eos at

880
00:32:30,710 --> 00:32:28,960
the american geophysical union thanks

881
00:32:32,070 --> 00:32:30,720
very much for doing this briefing

882
00:32:34,549 --> 00:32:32,080
i wanted to ask

883
00:32:36,310 --> 00:32:34,559
each of you what surprises you the most

884
00:32:38,230 --> 00:32:36,320
in the recent studies and findings about

885
00:32:40,710 --> 00:32:38,240
the search for water inhabitable planets

886
00:32:43,269 --> 00:32:40,720
and what are you looking forward to

887
00:32:47,350 --> 00:32:43,279
what most excites you uh in the coming

888
00:32:51,110 --> 00:32:49,669

well i think that you know

889
00:32:52,950 --> 00:32:51,120
some scientists

890
00:32:56,470 --> 00:32:52,960
would have predicted and have predicted

891
00:32:58,070 --> 00:32:56,480
plumes on europa but i think the uh

892
00:33:00,389 --> 00:32:58,080
serendipity that we are planning a

893
00:33:02,630 --> 00:33:00,399
mission to europa and that hubble has

894
00:33:04,789 --> 00:33:02,640
observed these putative plumes gives us

895
00:33:07,990 --> 00:33:04,799
an opportunity for the first time to not

896
00:33:10,470 --> 00:33:08,000
only try and understand the structure of

897
00:33:12,310 --> 00:33:10,480
europa as an icy moon you know the

898
00:33:14,870 --> 00:33:12,320
thickness of the crust the composition

899
00:33:16,710 --> 00:33:14,880
of the surface you know the density you

900
00:33:18,230 --> 00:33:16,720
know the gravity field all the things

901
00:33:20,149 --> 00:33:18,240
that we've done previously in our

902
00:33:23,190 --> 00:33:20,159
orbiting missions but it has the

903
00:33:25,669 --> 00:33:23,200
potential to allow us actually

904
00:33:27,669 --> 00:33:25,679
to interrogate the plume and see if we

905
00:33:30,470 --> 00:33:27,679
see any signs of what might be

906
00:33:32,950 --> 00:33:30,480
subsurface life on an ocean

907
00:33:35,269 --> 00:33:32,960
on europa it's an opportunity that we're

908
00:33:37,430 --> 00:33:35,279
exploring i think you know that's going

909
00:33:39,669 --> 00:33:37,440
to be really fantastic to be able to do

910
00:33:41,830 --> 00:33:39,679
that but that it's not just europa that

911
00:33:45,509 --> 00:33:41,840
potentially we have ganymede and we do

912
00:33:47,190 --> 00:33:45,519
see plumes on enceladus around uh

913
00:33:48,950 --> 00:33:47,200

saturn that cassini has been

914
00:33:50,870 --> 00:33:48,960
interrogating and has seen very

915
00:33:52,070 --> 00:33:50,880
intriguing signs and and that's

916
00:33:55,750 --> 00:33:52,080
something you might ask ellen moore

917
00:33:58,470 --> 00:33:55,760
about as a cassini investigator

918
00:34:00,230 --> 00:33:58,480
so from my perspective i think our

919
00:34:02,950 --> 00:34:00,240
science community is making enormous

920
00:34:05,029 --> 00:34:02,960
progress in various ways that i couldn't

921
00:34:07,029 --> 00:34:05,039
even conceive of and that might be

922
00:34:08,869 --> 00:34:07,039
because i've scared the heck out of them

923
00:34:11,030 --> 00:34:08,879
in the sense that i've said i'm planning

924
00:34:12,629 --> 00:34:11,040
to be the director of planetary science

925
00:34:14,710 --> 00:34:12,639
when we discover life in the solar

926
00:34:17,109 --> 00:34:14,720
system so they better get busy

927
00:34:19,669 --> 00:34:17,119
and and as i said uh

928
00:34:21,589 --> 00:34:19,679
it's just such an exciting time for us

929
00:34:23,190 --> 00:34:21,599
going out to europa building the

930
00:34:23,990 --> 00:34:23,200
building the spacecraft we need to do

931
00:34:25,030 --> 00:34:24,000
that

932
00:34:26,790 --> 00:34:25,040
mars

933
00:34:30,790 --> 00:34:26,800
in terms of being able to look at that

934
00:34:33,109 --> 00:34:30,800
geological record go back with a in 2020

935
00:34:36,230 --> 00:34:33,119
into a what we now can recognize our

936
00:34:38,950 --> 00:34:36,240
habitable past habitable regions on mars

937
00:34:41,190 --> 00:34:38,960
really interrogate a another region like

938
00:34:43,349 --> 00:34:41,200

curiosity is man i don't know what we're

939
00:34:45,190 --> 00:34:43,359
gonna find there but we you know we're

940
00:34:47,510 --> 00:34:45,200
gonna save the geological record for

941
00:34:49,430 --> 00:34:47,520
potential return back to the earth

942
00:34:51,990 --> 00:34:49,440
so we're making these huge strides along

943
00:34:54,149 --> 00:34:52,000
the way and i i really think and i

944
00:34:56,629 --> 00:34:54,159
should bet paul this that we'll find

945
00:34:59,349 --> 00:34:56,639
life in the solar system before we find

946
00:35:04,550 --> 00:34:59,359
it uh in in exoplanets but we'll find it

947
00:35:08,310 --> 00:35:06,790
okay um before i see if we have any

948
00:35:10,230 --> 00:35:08,320
other questions or honestly and then

949
00:35:11,990 --> 00:35:10,240
we're going to go to social media

950
00:35:13,670 --> 00:35:12,000
we have uh some folks i want to

951
00:35:15,030 --> 00:35:13,680
recognize and be honest dr green's

952
00:35:16,950 --> 00:35:15,040
talking about getting busy these folks

953
00:35:20,390 --> 00:35:16,960
are getting busy

954
00:35:23,109 --> 00:35:20,400
every day first the new program director

955
00:35:24,870 --> 00:35:23,119
for the james webb space telescope dr

956
00:35:27,430 --> 00:35:24,880
eric smith

957
00:35:30,870 --> 00:35:27,440
we all know we celebrate 25 years of

958
00:35:33,270 --> 00:35:30,880
hubble you ain't seen nothing yet after

959
00:35:35,829 --> 00:35:33,280
james webb space telescope gets up there

960
00:35:38,390 --> 00:35:35,839
thank you dr smith and behind dr smith

961
00:35:40,630 --> 00:35:38,400
is dr mary voltek

962
00:35:42,310 --> 00:35:40,640
the director of astrobiology and she's

963
00:35:44,310 --> 00:35:42,320

getting busy because she's got some

964
00:35:47,430 --> 00:35:44,320
conferences coming up with these folks

965
00:35:49,430 --> 00:35:47,440
are getting together and as jim said

966
00:35:51,589 --> 00:35:49,440
things are moving to answer these

967
00:35:54,150 --> 00:35:51,599
questions and they're moving fast any

968
00:35:55,589 --> 00:35:54,160
questions from our audience we have

969
00:35:58,069 --> 00:35:55,599
yes sir

970
00:36:00,390 --> 00:35:58,079
please identify yourself and thank you

971
00:36:02,790 --> 00:36:00,400
very much my name is kai torstulaine i'm

972
00:36:05,349 --> 00:36:02,800
from rovio entertainment makers of angry

973
00:36:06,710 --> 00:36:05,359
birds and perhaps more importantly angry

974
00:36:07,670 --> 00:36:06,720
birds space

975
00:36:08,630 --> 00:36:07,680
welcome

976
00:36:11,349 --> 00:36:08,640
um

977
00:36:13,589 --> 00:36:11,359
i have a question for you regarding

978
00:36:15,510 --> 00:36:13,599
today's announcement so many interesting

979
00:36:17,190 --> 00:36:15,520
advances

980
00:36:19,750 --> 00:36:17,200
what would be

981
00:36:22,550 --> 00:36:19,760
perhaps the single most exciting thing

982
00:36:24,470 --> 00:36:22,560
that you would like me to take back

983
00:36:28,069 --> 00:36:24,480
to the entertainment and to the

984
00:36:31,030 --> 00:36:29,270
you know when i go out and talk to

985
00:36:33,109 --> 00:36:31,040
student audiences you know i always tell

986
00:36:36,069 --> 00:36:33,119
them i'm almost jealous of them because

987
00:36:37,349 --> 00:36:36,079
to me they're living in a world in which

988
00:36:39,430 --> 00:36:37,359

you know maybe i'm a little slightly

989
00:36:40,790 --> 00:36:39,440
less optimistic than jim that within all

990
00:36:42,550 --> 00:36:40,800
of our lifetime though we're going to

991
00:36:43,910 --> 00:36:42,560
understand that there is life on other

992
00:36:45,750 --> 00:36:43,920
bodies in the solar system we're going

993
00:36:47,750 --> 00:36:45,760
to understand the implications of that

994
00:36:49,510 --> 00:36:47,760
for evolution of life here on earth

995
00:36:51,990 --> 00:36:49,520
we're going to find planets around other

996
00:36:53,510 --> 00:36:52,000
stars that we can say we see potential

997
00:36:55,270 --> 00:36:53,520
signs of habitability in their

998
00:36:57,670 --> 00:36:55,280
atmospheres that's all going to happen

999
00:36:59,670 --> 00:36:57,680
in the next 10 to 20 years how exciting

1000
00:37:01,270 --> 00:36:59,680
is that we're on the verge of things

1001
00:37:04,390 --> 00:37:01,280
that people have wondered about for

1002
00:37:07,190 --> 00:37:04,400
millennia are we alone and here we are

1003
00:37:08,870 --> 00:37:07,200
on the verge of finding that out and i

1004
00:37:10,950 --> 00:37:08,880
tell the kids you better study science

1005
00:37:12,710 --> 00:37:10,960
and math and engineering you better be

1006
00:37:15,670 --> 00:37:12,720
practicing your computer skills on angry

1007
00:37:17,430 --> 00:37:15,680
birds because we're on the verge

1008
00:37:19,270 --> 00:37:17,440
and we need you guys to study because

1009
00:37:21,190 --> 00:37:19,280
you're going to have so much work to do

1010
00:37:22,790 --> 00:37:21,200
studying these planets these potentially

1011
00:37:23,910 --> 00:37:22,800
habitable worlds so you better get to

1012
00:37:26,790 --> 00:37:23,920
work because we're going to need you to

1013
00:37:27,670 --> 00:37:26,800

be our scientists of the future

1014
00:37:29,430 --> 00:37:27,680
good

1015
00:37:31,190 --> 00:37:29,440
any other questions before we go to

1016
00:37:33,990 --> 00:37:31,200
social media yes

1017
00:37:39,109 --> 00:37:34,000
the gentleman here

1018
00:37:43,750 --> 00:37:40,710
uh mike helton

1019
00:37:45,589 --> 00:37:43,760
is there any consideration uh by nasa to

1020
00:37:47,589 --> 00:37:45,599
take a look at these rocky planets that

1021
00:37:49,589 --> 00:37:47,599
you are discovering with other

1022
00:37:50,390 --> 00:37:49,599
instruments like radio telescopes to

1023
00:37:52,950 --> 00:37:50,400
maybe

1024
00:37:55,030 --> 00:37:52,960
pick up any kind of radio signals from

1025
00:37:57,349 --> 00:37:55,040
them assuming that they might be some

1026
00:38:00,069 --> 00:37:57,359
advanced system like we have

1027
00:38:02,829 --> 00:38:00,079
and we're after all sending out

1028
00:38:06,630 --> 00:38:02,839
radio signals outside of our solar

1029
00:38:09,270 --> 00:38:06,640
system so uh nasa doesn't operate the

1030
00:38:11,910 --> 00:38:09,280
radio telescopes uh that are that are

1031
00:38:14,230 --> 00:38:11,920
used but i know that the operators of

1032
00:38:16,470 --> 00:38:14,240
those telescopes think very carefully

1033
00:38:19,430 --> 00:38:16,480
about whether that is a useful

1034
00:38:21,990 --> 00:38:19,440
investigation to do

1035
00:38:25,030 --> 00:38:22,000
the what the particular rocky planets

1036
00:38:27,030 --> 00:38:25,040
that kepler has found are very far away

1037
00:38:29,750 --> 00:38:27,040
and so i haven't done the calculations

1038
00:38:31,190 --> 00:38:29,760

to know if if radio signals analogous to

1039
00:38:33,109 --> 00:38:31,200
the ones that the earth gives off would

1040
00:38:34,950 --> 00:38:33,119
be detectable with today's radio

1041
00:38:36,710 --> 00:38:34,960
telescopes but that would be the the

1042
00:38:38,069 --> 00:38:36,720
right calculation to do before one

1043
00:38:40,310 --> 00:38:38,079
decided to undertake such an

1044
00:38:42,950 --> 00:38:40,320
investigation

1045
00:38:44,630 --> 00:38:42,960
now there actually are some observations

1046
00:38:47,349 --> 00:38:44,640
in our solar system that might help

1047
00:38:48,390 --> 00:38:47,359
inform what we might do next and that is

1048
00:38:50,870 --> 00:38:48,400
we know

1049
00:38:53,190 --> 00:38:50,880
that planets that have magnetic fields

1050
00:38:55,829 --> 00:38:53,200
and they're bathed in the solar wind

1051
00:38:58,870 --> 00:38:55,839
that interaction actually produces radio

1052
00:39:01,510 --> 00:38:58,880
emissions above these aurora that occur

1053
00:39:03,990 --> 00:39:01,520
now that that may not tell us that that

1054
00:39:06,310 --> 00:39:04,000
planet is habitable so much as it does

1055
00:39:08,630 --> 00:39:06,320
it tells us about the magnetic field but

1056
00:39:10,470 --> 00:39:08,640
we're finding it when we look at mars

1057
00:39:12,470 --> 00:39:10,480
which did have a magnetic field at one

1058
00:39:14,310 --> 00:39:12,480
time and it's passed and now it doesn't

1059
00:39:16,470 --> 00:39:14,320
and now its atmosphere has been stripped

1060
00:39:18,390 --> 00:39:16,480
away there might be something there that

1061
00:39:21,589 --> 00:39:18,400
we ought to continue to do research on

1062
00:39:23,750 --> 00:39:21,599
but radio telescopes could be used to to

1063
00:39:26,069 --> 00:39:23,760

look for planets that have magnetic

1064
00:39:29,430 --> 00:39:26,079
fields and generate these radio waves

1065
00:39:31,990 --> 00:39:29,440
from natural and natural ways

1066
00:39:32,870 --> 00:39:32,000
okay let's uh switch gears and uh see

1067
00:39:35,030 --> 00:39:32,880
what's

1068
00:39:36,630 --> 00:39:35,040
going on on social media my colleague

1069
00:39:39,270 --> 00:39:36,640
felicia chao

1070
00:39:40,790 --> 00:39:39,280
what's the conversation like out there

1071
00:39:42,790 --> 00:39:40,800
well dwayne um there are a bunch of

1072
00:39:45,430 --> 00:39:42,800
social media questions on nasa's search

1073
00:39:47,430 --> 00:39:45,440
for life uh daniel robinson from twitter

1074
00:39:49,430 --> 00:39:47,440
asked do you think life could have

1075
00:39:51,589 --> 00:39:49,440
evolved out there that would have been

1076
00:39:55,190 --> 00:39:51,599
hostile to what we understand such as

1077
00:39:59,270 --> 00:39:57,670
who wants to take that

1078
00:40:01,349 --> 00:39:59,280
you know obviously we're very biased by

1079
00:40:03,349 --> 00:40:01,359
what we understand of life here on earth

1080
00:40:05,589 --> 00:40:03,359
and and pushing the limits to that what

1081
00:40:07,589 --> 00:40:05,599
the limits to life are is something that

1082
00:40:09,829 --> 00:40:07,599
we have scientists looking at you know

1083
00:40:11,750 --> 00:40:09,839
that that question but but certainly the

1084
00:40:13,190 --> 00:40:11,760
basis that we understand for life

1085
00:40:15,589 --> 00:40:13,200
carbon-based life

1086
00:40:17,349 --> 00:40:15,599
um we know those building blocks are not

1087
00:40:18,950 --> 00:40:17,359
only all over our solar system but we

1088
00:40:21,030 --> 00:40:18,960

know they're all over our galaxy they're

1089
00:40:22,630 --> 00:40:21,040
all over the universe so given that the

1090
00:40:24,550 --> 00:40:22,640
right building blocks are out there

1091
00:40:26,630 --> 00:40:24,560
given that there's water out there

1092
00:40:28,630 --> 00:40:26,640
that's what makes us really lean towards

1093
00:40:30,150 --> 00:40:28,640
looking for life like it is here on

1094
00:40:31,750 --> 00:40:30,160
earth but certainly even in our own

1095
00:40:33,670 --> 00:40:31,760
solar system when we look at a place

1096
00:40:36,069 --> 00:40:33,680
like titan that doesn't have liquid

1097
00:40:37,510 --> 00:40:36,079
water but it has seas of liquid methane

1098
00:40:39,510 --> 00:40:37,520
and ethane

1099
00:40:41,109 --> 00:40:39,520
we've got scientists who suggest maybe

1100
00:40:44,150 --> 00:40:41,119
you could form some sort of cell

1101
00:40:45,829 --> 00:40:44,160
membranes even on on titan um

1102
00:40:47,270 --> 00:40:45,839
so maybe in our own solar system we'll

1103
00:40:49,750 --> 00:40:47,280
be able to push the limits of this

1104
00:40:50,829 --> 00:40:49,760
theory already

1105
00:40:53,829 --> 00:40:50,839
thank you

1106
00:40:55,990 --> 00:40:53,839
um uh related to that what role does

1107
00:40:58,950 --> 00:40:56,000
gravity of a planet play in the chances

1108
00:41:03,109 --> 00:40:58,960
of it being habitable

1109
00:41:06,630 --> 00:41:04,550
i guess the follow-up question to that

1110
00:41:09,030 --> 00:41:06,640
um from lassi rooney would be is

1111
00:41:11,270 --> 00:41:09,040
presence of water or man or magnetic

1112
00:41:13,990 --> 00:41:11,280
field more important for life and the

1113
00:41:16,870 --> 00:41:14,000

priority and optimism for mars europa

1114
00:41:20,790 --> 00:41:16,880
versus ganymede

1115
00:41:23,030 --> 00:41:20,800
well as i mentioned a little bit earlier

1116
00:41:24,790 --> 00:41:23,040
the the study of the magnetic field and

1117
00:41:26,550 --> 00:41:24,800
its interaction with the solar wind is

1118
00:41:28,470 --> 00:41:26,560
such an important element for us to

1119
00:41:31,270 --> 00:41:28,480
understand how that might have protected

1120
00:41:33,589 --> 00:41:31,280
the earth over millennia and we're doing

1121
00:41:35,829 --> 00:41:33,599
that by having maven at mars and looking

1122
00:41:38,309 --> 00:41:35,839
at how mars which no longer has its

1123
00:41:40,550 --> 00:41:38,319
magnetic field and how its atmosphere is

1124
00:41:42,470 --> 00:41:40,560
being stripped away so i think we're

1125
00:41:45,430 --> 00:41:42,480
recognizing now

1126
00:41:47,670 --> 00:41:45,440
how complicated but yet connected

1127
00:41:50,230 --> 00:41:47,680
the kinds of phenomena

1128
00:41:51,750 --> 00:41:50,240
like gravity like like rocky bodies like

1129
00:41:54,390 --> 00:41:51,760
magnetic fields

1130
00:41:56,230 --> 00:41:54,400
and like water is playing in in

1131
00:41:57,430 --> 00:41:56,240
developing an environment

1132
00:41:58,710 --> 00:41:57,440
for life

1133
00:42:01,030 --> 00:41:58,720
and then

1134
00:42:03,349 --> 00:42:01,040
also maintaining it for long periods of

1135
00:42:05,589 --> 00:42:03,359
time you know we're at a time when it's

1136
00:42:08,470 --> 00:42:05,599
just a snapshot

1137
00:42:10,790 --> 00:42:08,480
of the evolution of our solar system

1138
00:42:13,990 --> 00:42:10,800

and and we need to think about times in

1139
00:42:16,470 --> 00:42:14,000
the past when life could have started

1140
00:42:19,190 --> 00:42:16,480
and where they could have started uh

1141
00:42:21,430 --> 00:42:19,200
when we look at mars and today we're

1142
00:42:22,870 --> 00:42:21,440
actually going back in time

1143
00:42:25,349 --> 00:42:22,880
in these regions

1144
00:42:28,069 --> 00:42:25,359
where it did have water we're going back

1145
00:42:30,630 --> 00:42:28,079
and perhaps there's the moment when life

1146
00:42:32,950 --> 00:42:30,640
actually started on mars and maybe we'll

1147
00:42:35,990 --> 00:42:32,960
find that environment and then we'll

1148
00:42:38,150 --> 00:42:36,000
understand a lot about life's origin

1149
00:42:40,550 --> 00:42:38,160
and put it in the context of how the

1150
00:42:41,829 --> 00:42:40,560
solar system evolves

1151
00:42:44,150 --> 00:42:41,839
i think the other part of the question

1152
00:42:46,790 --> 00:42:44,160
paul answered earlier which is at the

1153
00:42:48,550 --> 00:42:46,800
large scale when a rocky planet gets

1154
00:42:50,230 --> 00:42:48,560
more than about twice the size of the

1155
00:42:51,829 --> 00:42:50,240
earth

1156
00:42:54,150 --> 00:42:51,839
and if it's a rocky planet so it has

1157
00:42:56,150 --> 00:42:54,160
that density it starts to accrete more

1158
00:42:57,430 --> 00:42:56,160
gas when it's forming and ends up like a

1159
00:42:58,630 --> 00:42:57,440
neptune

1160
00:42:59,990 --> 00:42:58,640
frozen

1161
00:43:02,630 --> 00:43:00,000
gas world

1162
00:43:04,550 --> 00:43:02,640
and so that probably sets a limit

1163
00:43:07,190 --> 00:43:04,560

to life on a planet that's much larger

1164
00:43:08,550 --> 00:43:07,200
than a couple of times or

1165
00:43:09,829 --> 00:43:08,560
thank you

1166
00:43:11,670 --> 00:43:09,839
um

1167
00:43:15,109 --> 00:43:11,680
so dr newmark pointed out that the

1168
00:43:17,270 --> 00:43:15,119
importance of having a magnetic field

1169
00:43:20,870 --> 00:43:17,280
lady signet asks is there a way to

1170
00:43:24,470 --> 00:43:20,880
create a synthetic magnosphere

1171
00:43:29,670 --> 00:43:26,710
i'm not really sure if you if you need

1172
00:43:32,790 --> 00:43:29,680
the synthetic for the long term for for

1173
00:43:36,390 --> 00:43:32,800
life again it's important but as as jim

1174
00:43:39,270 --> 00:43:36,400
was was mentioning it's the evolution

1175
00:43:42,630 --> 00:43:39,280
it's the interaction of course with your

1176
00:43:44,470 --> 00:43:42,640
our son or a local star and that planet

1177
00:43:47,270 --> 00:43:44,480
over a long period of time is what we're

1178
00:43:48,550 --> 00:43:47,280
looking for and how that evolves not

1179
00:43:51,109 --> 00:43:48,560
sort of a

1180
00:43:53,270 --> 00:43:51,119
short-term uh magnetic field that

1181
00:43:55,270 --> 00:43:53,280
protects current life it's really the

1182
00:43:58,150 --> 00:43:55,280
long-term evolution of life

1183
00:43:59,829 --> 00:43:58,160
that this becomes important for

1184
00:44:01,990 --> 00:43:59,839
now that said we have done studies of

1185
00:44:05,109 --> 00:44:02,000
creating relatively small magnetic

1186
00:44:06,950 --> 00:44:05,119
bubbles around spacecraft for future

1187
00:44:09,030 --> 00:44:06,960
interplanetary and maybe someday future

1188
00:44:11,990 --> 00:44:09,040

interstellar travelers to have their own

1189
00:44:14,870 --> 00:44:12,000
protective magnetic field

1190
00:44:16,069 --> 00:44:14,880
so felicia before we go uh to social

1191
00:44:17,190 --> 00:44:16,079
media i want to

1192
00:44:19,430 --> 00:44:17,200
i'll tell you where you're here i'm

1193
00:44:21,190 --> 00:44:19,440
hearing i'm being told we have a lot of

1194
00:44:23,270 --> 00:44:21,200
questions coming in

1195
00:44:24,550 --> 00:44:23,280
i tell my tv audience and the folks on

1196
00:44:25,670 --> 00:44:24,560
social media we're not going to be able

1197
00:44:27,589 --> 00:44:25,680
to get to

1198
00:44:29,990 --> 00:44:27,599
many of them but send those questions in

1199
00:44:31,670 --> 00:44:30,000
hashtag ask nasa we'll get those

1200
00:44:33,270 --> 00:44:31,680
answered as soon as we can i also want

1201
00:44:34,790 --> 00:44:33,280
to tell our panelists that i'm going to

1202
00:44:35,589 --> 00:44:34,800
like to close

1203
00:44:37,510 --> 00:44:35,599
with

1204
00:44:38,950 --> 00:44:37,520
each one of you giving your personal

1205
00:44:40,950 --> 00:44:38,960
views

1206
00:44:42,550 --> 00:44:40,960
and maybe a crystal ball or predictions

1207
00:44:45,030 --> 00:44:42,560
however you want to do it but the

1208
00:44:47,430 --> 00:44:45,040
personal human being personal views of

1209
00:44:49,430 --> 00:44:47,440
how close are we what does this mean it

1210
00:44:51,750 --> 00:44:49,440
with all of these assets

1211
00:44:53,750 --> 00:44:51,760
what we're finding how close are we

1212
00:44:54,710 --> 00:44:53,760
are we going to answer the question

1213
00:44:56,710 --> 00:44:54,720

sooner

1214
00:44:58,630 --> 00:44:56,720
than we think so think about that so

1215
00:45:00,069 --> 00:44:58,640
let's take a one more question from

1216
00:45:03,750 --> 00:45:00,079
social media and we're going to wrap it

1217
00:45:05,990 --> 00:45:03,760
up okay great um here's some questions

1218
00:45:08,230 --> 00:45:06,000
mostly around exoplanets so what is

1219
00:45:10,550 --> 00:45:08,240
nasa's current definition of a habitable

1220
00:45:12,550 --> 00:45:10,560
zone and what are the requirements for

1221
00:45:14,550 --> 00:45:12,560
the planet to be habitable

1222
00:45:16,550 --> 00:45:14,560
um and what are uh

1223
00:45:17,589 --> 00:45:16,560
all the conditions required

1224
00:45:21,030 --> 00:45:17,599
for

1225
00:45:24,390 --> 00:45:21,040
we know it

1226
00:45:26,950 --> 00:45:24,400
so uh habitable zone is a fuzzy concept

1227
00:45:29,589 --> 00:45:26,960
and scientists argue a lot about what

1228
00:45:31,910 --> 00:45:29,599
the boundaries of the habitable zone are

1229
00:45:33,670 --> 00:45:31,920
the general ideas exactly what i said

1230
00:45:36,150 --> 00:45:33,680
earlier it's that

1231
00:45:38,630 --> 00:45:36,160
region of space around a star where one

1232
00:45:40,950 --> 00:45:38,640
would expect to find liquid water on the

1233
00:45:43,589 --> 00:45:40,960
surface but as we can see in our own

1234
00:45:46,630 --> 00:45:43,599
solar system both venus and mars

1235
00:45:48,150 --> 00:45:46,640
arguably fall within that definition of

1236
00:45:50,470 --> 00:45:48,160
a habitable zone and neither one of them

1237
00:45:51,670 --> 00:45:50,480
currently have liquid water on their

1238
00:45:53,270 --> 00:45:51,680

surface and so

1239
00:45:54,950 --> 00:45:53,280
it matters what the atmosphere of the

1240
00:45:57,670 --> 00:45:54,960
planet is it matters whether it has a

1241
00:45:59,349 --> 00:45:57,680
magnetic field and probably lots of

1242
00:46:01,750 --> 00:45:59,359
other things matter that scientists are

1243
00:46:04,390 --> 00:46:01,760
arguing about so you can't write down a

1244
00:46:08,950 --> 00:46:04,400
formula for it um but you know it when

1245
00:46:12,710 --> 00:46:11,349
okay let's um we i'm told that we have

1246
00:46:14,390 --> 00:46:12,720
uh we're gonna go to the phone lines and

1247
00:46:16,710 --> 00:46:14,400
then i'm gonna bring it back on stage

1248
00:46:18,950 --> 00:46:16,720
for the person reviews before we wrap up

1249
00:46:20,550 --> 00:46:18,960
and again i um for social media we're

1250
00:46:21,430 --> 00:46:20,560
gonna answer your questions keep sending

1251
00:46:23,510 --> 00:46:21,440
in

1252
00:46:28,630 --> 00:46:23,520
hashtag ask nasa let's go to the phone

1253
00:46:30,550 --> 00:46:28,640
lines uh mike wall i believe are you on

1254
00:46:32,230 --> 00:46:30,560
oh yeah i'm i'm here this is mike wahl

1255
00:46:33,990 --> 00:46:32,240
from space.com

1256
00:46:36,470 --> 00:46:34,000
um hi this

1257
00:46:38,230 --> 00:46:36,480
like this one is probably for um by the

1258
00:46:40,150 --> 00:46:38,240
doctor stofan you were mentioning having

1259
00:46:41,589 --> 00:46:40,160
astrobiologists on the surface of mars

1260
00:46:43,510 --> 00:46:41,599
could you mention like a little bit

1261
00:46:45,750 --> 00:46:43,520
about what you think i think is the role

1262
00:46:47,430 --> 00:46:45,760
for sample return

1263
00:46:48,950 --> 00:46:47,440

like in the search for

1264
00:46:51,190 --> 00:46:48,960
like fractional life on mars where do

1265
00:46:53,270 --> 00:46:51,200
you see that that sort of fitting in to

1266
00:46:54,630 --> 00:46:53,280
to the strander pattern

1267
00:46:56,150 --> 00:46:54,640
you know i think sample return that's a

1268
00:46:57,910 --> 00:46:56,160
great question sample return i think is

1269
00:46:59,510 --> 00:46:57,920
important for a couple different reasons

1270
00:47:01,349 --> 00:46:59,520
for one thing i personally think that

1271
00:47:03,270 --> 00:47:01,359
that demonstrating that that round trip

1272
00:47:03,990 --> 00:47:03,280
to mars is is something we would want to

1273
00:47:05,750 --> 00:47:04,000
do

1274
00:47:07,109 --> 00:47:05,760
um potentially when we're thinking about

1275
00:47:09,750 --> 00:47:07,119
sending humans obviously they've got to

1276
00:47:11,349 --> 00:47:09,760
get there they've got to get back um so

1277
00:47:13,670 --> 00:47:11,359
practicing getting down to the surface

1278
00:47:15,990 --> 00:47:13,680
of mars getting off rendezvousing in

1279
00:47:17,910 --> 00:47:16,000
orbit coming back think of it back to a

1280
00:47:19,349 --> 00:47:17,920
lot of the work that we did prior to

1281
00:47:20,950 --> 00:47:19,359
sending humans to the surface of the

1282
00:47:22,870 --> 00:47:20,960
moon we did missions kind of like that

1283
00:47:24,309 --> 00:47:22,880
so you can look at sample return that

1284
00:47:26,390 --> 00:47:24,319
way but certainly if you're going from a

1285
00:47:28,069 --> 00:47:26,400
purely scientific point of view

1286
00:47:30,309 --> 00:47:28,079
there's a lot we could learn from

1287
00:47:31,910 --> 00:47:30,319
samples returned from mars

1288
00:47:33,990 --> 00:47:31,920

you know a lot of the instrumentations

1289
00:47:35,750 --> 00:47:34,000
if you go into a geology department at a

1290
00:47:37,750 --> 00:47:35,760
typical university here in the united

1291
00:47:40,710 --> 00:47:37,760
states the equipment and geology labs

1292
00:47:42,790 --> 00:47:40,720
are are gigantic and so it's hard for us

1293
00:47:44,950 --> 00:47:42,800
to shrink those down and have them be as

1294
00:47:47,030 --> 00:47:44,960
capable on a spacecraft we send great

1295
00:47:49,190 --> 00:47:47,040
instruments but the instrumentation here

1296
00:47:50,950 --> 00:47:49,200
on earth is always better

1297
00:47:52,630 --> 00:47:50,960
and so the scientific community for a

1298
00:47:54,950 --> 00:47:52,640
long time that's been one of their top

1299
00:47:58,069 --> 00:47:54,960
priorities is to bring a sample

1300
00:48:00,309 --> 00:47:58,079
back and and it remains so

1301
00:48:02,390 --> 00:48:00,319
okay before we wrap up i'm going to

1302
00:48:04,309 --> 00:48:02,400
bring it back and ask dr grunsfeld to

1303
00:48:05,430 --> 00:48:04,319
start us off and we'll go down the row

1304
00:48:07,910 --> 00:48:05,440
here

1305
00:48:10,549 --> 00:48:07,920
bringing home personal feelings

1306
00:48:11,510 --> 00:48:10,559
about why i mean this is an incredible

1307
00:48:15,510 --> 00:48:11,520
subject

1308
00:48:18,470 --> 00:48:16,950
well as you've heard

1309
00:48:19,910 --> 00:48:18,480
in all of these discussions about our

1310
00:48:20,950 --> 00:48:19,920
exploration of the solar system and

1311
00:48:22,950 --> 00:48:20,960
beyond

1312
00:48:23,910 --> 00:48:22,960
we're finding

1313
00:48:25,910 --> 00:48:23,920

you know

1314
00:48:28,230 --> 00:48:25,920
somewhat surprisingly that

1315
00:48:30,150 --> 00:48:28,240
our universe our galaxy is filled with

1316
00:48:31,829 --> 00:48:30,160
habitable environments

1317
00:48:33,589 --> 00:48:31,839
and it really does beg the question you

1318
00:48:35,349 --> 00:48:33,599
know if

1319
00:48:37,750 --> 00:48:35,359
if there's so many places that life

1320
00:48:39,829 --> 00:48:37,760
could exist you know where is everybody

1321
00:48:42,230 --> 00:48:39,839
you know and and you know that's part of

1322
00:48:45,190 --> 00:48:42,240
the question of are we alone

1323
00:48:47,270 --> 00:48:45,200
of course we've only been a space faring

1324
00:48:50,549 --> 00:48:47,280
world you know for a little over 50

1325
00:48:52,549 --> 00:48:50,559
years so i think it's amazing that we've

1326
00:48:54,630 --> 00:48:52,559
made so much progress in such a short

1327
00:48:56,710 --> 00:48:54,640
time that we have a hubble space

1328
00:48:58,790 --> 00:48:56,720
telescope that can look at the

1329
00:49:00,309 --> 00:48:58,800
atmosphere of a planet around a nearby

1330
00:49:01,990 --> 00:49:00,319
star

1331
00:49:03,670 --> 00:49:02,000
because when we imagined the hubble

1332
00:49:06,069 --> 00:49:03,680
space telescope and built it we didn't

1333
00:49:08,790 --> 00:49:06,079
know about any planets outside of our

1334
00:49:10,069 --> 00:49:08,800
own solar system

1335
00:49:11,990 --> 00:49:10,079
this july

1336
00:49:14,069 --> 00:49:12,000
we're going to make our first visit to

1337
00:49:16,230 --> 00:49:14,079
the planet pluto we don't know what

1338
00:49:18,790 --> 00:49:16,240

we're going to find you know and the us

1339
00:49:22,150 --> 00:49:18,800
will have by july been to the first

1340
00:49:24,870 --> 00:49:22,160
every planet in our solar system

1341
00:49:26,230 --> 00:49:24,880
and launch the james webb and by 2018

1342
00:49:28,630 --> 00:49:26,240
will launch the james webb space

1343
00:49:30,710 --> 00:49:28,640
telescope which will allow us access to

1344
00:49:32,710 --> 00:49:30,720
many more planetary atmospheres

1345
00:49:34,390 --> 00:49:32,720
including some super earths

1346
00:49:36,390 --> 00:49:34,400
so i think that

1347
00:49:38,390 --> 00:49:36,400
in our own solar system we have a chance

1348
00:49:41,430 --> 00:49:38,400
of finding that there might have been

1349
00:49:42,870 --> 00:49:41,440
past life on mars or evidence of current

1350
00:49:44,950 --> 00:49:42,880
microbial life

1351
00:49:47,030 --> 00:49:44,960
sometime in the next generation of

1352
00:49:49,030 --> 00:49:47,040
explorers to mars whether human

1353
00:49:51,190 --> 00:49:49,040
explorers and i share ellen's view that

1354
00:49:53,589 --> 00:49:51,200
the fast progress will be made once we

1355
00:49:55,829 --> 00:49:53,599
have astrobiologists and geologists on

1356
00:49:57,510 --> 00:49:55,839
the surface of mars

1357
00:49:59,349 --> 00:49:57,520
but the next generation of space

1358
00:50:01,030 --> 00:49:59,359
telescope after the james webb space

1359
00:50:02,870 --> 00:50:01,040
telescope that we'll be able to get high

1360
00:50:05,589 --> 00:50:02,880
precision spectrum

1361
00:50:07,829 --> 00:50:05,599
from a planet around a nearby star that

1362
00:50:09,589 --> 00:50:07,839
we'll be able to see the kind of

1363
00:50:11,990 --> 00:50:09,599

components in the atmosphere that would

1364
00:50:14,549 --> 00:50:12,000
be solid evidence that there's some sign

1365
00:50:17,270 --> 00:50:14,559
of life out there what that is

1366
00:50:18,870 --> 00:50:17,280
again get a group of scientists together

1367
00:50:21,589 --> 00:50:18,880
a dozen scientists you'll get 20

1368
00:50:23,589 --> 00:50:21,599
opinions on what that sign of life might

1369
00:50:25,510 --> 00:50:23,599
be but i think we're one generation away

1370
00:50:28,230 --> 00:50:25,520
in our solar system whether it's on an

1371
00:50:30,630 --> 00:50:28,240
icy moon or on mars and one generation

1372
00:50:31,990 --> 00:50:30,640
on a planet around a nearby star there's

1373
00:50:33,990 --> 00:50:32,000
one other question though that if we

1374
00:50:35,829 --> 00:50:34,000
find life on mars

1375
00:50:37,270 --> 00:50:35,839
microbial life is going to be does it

1376
00:50:38,790 --> 00:50:37,280
look like life on earth or is it

1377
00:50:41,109 --> 00:50:38,800
completely different

1378
00:50:43,750 --> 00:50:41,119
once we get out beyond mars

1379
00:50:45,589 --> 00:50:43,760
the likelihood that it's similar to

1380
00:50:47,670 --> 00:50:45,599
earth because we share that material

1381
00:50:48,790 --> 00:50:47,680
gets very very low right and so that's

1382
00:50:50,790 --> 00:50:48,800
where i think it starts getting

1383
00:50:51,510 --> 00:50:50,800
exceptionally exciting excellent dr

1384
00:50:53,589 --> 00:50:51,520
green

1385
00:50:55,910 --> 00:50:53,599
so i share all of john's views but i'll

1386
00:50:58,069 --> 00:50:55,920
tug on one part of something that he

1387
00:50:59,510 --> 00:50:58,079
said uh with a little different angle

1388
00:51:02,549 --> 00:50:59,520

and that is um

1389
00:51:04,710 --> 00:51:02,559
uh if if indeed the environments that

1390
00:51:06,069 --> 00:51:04,720
we're discovering are

1391
00:51:09,109 --> 00:51:06,079
potentially

1392
00:51:10,549 --> 00:51:09,119
environments where life could arose

1393
00:51:12,790 --> 00:51:10,559
where are they

1394
00:51:15,349 --> 00:51:12,800
well you know there's a couple ways to

1395
00:51:17,750 --> 00:51:15,359
look at that one well a complex life

1396
00:51:19,510 --> 00:51:17,760
like us perhaps doesn't last long that's

1397
00:51:21,109 --> 00:51:19,520
pretty that's a big downer i don't like

1398
00:51:23,750 --> 00:51:21,119
that view

1399
00:51:25,190 --> 00:51:23,760
uh and when you think about modern

1400
00:51:27,109 --> 00:51:25,200
humans where we actually had an

1401
00:51:29,510 --> 00:51:27,119
opportunity to change our environment i

1402
00:51:31,750 --> 00:51:29,520
believe that started about 10 to 15 000

1403
00:51:33,910 --> 00:51:31,760
years ago when agriculture got going

1404
00:51:37,349 --> 00:51:33,920
then we actually are in control of our

1405
00:51:39,510 --> 00:51:37,359
environment and and and that's just a

1406
00:51:41,910 --> 00:51:39,520
hardly a blink

1407
00:51:43,349 --> 00:51:41,920
of the eye in the time of uh of the

1408
00:51:44,309 --> 00:51:43,359
solar system

1409
00:51:45,670 --> 00:51:44,319
so

1410
00:51:47,670 --> 00:51:45,680
where are they

1411
00:51:51,030 --> 00:51:47,680
maybe they are us

1412
00:51:53,589 --> 00:51:51,040
maybe we are the first species to

1413
00:51:55,270 --> 00:51:53,599

continue on maybe we indeed have that

1414
00:51:57,430 --> 00:51:55,280
explorer gene

1415
00:52:00,390 --> 00:51:57,440
that allows us to leave the bounds of

1416
00:52:02,710 --> 00:52:00,400
earth and move out into the solar system

1417
00:52:06,230 --> 00:52:02,720
and i truly believe that a species that

1418
00:52:07,990 --> 00:52:06,240
does that has the opportunity to survive

1419
00:52:09,750 --> 00:52:08,000
once we know our environment once we

1420
00:52:11,990 --> 00:52:09,760
know the hazards that are around us and

1421
00:52:13,190 --> 00:52:12,000
other types of stars that explode

1422
00:52:15,990 --> 00:52:13,200
and

1423
00:52:18,150 --> 00:52:16,000
near-earth objects etc that

1424
00:52:19,990 --> 00:52:18,160
climate change all the kind of hazards

1425
00:52:22,950 --> 00:52:20,000
that we're uncovering now

1426
00:52:25,430 --> 00:52:22,960
uh for the for the long term uh survival

1427
00:52:27,670 --> 00:52:25,440
of this species it's just we've just got

1428
00:52:29,109 --> 00:52:27,680
to continue on the explorer

1429
00:52:32,470 --> 00:52:29,119
the explorer route and i think we're

1430
00:52:33,829 --> 00:52:32,480
doing a fabulous job let's keep it up

1431
00:52:37,190 --> 00:52:33,839
dr newmark

1432
00:52:38,790 --> 00:52:37,200
um i'll pick up right there uh

1433
00:52:40,790 --> 00:52:38,800
discovery

1434
00:52:42,950 --> 00:52:40,800
that really is it i mean

1435
00:52:45,510 --> 00:52:42,960
all of us up here started watching man

1436
00:52:46,870 --> 00:52:45,520
first walking the moon

1437
00:52:50,309 --> 00:52:46,880
and

1438
00:52:52,630 --> 00:52:50,319

as john mentioned

1439
00:52:54,549 --> 00:52:52,640
we'll be visiting with pluto the last of

1440
00:52:56,150 --> 00:52:54,559
the planets that we haven't seen with

1441
00:52:58,630 --> 00:52:56,160
solar pro plus we'll be visiting our

1442
00:53:01,349 --> 00:52:58,640
nearest star in a few years

1443
00:53:03,349 --> 00:53:01,359
we're just continuing to discover what's

1444
00:53:05,430 --> 00:53:03,359
out there so in terms of optimism for

1445
00:53:07,750 --> 00:53:05,440
discovering life it's not it's it's

1446
00:53:10,230 --> 00:53:07,760
definitely an if not when and

1447
00:53:11,270 --> 00:53:10,240
i'm it's a when not in there

1448
00:53:12,230 --> 00:53:11,280
of course

1449
00:53:14,230 --> 00:53:12,240
uh

1450
00:53:16,710 --> 00:53:14,240
we're we're there with the the pace of

1451
00:53:18,710 --> 00:53:16,720
our discovery is continuing to to grow

1452
00:53:20,950 --> 00:53:18,720
where our understanding of our physical

1453
00:53:22,630 --> 00:53:20,960
environment around us and understanding

1454
00:53:25,430 --> 00:53:22,640
the conditions

1455
00:53:27,349 --> 00:53:25,440
that that enable this environment are

1456
00:53:30,230 --> 00:53:27,359
are we're just poised at that edge as

1457
00:53:32,470 --> 00:53:30,240
ellen was saying and so i'm extremely

1458
00:53:35,349 --> 00:53:32,480
optimistic dr hertz

1459
00:53:36,470 --> 00:53:35,359
20 years ago as i'm an astronomer 20

1460
00:53:38,470 --> 00:53:36,480
years ago

1461
00:53:40,069 --> 00:53:38,480
most astronomers believe that planets

1462
00:53:41,910 --> 00:53:40,079
around other stars must be common

1463
00:53:44,069 --> 00:53:41,920

because there's nothing special about

1464
00:53:46,150 --> 00:53:44,079
our sun but we thought that it was just

1465
00:53:48,309 --> 00:53:46,160
way too hard to discover them and that

1466
00:53:50,630 --> 00:53:48,319
we would probably remain unsatisfied in

1467
00:53:53,510 --> 00:53:50,640
proving whether that was true or not

1468
00:53:55,349 --> 00:53:53,520
because clever people found ways that we

1469
00:53:57,109 --> 00:53:55,359
could discover and study plants around

1470
00:53:59,430 --> 00:53:57,119
other stars with the kinds of

1471
00:54:03,190 --> 00:53:59,440
capabilities we're currently

1472
00:54:06,549 --> 00:54:03,200
able to do we now have directly found

1473
00:54:08,309 --> 00:54:06,559
over 5 000 planets around other stars we

1474
00:54:11,670 --> 00:54:08,319
know that they're common

1475
00:54:14,630 --> 00:54:11,680
and we are thinking constantly of more

1476
00:54:17,270 --> 00:54:14,640
and better ways of interrogating the

1477
00:54:19,510 --> 00:54:17,280
small amounts of light we can get from

1478
00:54:21,190 --> 00:54:19,520
planets around other stars in learning

1479
00:54:22,549 --> 00:54:21,200
about those planets learning about their

1480
00:54:25,510 --> 00:54:22,559
atmospheres learning about their

1481
00:54:28,230 --> 00:54:25,520
evolution learning about how our solar

1482
00:54:29,990 --> 00:54:28,240
system might not be a typical solar

1483
00:54:32,230 --> 00:54:30,000
system but other solar systems seem to

1484
00:54:34,950 --> 00:54:32,240
have lots of planets closer to their

1485
00:54:37,109 --> 00:54:34,960
star than mercury is to the sun or have

1486
00:54:38,789 --> 00:54:37,119
lots of gas giants or to have lots of

1487
00:54:40,950 --> 00:54:38,799
planets in size between earth and

1488
00:54:42,710 --> 00:54:40,960

neptune super earths and many neptunes

1489
00:54:44,309 --> 00:54:42,720
that have no analogues in our own solar

1490
00:54:47,030 --> 00:54:44,319
system

1491
00:54:49,190 --> 00:54:47,040
it's such an exciting area of astronomy

1492
00:54:52,630 --> 00:54:49,200
that when i go to astronomy conferences

1493
00:54:54,630 --> 00:54:52,640
i notice that huge fractions of all the

1494
00:54:57,750 --> 00:54:54,640
earlier career astronomers people whose

1495
00:54:59,349 --> 00:54:57,760
hair colors are darker than mine

1496
00:55:01,430 --> 00:54:59,359
are are interested in studying

1497
00:55:03,190 --> 00:55:01,440
exoplanets that it's a growth industry

1498
00:55:05,270 --> 00:55:03,200
in astronomy it's the most exciting

1499
00:55:07,829 --> 00:55:05,280
areas drawing some of the most creative

1500
00:55:10,150 --> 00:55:07,839
and innovative minds in science to

1501
00:55:11,910 --> 00:55:10,160
trying to understand not just what's

1502
00:55:14,630 --> 00:55:11,920
going on in our own solar system but

1503
00:55:17,510 --> 00:55:14,640
what's going on on planets around other

1504
00:55:20,470 --> 00:55:17,520
stars and trying to answer the question

1505
00:55:22,309 --> 00:55:20,480
are we alone and are we typical even in

1506
00:55:24,150 --> 00:55:22,319
the rest of the galaxy

1507
00:55:25,750 --> 00:55:24,160
dr stofan

1508
00:55:28,069 --> 00:55:25,760
well i'm going to go out a little bit on

1509
00:55:29,109 --> 00:55:28,079
a limb here and i'm i'm going to say i i

1510
00:55:31,670 --> 00:55:29,119
think we're going to have strong

1511
00:55:33,910 --> 00:55:31,680
indications of life beyond earth within

1512
00:55:36,390 --> 00:55:33,920
a decade um and i think we're going to

1513
00:55:39,670 --> 00:55:36,400

have definitive evidence within 10 20 to

1514
00:55:41,910 --> 00:55:39,680
30 years we we know where to look we

1515
00:55:44,470 --> 00:55:41,920
know how to look in most cases we have

1516
00:55:46,470 --> 00:55:44,480
the technology um and we're on a path to

1517
00:55:48,230 --> 00:55:46,480
implementing it and so i think we're

1518
00:55:49,990 --> 00:55:48,240
definitely on the road and what to me is

1519
00:55:52,309 --> 00:55:50,000
even more exciting is that we can bring

1520
00:55:54,390 --> 00:55:52,319
all of you along with us because if you

1521
00:55:56,309 --> 00:55:54,400
go to our nasa website look for our

1522
00:55:58,870 --> 00:55:56,319
projects in citizen science where we

1523
00:56:00,710 --> 00:55:58,880
have projects from looking at

1524
00:56:02,549 --> 00:56:00,720
stars to help classify whether they're

1525
00:56:04,789 --> 00:56:02,559
potentially likely to have planets it's

1526
00:56:06,549 --> 00:56:04,799
a program we have called disk detective

1527
00:56:09,109 --> 00:56:06,559
to looking at the data was that was

1528
00:56:11,030 --> 00:56:09,119
returned from stardust or helping us to

1529
00:56:12,549 --> 00:56:11,040
understand mars these are projects that

1530
00:56:15,589 --> 00:56:12,559
everybody around the country can get

1531
00:56:17,750 --> 00:56:15,599
involved with um so don't just listen to

1532
00:56:19,109 --> 00:56:17,760
us don't just read about it come help us

1533
00:56:21,349 --> 00:56:19,119
discover whether there's life in the

1534
00:56:22,950 --> 00:56:21,359
solar system and beyond

1535
00:56:36,710 --> 00:56:22,960
ladies and gentlemen please give a round

1536
00:56:40,470 --> 00:56:38,390
and i want to thank our tv audience on

1537
00:56:41,510 --> 00:56:40,480
our website for joining us today

1538
00:56:43,670 --> 00:56:41,520

i want to

1539
00:56:46,230 --> 00:56:43,680
say that this is the official kickoff

1540
00:56:47,349 --> 00:56:46,240
for nasa's solar system and beyond

1541
00:56:49,109 --> 00:56:47,359
campaign

1542
00:56:52,230 --> 00:56:49,119
and you can find out more because

1543
00:56:55,270 --> 00:56:52,240
there's going to be a lot more coming at

1544
00:56:55,990 --> 00:56:55,280
nasa beyond and of course you can always

1545
00:56:57,349 --> 00:56:56,000
get

1546
00:56:58,630 --> 00:56:57,359
updates and information on all the

1547
00:57:00,309 --> 00:56:58,640
incredible missions and the science

1548
00:57:03,270 --> 00:57:00,319
mission directorate and nasa as a whole

1549
00:57:05,349 --> 00:57:03,280
on www.nasa.gov

1550
00:57:07,030 --> 00:57:05,359
and finally ladies and gentlemen

1551
00:57:09,190 --> 00:57:07,040
the next time

1552
00:57:11,510 --> 00:57:09,200
you go outside and look up the night sky

1553
00:57:14,710 --> 00:57:11,520
and see the stars

1554
00:57:16,870 --> 00:57:14,720
remember your nation space program nasa

1555
00:57:19,030 --> 00:57:16,880
has assets and more coming

1556
00:57:21,109 --> 00:57:19,040
looking to answer the questions

1557
00:57:23,589 --> 00:57:21,119
discussed today

1558
00:57:24,829 --> 00:57:23,599
nasa is determined

1559
00:57:27,510 --> 00:57:24,839
nasa is

1560
00:57:28,950 --> 00:57:27,520
committed and