



OCEANS BEYOND EARTH

April 13, 2017 at 11 a.m. PT
(2 p.m. ET, 1800 UTC)

#askNASA

youtube.com/nasajpl/live



Jet Propulsion Laboratory
California Institute of Technology

1
00:00:13,749 --> 00:00:11,110
we're here live in washington dc

2
00:00:15,749 --> 00:00:13,759
today we have not one but two scientific

3
00:00:18,150 --> 00:00:15,759
findings for you about oceans beyond

4
00:00:20,390 --> 00:00:18,160
earth we'll be going coast to coast and

5
00:00:21,830 --> 00:00:20,400
ocean to ocean to talk to experts

6
00:00:23,670 --> 00:00:21,840
starting from people right here in

7
00:00:25,670 --> 00:00:23,680
washington dc

8
00:00:27,990 --> 00:00:25,680
and then all also going all the way to

9
00:00:30,710 --> 00:00:28,000
the west coast to talk to nasa's jet

10
00:00:32,870 --> 00:00:30,720
propulsion laboratory in pasadena

11
00:00:34,069 --> 00:00:32,880
california

12
00:00:36,310 --> 00:00:34,079
and then we're going to go all the way

13
00:00:38,549 --> 00:00:36,320

to the east coast to talk to nasa's

14

00:00:40,150 --> 00:00:38,559

goddard space flight center in greenbelt

15

00:00:42,310 --> 00:00:40,160

maryland

16

00:00:44,950 --> 00:00:42,320

today's panelists are

17

00:00:48,150 --> 00:00:44,960

thomas zurbukin associate administrator

18

00:00:52,790 --> 00:00:48,160

for the science mission directorate

19

00:00:55,670 --> 00:00:52,800

jim greene director of planetary science

20

00:00:58,470 --> 00:00:55,680

mary wojtek lead scientist for nasa's

21

00:01:02,630 --> 00:00:58,480

astrobiology program

22

00:01:04,070 --> 00:01:02,640

the panelists at jpl in california are

23

00:01:06,950 --> 00:01:04,080

linda spilker

24

00:01:10,950 --> 00:01:06,960

cassini project scientist

25

00:01:13,190 --> 00:01:10,960

hunter waite cassini inms team lead with

26

00:01:17,109 --> 00:01:13,200

the southwest research institute or

27

00:01:21,030 --> 00:01:17,119

sweari in san antonio texas

28

00:01:23,590 --> 00:01:21,040

chris glenn cassini inms team associate

29

00:01:25,670 --> 00:01:23,600

also from sweary

30

00:01:27,990 --> 00:01:25,680

and joining us from goddard in maryland

31

00:01:29,830 --> 00:01:28,000

we have william sparks astronomer and

32

00:01:31,749 --> 00:01:29,840

lead author of the hubble findings with

33

00:01:33,990 --> 00:01:31,759

the space telescope science institute in

34

00:01:35,990 --> 00:01:34,000

baltimore

35

00:01:38,469 --> 00:01:36,000

the news today can be found at

36

00:01:41,190 --> 00:01:38,479

www.nasa.gov

37

00:01:42,630 --> 00:01:41,200

and also the following webpages

38

00:01:45,510 --> 00:01:42,640

if you'd like to ask a question via

39

00:01:47,270 --> 00:01:45,520

social media please use the hashtag ask

40

00:01:50,389 --> 00:01:47,280

nasa

41

00:01:52,310 --> 00:01:50,399

and with that thomas can you kick us off

42

00:01:54,230 --> 00:01:52,320

hey thanks so much felicia

43

00:01:56,950 --> 00:01:54,240

it's another great day of science at

44

00:01:59,270 --> 00:01:56,960

nasa here and in the science directorate

45

00:02:01,670 --> 00:01:59,280

we really focus on three objectives the

46

00:02:04,230 --> 00:02:01,680

first one is to understand and to

47

00:02:06,630 --> 00:02:04,240

improve life on earth

48

00:02:09,510 --> 00:02:06,640

we also do fundamental research from

49

00:02:11,270 --> 00:02:09,520

here to the depths of the universe and

50

00:02:12,790 --> 00:02:11,280

understand processes we've never

51
00:02:15,270 --> 00:02:12,800
understood before

52
00:02:17,670 --> 00:02:15,280
and the third topic is one that this is

53
00:02:20,949 --> 00:02:17,680
all about which is about a fundamental

54
00:02:26,229 --> 00:02:23,910
has failed the thinking of so many in

55
00:02:29,030 --> 00:02:26,239
the past and we can answer now hopefully

56
00:02:32,390 --> 00:02:29,040
in the near future and that is is there

57
00:02:34,150 --> 00:02:32,400
life elsewhere see here on earth there's

58
00:02:36,869 --> 00:02:34,160
a number of things that help life

59
00:02:38,630 --> 00:02:36,879
there's water in a liquid form we have

60
00:02:41,030 --> 00:02:38,640
an atmosphere we have a magnetic field

61
00:02:43,589 --> 00:02:41,040
that protects us from the hazards of

62
00:02:45,270 --> 00:02:43,599
space there's many things we have going

63
00:02:46,949 --> 00:02:45,280

for ourselves

64

00:02:47,830 --> 00:02:46,959

so the question where there's life out

65

00:02:50,070 --> 00:02:47,840

there

66

00:02:53,670 --> 00:02:50,080

relates to questions that we're making

67

00:02:55,830 --> 00:02:53,680

progress with all the time and questions

68

00:02:58,229 --> 00:02:55,840

that we have new questions that are

69

00:03:00,070 --> 00:02:58,239

coming forward we don't know yet whether

70

00:03:00,949 --> 00:03:00,080

there is life out there

71

00:03:02,869 --> 00:03:00,959

but

72

00:03:06,790 --> 00:03:02,879

right now we're making a lot of progress

73

00:03:09,110 --> 00:03:06,800

especially the outer solar system

74

00:03:10,790 --> 00:03:09,120

so this is exactly what today's stories

75

00:03:12,630 --> 00:03:10,800

are all about

76

00:03:16,070 --> 00:03:12,640

with this research

77

00:03:17,830 --> 00:03:16,080

we're making a big step forward towards

78

00:03:20,630 --> 00:03:17,840

answering the question

79

00:03:22,309 --> 00:03:20,640

is there life out there and with that

80

00:03:24,390 --> 00:03:22,319

i'm really turning it over to the team

81

00:03:26,790 --> 00:03:24,400

co-team

82

00:03:28,390 --> 00:03:26,800

thank you thomas so nasa's strategy for

83

00:03:29,990 --> 00:03:28,400

searching for life in the universe

84

00:03:31,670 --> 00:03:30,000

begins at home

85

00:03:33,990 --> 00:03:31,680

with an understanding of how life

86

00:03:35,670 --> 00:03:34,000

emerged and evolved here on earth and

87

00:03:38,070 --> 00:03:35,680

what the limits to life are on this

88

00:03:40,070 --> 00:03:38,080

planet we then project that out onto

89

00:03:42,550 --> 00:03:40,080

other places in our solar system to see

90

00:03:45,430 --> 00:03:42,560

if we can find habitable environments

91

00:03:47,350 --> 00:03:45,440

that could support life as we know it

92

00:03:50,309 --> 00:03:47,360

just 40 years ago

93

00:03:51,830 --> 00:03:50,319

nasa sent two viking landers to mars to

94

00:03:55,270 --> 00:03:51,840

look for evidence of life on the red

95

00:03:57,670 --> 00:03:55,280

planet at the same time oceanographers

96

00:04:00,070 --> 00:03:57,680

here on this planet on earth were

97

00:04:01,190 --> 00:04:00,080

exploring the last frontier the deep

98

00:04:02,869 --> 00:04:01,200

ocean

99

00:04:05,589 --> 00:04:02,879

and during that exploration they found

100

00:04:07,589 --> 00:04:05,599

an astonishing made an astonishing

101
00:04:09,350 --> 00:04:07,599
discovery that changed how we thought

102
00:04:11,830 --> 00:04:09,360
about earth and how we thought about

103
00:04:15,509 --> 00:04:11,840
life here on earth and that was an

104
00:04:17,670 --> 00:04:15,519
incredible oasis of life supported

105
00:04:20,550 --> 00:04:17,680
thousands of meters beneath the surface

106
00:04:22,310 --> 00:04:20,560
of the ocean far away from sunlight

107
00:04:25,510 --> 00:04:22,320
and it was supported by the energy

108
00:04:27,990 --> 00:04:25,520
produced by hydrothermal activity

109
00:04:30,870 --> 00:04:28,000
now this is actually this discovery was

110
00:04:34,150 --> 00:04:30,880
incredible for here on earth it led to

111
00:04:36,070 --> 00:04:34,160
but it pointed out a new type of biology

112
00:04:38,710 --> 00:04:36,080
supported by chemistry

113
00:04:40,629 --> 00:04:38,720

that didn't require sunlight which meant

114

00:04:50,550 --> 00:04:40,639

that we could extend our habitable

115

00:04:55,189 --> 00:04:52,790

as we imagine environments very much

116

00:04:57,830 --> 00:04:55,199

like our own hydrothermal vents here on

117

00:04:59,350 --> 00:04:57,840

earth could exist out there so today's

118

00:05:01,430 --> 00:04:59,360

discoveries

119

00:05:03,030 --> 00:05:01,440

have to do with ocean worlds beyond our

120

00:05:04,469 --> 00:05:03,040

own planet and jim's going to tell you

121

00:05:05,270 --> 00:05:04,479

about the missions that brought this to

122

00:05:07,909 --> 00:05:05,280

us

123

00:05:11,270 --> 00:05:07,919

you know it really began in the late

124

00:05:13,350 --> 00:05:11,280

1990s with the mission galileo

125

00:05:16,550 --> 00:05:13,360

galileo orbiting

126

00:05:19,830 --> 00:05:16,560

jupiter was flying by the individual

127

00:05:21,749 --> 00:05:19,840

moons the galilean moons and making

128

00:05:24,310 --> 00:05:21,759

observations of the atmosphere and many

129

00:05:27,110 --> 00:05:24,320

things in that solar system that mini

130

00:05:30,070 --> 00:05:27,120

solar system what it discovered from its

131

00:05:30,870 --> 00:05:30,080

magnetometers it flew real close

132

00:05:34,150 --> 00:05:30,880

to

133

00:05:36,790 --> 00:05:34,160

europa was a magnetic signature

134

00:05:39,270 --> 00:05:36,800

that's very familiar with our scientists

135

00:05:44,310 --> 00:05:39,280

because we interpreted as a current

136

00:05:45,990 --> 00:05:44,320

within an ocean underneath an ice shell

137

00:05:47,189 --> 00:05:46,000

in 2005

138

00:05:50,710 --> 00:05:47,199

cassini

139

00:05:51,749 --> 00:05:50,720

orbiting saturn flying by the moons of

140

00:05:54,710 --> 00:05:51,759

saturn

141

00:05:58,070 --> 00:05:54,720

with close flybys of enceladus it

142

00:05:59,430 --> 00:05:58,080

observed huge plumes of water emanating

143

00:06:03,110 --> 00:05:59,440

from cracks

144

00:06:04,790 --> 00:06:03,120

we now believe that enceladus also has a

145

00:06:07,029 --> 00:06:04,800

huge ocean

146

00:06:10,230 --> 00:06:07,039

we call these bodies and many others

147

00:06:13,909 --> 00:06:10,240

that are like them ocean worlds

148

00:06:17,189 --> 00:06:13,919

they are protected by an ice shell much

149

00:06:20,309 --> 00:06:17,199

like our atmosphere protects us our life

150

00:06:21,590 --> 00:06:20,319

here on earth and our ocean maintaining

151
00:06:24,150 --> 00:06:21,600
its liquid

152
00:06:26,150 --> 00:06:24,160
this is truly an exciting time for us to

153
00:06:28,469 --> 00:06:26,160
be able to probe those

154
00:06:31,909 --> 00:06:28,479
and really try to understand what's

155
00:06:34,230 --> 00:06:31,919
happening in these ocean worlds

156
00:06:37,189 --> 00:06:34,240
what we're going to talk about today are

157
00:06:39,510 --> 00:06:37,199
two really wonderful discoveries

158
00:06:42,150 --> 00:06:39,520
continuing back to cassini which has

159
00:06:44,629 --> 00:06:42,160
always been one of the major

160
00:06:46,150 --> 00:06:44,639
missions that we have making huge number

161
00:06:48,309 --> 00:06:46,160
of discoveries

162
00:06:50,629 --> 00:06:48,319
and we're going to talk about enceladus

163
00:06:53,670 --> 00:06:50,639

and what it's found out we're also going

164

00:06:55,270 --> 00:06:53,680

to talk about hubble observations

165

00:06:58,070 --> 00:06:55,280

back to europa

166

00:07:01,029 --> 00:06:58,080

these two ocean worlds were going to

167

00:07:03,909 --> 00:07:01,039

link together because they're so similar

168

00:07:06,710 --> 00:07:03,919

in many many ways that i hope you'll see

169

00:07:09,749 --> 00:07:06,720

as we go through our discoveries today

170

00:07:12,469 --> 00:07:09,759

so without further ado let's go to jpl

171

00:07:15,350 --> 00:07:12,479

and talk to linda spilker linda what's

172

00:07:17,350 --> 00:07:15,360

cassini been observing

173

00:07:20,870 --> 00:07:17,360

well thanks jim well cassini has been in

174

00:07:22,790 --> 00:07:20,880

orbit around saturn for almost 13 years

175

00:07:24,790 --> 00:07:22,800

and our unexpected discoveries about

176

00:07:26,309 --> 00:07:24,800

enceladus have been some of the most

177

00:07:28,469 --> 00:07:26,319

surprising

178

00:07:31,589 --> 00:07:28,479

today we're publishing a paper about our

179

00:07:34,230 --> 00:07:31,599

recent findings by cassini on enceladus

180

00:07:36,629 --> 00:07:34,240

we've detected hydrogen in the plume of

181

00:07:39,189 --> 00:07:36,639

enceladus that hydrogen is coming from a

182

00:07:41,670 --> 00:07:39,199

hydrothermal vent on the sea floor of

183

00:07:42,710 --> 00:07:41,680

enceladus going out into space through

184

00:07:44,309 --> 00:07:42,720

the plume

185

00:07:46,710 --> 00:07:44,319

and so this is a very significant

186

00:07:49,430 --> 00:07:46,720

finding because the hydrogen could be a

187

00:07:52,230 --> 00:07:49,440

potential source of chemical energy for

188

00:07:53,029 --> 00:07:52,240

any microbes that might be an enceladus

189

00:07:55,749 --> 00:07:53,039

ocean

190

00:07:57,430 --> 00:07:55,759

so this is a very exciting finding for

191

00:07:59,990 --> 00:07:57,440

the cassini tea

192

00:08:02,550 --> 00:08:00,000

now enceladus is too small to have

193

00:08:04,550 --> 00:08:02,560

retained the hydrogen when it formed and

194

00:08:07,189 --> 00:08:04,560

so the hydrogen we see today the

195

00:08:09,589 --> 00:08:07,199

hydrogen gas is coming from inside

196

00:08:12,230 --> 00:08:09,599

enceladus so let's take a quick look at

197

00:08:14,309 --> 00:08:12,240

some of cassini's past findings with

198

00:08:16,309 --> 00:08:14,319

this first image this is a view of the

199

00:08:18,230 --> 00:08:16,319

south pole of enceladus

200

00:08:20,629 --> 00:08:18,240

and the geysers or the jets are coming

201
00:08:22,869 --> 00:08:20,639
from those four cracks we nicknamed

202
00:08:24,550 --> 00:08:22,879
tiger stripes those bluish fractures

203
00:08:27,189 --> 00:08:24,560
that you can see at the south pole of

204
00:08:28,869 --> 00:08:27,199
enceladus in the next picture you can

205
00:08:31,909 --> 00:08:28,879
see that these jets are shooting out

206
00:08:33,589 --> 00:08:31,919
into space forming the giant plume

207
00:08:35,509 --> 00:08:33,599
around enceladus

208
00:08:38,310 --> 00:08:35,519
underneath that icy crust as jim said

209
00:08:40,870 --> 00:08:38,320
there's a global ocean that global ocean

210
00:08:42,870 --> 00:08:40,880
sits on top of a rocky core

211
00:08:45,190 --> 00:08:42,880
and some of cassini's findings pointed

212
00:08:47,190 --> 00:08:45,200
to hydrothermal vents

213
00:08:49,670 --> 00:08:47,200

basically hot water coming out after

214

00:08:52,550 --> 00:08:49,680

it's been mixed with the rocky core and

215

00:08:54,949 --> 00:08:52,560

this final image shows a thermal map the

216

00:08:56,790 --> 00:08:54,959

temperature of the south pole we can see

217

00:08:59,990 --> 00:08:56,800

the warmest temperatures with the yellow

218

00:09:01,190 --> 00:09:00,000

and red are right along the tiger stripe

219

00:09:03,910 --> 00:09:01,200

fractures

220

00:09:05,990 --> 00:09:03,920

so what's new today the new finding is

221

00:09:07,910 --> 00:09:06,000

finding hydrogen

222

00:09:09,670 --> 00:09:07,920

coming from the plume of enceladus and

223

00:09:12,790 --> 00:09:09,680

the fact that it could support

224

00:09:15,430 --> 00:09:12,800

potentially microbes with energy on the

225

00:09:18,389 --> 00:09:15,440

seafloor of enceladus now this finding

226

00:09:20,870 --> 00:09:18,399

is the result of 12 years of cassini

227

00:09:23,829 --> 00:09:20,880

investigations and it really represents

228

00:09:26,230 --> 00:09:23,839

a capstone finding for the mission

229

00:09:27,750 --> 00:09:26,240

because we now know that enceladus has

230

00:09:29,910 --> 00:09:27,760

almost all

231

00:09:33,509 --> 00:09:29,920

of the ingredients that you would need

232

00:09:35,590 --> 00:09:33,519

to support life as we know it on earth

233

00:09:38,070 --> 00:09:35,600

well here i have a model of the cassini

234

00:09:39,269 --> 00:09:38,080

spacecraft and hunter maybe you can show

235

00:09:41,670 --> 00:09:39,279

us where your instrument is that

236

00:09:44,150 --> 00:09:41,680

detected the hydrogen yes linda

237

00:09:45,750 --> 00:09:44,160

the ions instrument the ion neutral mass

238

00:09:48,710 --> 00:09:45,760

spectrometer is sitting on the fields

239

00:09:51,350 --> 00:09:48,720

and particle platform right here and it

240

00:09:53,269 --> 00:09:51,360

directly samples the gas that comes in

241

00:09:54,949 --> 00:09:53,279

as we fly through the plume

242

00:09:57,110 --> 00:09:54,959

as opposed to an ultraviolet

243

00:09:59,110 --> 00:09:57,120

spectrometer an infrared spectrometer

244

00:10:02,150 --> 00:09:59,120

which would look for scattered

245

00:10:04,550 --> 00:10:02,160

absorbed or emitted light coming from

246

00:10:08,790 --> 00:10:04,560

the molecules in a in a faraway lake

247

00:10:11,350 --> 00:10:08,800

location so this sampling is extremely

248

00:10:12,870 --> 00:10:11,360

important for detecting trace species and

249

00:10:14,949 --> 00:10:12,880

we were able to

250

00:10:17,430 --> 00:10:14,959

from previous flybys and previous

251
00:10:18,550 --> 00:10:17,440
measurements find out that the plume is

252
00:10:19,829 --> 00:10:18,560
98

253
00:10:20,870 --> 00:10:19,839
water

254
00:10:22,949 --> 00:10:20,880
it has

255
00:10:25,750 --> 00:10:22,959
traces of ammonia

256
00:10:27,350 --> 00:10:25,760
carbon dioxide and methane as well as

257
00:10:30,389 --> 00:10:27,360
some organics

258
00:10:32,870 --> 00:10:30,399
now the part that had been elusive to it

259
00:10:34,630 --> 00:10:32,880
before was the hydrogen

260
00:10:37,750 --> 00:10:34,640
and so let me

261
00:10:39,829 --> 00:10:37,760
back off here and pick up a

262
00:10:42,870 --> 00:10:39,839
similar model

263
00:10:46,630 --> 00:10:42,880

we have a simulation here of in the

264

00:10:49,190 --> 00:10:46,640

enceladus and the tiger stripes and so

265

00:10:51,269 --> 00:10:49,200

let me fly my spacecraft

266

00:10:53,350 --> 00:10:51,279

with the ims pointed in the direction of

267

00:10:54,870 --> 00:10:53,360

motion of the spacecraft through the

268

00:10:57,990 --> 00:10:54,880

plume material

269

00:11:00,230 --> 00:10:58,000

sampling the gas this is how it happened

270

00:11:02,870 --> 00:11:00,240

when we were making measurements it was

271

00:11:06,790 --> 00:11:02,880

about 8 kilometers above the surface and

272

00:11:09,350 --> 00:11:06,800

this happened in october of 2015.

273

00:11:11,110 --> 00:11:09,360

it's interesting to put this together

274

00:11:12,829 --> 00:11:11,120

with the other measures measurements

275

00:11:15,750 --> 00:11:12,839

we've made of the diff of the

276

00:11:17,750 --> 00:11:15,760

composition to try to draw some infra

277

00:11:19,430 --> 00:11:17,760

inferences about what's going on in the

278

00:11:21,990 --> 00:11:19,440

interior of the ocean because this

279

00:11:23,190 --> 00:11:22,000

material is telling us about composition

280

00:11:25,030 --> 00:11:23,200

of the ocean

281

00:11:27,190 --> 00:11:25,040

well hunter what was going through your

282

00:11:28,550 --> 00:11:27,200

head when you looked at the data and you

283

00:11:30,389 --> 00:11:28,560

saw hydrogen

284

00:11:32,150 --> 00:11:30,399

well of course we were very excited

285

00:11:33,990 --> 00:11:32,160

because we've been planning this for

286

00:11:36,790 --> 00:11:34,000

quite a while and we've been thinking

287

00:11:39,590 --> 00:11:36,800

about what possible implications might

288

00:11:41,190 --> 00:11:39,600

be so for to discuss that let me turn

289

00:11:42,550 --> 00:11:41,200

over to chris and let him talk a little

290

00:11:44,790 --> 00:11:42,560

bit about that

291

00:11:47,030 --> 00:11:44,800

well linda our team considered numerous

292

00:11:49,269 --> 00:11:47,040

possibilities and after performing

293

00:11:51,110 --> 00:11:49,279

detailed geometrical analysis

294

00:11:52,550 --> 00:11:51,120

we found that the best explanation is

295

00:11:55,190 --> 00:11:52,560

that the hydrogen is produced by

296

00:11:57,590 --> 00:11:55,200

chemical reactions between warm water

297

00:12:00,790 --> 00:11:57,600

and rocks here's a graphic showing what

298

00:12:04,949 --> 00:12:02,870

we think that hydrothermal fluids are

299

00:12:06,150 --> 00:12:04,959

circulating below the ocean floor on

300

00:12:09,430 --> 00:12:06,160

enceladus

301
00:12:12,389 --> 00:12:09,440
this exposes rocks to warm water which

302
00:12:14,470 --> 00:12:12,399
drives geochemical transformations an

303
00:12:16,310 --> 00:12:14,480
important process that produces huge

304
00:12:18,069 --> 00:12:16,320
amounts of hydrogen is called

305
00:12:19,910 --> 00:12:18,079
serpentinization

306
00:12:22,470 --> 00:12:19,920
in this process certain minerals that

307
00:12:24,710 --> 00:12:22,480
are rich in iron react with water to

308
00:12:27,110 --> 00:12:24,720
form new minerals and hydrogen is

309
00:12:29,509 --> 00:12:27,120
produced

310
00:12:32,870 --> 00:12:29,519
this is important because it shows that

311
00:12:34,710 --> 00:12:32,880
the geochemistry acts on enceladus

312
00:12:36,949 --> 00:12:34,720
in addition to this we think that these

313
00:12:38,790 --> 00:12:36,959

warm hydrothermal fluids contain

314

00:12:41,269 --> 00:12:38,800

dissolved minerals and when these

315

00:12:44,629 --> 00:12:41,279

minerals mix with the ocean water which

316

00:12:46,150 --> 00:12:44,639

is cold mineral precipitates form at the

317

00:12:48,949 --> 00:12:46,160

sea floor

318

00:12:51,670 --> 00:12:48,959

these mineral precipitates on the earth

319

00:12:53,910 --> 00:12:51,680

form white solids so we call them white

320

00:12:55,990 --> 00:12:53,920

smokers

321

00:12:58,069 --> 00:12:56,000

here's a video showing an example of one

322

00:13:00,629 --> 00:12:58,079

of these systems on enceladus

323

00:13:02,629 --> 00:13:00,639

i mean on the earth we don't know if the

324

00:13:04,870 --> 00:13:02,639

systems on enceladus look like this but

325

00:13:07,670 --> 00:13:04,880

this is an example from the earth

326

00:13:09,990 --> 00:13:07,680

these vents on the earth support teeming

327

00:13:12,949 --> 00:13:10,000

communities of organisms anchored by

328

00:13:15,430 --> 00:13:12,959

microbes that feed on chemical energy

329

00:13:17,910 --> 00:13:15,440

rather than sunlight an important

330

00:13:20,470 --> 00:13:17,920

reaction at the base of the food chain

331

00:13:22,949 --> 00:13:20,480

is called methanogenesis this is where

332

00:13:25,509 --> 00:13:22,959

microbes combine hydrogen with carbon

333

00:13:27,829 --> 00:13:25,519

dioxide to make methane and they get a

334

00:13:30,150 --> 00:13:27,839

jolt of energy out of the process

335

00:13:32,949 --> 00:13:30,160

they use this energy to synthesize some

336

00:13:34,790 --> 00:13:32,959

of their complex biomolecules such as

337

00:13:36,550 --> 00:13:34,800

sugar molecules

338

00:13:39,190 --> 00:13:36,560

what is intriguing about the data at

339

00:13:41,190 --> 00:13:39,200

enceladus with the hydrogen detection

340

00:13:43,430 --> 00:13:41,200

is that we are now able to determine how

341

00:13:46,870 --> 00:13:43,440

much energy would be available from the

342

00:13:49,509 --> 00:13:46,880

methanogenesis reaction at enceladus

343

00:13:51,030 --> 00:13:49,519

we have made the first calorie count in

344

00:13:53,190 --> 00:13:51,040

an alien ocean

345

00:13:55,829 --> 00:13:53,200

this is a key step towards understanding

346

00:13:57,269 --> 00:13:55,839

the habitability of enceladus

347

00:13:59,990 --> 00:13:57,279

well chris do you think there could be

348

00:14:01,910 --> 00:14:00,000

microbes or even shrimp in the ocean on

349

00:14:04,550 --> 00:14:01,920

enceladus why that would be wonderful

350

00:14:06,949 --> 00:14:04,560

linda but we haven't discovered evidence

351

00:14:07,750 --> 00:14:06,959

of organisms on enceladus

352

00:14:10,069 --> 00:14:07,760

but

353

00:14:13,030 --> 00:14:10,079

i'm encouraged by the geochemical data

354

00:14:14,790 --> 00:14:13,040

which could allow for this possibility

355

00:14:17,509 --> 00:14:14,800

well thank you very much hunter thank

356

00:14:20,629 --> 00:14:17,519

you chris well when cassini was first

357

00:14:23,110 --> 00:14:20,639

built we never thought we would see an

358

00:14:24,230 --> 00:14:23,120

active ocean world like enceladus at

359

00:14:26,949 --> 00:14:24,240

saturn

360

00:14:29,509 --> 00:14:26,959

so cassini can look for habitability but

361

00:14:32,230 --> 00:14:29,519

we don't have the instruments to look

362

00:14:34,550 --> 00:14:32,240

for life we've come as far as we can go

363

00:14:37,110 --> 00:14:34,560

so it remains for a future mission to

364

00:14:39,030 --> 00:14:37,120

detect life at enceladus

365

00:14:41,509 --> 00:14:39,040

and the cassini team is so excited about

366

00:14:44,949 --> 00:14:41,519

these new findings and so many why don't

367

00:14:46,230 --> 00:14:44,959

you put this in a broader context for us

368

00:14:48,150 --> 00:14:46,240

thank you linda

369

00:14:50,710 --> 00:14:48,160

well first of all chris i recognize that

370

00:14:53,189 --> 00:14:50,720

footage from one of the nasa researchers

371

00:14:54,790 --> 00:14:53,199

chris german uh exploring the east

372

00:14:56,829 --> 00:14:54,800

pacific rise which was actually a

373

00:15:00,310 --> 00:14:56,839

hydrothermal system very close to the

374

00:15:03,590 --> 00:15:00,320

original uh observation 40 years ago at

375

00:15:06,230 --> 00:15:03,600

the galapagos rift

376

00:15:07,829 --> 00:15:06,240

so while we don't understand what the

377

00:15:09,990 --> 00:15:07,839

structures would be and there may be no

378

00:15:12,310 --> 00:15:10,000

way for us to tell remotely until we

379

00:15:13,990 --> 00:15:12,320

actually get into these oceans certainly

380

00:15:15,829 --> 00:15:14,000

this finding suggests that there's a

381

00:15:18,470 --> 00:15:15,839

significant amount of hydrothermal

382

00:15:19,990 --> 00:15:18,480

activity to produce such a strong signal

383

00:15:23,189 --> 00:15:20,000

of hydrogen

384

00:15:26,230 --> 00:15:23,199

and this hydrogen is a good source of

385

00:15:27,829 --> 00:15:26,240

chemical energy to support life now what

386

00:15:29,670 --> 00:15:27,839

else have we been thinking about that

387

00:15:32,069 --> 00:15:29,680

life needs so i have a figure here to go

388

00:15:35,189 --> 00:15:32,079

over sort of the triad of what we need

389

00:15:37,350 --> 00:15:35,199

for life so can i have the figure please

390

00:15:39,430 --> 00:15:37,360

so of course you know that we need water

391

00:15:40,710 --> 00:15:39,440

and here we are at ocean worlds so we

392

00:15:43,189 --> 00:15:40,720

have the water

393

00:15:45,670 --> 00:15:43,199

we need chemical elements that can make

394

00:15:47,430 --> 00:15:45,680

the building blocks that go into making

395

00:15:49,829 --> 00:15:47,440

cells and provide

396

00:15:52,550 --> 00:15:49,839

molecules for metabolism we need carbon

397

00:15:54,230 --> 00:15:52,560

hydrogen nitrogen oxygen phosphorus and

398

00:15:56,790 --> 00:15:54,240

sulfur which are down in the lower left

399

00:15:59,269 --> 00:15:56,800

of the triangle and here we get to check

400

00:16:01,990 --> 00:15:59,279

off another box we have found energy to

401
00:16:04,310 --> 00:16:02,000
support life hydrogen gas provides that

402
00:16:06,629 --> 00:16:04,320
energy now all we need is to see if

403
00:16:08,470 --> 00:16:06,639
enceladus had enough time or any of the

404
00:16:11,910 --> 00:16:08,480
other systems in the saturn in her

405
00:16:13,910 --> 00:16:11,920
jovian world had enough time to evolve

406
00:16:16,470 --> 00:16:13,920
life and have life

407
00:16:18,710 --> 00:16:16,480
make its imprint on its ocean

408
00:16:20,389 --> 00:16:18,720
so now we have a another observation

409
00:16:22,550 --> 00:16:20,399
that kind of connects the world and is

410
00:16:24,629 --> 00:16:22,560
related to what we just heard about and

411
00:16:26,870 --> 00:16:24,639
jim's going to tell you about this

412
00:16:29,030 --> 00:16:26,880
so indeed the next discovery we want to

413
00:16:31,030 --> 00:16:29,040

talk about which is also coming out this

414

00:16:33,509 --> 00:16:31,040

week in our science journals

415

00:16:35,990 --> 00:16:33,519

is from the hubble space telescope that

416

00:16:38,310 --> 00:16:36,000

famous telescope that just keeps on

417

00:16:39,990 --> 00:16:38,320

making wonderful observations has

418

00:16:42,550 --> 00:16:40,000

actually been observing

419

00:16:44,470 --> 00:16:42,560

europa for many years

420

00:16:47,430 --> 00:16:44,480

so let's go to goddard space flight

421

00:16:49,509 --> 00:16:47,440

center and talk to william sparks bill

422

00:16:53,670 --> 00:16:49,519

give us a little background on what we

423

00:16:59,189 --> 00:16:56,389

europa is one of the four major moons of

424

00:17:01,829 --> 00:16:59,199

jupiter it's about the same size as our

425

00:17:04,949 --> 00:17:01,839

own moon but it looks very different

426

00:17:07,110 --> 00:17:04,959

it's got a smooth bright white surface

427

00:17:08,710 --> 00:17:07,120

covered in these dark cracks and red

428

00:17:10,789 --> 00:17:08,720

patches

429

00:17:13,189 --> 00:17:10,799

the reason for that and what makes

430

00:17:15,429 --> 00:17:13,199

europas incredibly interesting

431

00:17:18,630 --> 00:17:15,439

is that it's thought to be engulfed by a

432

00:17:20,630 --> 00:17:18,640

global ocean under a thick crust of ice

433

00:17:22,390 --> 00:17:20,640

in fact it's got twice as much ocean as

434

00:17:25,350 --> 00:17:22,400

planet earth

435

00:17:27,110 --> 00:17:25,360

if we have a salty ocean in contact with

436

00:17:29,510 --> 00:17:27,120

a rocky core

437

00:17:31,590 --> 00:17:29,520

and energy from a variety of sources as

438

00:17:33,750 --> 00:17:31,600

we just heard from mary we have many of

439

00:17:38,630 --> 00:17:33,760

the ingredients thought to be necessary

440

00:17:42,549 --> 00:17:40,230

your observations from hubble what are

441

00:17:46,549 --> 00:17:42,559

you now seeing that's important to our

442

00:17:49,590 --> 00:17:46,559

understanding of habitability on europa

443

00:17:52,070 --> 00:17:49,600

in 2014 we used the hubble and

444

00:17:54,390 --> 00:17:52,080

detected evidence of what are probably

445

00:17:56,710 --> 00:17:54,400

water vapor plumes emerging from the

446

00:17:59,190 --> 00:17:56,720

surface of europa that's important

447

00:18:01,270 --> 00:17:59,200

because it could be giving us access to

448

00:18:03,270 --> 00:18:01,280

surface liquid water without having to

449

00:18:05,110 --> 00:18:03,280

drill through miles of ice

450

00:18:06,710 --> 00:18:05,120

in 2016

451
00:18:07,909 --> 00:18:06,720
the new observations that we're just

452
00:18:10,230 --> 00:18:07,919
publishing

453
00:18:12,549 --> 00:18:10,240
we saw a similar candidate almost

454
00:18:15,669 --> 00:18:12,559
identical in appearance and at the

455
00:18:18,630 --> 00:18:15,679
identical location to one of the 20 40

456
00:18:20,710 --> 00:18:18,640
candidates it's very important uh in an

457
00:18:22,710 --> 00:18:20,720
intermittent phenomenon to establish

458
00:18:25,270 --> 00:18:22,720
repeatability it gives us a lot more

459
00:18:27,029 --> 00:18:25,280
faith in the observation

460
00:18:29,029 --> 00:18:27,039
the other thing it allows us to do given

461
00:18:31,430 --> 00:18:29,039
the position of europa uh given the

462
00:18:32,549 --> 00:18:31,440
position of the candidate on europa uh

463
00:18:34,710 --> 00:18:32,559

is to look

464

00:18:36,789 --> 00:18:34,720

with more fidelity at that position and

465

00:18:39,510 --> 00:18:36,799

see what else we can find there if we

466

00:18:41,270 --> 00:18:39,520

just look at the map of europa uh we

467

00:18:43,909 --> 00:18:41,280

don't see anything particularly

468

00:18:45,830 --> 00:18:43,919

remarkable the exact location of the

469

00:18:47,029 --> 00:18:45,840

plume candidate shown by the green

470

00:18:49,830 --> 00:18:47,039

ellipse

471

00:18:52,630 --> 00:18:49,840

but if we look back to the galileo data

472

00:18:54,150 --> 00:18:52,640

galileo in the 1990s published a thermal

473

00:18:57,190 --> 00:18:54,160

image and

474

00:18:59,750 --> 00:18:57,200

right at the peak of the thermal image

475

00:19:02,470 --> 00:18:59,760

that's where the plume candidate is

476

00:19:05,190 --> 00:19:02,480

this uh hot spot on the surface of

477

00:19:06,950 --> 00:19:05,200

europa on the europa night side was

478

00:19:09,909 --> 00:19:06,960

identified at the time as a thermal

479

00:19:13,270 --> 00:19:09,919

anomaly and it's sitting right on top of

480

00:19:16,390 --> 00:19:13,280

the position of our plume candidate

481

00:19:18,870 --> 00:19:16,400

bill wow that's fantastic

482

00:19:21,669 --> 00:19:18,880

you know we didn't know when galileo was

483

00:19:24,630 --> 00:19:21,679

flying by europa how the ocean could

484

00:19:27,510 --> 00:19:24,640

possibly communicate with the surface

485

00:19:29,750 --> 00:19:27,520

and now these plumes that hubble may be

486

00:19:32,549 --> 00:19:29,760

observing is giving us that tantalizing

487

00:19:35,029 --> 00:19:32,559

glimpse something exactly what we see on

488

00:19:38,230 --> 00:19:35,039

enceladus may be going on can you tell

489

00:19:40,230 --> 00:19:38,240

us a little more about how these plumes

490

00:19:42,390 --> 00:19:40,240

and that hot spot might relate to each

491

00:19:44,470 --> 00:19:42,400

other

492

00:19:46,470 --> 00:19:44,480

uh yes jim it's it's it's really

493

00:19:48,789 --> 00:19:46,480

intriguing it was quite astonishing in

494

00:19:50,470 --> 00:19:48,799

fact just to see the coincidence of the

495

00:19:51,430 --> 00:19:50,480

two

496

00:19:53,029 --> 00:19:51,440

but

497

00:19:55,270 --> 00:19:53,039

it wasn't an accident that we looked for

498

00:19:58,070 --> 00:19:55,280

the thermal imaging uh we did it by

499

00:19:59,669 --> 00:19:58,080

analogy within itself as as we all know

500

00:20:01,750 --> 00:19:59,679

as you know and the other people here

501
00:20:03,590 --> 00:20:01,760
know uh the plumes of enceladus are

502
00:20:05,669 --> 00:20:03,600
associated with a heat source and it's

503
00:20:07,350 --> 00:20:05,679
very distinctive signature and so we

504
00:20:09,909 --> 00:20:07,360
looked to see if we could find thermal

505
00:20:12,630 --> 00:20:09,919
imaging of the surface of europa and we

506
00:20:14,310 --> 00:20:12,640
did and the peak hottest point in the

507
00:20:16,390 --> 00:20:14,320
europa night side was right where our

508
00:20:18,789 --> 00:20:16,400
plume candidate is there's two like

509
00:20:21,110 --> 00:20:18,799
there's two possible explanations for a

510
00:20:23,110 --> 00:20:21,120
causal connection obviously coincidences

511
00:20:24,789 --> 00:20:23,120
could just occur but there are reasons

512
00:20:25,990 --> 00:20:24,799
to think there could be a causal

513
00:20:28,070 --> 00:20:26,000

relationship

514

00:20:29,990 --> 00:20:28,080

one possibility is if

515

00:20:31,110 --> 00:20:30,000

there's liquid water at the depth below

516

00:20:33,430 --> 00:20:31,120

the ice

517

00:20:34,950 --> 00:20:33,440

surface and the liquid water is

518

00:20:37,190 --> 00:20:34,960

obviously warmer than the surface the

519

00:20:39,029 --> 00:20:37,200

heat can flow up through the ice and

520

00:20:41,270 --> 00:20:39,039

cause a thermal anomaly and cracks in

521

00:20:44,230 --> 00:20:41,280

the ice could give us the plumes

522

00:20:45,909 --> 00:20:44,240

conversely the plumes themselves could

523

00:20:48,390 --> 00:20:45,919

simply be venting

524

00:20:50,630 --> 00:20:48,400

water vapor high into space

525

00:20:53,909 --> 00:20:50,640

from the europa surface we see plumes

526

00:20:55,750 --> 00:20:53,919

rising to a 100 kilometers 60 miles

527

00:20:58,630 --> 00:20:55,760

and we would expect the water vapor to

528

00:20:59,750 --> 00:20:58,640

spread out over a much bigger area than

529

00:21:01,510 --> 00:20:59,760

that

530

00:21:03,990 --> 00:21:01,520

we're not at escape velocity so it's got

531

00:21:05,990 --> 00:21:04,000

to come back down if a fine mist of

532

00:21:08,310 --> 00:21:06,000

water vapor rains back down onto the

533

00:21:10,390 --> 00:21:08,320

surface then it can change the thermal

534

00:21:13,190 --> 00:21:10,400

character of that surface and allow it

535

00:21:14,789 --> 00:21:13,200

to retain heat longer and so instead of

536

00:21:19,029 --> 00:21:14,799

heat coming up from below it could be

537

00:21:21,430 --> 00:21:19,039

heat from above being slowly re-radiated

538

00:21:23,110 --> 00:21:21,440

during the europa night time

539

00:21:25,669 --> 00:21:23,120

and so it's a very intriguing pair of

540

00:21:27,270 --> 00:21:25,679

results we discovered a repeating plume

541

00:21:29,190 --> 00:21:27,280

candidate and when we looked at the

542

00:21:31,430 --> 00:21:29,200

galileo data we found the position of

543

00:21:33,029 --> 00:21:31,440

that repeating plume candidate that was

544

00:21:35,510 --> 00:21:33,039

right at the position of a thermal

545

00:21:37,430 --> 00:21:35,520

anomaly we look forward to the europa

546

00:21:38,950 --> 00:21:37,440

clipper mission which jim is going to

547

00:21:40,950 --> 00:21:38,960

tell us about and

548

00:21:44,230 --> 00:21:40,960

that will characterize this and other

549

00:21:46,230 --> 00:21:44,240

areas in great detail

550

00:21:48,789 --> 00:21:46,240

you know the cassini observations that

551
00:21:51,110 --> 00:21:48,799
enceladus and the hubble observations at

552
00:21:53,750 --> 00:21:51,120
europa tells you you we're using

553
00:21:56,310 --> 00:21:53,760
everything in our arsenal to probe these

554
00:21:59,510 --> 00:21:56,320
new ocean worlds that we've discovered

555
00:22:03,029 --> 00:21:59,520
this is truly a really exciting time

556
00:22:05,190 --> 00:22:03,039
cassini unfortunately is near its end uh

557
00:22:07,430 --> 00:22:05,200
it will be uh plunged into the

558
00:22:10,310 --> 00:22:07,440
atmosphere of saturn it's running out of

559
00:22:12,950 --> 00:22:10,320
fuel on the 15th of september and so

560
00:22:15,430 --> 00:22:12,960
these indeed are the last discoveries

561
00:22:17,990 --> 00:22:15,440
that we're talking about from cassini as

562
00:22:19,830 --> 00:22:18,000
it relates to enceladus

563
00:22:22,549 --> 00:22:19,840

the next big mission that we're working

564

00:22:25,750 --> 00:22:22,559

on is called the europa clipper and this

565

00:22:28,390 --> 00:22:25,760

particular mission is going to enceladus

566

00:22:30,630 --> 00:22:28,400

it has nine major instruments on it and

567

00:22:34,549 --> 00:22:30,640

these discoveries are coming at just the

568

00:22:37,430 --> 00:22:34,559

perfect time it enables us to make the

569

00:22:40,710 --> 00:22:37,440

right set of observations that can tell

570

00:22:42,630 --> 00:22:40,720

us much more about these ocean worlds

571

00:22:44,230 --> 00:22:42,640

europa in particular

572

00:22:45,750 --> 00:22:44,240

can i have my

573

00:22:48,070 --> 00:22:45,760

video please

574

00:22:52,950 --> 00:22:48,080

the europa clipper will orbit jupiter

575

00:22:55,830 --> 00:22:52,960

but it makes very close flybys of europa

576

00:22:57,669 --> 00:22:55,840

it has instruments like the magnetometer

577

00:22:59,029 --> 00:22:57,679

once again that will make measurements

578

00:23:02,470 --> 00:22:59,039

of its ocean

579

00:23:05,270 --> 00:23:02,480

it also has an ice penetrating radar

580

00:23:08,789 --> 00:23:05,280

this radar will tell us how thick or

581

00:23:11,909 --> 00:23:08,799

thin these ice shelves are and how close

582

00:23:14,070 --> 00:23:11,919

then the ocean might be to cracks

583

00:23:15,029 --> 00:23:14,080

the next major instrument that it has is

584

00:23:17,430 --> 00:23:15,039

thermal

585

00:23:20,870 --> 00:23:17,440

imaging going back to what we learned

586

00:23:23,750 --> 00:23:20,880

from enceladus how hot are these areas

587

00:23:26,470 --> 00:23:23,760

are there cracks there like we see now

588

00:23:29,750 --> 00:23:26,480

with the plumes from uh the hubble

589

00:23:32,710 --> 00:23:29,760

observations and the hot spots still

590

00:23:35,590 --> 00:23:32,720

being hot from galileo observations more

591

00:23:38,789 --> 00:23:35,600

than 15 or so years ago

592

00:23:41,110 --> 00:23:38,799

in addition to that we have a uv

593

00:23:44,070 --> 00:23:41,120

spectrometer this imager is going to be

594

00:23:45,990 --> 00:23:44,080

the plume finder so as we go back and

595

00:23:47,909 --> 00:23:46,000

orbit out away from jupiter we're going

596

00:23:50,070 --> 00:23:47,919

to look back at enceladus we're going to

597

00:23:52,789 --> 00:23:50,080

be looking for those plumes and then

598

00:23:54,950 --> 00:23:52,799

diving back in and hopefully if

599

00:23:58,470 --> 00:23:54,960

everything works right flying through

600

00:24:01,190 --> 00:23:58,480

the plumes much like cassini has done

601
00:24:03,750 --> 00:24:01,200
at enceladus but now we'll have the

602
00:24:06,070 --> 00:24:03,760
right set of observations to make on

603
00:24:07,750 --> 00:24:06,080
that spacecraft the europa clipper will

604
00:24:10,870 --> 00:24:07,760
have an advanced

605
00:24:13,269 --> 00:24:10,880
mass spectrometer actually hunter weight

606
00:24:15,830 --> 00:24:13,279
is our principal scientist or principal

607
00:24:18,390 --> 00:24:15,840
investigator for that instrument

608
00:24:21,110 --> 00:24:18,400
so what a fantastic time

609
00:24:22,549 --> 00:24:21,120
coming up these observations are really

610
00:24:25,029 --> 00:24:22,559
informing us

611
00:24:26,870 --> 00:24:25,039
of major things happening in these ocean

612
00:24:29,510 --> 00:24:26,880
worlds right now

613
00:24:32,310 --> 00:24:29,520

what i really want you to walk away with

614

00:24:34,870 --> 00:24:32,320

is we're pushing the frontiers we're

615

00:24:37,510 --> 00:24:34,880

finding new environments

616

00:24:39,750 --> 00:24:37,520

we're looking in a way that we've never

617

00:24:43,269 --> 00:24:39,760

thought possible before

618

00:24:45,269 --> 00:24:43,279

for environments in our solar system

619

00:24:46,470 --> 00:24:45,279

which may harbor life

620

00:24:49,909 --> 00:24:46,480

today

621

00:24:51,830 --> 00:24:49,919

with that let me give it back to felicia

622

00:24:54,149 --> 00:24:51,840

thanks jim now we're going to go into

623

00:24:56,230 --> 00:24:54,159

our q a session for those joining us

624

00:24:58,710 --> 00:24:56,240

online please submit a question using

625

00:24:59,990 --> 00:24:58,720

the hashtag asknasa

626

00:25:01,510 --> 00:25:00,000

for those in the room if you'd like to

627

00:25:03,430 --> 00:25:01,520

ask a question please raise your hand

628

00:25:04,789 --> 00:25:03,440

and a mic will be passed to you and if

629

00:25:06,390 --> 00:25:04,799

you're pressed please state your name

630

00:25:08,149 --> 00:25:06,400

and affiliation

631

00:25:11,909 --> 00:25:08,159

so let's start with questions from the

632

00:25:15,190 --> 00:25:13,590

okay well before we go to questions from

633

00:25:17,590 --> 00:25:15,200

the room let's go ahead to the phone

634

00:25:21,590 --> 00:25:17,600

lines first we have camille carlisle

635

00:25:24,390 --> 00:25:21,600

from the sky and telescope magazine

636

00:25:25,430 --> 00:25:24,400

hi can you hear me yes

637

00:25:27,269 --> 00:25:25,440

okay

638

00:25:29,830 --> 00:25:27,279

thanks to my call

639

00:25:31,990 --> 00:25:29,840

two questions one you mentioned that we

640

00:25:33,190 --> 00:25:32,000

essentially have a calorie count now

641

00:25:35,350 --> 00:25:33,200

with the tire

642

00:25:38,070 --> 00:25:35,360

just how much energy is available can

643

00:25:40,390 --> 00:25:38,080

you put some sort of detail on that

644

00:25:42,230 --> 00:25:40,400

and this is a logistics question maybe i

645

00:25:44,390 --> 00:25:42,240

missed it is there a website for all the

646

00:25:45,830 --> 00:25:44,400

press images that we can go to and and

647

00:25:47,750 --> 00:25:45,840

get them

648

00:25:49,990 --> 00:25:47,760

so felicia can you tell us the press

649

00:25:51,510 --> 00:25:50,000

site and we'll go to jpl to get the

650

00:25:53,269 --> 00:25:51,520

calorie count

651
00:25:54,789 --> 00:25:53,279
so if you want more information about

652
00:25:56,510 --> 00:25:54,799
everything we've talked about today

653
00:25:58,870 --> 00:25:56,520
definitely go to

654
00:26:00,470 --> 00:25:58,880
www.nasa.gov our press release will be

655
00:26:02,149 --> 00:26:00,480
on that page and that will link to

656
00:26:03,990 --> 00:26:02,159
additional materials

657
00:26:05,830 --> 00:26:04,000
i believe by going to the jpl saturn

658
00:26:07,510 --> 00:26:05,840
page also there's materials so please

659
00:26:09,350 --> 00:26:07,520
just go to the two pages that were just

660
00:26:11,269 --> 00:26:09,360
on the screen earlier and you should be

661
00:26:12,630 --> 00:26:11,279
able to get the materials you need and i

662
00:26:18,870 --> 00:26:12,640
guess uh for the second part of the

663
00:26:23,190 --> 00:26:20,630

that's an excellent question the plume

664

00:26:26,310 --> 00:26:23,200

gas mixture from the hydrogen number we

665

00:26:37,990 --> 00:26:26,320

derived is equivalent to roughly 300

666

00:26:46,149 --> 00:26:39,909

next uh we have on the phone lines we

667

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

hi thanks very much for having this call

668

00:26:52,390 --> 00:26:50,480

i was questioned about the plume

669

00:26:54,870 --> 00:26:52,400

evidence europa

670

00:26:57,110 --> 00:26:54,880

you said you found it in 2014 in 2016

671

00:26:58,789 --> 00:26:57,120

this evidence of water plumes

672

00:27:00,230 --> 00:26:58,799

how many times did you look

673

00:27:01,909 --> 00:27:00,240

and was it not there and i guess what

674

00:27:04,950 --> 00:27:01,919

i'm trying to get at is there any sense

675

00:27:07,269 --> 00:27:04,960

of how intermittent this plume might be

676
00:27:09,669 --> 00:27:07,279
if it does indeed exist

677
00:27:12,630 --> 00:27:09,679
of course bill now has been on the uh a

678
00:27:17,269 --> 00:27:12,640
number of major observations from hubble

679
00:27:22,230 --> 00:27:18,470
uh yes

680
00:27:24,950 --> 00:27:22,240
we look 12 times and we saw it twice in

681
00:27:27,590 --> 00:27:24,960
that location we did see

682
00:27:30,950 --> 00:27:27,600
some evidence of plumes around the south

683
00:27:32,870 --> 00:27:30,960
pole polar regions a couple of times too

684
00:27:35,110 --> 00:27:32,880
but it's much harder to

685
00:27:37,269 --> 00:27:35,120
locate

686
00:27:40,149 --> 00:27:37,279
the source when you're down at the polar

687
00:27:42,310 --> 00:27:40,159
region and there isn't any uh coverage

688
00:27:45,190 --> 00:27:42,320

by galileo in that region either so we

689

00:27:48,070 --> 00:27:45,200

were we were lucky to find this one that

690

00:27:50,630 --> 00:27:48,080

did repeat was actually near the equator

691

00:27:53,430 --> 00:27:50,640

and so it was twice out of 12 times one

692

00:27:56,310 --> 00:27:54,789

would you care to characterize how

693

00:27:58,230 --> 00:27:56,320

confident you are these are actually

694

00:27:59,750 --> 00:27:58,240

plumes

695

00:28:01,029 --> 00:27:59,760

yeah

696

00:28:11,990 --> 00:28:01,039

uh

697

00:28:14,549 --> 00:28:12,000

four sigma results now that's

698

00:28:15,750 --> 00:28:14,559

not quite as uh

699

00:28:18,230 --> 00:28:15,760

strong

700

00:28:19,510 --> 00:28:18,240

evidences you'd really like you'd prefer

701
00:28:21,510 --> 00:28:19,520
it to be

702
00:28:23,110 --> 00:28:21,520
stronger than that because at that level

703
00:28:25,110 --> 00:28:23,120
there's always the possibility that

704
00:28:26,950 --> 00:28:25,120
there's some sort of instrumental effect

705
00:28:31,029 --> 00:28:26,960
that you don't know about

706
00:28:32,470 --> 00:28:31,039
we've covered our cells in terms of

707
00:28:34,470 --> 00:28:32,480
trying to

708
00:28:37,909 --> 00:28:34,480
understand what possible instrumental

709
00:28:39,750 --> 00:28:37,919
effects could have caused this

710
00:28:40,470 --> 00:28:39,760
and every single one that we can think

711
00:28:44,389 --> 00:28:40,480
of

712
00:28:46,230 --> 00:28:44,399
it so for example

713
00:28:48,950 --> 00:28:46,240

the two observations that i showed

714

00:28:51,750 --> 00:28:48,960

although they look the same in the same

715

00:28:54,070 --> 00:28:51,760

position when we project them on the sky

716

00:28:55,830 --> 00:28:54,080

when they were taken with the camera the

717

00:28:58,710 --> 00:28:55,840

hubble was in a completely different

718

00:29:00,630 --> 00:28:58,720

orientation for those two images and so

719

00:29:03,029 --> 00:29:00,640

they're in completely different parts of

720

00:29:05,029 --> 00:29:03,039

the camera uh with the telescope rolled

721

00:29:08,630 --> 00:29:05,039

around at a completely different angle

722

00:29:10,789 --> 00:29:08,640

and that eliminates a a whole bunch of

723

00:29:16,070 --> 00:29:10,799

potential systematics that could cause

724

00:29:17,190 --> 00:29:16,080

it so from the hubble uh perspective um

725

00:29:18,710 --> 00:29:17,200

we're

726

00:29:20,789 --> 00:29:18,720

i wouldn't say it's not completely

727

00:29:22,389 --> 00:29:20,799

unequivocal the way it is with enceladus

728

00:29:23,430 --> 00:29:22,399

we're still at the limits of what hubble

729

00:29:25,750 --> 00:29:23,440

can do

730

00:29:28,310 --> 00:29:25,760

but we're growing in confidence because

731

00:29:30,310 --> 00:29:28,320

of the repeat and because of in my case

732

00:29:31,430 --> 00:29:30,320

at least with i i find the correlation

733

00:29:33,750 --> 00:29:31,440

with the

734

00:29:36,470 --> 00:29:33,760

galileo thermal data quite quite quite

735

00:29:38,549 --> 00:29:36,480

intriguing and quite compelling

736

00:29:41,990 --> 00:29:38,559

you know from my perspective

737

00:29:44,310 --> 00:29:42,000

uh as as bill mentioned these plumes are

738

00:29:47,909 --> 00:29:44,320

up to 50 kilometers and perhaps as high

739

00:29:51,190 --> 00:29:47,919

as a 100 kilometers europa is the size

740

00:29:52,950 --> 00:29:51,200

of our own moon it's an enormous body

741

00:29:55,510 --> 00:29:52,960

and therefore there must be enormous

742

00:29:57,430 --> 00:29:55,520

energy to be able to loft these

743

00:30:00,070 --> 00:29:57,440

potential water

744

00:30:01,190 --> 00:30:00,080

jets high enough for us to be able to

745

00:30:04,149 --> 00:30:01,200

observe it

746

00:30:06,549 --> 00:30:04,159

five astronomical units away it's really

747

00:30:08,950 --> 00:30:06,559

a remarkable set of observations

748

00:30:11,190 --> 00:30:08,960

unfortunately you know it's not as

749

00:30:14,710 --> 00:30:11,200

periodic as the enceladus plumes which

750

00:30:17,830 --> 00:30:14,720

are on all the time and so uh

751
00:30:19,990 --> 00:30:17,840
going back to europa as bill has uh and

752
00:30:22,070 --> 00:30:20,000
his team and looked at it periodically

753
00:30:23,909 --> 00:30:22,080
is really giving us the confidence that

754
00:30:26,470 --> 00:30:23,919
they're there they may not be as

755
00:30:29,190 --> 00:30:26,480
periodic but indeed now it looks like

756
00:30:30,470 --> 00:30:29,200
the water the ocean is communicating

757
00:30:32,710 --> 00:30:30,480
with the surface

758
00:30:35,350 --> 00:30:32,720
bill and his team is also talking about

759
00:30:37,830 --> 00:30:35,360
how they can make more observations

760
00:30:41,669 --> 00:30:37,840
between now and when we do indeed launch

761
00:30:44,070 --> 00:30:41,679
the europa clipper in the 2020s

762
00:30:45,830 --> 00:30:44,080
let's go to the phones

763
00:30:47,750 --> 00:30:45,840

okay well before we go to the phones

764

00:30:50,230 --> 00:30:47,760

let's go ahead to social media where

765

00:30:51,110 --> 00:30:50,240

emily is helping field the questions so

766

00:30:52,950 --> 00:30:51,120

emily

767

00:30:54,789 --> 00:30:52,960

sure we have a lot of good questions

768

00:30:57,430 --> 00:30:54,799

coming in uh this first one is from t

769

00:30:59,430 --> 00:30:57,440

buttini on twitter and she wants to know

770

00:31:00,720 --> 00:30:59,440

are we talking about giant squids or

771

00:31:02,549 --> 00:31:00,730

algae and bacteria

772

00:31:05,029 --> 00:31:02,559

[Laughter]

773

00:31:06,950 --> 00:31:05,039

mary

774

00:31:09,190 --> 00:31:06,960

i think that most of us would be excited

775

00:31:10,950 --> 00:31:09,200

with any life um and we're certainly

776

00:31:13,510 --> 00:31:10,960

when we're talking about the sources of

777

00:31:15,430 --> 00:31:13,520

energy this is to feed the base of a

778

00:31:17,430 --> 00:31:15,440

food web so we're going to start with

779

00:31:19,909 --> 00:31:17,440

bacteria and if we get lucky maybe

780

00:31:21,590 --> 00:31:19,919

there's something that's larger

781

00:31:23,909 --> 00:31:21,600

you know i think what's really also

782

00:31:26,230 --> 00:31:23,919

exciting about these discoveries

783

00:31:30,149 --> 00:31:26,240

is these ocean worlds with the with

784

00:31:33,190 --> 00:31:30,159

their uh a protective uh outer shell if

785

00:31:36,070 --> 00:31:33,200

indeed there's life in there it it has

786

00:31:39,110 --> 00:31:36,080

to be completely different than ours in

787

00:31:41,190 --> 00:31:39,120

the sense that it's generated in a way

788

00:31:49,029 --> 00:31:41,200

that's not related to our life we call

789

00:31:53,350 --> 00:31:51,269

uh this second question is from decent

790

00:31:55,029 --> 00:31:53,360

matt sai on twitter and he wants to know

791

00:31:57,110 --> 00:31:55,039

could there be movement of ice

792

00:31:59,110 --> 00:31:57,120

surrounding enceladus driven by ocean

793

00:32:03,029 --> 00:31:59,120

convection currents similar to plate

794

00:32:06,789 --> 00:32:04,789

you know that's a really great question

795

00:32:09,830 --> 00:32:06,799

and the reason why is it was only within

796

00:32:13,750 --> 00:32:09,840

the last couple years that that we have

797

00:32:16,389 --> 00:32:13,760

started to look back at the europa data

798

00:32:18,149 --> 00:32:16,399

uh that has been gathered by galileo you

799

00:32:21,509 --> 00:32:18,159

know galileo only

800

00:32:24,470 --> 00:32:21,519

made like uh 10 or 11 flybys

801
00:32:26,789 --> 00:32:24,480
successfully by europa and so we have

802
00:32:29,430 --> 00:32:26,799
very limited images but there does

803
00:32:31,590 --> 00:32:29,440
appear to be a certain location for

804
00:32:34,710 --> 00:32:31,600
which some sort of subduction is going

805
00:32:36,870 --> 00:32:34,720
on in a crack where one element or plate

806
00:32:39,750 --> 00:32:36,880
of the of that uh

807
00:32:42,310 --> 00:32:39,760
icy shell is moving underneath another

808
00:32:44,870 --> 00:32:42,320
we don't know that that's true it may be

809
00:32:47,350 --> 00:32:44,880
in much greater locations all around

810
00:32:49,269 --> 00:32:47,360
that all around that body but you can

811
00:32:51,990 --> 00:32:49,279
understand the stresses when you think

812
00:32:54,070 --> 00:32:52,000
about the tidal forces europa is in an

813
00:32:56,470 --> 00:32:54,080

elliptical orbit

814

00:32:58,310 --> 00:32:56,480

around jupiter and it also has tidal

815

00:33:00,710 --> 00:32:58,320

forces being pushed around by the other

816

00:33:02,870 --> 00:33:00,720

galilean moons and so when it's close to

817

00:33:05,269 --> 00:33:02,880

jupiter gets squeezed and when it's

818

00:33:07,350 --> 00:33:05,279

further away it relaxes

819

00:33:10,630 --> 00:33:07,360

every two and a half to three days as it

820

00:33:12,950 --> 00:33:10,640

makes its orbit it is being squeezed and

821

00:33:16,389 --> 00:33:12,960

released and squeezed and released our

822

00:33:18,950 --> 00:33:16,399

estimate today is that the surface moves

823

00:33:20,710 --> 00:33:18,960

as much as 30 meters you know that's the

824

00:33:24,630 --> 00:33:20,720

height of an eight or nine story

825

00:33:27,269 --> 00:33:24,640

building every every two or three days

826

00:33:29,750 --> 00:33:27,279

that heat it's got to go somewhere and

827

00:33:33,509 --> 00:33:29,760

and the pushing and the stresses on on

828

00:33:35,029 --> 00:33:33,519

the icy shell may indeed uh be like our

829

00:33:36,310 --> 00:33:35,039

plate tectonics

830

00:33:37,430 --> 00:33:36,320

can i add one

831

00:33:39,990 --> 00:33:37,440

thing about it that actually is

832

00:33:42,389 --> 00:33:40,000

important for life so here on earth many

833

00:33:44,070 --> 00:33:42,399

people believe that we wouldn't have

834

00:33:46,070 --> 00:33:44,080

sustained life on earth if it weren't

835

00:33:49,269 --> 00:33:46,080

for plate tectonics oh

836

00:33:51,590 --> 00:33:49,279

and so it that kind of a process is very

837

00:33:53,990 --> 00:33:51,600

important on these icy moons as well

838

00:33:55,669 --> 00:33:54,000

because we think about

839

00:33:57,029 --> 00:33:55,679

we've just heard about some sources of

840

00:33:59,269 --> 00:33:57,039

energy that are coming from the

841

00:34:01,830 --> 00:33:59,279

interaction of the water and the core we

842

00:34:04,470 --> 00:34:01,840

also think on europa there are creations

843

00:34:07,430 --> 00:34:04,480

of oxidants at the surface as a result

844

00:34:10,629 --> 00:34:07,440

of the radiation at the surface and we

845

00:34:13,510 --> 00:34:10,639

need some sort of active shell

846

00:34:16,310 --> 00:34:13,520

a ice tectonics if you will to actually

847

00:34:18,869 --> 00:34:16,320

bring those into contact much like a

848

00:34:20,470 --> 00:34:18,879

battery where you have a positive and a

849

00:34:23,030 --> 00:34:20,480

negative pull

850

00:34:24,710 --> 00:34:23,040

to actually connect to drive life and so

851
00:34:25,750 --> 00:34:24,720
this process is really important for

852
00:34:27,510 --> 00:34:25,760
life

853
00:34:28,710 --> 00:34:27,520
okay well thank you very much we're

854
00:34:30,149 --> 00:34:28,720
going to take one more question to

855
00:34:33,510 --> 00:34:30,159
social media and then we're going to go

856
00:34:35,349 --> 00:34:33,520
to the phone lines so emily sure this

857
00:34:36,950 --> 00:34:35,359
question is from philip on facebook and

858
00:34:38,950 --> 00:34:36,960
he wants to know which moon do you think

859
00:34:41,589 --> 00:34:38,960
offers more possibility of life on it

860
00:34:43,589 --> 00:34:41,599
europa or enceladus

861
00:34:45,589 --> 00:34:43,599
well that's a good good that's a great

862
00:34:47,589 --> 00:34:45,599
question i wish i knew for sure i

863
00:34:49,669 --> 00:34:47,599

haven't i haven't all right mary mary

864

00:34:52,310 --> 00:34:49,679

will give her give it a shot well so i

865

00:34:53,909 --> 00:34:52,320

think that this result of finding um

866

00:34:55,750 --> 00:34:53,919

such a significant amount of

867

00:34:58,390 --> 00:34:55,760

hydrothermal activity and a lot of

868

00:35:01,030 --> 00:34:58,400

hydrogen is incredible it speaks to the

869

00:35:04,310 --> 00:35:01,040

habitability on the other hand it also

870

00:35:06,390 --> 00:35:04,320

the fact that we can measure such

871

00:35:09,030 --> 00:35:06,400

high concentrations of hydrogen and

872

00:35:11,829 --> 00:35:09,040

carbon dioxide means that there might

873

00:35:14,230 --> 00:35:11,839

not be life there at all and if there is

874

00:35:17,910 --> 00:35:14,240

life it's not very active because when

875

00:35:20,230 --> 00:35:17,920

you have those stacks of pizza much like

876

00:35:22,790 --> 00:35:20,240

in a graduate school department it

877

00:35:25,349 --> 00:35:22,800

disappears so we have this build up of

878

00:35:27,510 --> 00:35:25,359

food that's not being used and part of

879

00:35:29,190 --> 00:35:27,520

that could be because we think enceladus

880

00:35:31,109 --> 00:35:29,200

might be fairly young

881

00:35:32,470 --> 00:35:31,119

on the other hand if the same process

882

00:35:34,790 --> 00:35:32,480

which there's no reason to think it

883

00:35:36,710 --> 00:35:34,800

wouldn't be happening on europa we know

884

00:35:38,790 --> 00:35:36,720

that europa and the moons around jupiter

885

00:35:41,270 --> 00:35:38,800

were formed four billion years ago so

886

00:35:42,950 --> 00:35:41,280

that's a lot more time for life to have

887

00:35:46,150 --> 00:35:42,960

emerged and start taking advantage of

888

00:35:47,829 --> 00:35:46,160

these energy sources so my money for the

889

00:35:49,589 --> 00:35:47,839

moment um

890

00:35:51,270 --> 00:35:49,599

is still on europa

891

00:35:53,349 --> 00:35:51,280

uh but this that

892

00:35:55,109 --> 00:35:53,359

but it could be any on any of these

893

00:35:56,829 --> 00:35:55,119

moons and certainly would be great if it

894

00:35:58,390 --> 00:35:56,839

was on in all of

895

00:36:00,150 --> 00:35:58,400

them

896

00:36:02,390 --> 00:36:00,160

well thank you so much

897

00:36:07,030 --> 00:36:02,400

next we have mike wahl from space.com

898

00:36:09,990 --> 00:36:08,390

yep i'm here

899

00:36:12,310 --> 00:36:10,000

thank you guys um this is really

900

00:36:13,990 --> 00:36:12,320

exciting stuff and like i have another

901
00:36:15,430 --> 00:36:14,000
question for actually bill about the

902
00:36:16,470 --> 00:36:15,440
plumes um

903
00:36:20,470 --> 00:36:16,480
so

904
00:36:22,310 --> 00:36:20,480
on this this is not a confirmation that

905
00:36:23,910 --> 00:36:22,320
the plumes exist i mean i know you guys

906
00:36:25,750 --> 00:36:23,920
i keep seeing more and more signs but

907
00:36:28,390 --> 00:36:25,760
you're but you're stopping short of

908
00:36:29,190 --> 00:36:28,400
saying that that they definitely exist

909
00:36:33,910 --> 00:36:29,200
and

910
00:36:36,630 --> 00:36:33,920
same location as as the original 2012

911
00:36:37,750 --> 00:36:36,640
detection or like do the plumes i mean

912
00:36:39,430 --> 00:36:37,760
have they been spotted in multiple

913
00:36:40,790 --> 00:36:39,440

locations

914

00:36:43,109 --> 00:36:40,800

around europa

915

00:36:44,870 --> 00:36:43,119

thank you

916

00:36:47,510 --> 00:36:44,880

yeah let's have bill sparks of course

917

00:36:52,390 --> 00:36:49,430

okay um

918

00:36:55,910 --> 00:36:52,400

it's not completely unequivocal but in

919

00:36:59,190 --> 00:36:55,920

my mind the pendulum has uh swung from

920

00:37:01,349 --> 00:36:59,200

uh caution to optimism

921

00:37:04,470 --> 00:37:01,359

the evidence is growing the fact that we

922

00:37:05,829 --> 00:37:04,480

saw a repeat at the exact same location

923

00:37:07,589 --> 00:37:05,839

that's one of the

924

00:37:09,670 --> 00:37:07,599

gold standards for

925

00:37:11,990 --> 00:37:09,680

dealing with an intermittent phenomenon

926

00:37:13,910 --> 00:37:12,000

it's not proof because we're right at

927

00:37:16,069 --> 00:37:13,920

the limit of what

928

00:37:19,030 --> 00:37:16,079

the hubble can do

929

00:37:21,190 --> 00:37:19,040

it's not completely unequivocal the way

930

00:37:23,670 --> 00:37:21,200

it is on enceladus so on enceladus

931

00:37:25,990 --> 00:37:23,680

you've got movies of the of the plumes

932

00:37:28,390 --> 00:37:26,000

and you've got wonderful maps and uh

933

00:37:30,790 --> 00:37:28,400

temperature maps and mass spectrometer

934

00:37:33,109 --> 00:37:30,800

measurements of the composition uh and

935

00:37:34,950 --> 00:37:33,119

we've got a little smudge uh next to an

936

00:37:37,190 --> 00:37:34,960

image from the hubble and you know it's

937

00:37:38,550 --> 00:37:37,200

a fantastic image and it's but it's

938

00:37:39,510 --> 00:37:38,560

right at the limit of what the hubble

939

00:37:41,990 --> 00:37:39,520

can do

940

00:37:43,910 --> 00:37:42,000

the fact that we've got to repeat uh

941

00:37:46,630 --> 00:37:43,920

tells you that in a formal statistical

942

00:37:48,870 --> 00:37:46,640

sense it can't happen by chance

943

00:37:51,349 --> 00:37:48,880

so we have to look for

944

00:37:53,829 --> 00:37:51,359

systematic effects that might cause it

945

00:37:55,910 --> 00:37:53,839

we don't know of any which is why uh

946

00:37:58,390 --> 00:37:55,920

most of us some of us are leaning

947

00:38:00,150 --> 00:37:58,400

towards thinking that this is uh this

948

00:38:02,230 --> 00:38:00,160

this means they're real

949

00:38:03,030 --> 00:38:02,240

and then the secondary information with

950

00:38:08,870 --> 00:38:03,040

the

951
00:38:11,270 --> 00:38:08,880
imaging that

952
00:38:13,270 --> 00:38:11,280
gives you some additional statistical

953
00:38:14,310 --> 00:38:13,280
evidence that in fact

954
00:38:16,390 --> 00:38:14,320
they're real

955
00:38:18,630 --> 00:38:16,400
it doesn't prove it because you know

956
00:38:19,910 --> 00:38:18,640
unfortunate coincidences can happen in

957
00:38:22,630 --> 00:38:19,920
the world

958
00:38:25,430 --> 00:38:22,640
in terms of the location uh the original

959
00:38:28,710 --> 00:38:25,440
uh detection by the roth team was around

960
00:38:31,670 --> 00:38:28,720
the south polar region uh these are the

961
00:38:33,190 --> 00:38:31,680
dissociation products of water

962
00:38:36,710 --> 00:38:33,200
in

963
00:38:39,910 --> 00:38:36,720

high altitude down around the south pole

964

00:38:41,750 --> 00:38:39,920

and uh in our transit observations where

965

00:38:45,190 --> 00:38:41,760

we were looking for absorbing material

966

00:38:46,630 --> 00:38:45,200

around europa uh we did see a couple of

967

00:38:50,470 --> 00:38:46,640

uh

968

00:38:52,390 --> 00:38:50,480

of features in that in in that area

969

00:38:55,349 --> 00:38:52,400

but it's harder to localize things

970

00:38:57,670 --> 00:38:55,359

around the poles this particular one

971

00:38:59,670 --> 00:38:57,680

was well localized it wasn't quite as

972

00:39:01,349 --> 00:38:59,680

high as the previous one and that's the

973

00:39:05,670 --> 00:39:01,359

one that repeated and so that's really

974

00:39:08,710 --> 00:39:07,109

thank you

975

00:39:11,270 --> 00:39:08,720

there's couple other pieces of evidence

976

00:39:13,510 --> 00:39:11,280

that i think is also really tantalizing

977

00:39:15,190 --> 00:39:13,520

you know when we look at enceladus

978

00:39:17,750 --> 00:39:15,200

particularly around those tiger straps

979

00:39:21,270 --> 00:39:17,760

there's absolutely no craters they're

980

00:39:24,069 --> 00:39:21,280

completely filled in as you go to

981

00:39:24,950 --> 00:39:24,079

the mid-latitudes and up to the north

982

00:39:27,910 --> 00:39:24,960

pole

983

00:39:29,349 --> 00:39:27,920

of enceladus you see you do indeed see a

984

00:39:33,190 --> 00:39:29,359

number of craters

985

00:39:36,150 --> 00:39:33,200

if we look now at europa we can hardly

986

00:39:39,270 --> 00:39:36,160

see any craters this has always been a

987

00:39:42,710 --> 00:39:39,280

big puzzle in terms of how this surface

988

00:39:45,030 --> 00:39:42,720

is morphing eliminating the craters that

989

00:39:48,230 --> 00:39:45,040

must have been there at one time and are

990

00:39:50,150 --> 00:39:48,240

continually bombarding the body but over

991

00:39:52,390 --> 00:39:50,160

the length of time that we've observed

992

00:39:55,190 --> 00:39:52,400

it with the galileo mission those

993

00:39:56,390 --> 00:39:55,200

several years only a handful of craters

994

00:39:59,829 --> 00:39:56,400

were found

995

00:40:01,430 --> 00:39:59,839

the plumes the plume idea that it is

996

00:40:03,270 --> 00:40:01,440

resurfacing

997

00:40:05,190 --> 00:40:03,280

and the subduction

998

00:40:07,910 --> 00:40:05,200

must be connected in a way that is

999

00:40:11,670 --> 00:40:07,920

eliminating those craters so this fits

1000

00:40:15,190 --> 00:40:11,680

perfectly with these observations

1001
00:40:19,910 --> 00:40:17,910
so um next we have two questions on the

1002
00:40:23,270 --> 00:40:19,920
phone line then we're going to go ahead

1003
00:40:25,349 --> 00:40:23,280
and go to social media so the first

1004
00:40:27,750 --> 00:40:25,359
call-in person we have is keith cowing

1005
00:40:29,589 --> 00:40:27,760
from nasa watch keith

1006
00:40:31,190 --> 00:40:29,599
a two-part question for thomas sir

1007
00:40:33,430 --> 00:40:31,200
brooke and first of all

1008
00:40:35,910 --> 00:40:33,440
several years ago nasa was directed to

1009
00:40:37,990 --> 00:40:35,920
create an ocean world's program now i

1010
00:40:40,550 --> 00:40:38,000
see that phrase everywhere but have you

1011
00:40:43,030 --> 00:40:40,560
formally established a program office is

1012
00:40:45,109 --> 00:40:43,040
who's in charge of it what's the budget

1013
00:40:46,790 --> 00:40:45,119

and second of all a question um why is

1014

00:40:49,670 --> 00:40:46,800

it that some news media were given

1015

00:40:52,069 --> 00:40:49,680

advance access to nasa personnel

1016

00:40:55,750 --> 00:40:52,079

on this taxpayer-funded research and

1017

00:40:58,950 --> 00:40:57,030

so uh

1018

00:41:01,190 --> 00:40:58,960

let me certainly take uh on the first

1019

00:41:03,109 --> 00:41:01,200

one as head of planetary science and we

1020

00:41:06,309 --> 00:41:03,119

did indeed receive congressional

1021

00:41:07,829 --> 00:41:06,319

direction about establishing an ocean

1022

00:41:10,069 --> 00:41:07,839

world's program

1023

00:41:12,950 --> 00:41:10,079

we have indeed communicated

1024

00:41:15,030 --> 00:41:12,960

back to congress uh in our budgetary

1025

00:41:16,309 --> 00:41:15,040

aspects that we are

1026

00:41:18,550 --> 00:41:16,319

doing that

1027

00:41:21,030 --> 00:41:18,560

in with respect to

1028

00:41:24,870 --> 00:41:21,040

the next set of missions and that next

1029

00:41:28,390 --> 00:41:24,880

set is indeed the europa clipper mission

1030

00:41:29,270 --> 00:41:28,400

uh as far as um uh the press interaction

1031

00:41:33,270 --> 00:41:29,280

that's

1032

00:41:35,190 --> 00:41:33,280

were directed to establish a program for

1033

00:41:38,309 --> 00:41:35,200

investigating ocean worlds and we went

1034

00:41:40,550 --> 00:41:38,319

to our outer planets assessment group

1035

00:41:42,470 --> 00:41:40,560

and asked them to help us out by

1036

00:41:44,870 --> 00:41:42,480

developing a road map for exploring

1037

00:41:46,950 --> 00:41:44,880

these worlds and that is in pro in

1038

00:41:50,390 --> 00:41:46,960

process they're about to deliver to that

1039

00:41:52,950 --> 00:41:50,400

to us any day now or any month now week

1040

00:41:55,190 --> 00:41:52,960

um and so we're moving forward on

1041

00:41:57,510 --> 00:41:55,200

setting the science as we always do

1042

00:41:59,030 --> 00:41:57,520

setting the science priorities and then

1043

00:42:01,030 --> 00:41:59,040

filling in the technologies that we're

1044

00:42:02,550 --> 00:42:01,040

going to need for it and and and

1045

00:42:04,630 --> 00:42:02,560

discussing the types of missions those

1046

00:42:07,349 --> 00:42:04,640

would look like to the various ocean

1047

00:42:10,150 --> 00:42:07,359

worlds that we have to explore

1048

00:42:12,309 --> 00:42:10,160

next we have tracy watson from usa today

1049

00:42:14,550 --> 00:42:12,319

tracy

1050

00:42:16,470 --> 00:42:14,560

hi thank you for dr green

1051
00:42:18,950 --> 00:42:16,480
can you talk about now how this mission

1052
00:42:20,630 --> 00:42:18,960
affects your desire to send

1053
00:42:23,829 --> 00:42:20,640
excuse me how these results affect your

1054
00:42:26,069 --> 00:42:23,839
desire to send a mission to and sell

1055
00:42:29,349 --> 00:42:26,079
this does this make it kind of rise to

1056
00:42:32,790 --> 00:42:29,359
the top of what should be next thanks

1057
00:42:35,270 --> 00:42:32,800
well indeed we announced in january uh a

1058
00:42:38,550 --> 00:42:35,280
program called new frontiers

1059
00:42:41,430 --> 00:42:38,560
and that is a very targeted list of of

1060
00:42:44,790 --> 00:42:41,440
of objects and on that list turns out to

1061
00:42:47,510 --> 00:42:44,800
be enceladus this is an element indeed

1062
00:42:49,670 --> 00:42:47,520
of recognition that this is an active

1063
00:42:51,109 --> 00:42:49,680

world that this is new discoveries that

1064

00:42:53,990 --> 00:42:51,119

have been made

1065

00:42:56,470 --> 00:42:54,000

by cassini since the time our planetary

1066

00:42:59,910 --> 00:42:56,480

decadal actually identified what those

1067

00:43:02,230 --> 00:42:59,920

targets are so uh that's in competition

1068

00:43:04,390 --> 00:43:02,240

right now and and we'll be receiving the

1069

00:43:06,870 --> 00:43:04,400

proposals uh soon and we'll be

1070

00:43:09,190 --> 00:43:06,880

evaluating them and announcing the the

1071

00:43:12,230 --> 00:43:09,200

uh the step one select these by the end

1072

00:43:13,990 --> 00:43:12,240

of the calendar year is what we hope

1073

00:43:16,870 --> 00:43:14,000

thanks jim uh next we're going to go to

1074

00:43:18,870 --> 00:43:16,880

social media so emily what are uh the

1075

00:43:20,390 --> 00:43:18,880

netizens talking about today

1076

00:43:22,710 --> 00:43:20,400

yeah there's a lot of interest on social

1077

00:43:25,030 --> 00:43:22,720

media um this question is from lorenzo

1078

00:43:27,270 --> 00:43:25,040

on facebook so the juno spacecraft just

1079

00:43:29,030 --> 00:43:27,280

recently went into orbit around jupiter

1080

00:43:30,950 --> 00:43:29,040

is there any possibility for that

1081

00:43:32,550 --> 00:43:30,960

spacecraft to help with

1082

00:43:34,309 --> 00:43:32,560

observations of the balloons around

1083

00:43:36,390 --> 00:43:34,319

europa

1084

00:43:39,270 --> 00:43:36,400

well indeed

1085

00:43:41,430 --> 00:43:39,280

juno was launched in 2011

1086

00:43:44,150 --> 00:43:41,440

we may have had a hint of the plumes of

1087

00:43:47,670 --> 00:43:44,160

course from cassini but absolutely

1088

00:43:50,550 --> 00:43:47,680

nothing from europa by that time and so

1089

00:43:53,270 --> 00:43:50,560

it's concentrating on really orbiting

1090

00:43:56,230 --> 00:43:53,280

jupiter and understanding the structure

1091

00:43:59,030 --> 00:43:56,240

that large uh planet the you know the

1092

00:44:02,150 --> 00:43:59,040

largest planet in our solar system it

1093

00:44:04,710 --> 00:44:02,160

also is uh uh so important to understand

1094

00:44:07,670 --> 00:44:04,720

that because the the remnants

1095

00:44:09,510 --> 00:44:07,680

left over after jupiter and sun accreted

1096

00:44:11,510 --> 00:44:09,520

was the rest of the solar system so

1097

00:44:13,990 --> 00:44:11,520

we're really really quite interested in

1098

00:44:15,670 --> 00:44:14,000

understanding the origin and evolution

1099

00:44:18,069 --> 00:44:15,680

of our solar system and understanding

1100

00:44:20,790 --> 00:44:18,079

how jupiter was put together is a major

1101

00:44:25,510 --> 00:44:20,800

segment of that so unfortunately

1102

00:44:29,109 --> 00:44:27,030

all right this next one is from Carrie

1103

00:44:30,790 --> 00:44:29,119

on Facebook uh they want to know what

1104

00:44:34,710 --> 00:44:30,800

chemicals are causing the coloration

1105

00:44:39,589 --> 00:44:37,589

so with that uh perhaps uh

1106

00:44:42,390 --> 00:44:39,599

uh Goddard could talk a little bit about

1107

00:44:46,470 --> 00:44:45,190

uh I think the short answer is we don't

1108

00:44:48,870 --> 00:44:46,480

know uh

1109

00:44:50,870 --> 00:44:48,880

there are the skins that they're salts

1110

00:44:53,430 --> 00:44:50,880

from the ocean but it's not known what

1111

00:44:55,510 --> 00:44:53,440

sort of salts and that potentially

1112

00:44:58,790 --> 00:44:55,520

there's a contribution from

1113

00:45:02,230 --> 00:44:58,800

uh the jovian magnetosphere of irons

1114

00:45:03,910 --> 00:45:02,240

being implanted from io the next moon in

1115

00:45:07,030 --> 00:45:03,920

that's definitely

1116

00:45:08,630 --> 00:45:07,040

got plumes it's got sulfur volcanoes

1117

00:45:09,990 --> 00:45:08,640

spraying sulfur into the whole

1118

00:45:12,390 --> 00:45:10,000

environment

1119

00:45:14,630 --> 00:45:12,400

but the detailed composition

1120

00:45:16,630 --> 00:45:14,640

of the cracks and the dark areas it's a

1121

00:45:19,190 --> 00:45:16,640

it's an ongoing study

1122

00:45:20,390 --> 00:45:19,200

for of research uh people are trying to

1123

00:45:23,030 --> 00:45:20,400

find out it's obviously a very

1124

00:45:24,870 --> 00:45:23,040

interesting question and uh

1125

00:45:27,430 --> 00:45:24,880

it's it will be very nice to know the

1126

00:45:29,030 --> 00:45:27,440

answer to that

1127

00:45:30,950 --> 00:45:29,040

all right we'll take one more question

1128

00:45:33,030 --> 00:45:30,960

from social

1129

00:45:34,550 --> 00:45:33,040

awesome media one's from stephanie on

1130

00:45:36,230 --> 00:45:34,560

twitter she wants to know what

1131

00:45:39,750 --> 00:45:36,240

instruments will be needed to detect

1132

00:45:41,030 --> 00:45:39,760

life on enceladus and how can we help

1133

00:45:46,630 --> 00:45:41,040

okay

1134

00:45:50,550 --> 00:45:48,230

all right um

1135

00:45:53,430 --> 00:45:50,560

well the instrument excuse me the

1136

00:45:55,430 --> 00:45:53,440

instrumentation that uh would be

1137

00:45:57,510 --> 00:45:55,440

uh could be told in this regard are

1138

00:46:00,230 --> 00:45:57,520

similar instruments to the ones that we

1139

00:46:01,910 --> 00:46:00,240

were flying on cassini they're

1140

00:46:03,589 --> 00:46:01,920

and they're certainly similar to the

1141

00:46:07,670 --> 00:46:03,599

instruments that are presently flying on

1142

00:46:09,910 --> 00:46:07,680

europa the mass spectrometer and

1143

00:46:13,270 --> 00:46:09,920

dust analyzer

1144

00:46:16,069 --> 00:46:13,280

are both important in determining this

1145

00:46:17,990 --> 00:46:16,079

habitability as well as looking for

1146

00:46:19,510 --> 00:46:18,000

perhaps amino acids

1147

00:46:23,510 --> 00:46:19,520

fatty acids

1148

00:46:24,550 --> 00:46:23,520

looking at isotopic ratios and trying to

1149

00:46:25,750 --> 00:46:24,560

determine

1150

00:46:29,030 --> 00:46:25,760

uh

1151
00:46:31,349 --> 00:46:29,040
signs of life as well as telling us more

1152
00:46:32,550 --> 00:46:31,359
about the habitability

1153
00:46:34,950 --> 00:46:32,560
learning a little bit about the

1154
00:46:36,870 --> 00:46:34,960
structure of the molecules themselves

1155
00:46:39,030 --> 00:46:36,880
would also be beneficial

1156
00:46:41,349 --> 00:46:39,040
and that can be done through tandem mass

1157
00:46:42,470 --> 00:46:41,359
spectrometry

1158
00:46:44,710 --> 00:46:42,480
there are certainly

1159
00:46:46,950 --> 00:46:44,720
other techniques that are being studied

1160
00:46:49,750 --> 00:46:46,960
for landers but for fly-through missions

1161
00:46:52,390 --> 00:46:49,760
which we think would be uh good enough

1162
00:46:54,790 --> 00:46:52,400
in the case of enceladus uh

1163
00:46:58,230 --> 00:46:54,800

this is the this is a next step that

1164

00:47:00,790 --> 00:46:58,240

would be a good a good approach

1165

00:47:02,870 --> 00:47:00,800

thank you now so before we close um jim

1166

00:47:05,510 --> 00:47:02,880

can you give us some closing thoughts um

1167

00:47:07,910 --> 00:47:05,520

anything you'd like to talk about

1168

00:47:11,030 --> 00:47:07,920

indeed you know this is really an

1169

00:47:13,589 --> 00:47:11,040

exciting time our science is proceeding

1170

00:47:15,190 --> 00:47:13,599

so rapidly we can hardly keep up with

1171

00:47:16,150 --> 00:47:15,200

these discoveries

1172

00:47:18,309 --> 00:47:16,160

you know

1173

00:47:20,630 --> 00:47:18,319

we really are looking forward to more of

1174

00:47:23,430 --> 00:47:20,640

the hubble observations

1175

00:47:25,990 --> 00:47:23,440

we may find that europa is far more

1176

00:47:28,950 --> 00:47:26,000

active in terms of not only one location

1177

00:47:31,270 --> 00:47:28,960

but a number of locations and that bodes

1178

00:47:32,870 --> 00:47:31,280

well with as i mentioned earlier filling

1179

00:47:35,430 --> 00:47:32,880

in these craters

1180

00:47:36,790 --> 00:47:35,440

these ocean worlds have just been

1181

00:47:39,750 --> 00:47:36,800

discovered

1182

00:47:41,910 --> 00:47:39,760

there are in our solar system we need to

1183

00:47:44,309 --> 00:47:41,920

probe them because they are one of the

1184

00:47:48,069 --> 00:47:44,319

best locations we believe

1185

00:47:49,510 --> 00:47:48,079

that may harbor life today

1186

00:47:51,990 --> 00:47:49,520

thank you and that's all the time that

1187

00:47:55,910 --> 00:47:52,000

we have left please keep those questions

1188

00:47:58,309 --> 00:47:55,920

coming online using the hashtag asknasa

1189

00:47:59,910 --> 00:47:58,319

before be sure to follow us on all our

1190

00:48:02,390 --> 00:47:59,920

social media

1191

00:48:04,950 --> 00:48:02,400

and for more information please visit