1
00:00:06,789 --> 00:00:05,190
nasa's jet propulsion laboratory

2
00:00:09,430 --> 00:00:06,799
presents

3
00:00:11,509 --> 00:00:09,440
the von carmen lecture a series of talks

4
00:00:13,430 --> 00:00:11,519
by scientists and engineers who are

5
00:00:15,829 --> 00:00:13,440
exploring our planet

6
00:00:16,450 --> 00:00:15,839
our solar system and all that lies

7
00:00:23,590 --> 00:00:16,460
beyond

8
00:00:25,429 --> 00:00:23,600
[Music]

9
00:00:27,349 --> 00:00:25,439
hello and a very pleasant good evening

10
00:00:28,870 --> 00:00:27,359
to you wherever you may be i am brian

11
00:00:30,790 --> 00:00:28,880
white from jpl's office of

12
00:00:32,630 --> 00:00:30,800
communications and education

13
00:00:33,910 --> 00:00:32,640

and welcome to the von karman lecture

14
00:00:35,270 --> 00:00:33,920
series

15
00:00:37,590 --> 00:00:35,280
now i had a teacher in college who on

16
00:00:39,270 --> 00:00:37,600
the very first day he drew a tiny little

17
00:00:40,790 --> 00:00:39,280
circle on the whiteboard

18
00:00:43,350 --> 00:00:40,800
and he said this is everything that you

19
00:00:43,750 --> 00:00:43,360
know now being college students we were

20
00:00:46,150 --> 00:00:43,760
a little

21
00:00:48,150 --> 00:00:46,160
insulted by him implying that we only

22
00:00:49,750 --> 00:00:48,160
knew a little bit of knowledge

23
00:00:51,350 --> 00:00:49,760
but he said it's okay because everything

24
00:00:54,229 --> 00:00:51,360
that circle is touching

25
00:00:55,430 --> 00:00:54,239
is everything you know you don't know he

26
00:00:56,790 --> 00:00:55,440
said by the end of the class he drew

27
00:00:59,670 --> 00:00:56,800
this much bigger circle all the way

28
00:01:01,590 --> 00:00:59,680
around it and he said i hope this is you

29
00:01:03,110 --> 00:01:01,600
and i hope that everything that that

30
00:01:03,750 --> 00:01:03,120
bigger circle is touching is everything

31
00:01:08,230 --> 00:01:03,760
you now

32
00:01:12,310 --> 00:01:09,750
tonight we'll be discussing the jupiter

33
00:01:13,910 --> 00:01:12,320
system and the many mysteries that is it

34
00:01:15,350 --> 00:01:13,920
has unveiled to us

35
00:01:18,230 --> 00:01:15,360
you're going to hear some very smart

36
00:01:19,990 --> 00:01:18,240
people tonight say i don't know

37
00:01:21,910 --> 00:01:20,000
but i want you to remember that's where

38
00:01:23,910 --> 00:01:21,920

discovery begins

39
00:01:25,190 --> 00:01:23,920
now joining us as co-host fielding your

40
00:01:26,230 --> 00:01:25,200
questions this evening is public

41
00:01:29,350 --> 00:01:26,240
outreach specialist

42
00:01:31,350 --> 00:01:29,360
lindsay mclaurin hiya lindsey

43
00:01:32,469 --> 00:01:31,360
hi brian thank you so much for having me

44
00:01:34,230 --> 00:01:32,479
join you tonight

45
00:01:36,230 --> 00:01:34,240
and to everyone at home we just want to

46
00:01:37,749 --> 00:01:36,240
remind you that this is your space

47
00:01:39,590 --> 00:01:37,759
program and we want you to be a part of

48
00:01:40,950 --> 00:01:39,600
the conversation tonight so from

49
00:01:42,870 --> 00:01:40,960
wherever you're joining us

50
00:01:44,630 --> 00:01:42,880
please use the chat function to ask us

51
00:01:46,310 --> 00:01:44,640
questions and a member of our amazing

52
00:01:47,270 --> 00:01:46,320
social media team will pass them along

53
00:01:48,389 --> 00:01:47,280
to us

54
00:01:50,310 --> 00:01:48,399
we'll try to get through as many

55
00:01:51,830 --> 00:01:50,320
questions as possible but if for some

56
00:01:53,590 --> 00:01:51,840
reason you don't see the chat

57
00:01:54,870 --> 00:01:53,600
please refresh the page and it should be

58
00:01:57,510 --> 00:01:54,880
up shortly

59
00:01:59,510 --> 00:01:57,520
let's get started brian thank you

60
00:02:01,270 --> 00:01:59,520
lindsey let's get started

61
00:02:02,789 --> 00:02:01,280
as a reminder folks if we run into any

62
00:02:04,469 --> 00:02:02,799
technical difficulties we ask that you

63
00:02:05,270 --> 00:02:04,479

do stick with us as we get those sorted

64
00:02:07,109 --> 00:02:05,280
out

65
00:02:08,550 --> 00:02:07,119
now our first speaker is the juno

66
00:02:10,469 --> 00:02:08,560
project scientist and the

67
00:02:11,990 --> 00:02:10,479
lead co-investigator for juno's

68
00:02:14,309 --> 00:02:12,000
microwave radio

69
00:02:16,630 --> 00:02:14,319
radiometer instrument has worked at the

70
00:02:18,710 --> 00:02:16,640
jet propulsion laboratory since 1990

71
00:02:19,750 --> 00:02:18,720
his research interests are many but he

72
00:02:21,910 --> 00:02:19,760
is also currently

73
00:02:24,470 --> 00:02:21,920
the lead scientist for the goldstone

74
00:02:26,390 --> 00:02:24,480
apple valley radio telescope project

75
00:02:27,750 --> 00:02:26,400
gavert in which students learn about

76
00:02:30,949 --> 00:02:27,760
science by doing

77
00:02:33,509 --> 00:02:30,959
real science please welcome dr steven

78
00:02:37,990 --> 00:02:36,390
hi nice nice to be here welcome well

79
00:02:39,110 --> 00:02:38,000
let's get started let's get started with

80
00:02:40,869 --> 00:02:39,120
your jpl

81
00:02:43,110 --> 00:02:40,879
origin story how you got to where you

82
00:02:45,350 --> 00:02:43,120
are today

83
00:02:46,470 --> 00:02:45,360
sure well you know i talk to school kids

84
00:02:48,470 --> 00:02:46,480
all the time

85
00:02:50,070 --> 00:02:48,480
so and they always ask that question so

86
00:02:52,710 --> 00:02:50,080
i have kind of a pat answer for

87
00:02:54,550 --> 00:02:52,720
it and the truth is i became a scientist

88
00:02:56,710 --> 00:02:54,560

because i have a bad memory

89
00:02:58,390 --> 00:02:56,720
so when i was a kid in school and

90
00:03:00,229 --> 00:02:58,400
there's tests and whatever i had trouble

91
00:03:02,630 --> 00:03:00,239
remembering what the teacher told me

92
00:03:04,710 --> 00:03:02,640
but i quickly learned that i could

93
00:03:06,790 --> 00:03:04,720
figure out the answer instead

94
00:03:07,990 --> 00:03:06,800
and by doing that i learned hey figuring

95
00:03:09,830 --> 00:03:08,000
out stuff is fun

96
00:03:11,270 --> 00:03:09,840
and it also turns out that figuring

97
00:03:13,350 --> 00:03:11,280
things out is

98
00:03:15,190 --> 00:03:13,360
what scientists really do so that's kind

99
00:03:18,229 --> 00:03:15,200
of how i became a scientist

100
00:03:20,149 --> 00:03:18,239
and pretty much all of my career choices

101
00:03:22,550 --> 00:03:20,159
about what kind of science have been

102
00:03:23,910 --> 00:03:22,560
made on the very careful basis of that

103
00:03:27,110 --> 00:03:23,920
sounds like fun

104
00:03:28,229 --> 00:03:27,120
so that's what i've been doing well it

105
00:03:28,550 --> 00:03:28,239
sounds like you've been doing more than

106
00:03:31,750 --> 00:03:28,560
that

107
00:03:33,509 --> 00:03:31,760
working on then is a lot of fun

108
00:03:35,750 --> 00:03:33,519
so talk to us a little bit about juno

109
00:03:37,270 --> 00:03:35,760
and what it is

110
00:03:39,110 --> 00:03:37,280
sure and i see we've got a slide up

111
00:03:40,869 --> 00:03:39,120
there with a little summary so

112
00:03:42,869 --> 00:03:40,879
juno is our spacecraft that's orbiting

113
00:03:46,149 --> 00:03:42,879

jupiter and we've been there since

114
00:03:47,830 --> 00:03:46,159
2016 and uh

115
00:03:49,030 --> 00:03:47,840
the slide here is a little overview i'm

116
00:03:50,869 --> 00:03:49,040
not going to read everything on the

117
00:03:53,110 --> 00:03:50,879
slide although i'll point out that

118
00:03:54,309 --> 00:03:53,120
we flew by ganymede last week and

119
00:03:56,710 --> 00:03:54,319
changed our orbiter

120
00:03:58,229 --> 00:03:56,720
orbital period so that 53-day polar

121
00:04:01,190 --> 00:03:58,239
orbit it says in the middle is now a

122
00:04:02,789 --> 00:04:01,200
43-day polar orbit

123
00:04:04,390 --> 00:04:02,799
but in that time what we've been trying

124
00:04:07,110 --> 00:04:04,400
to do is understand

125
00:04:09,350 --> 00:04:07,120
the origin the interior the atmosphere

126
00:04:11,030 --> 00:04:09,360
the magnetosphere of the solar system's

127
00:04:13,589 --> 00:04:11,040
largest planet

128
00:04:15,509 --> 00:04:13,599
and we have an extended mission approved

129
00:04:17,749 --> 00:04:15,519
by nasa so that starts in august and

130
00:04:20,310 --> 00:04:17,759
we'll fly by other satellites and we'll

131
00:04:22,069 --> 00:04:20,320
get close-up data or closer up data of

132
00:04:26,550 --> 00:04:22,079
the north pole of jupiter

133
00:04:27,990 --> 00:04:26,560
and keep on going and i guess that means

134
00:04:30,070 --> 00:04:28,000
now's a good time to talk about all the

135
00:04:31,670 --> 00:04:30,080
cool stuff we've learned so far

136
00:04:33,749 --> 00:04:31,680
well i think so but you also had a

137
00:04:35,830 --> 00:04:33,759
pretty exciting day this past week and a

138
00:04:37,990 --> 00:04:35,840

half right

139
00:04:39,189 --> 00:04:38,000
sure we had a juno science team meeting

140
00:04:42,870 --> 00:04:39,199
this week and we had a

141
00:04:44,550 --> 00:04:42,880
flyby of ganymede last monday

142
00:04:47,030 --> 00:04:44,560
and so we have all kinds of cool stuff

143
00:04:49,670 --> 00:04:47,040
and yeah here's a great new picture

144
00:04:51,350 --> 00:04:49,680
of ganymede that we took with ganymede's

145
00:04:53,350 --> 00:04:51,360
first close-up in about

146
00:04:54,710 --> 00:04:53,360
i don't know what generation 25 years or

147
00:04:57,590 --> 00:04:54,720
so

148
00:04:59,270 --> 00:04:57,600
we have lots more to come but you know

149
00:05:00,629 --> 00:04:59,280
we only have the data about a week

150
00:05:02,629 --> 00:05:00,639
and we're still trying to understand

151
00:05:05,029 --> 00:05:02,639
things and analyze it

152
00:05:06,070 --> 00:05:05,039
so you can find tons of pretty pictures

153
00:05:08,790 --> 00:05:06,080
from the flyby

154
00:05:09,430 --> 00:05:08,800
on the mission juno website uh and

155
00:05:11,909 --> 00:05:09,440
there'll be

156
00:05:13,430 --> 00:05:11,919
lots more science results on ganymede we

157
00:05:15,430 --> 00:05:13,440
looked at ganymede in a new way

158
00:05:16,550 --> 00:05:15,440
as well as just for the first time in a

159
00:05:18,469 --> 00:05:16,560
long time

160
00:05:19,749 --> 00:05:18,479
and uh we'll have lots of science

161
00:05:23,189 --> 00:05:19,759
results for that but

162
00:05:25,189 --> 00:05:23,199
not today because a week is way too fast

163
00:05:26,950 --> 00:05:25,199

to be sure that we're right about pretty

164
00:05:29,110 --> 00:05:26,960
much anything we say about the science

165
00:05:31,670 --> 00:05:29,120
results

166
00:05:32,629 --> 00:05:31,680
well that's a good one that's a great

167
00:05:34,150 --> 00:05:32,639
segue though because

168
00:05:36,550 --> 00:05:34,160
you just said before we we know we're

169
00:05:38,469 --> 00:05:36,560
right about things um

170
00:05:39,590 --> 00:05:38,479
this mission you've told me when we were

171
00:05:42,870 --> 00:05:39,600
talking about this

172
00:05:45,510 --> 00:05:42,880
has surprised you in many ways

173
00:05:47,189 --> 00:05:45,520
yes and in fact why don't we switch to

174
00:05:51,510 --> 00:05:47,199
that next slide

175
00:05:52,070 --> 00:05:51,520
which is there's a way more than 10

176
00:05:55,189 --> 00:05:52,080
there's

177
00:05:57,909 --> 00:05:55,199
so many new discoveries and surprises

178
00:05:59,670 --> 00:05:57,919
that you know i couldn't make one list i

179
00:06:01,189 --> 00:05:59,680
couldn't make one talk that was just

180
00:06:03,990 --> 00:06:01,199
about the most exciting

181
00:06:05,830 --> 00:06:04,000
discoveries um but the short version is

182
00:06:06,629 --> 00:06:05,840
it's a whole new jupiter i love that

183
00:06:08,790 --> 00:06:06,639
quote from

184
00:06:10,150 --> 00:06:08,800
mike janssen one of our scientists when

185
00:06:12,629 --> 00:06:10,160
we first started getting

186
00:06:14,390 --> 00:06:12,639
data on jupiter and finding out that all

187
00:06:17,510 --> 00:06:14,400
our ideas were wrong

188
00:06:19,830 --> 00:06:17,520

so basically juno measures jupiter has

189
00:06:20,710 --> 00:06:19,840
measured jupiter in a bunch of new ways

190
00:06:22,710 --> 00:06:20,720
and pretty much

191
00:06:24,629 --> 00:06:22,720
every time we did a measurement in a way

192
00:06:26,230 --> 00:06:24,639
that hadn't been done before

193
00:06:27,830 --> 00:06:26,240
we found that our ideas about what we

194
00:06:28,550 --> 00:06:27,840
were going to see were just wrong we got

195
00:06:29,909 --> 00:06:28,560
surprises

196
00:06:32,070 --> 00:06:29,919
which is a lot of fun if you're an

197
00:06:33,909 --> 00:06:32,080
experimentalist like me you like

198
00:06:35,350 --> 00:06:33,919
you know getting the new data and making

199
00:06:37,830 --> 00:06:35,360
all the theorists start over

200
00:06:39,189 --> 00:06:37,840
so i'll tell you a few of them out of

201
00:06:40,230 --> 00:06:39,199
this list i'm not even going to try to

202
00:06:41,749 --> 00:06:40,240
read the list of

203
00:06:43,430 --> 00:06:41,759
top 10 but i'll tell you a couple of my

204
00:06:46,469 --> 00:06:43,440
favorites one of them

205
00:06:48,790 --> 00:06:46,479
is the deep atmosphere is not well mixed

206
00:06:50,790 --> 00:06:48,800
so what that means is you know jupiter's

207
00:06:52,870 --> 00:06:50,800
this giant ball of gas

208
00:06:54,950 --> 00:06:52,880
right and what everybody thought before

209
00:06:56,070 --> 00:06:54,960
we sent juno there to try to look below

210
00:06:58,629 --> 00:06:56,080
the clouds

211
00:06:59,110 --> 00:06:58,639
was if you got deep enough below where

212
00:07:01,589 --> 00:06:59,120
the sun

213
00:07:03,110 --> 00:07:01,599

shines in jupiter and below the where

214
00:07:05,589 --> 00:07:03,120
the clouds form

215
00:07:07,270 --> 00:07:05,599
it's all gas it would it's all fluid it

216
00:07:08,629 --> 00:07:07,280
would be well mixed and you'd find

217
00:07:09,830 --> 00:07:08,639
pretty much anywhere on the planet

218
00:07:11,670 --> 00:07:09,840
looked about the same

219
00:07:13,189 --> 00:07:11,680
and when you look through at depth it

220
00:07:14,550 --> 00:07:13,199
would make sense it would be smoothly

221
00:07:17,029 --> 00:07:14,560
varying and things and well that was

222
00:07:18,550 --> 00:07:17,039
totally wrong what we found is

223
00:07:20,070 --> 00:07:18,560
all kinds of structure with our

224
00:07:21,189 --> 00:07:20,080
microwave radiometer that can see

225
00:07:22,550 --> 00:07:21,199
beneath the clouds

226
00:07:24,629 --> 00:07:22,560
all the way down to several hundred

227
00:07:26,710 --> 00:07:24,639
kilometers as deep as we can see

228
00:07:28,390 --> 00:07:26,720
we see structure so that was really cool

229
00:07:30,230 --> 00:07:28,400
gives us all kinds of puzzles and things

230
00:07:32,629 --> 00:07:30,240
to try to figure out

231
00:07:33,270 --> 00:07:32,639
some of the other things we found were

232
00:07:35,510 --> 00:07:33,280
there's a

233
00:07:36,950 --> 00:07:35,520
the core in the middle is extended it's

234
00:07:39,029 --> 00:07:36,960
diluted it's fuzzy

235
00:07:40,790 --> 00:07:39,039
so we all knew that there ought to be

236
00:07:42,390 --> 00:07:40,800
down in the center of jupiter

237
00:07:43,909 --> 00:07:42,400
some kind of core where the heavy

238
00:07:45,510 --> 00:07:43,919

elements sank to the middle of the

239
00:07:46,790 --> 00:07:45,520
planet right if it's all fluid all the

240
00:07:47,510 --> 00:07:46,800
heavy stuff should be down there at the

241
00:07:49,589 --> 00:07:47,520
bottom

242
00:07:50,790 --> 00:07:49,599
and people kind of expected a sharply

243
00:07:52,710 --> 00:07:50,800
delineated

244
00:07:53,990 --> 00:07:52,720
core down in the middle maybe not a

245
00:07:56,790 --> 00:07:54,000
solid core

246
00:07:58,390 --> 00:07:56,800
but three to five maybe ten times the

247
00:07:59,350 --> 00:07:58,400
mass of the earth maybe even 20 times

248
00:08:01,270 --> 00:07:59,360
the mass of the earth

249
00:08:03,189 --> 00:08:01,280
but mostly way down in the center and

250
00:08:06,550 --> 00:08:03,199
what we think we found with the gravity

251
00:08:09,029 --> 00:08:06,560
is yeah that stuff is there but it's way

252
00:08:10,550 --> 00:08:09,039
up higher it's spread out and diluted up

253
00:08:12,629 --> 00:08:10,560
to half or maybe even

254
00:08:13,670 --> 00:08:12,639
three quarters of the radius of the

255
00:08:15,430 --> 00:08:13,680
planet

256
00:08:16,950 --> 00:08:15,440
so that's really strange and now one of

257
00:08:19,110 --> 00:08:16,960
the things we're trying to figure out is

258
00:08:20,550 --> 00:08:19,120
is there an even denser core down in the

259
00:08:23,990 --> 00:08:20,560
middle that that is

260
00:08:25,430 --> 00:08:24,000
separated uh there's a lot new of a lot

261
00:08:27,589 --> 00:08:25,440
new data to be collected and a lot of

262
00:08:29,749 --> 00:08:27,599
puzzles to try to solve

263
00:08:31,589 --> 00:08:29,759

i'll pick out another one of these is

264
00:08:33,350 --> 00:08:31,599
the magnetic field when we first got our

265
00:08:34,949 --> 00:08:33,360
look at the magnetic field of jupiter we

266
00:08:35,750 --> 00:08:34,959
found it was more complicated than we

267
00:08:38,709 --> 00:08:35,760
expected

268
00:08:39,990 --> 00:08:38,719
and we now know that it's asymmetric the

269
00:08:41,909 --> 00:08:40,000
north part of jupiter has

270
00:08:43,430 --> 00:08:41,919
a much more structured complicated

271
00:08:44,470 --> 00:08:43,440
magnetic field than the south part of

272
00:08:46,310 --> 00:08:44,480
jupiter

273
00:08:48,550 --> 00:08:46,320
now we knew before we got there that

274
00:08:50,310 --> 00:08:48,560
jupiter had the largest magnetic field

275
00:08:53,190 --> 00:08:50,320
of any planet in the solar system

276
00:08:55,590 --> 00:08:53,200
and we expected it's caused by swirling

277
00:08:57,750 --> 00:08:55,600
motions in the ocean of liquid metallic

278
00:09:01,030 --> 00:08:57,760
hydrogen deep inside the planet so

279
00:09:03,430 --> 00:09:01,040
hydrogen gas squeezed by gravity so much

280
00:09:05,110 --> 00:09:03,440
that it conducts electricity and it can

281
00:09:07,509 --> 00:09:05,120
make a magnetic field

282
00:09:09,030 --> 00:09:07,519
but what we didn't expect was all the

283
00:09:10,470 --> 00:09:09,040
structure that we see

284
00:09:12,310 --> 00:09:10,480
because even though we're getting this

285
00:09:13,750 --> 00:09:12,320
close-up view of the magnetic field

286
00:09:15,190 --> 00:09:13,760
we're not getting any closer than the

287
00:09:17,509 --> 00:09:15,200
surface of the planet

288
00:09:19,269 --> 00:09:17,519

and so we're seeing it still from a

289
00:09:20,550 --> 00:09:19,279
distance and the only way we can see

290
00:09:22,630 --> 00:09:20,560
that much structure

291
00:09:23,910 --> 00:09:22,640
is if something is going on at a

292
00:09:25,509 --> 00:09:23,920
shallower place

293
00:09:27,910 --> 00:09:25,519
than where we thought the magnetic field

294
00:09:29,670 --> 00:09:27,920
was generated so that's pretty exciting

295
00:09:31,430 --> 00:09:29,680
and then of course all this asymmetry is

296
00:09:32,949 --> 00:09:31,440
really strange that it's got all this

297
00:09:34,550 --> 00:09:32,959
complication in the north

298
00:09:36,790 --> 00:09:34,560
and it looks kind of smooth and a lot

299
00:09:37,509 --> 00:09:36,800
more like a regular earth type dipole in

300
00:09:40,389 --> 00:09:37,519
the south

301
00:09:42,070 --> 00:09:40,399
so that's another mystery i could go on

302
00:09:42,870 --> 00:09:42,080
and talk about all of these and use them

303
00:09:44,710 --> 00:09:42,880
all the time

304
00:09:46,389 --> 00:09:44,720
but i really want to talk about whatever

305
00:09:48,470 --> 00:09:46,399
people want me to talk about

306
00:09:50,550 --> 00:09:48,480
so what i'm hoping to do is stop right

307
00:09:51,750 --> 00:09:50,560
here with me telling you and let people

308
00:09:54,550 --> 00:09:51,760
ask questions

309
00:09:56,710 --> 00:09:54,560
and i can answer whatever anybody asks

310
00:09:58,630 --> 00:09:56,720
even if the answer is i don't know

311
00:10:00,470 --> 00:09:58,640
well let's find out what they are asking

312
00:10:00,870 --> 00:10:00,480
online remember if you don't see the

313
00:10:03,030 --> 00:10:00,880

chat

314
00:10:04,389 --> 00:10:03,040
refresh and you can get that popping up

315
00:10:06,790 --> 00:10:04,399
but lindsay what are they saying out

316
00:10:11,030 --> 00:10:08,630
steve the folks in the chat are super

317
00:10:12,870 --> 00:10:11,040
excited about talking about jupiter

318
00:10:14,310 --> 00:10:12,880
and so one of the questions chris wants

319
00:10:18,310 --> 00:10:14,320
to know on youtube

320
00:10:21,350 --> 00:10:18,320
what is the atmosphere like on jupiter

321
00:10:22,310 --> 00:10:21,360
okay so jupiter is mostly hydrogen and

322
00:10:24,790 --> 00:10:22,320
helium

323
00:10:25,910 --> 00:10:24,800
right so hydrogen is the lightest

324
00:10:27,670 --> 00:10:25,920
element there is

325
00:10:30,630 --> 00:10:27,680
here on earth it would float up into the

326
00:10:33,190 --> 00:10:30,640
sky but jupiter is so massive

327
00:10:34,310 --> 00:10:33,200
300 times the mass of the earth that the

328
00:10:36,870 --> 00:10:34,320
pressure is so

329
00:10:38,470 --> 00:10:36,880
high that you don't have to get very far

330
00:10:41,430 --> 00:10:38,480
into the planet very far

331
00:10:42,470 --> 00:10:41,440
below the cloud tops to get to a region

332
00:10:44,470 --> 00:10:42,480
where that hydrogen

333
00:10:46,630 --> 00:10:44,480
is compressed to something much

334
00:10:47,990 --> 00:10:46,640
different from what we experience here

335
00:10:49,990 --> 00:10:48,000
on the earth if you get

336
00:10:51,750 --> 00:10:50,000
a quarter or a third of the way in to

337
00:10:52,630 --> 00:10:51,760
the planet it's squeezed so much it's a

338
00:10:54,470 --> 00:10:52,640

liquid

339
00:10:56,630 --> 00:10:54,480
it can even be squeezed so much it

340
00:10:58,790 --> 00:10:56,640
conducts electricity it's a liquid metal

341
00:10:59,750 --> 00:10:58,800
so that's just the hydrogen now that's

342
00:11:02,150 --> 00:10:59,760
way down in

343
00:11:03,110 --> 00:11:02,160
at the top of the planet the top of the

344
00:11:05,190 --> 00:11:03,120
atmosphere

345
00:11:06,630 --> 00:11:05,200
there's still hydrogen there's helium as

346
00:11:09,190 --> 00:11:06,640
the next most abundant

347
00:11:10,949 --> 00:11:09,200
then there's ammonia so the nitrogen

348
00:11:12,710 --> 00:11:10,959
there is bound up with the hydrogen and

349
00:11:14,150 --> 00:11:12,720
h3 makes ammonia

350
00:11:16,790 --> 00:11:14,160
so you have a lot of ammonia in

351
00:11:18,710 --> 00:11:16,800
jupiter's atmosphere you have methane

352
00:11:20,069 --> 00:11:18,720
you have lots of different chemicals now

353
00:11:21,190 --> 00:11:20,079
because way up at the top of the

354
00:11:23,990 --> 00:11:21,200
atmosphere

355
00:11:26,389 --> 00:11:24,000
it's less dense it's not squeezed the

356
00:11:28,310 --> 00:11:26,399
same way and it can let the sunlight in

357
00:11:30,790 --> 00:11:28,320
and the sunlight causes all kinds of

358
00:11:32,790 --> 00:11:30,800
chemist chemical reactions to happen

359
00:11:34,230 --> 00:11:32,800
and then it circulates because jupiter's

360
00:11:36,389 --> 00:11:34,240
hot down in the middle and

361
00:11:37,910 --> 00:11:36,399
cold up at the top so we got a wide

362
00:11:39,509 --> 00:11:37,920
range of different elements and

363
00:11:41,190 --> 00:11:39,519

different chemicals different chemical

364
00:11:42,470 --> 00:11:41,200
compounds

365
00:11:45,670 --> 00:11:42,480
i don't know that's probably more than

366
00:11:47,590 --> 00:11:45,680
he wanted to hear to hear me say

367
00:11:48,790 --> 00:11:47,600
but it's a pretty complicated atmosphere

368
00:11:50,389 --> 00:11:48,800
and we can use

369
00:11:52,069 --> 00:11:50,399
some of what we learn at jupiter to try

370
00:11:54,949 --> 00:11:52,079
to understand more about the earth and

371
00:11:58,150 --> 00:11:57,509
thanks steve anthony on linkedin is

372
00:12:00,470 --> 00:11:58,160
asking

373
00:12:02,470 --> 00:12:00,480
is jupiter a gas giant that will be

374
00:12:06,550 --> 00:12:02,480
dangerous for the long-term future

375
00:12:07,430 --> 00:12:06,560
of planet earth so jupiter is certainly

376
00:12:09,190 --> 00:12:07,440
a gas giant

377
00:12:11,430 --> 00:12:09,200
i don't think i would say it's dangerous

378
00:12:13,910 --> 00:12:11,440
for the long-term future of planet earth

379
00:12:15,269 --> 00:12:13,920
in fact i'd say maybe jupiter you should

380
00:12:16,790 --> 00:12:15,279
think of jupiter like kind of a big

381
00:12:18,470 --> 00:12:16,800
brother that protects us

382
00:12:20,550 --> 00:12:18,480
now it's a little bit of a two-edged

383
00:12:22,550 --> 00:12:20,560
sword but if you imagine something

384
00:12:24,389 --> 00:12:22,560
falling into the inner solar system like

385
00:12:26,629 --> 00:12:24,399
a distant comet

386
00:12:27,750 --> 00:12:26,639
as it comes into the inner solar system

387
00:12:30,310 --> 00:12:27,760
it's going to interact

388
00:12:32,310 --> 00:12:30,320

most likely with jupiter before it

389
00:12:34,230 --> 00:12:32,320
interacts with the earth or with

390
00:12:35,590 --> 00:12:34,240
the other planets because jupiter is

391
00:12:38,230 --> 00:12:35,600
further out and it's

392
00:12:39,750 --> 00:12:38,240
way more massive and most of the ways in

393
00:12:40,870 --> 00:12:39,760
which something falling into the inner

394
00:12:42,550 --> 00:12:40,880
solar system

395
00:12:44,710 --> 00:12:42,560
could gravitationally interact with

396
00:12:46,790 --> 00:12:44,720
jupiter would result in

397
00:12:48,710 --> 00:12:46,800
kicking it out away from the inner solar

398
00:12:49,430 --> 00:12:48,720
system so it'd be less likely to hit the

399
00:12:51,750 --> 00:12:49,440
earth

400
00:12:53,590 --> 00:12:51,760
now that's not the whole story jupiter's

401
00:12:55,670 --> 00:12:53,600
got this enormous gravity it can also

402
00:12:55,990 --> 00:12:55,680
perturb the orbits of things and i won't

403
00:12:58,230 --> 00:12:56,000
say

404
00:13:00,069 --> 00:12:58,240
won't promise that jupiter's gravity

405
00:13:00,870 --> 00:13:00,079
couldn't perturb some comet and have it

406
00:13:03,030 --> 00:13:00,880
result in

407
00:13:05,590 --> 00:13:03,040
hitting the earth instead of avoiding

408
00:13:06,790 --> 00:13:05,600
the earth but on balance i'd say jupiter

409
00:13:08,710 --> 00:13:06,800
is more protective

410
00:13:10,069 --> 00:13:08,720
than it is dangerous to us and of course

411
00:13:12,550 --> 00:13:10,079
it's really far away

412
00:13:14,310 --> 00:13:12,560
so you don't have to worry about like

413
00:13:21,030 --> 00:13:14,320

gravity jupiter's gravity affecting the

414
00:13:23,430 --> 00:13:21,040
earth in any in any major way

415
00:13:25,269 --> 00:13:23,440
dimitri on twitter would like to know

416
00:13:26,150 --> 00:13:25,279
why are there such distinct colored

417
00:13:29,350 --> 00:13:26,160
storm rings

418
00:13:31,509 --> 00:13:29,360
around the equator of jupiter

419
00:13:32,870 --> 00:13:31,519
yeah great question so we call those the

420
00:13:34,790 --> 00:13:32,880
belts and zones

421
00:13:36,230 --> 00:13:34,800
and if you look at a map of jupiter

422
00:13:38,470 --> 00:13:36,240
let's see actually

423
00:13:39,269 --> 00:13:38,480
i think we have one of those backup

424
00:13:43,189 --> 00:13:39,279
slides

425
00:13:47,189 --> 00:13:43,199
shows let's see if i can find it

426
00:13:48,230 --> 00:13:47,199
uh it's too hard to look through all

427
00:13:49,829 --> 00:13:48,240
these pictures and

428
00:13:52,470 --> 00:13:49,839
find the right one but if you see one

429
00:13:54,310 --> 00:13:52,480
that's got shows the

430
00:13:56,150 --> 00:13:54,320
uh depth of the belts and zones you

431
00:13:58,069 --> 00:13:56,160
could put it up um

432
00:13:59,430 --> 00:13:58,079
so what's happening those things are jet

433
00:14:00,949 --> 00:13:59,440
streams so

434
00:14:02,629 --> 00:14:00,959
we've we've known for a long time

435
00:14:04,150 --> 00:14:02,639
because we can watch them from the earth

436
00:14:06,069 --> 00:14:04,160
in the upper atmosphere

437
00:14:07,590 --> 00:14:06,079
that they move relative to the rest of

438
00:14:09,430 --> 00:14:07,600

the planet left and right

439
00:14:11,509 --> 00:14:09,440
so if you go back and forth from those

440
00:14:12,790 --> 00:14:11,519
stripes from the orange to the white to

441
00:14:14,310 --> 00:14:12,800
the orange to the white as the

442
00:14:16,310 --> 00:14:14,320
alternating stripes you see

443
00:14:17,910 --> 00:14:16,320
on jupiter some of them moved to the

444
00:14:19,670 --> 00:14:17,920
left and some of them moved

445
00:14:21,350 --> 00:14:19,680
to the right not the picture i had in

446
00:14:23,189 --> 00:14:21,360
mind but we can use it

447
00:14:24,790 --> 00:14:23,199
if you look at that picture and ignore

448
00:14:25,990 --> 00:14:24,800
the magnetic field that's drawn on in

449
00:14:28,230 --> 00:14:26,000
blue and red

450
00:14:30,310 --> 00:14:28,240
you can still see the the belts and

451
00:14:33,189 --> 00:14:30,320
zones as as in this case

452
00:14:35,269 --> 00:14:33,199
white and dark stripes so they move in

453
00:14:37,269 --> 00:14:35,279
alternating directions

454
00:14:38,470 --> 00:14:37,279
what we didn't know until juno got there

455
00:14:40,550 --> 00:14:38,480
was how deep

456
00:14:42,230 --> 00:14:40,560
those things go now we know if you have

457
00:14:44,230 --> 00:14:42,240
a rapidly rotating planet

458
00:14:46,310 --> 00:14:44,240
and jupiter rotates pretty rapidly every

459
00:14:47,430 --> 00:14:46,320
10 hours so more than twice as fast as

460
00:14:50,150 --> 00:14:47,440
the earth

461
00:14:51,350 --> 00:14:50,160
and it's giant right it's it's 300 times

462
00:14:53,509 --> 00:14:51,360
the mass of the earth

463
00:14:55,030 --> 00:14:53,519

more than a thousand times the volume so

464
00:14:56,389 --> 00:14:55,040
rotating that fast

465
00:14:58,389 --> 00:14:56,399
means it's really going to affect the

466
00:15:00,790 --> 00:14:58,399
motions of the of the fluid

467
00:15:03,269 --> 00:15:00,800
and because it's a fluid most of the way

468
00:15:05,030 --> 00:15:03,279
down maybe all the way down

469
00:15:06,629 --> 00:15:05,040
we knew that doing that would tend to

470
00:15:09,189 --> 00:15:06,639
result in

471
00:15:09,990 --> 00:15:09,199
back and forth jets like that what we

472
00:15:12,629 --> 00:15:10,000
didn't know

473
00:15:13,910 --> 00:15:12,639
is how deep they go juno's been able to

474
00:15:17,509 --> 00:15:13,920
measure that and found they go

475
00:15:19,829 --> 00:15:17,519
3 000 kilometers down into the planet

476
00:15:20,949 --> 00:15:19,839
so understanding how that works is

477
00:15:23,829 --> 00:15:20,959
complicated

478
00:15:25,430 --> 00:15:23,839
but we can do experiments where you spin

479
00:15:26,069 --> 00:15:25,440
things or spin fluids around and watch

480
00:15:27,990 --> 00:15:26,079
what happens

481
00:15:29,509 --> 00:15:28,000
we can do numerical experiments where

482
00:15:32,949 --> 00:15:29,519
you try to calculate

483
00:15:34,550 --> 00:15:32,959
what happens and the combination of

484
00:15:36,550 --> 00:15:34,560
you know the the heat in the middle

485
00:15:38,629 --> 00:15:36,560
trying to escape that causes confection

486
00:15:39,990 --> 00:15:38,639
convection and the rotation of the

487
00:15:41,509 --> 00:15:40,000
planet that gives you things like the

488
00:15:45,269 --> 00:15:41,519

coriolis effect

489
00:15:46,550 --> 00:15:45,279
results in upwelling has to spread out

490
00:15:48,389 --> 00:15:46,560
and when it spreads out

491
00:15:49,910 --> 00:15:48,399
the part that spreads out goes in

492
00:15:52,150 --> 00:15:49,920
opposite directions

493
00:15:53,430 --> 00:15:52,160
so if you think about something rising

494
00:15:57,509 --> 00:15:53,440
near the equator

495
00:15:59,430 --> 00:15:57,519
goes a little bit north what happens

496
00:16:01,269 --> 00:15:59,440
well if it's right there at the equator

497
00:16:03,910 --> 00:16:01,279
and it goes a little bit north

498
00:16:05,990 --> 00:16:03,920
now to keep up with the rotating planet

499
00:16:06,710 --> 00:16:06,000
it doesn't have to go quite as fast as

500
00:16:09,030 --> 00:16:06,720
it did

501
00:16:10,230 --> 00:16:09,040
in the place where it rose if you go a

502
00:16:12,470 --> 00:16:10,240
little bit south

503
00:16:13,509 --> 00:16:12,480
same thing happens so you'd expect at

504
00:16:16,790 --> 00:16:13,519
the equator

505
00:16:18,870 --> 00:16:16,800
to have if if air is rising to have it

506
00:16:20,710 --> 00:16:18,880
move at slightly different speeds

507
00:16:22,710 --> 00:16:20,720
at the equator than it does north of it

508
00:16:24,550 --> 00:16:22,720
or south of it and if you do it again

509
00:16:26,870 --> 00:16:24,560
with an x-stripe and figure that out

510
00:16:27,829 --> 00:16:26,880
you wind up concluding that yeah it sort

511
00:16:29,509 --> 00:16:27,839
of makes sense

512
00:16:31,430 --> 00:16:29,519
to have all these stripes go back and

513
00:16:33,749 --> 00:16:31,440

forth in opposite directions

514
00:16:35,670 --> 00:16:33,759
if i have air upwelling and falling back

515
00:16:37,590 --> 00:16:35,680
down into the planet

516
00:16:39,030 --> 00:16:37,600
and if you bring up image 20 i think we

517
00:16:41,590 --> 00:16:39,040
can see a little bit of a chart that he

518
00:16:42,949 --> 00:16:41,600
was talking about

519
00:16:45,990 --> 00:16:42,959
yeah sorry it was hard for me to keep

520
00:16:49,350 --> 00:16:46,000
track of uh oh you're the expert here

521
00:16:51,749 --> 00:16:49,360
yep here it is right okay so the

522
00:16:54,389 --> 00:16:51,759
what you're seeing there the zonal winds

523
00:16:57,030 --> 00:16:54,399
that's the speed of those jet streams

524
00:16:57,670 --> 00:16:57,040
right plotted that's the squiggly line

525
00:17:00,310 --> 00:16:57,680
and it's

526
00:17:02,550 --> 00:17:00,320
plotted on top of an image of jupiter so

527
00:17:04,069 --> 00:17:02,560
you can see how the winds match up

528
00:17:05,669 --> 00:17:04,079
with those belts and zones with the

529
00:17:07,750 --> 00:17:05,679
different colors which are

530
00:17:08,949 --> 00:17:07,760
different chemicals in the very top of

531
00:17:12,150 --> 00:17:08,959
the atmosphere

532
00:17:13,990 --> 00:17:12,160
and then what juno has added to that is

533
00:17:16,870 --> 00:17:14,000
our gravity signature

534
00:17:18,390 --> 00:17:16,880
as juno flew really close to jupiter

535
00:17:21,829 --> 00:17:18,400
very close we fly

536
00:17:23,750 --> 00:17:21,839
uh about a 20th of the the radius of

537
00:17:25,189 --> 00:17:23,760
jupiter away from it so just skimming

538
00:17:27,429 --> 00:17:25,199

above the cloud tops

539
00:17:28,230 --> 00:17:27,439
as the spacecraft flies really close to

540
00:17:30,070 --> 00:17:28,240
jupiter

541
00:17:31,510 --> 00:17:30,080
gravity from the planet makes it speed

542
00:17:32,950 --> 00:17:31,520
up and slow down

543
00:17:34,789 --> 00:17:32,960
not just the gravity from the whole

544
00:17:35,909 --> 00:17:34,799
thing but from stuff that's close to us

545
00:17:37,590 --> 00:17:35,919
if you imagine

546
00:17:39,669 --> 00:17:37,600
if you flew over something that's a

547
00:17:41,029 --> 00:17:39,679
little denser as you approach it you're

548
00:17:42,549 --> 00:17:41,039
going to speed up a little

549
00:17:44,710 --> 00:17:42,559
and as you pass it you're going to start

550
00:17:47,110 --> 00:17:44,720
slowing down a loop so by measuring

551
00:17:49,190 --> 00:17:47,120
all of those things in great detail we

552
00:17:51,669 --> 00:17:49,200
can figure out among other things

553
00:17:53,270 --> 00:17:51,679
how deep those belts and zones go and

554
00:17:56,070 --> 00:17:53,280
the answer is they go

555
00:17:56,870 --> 00:17:56,080
quite deep 3000 kilometers is a lot

556
00:17:58,830 --> 00:17:56,880
deeper than

557
00:18:03,110 --> 00:17:58,840
many people thought we were going to

558
00:18:03,120 --> 00:18:06,789
that's probably enough steve

559
00:18:11,110 --> 00:18:08,789
we can talk about that that forever

560
00:18:13,750 --> 00:18:11,120
jupiter is just so beautiful and amazing

561
00:18:14,150 --> 00:18:13,760
and so gustav on twitter wants to know

562
00:18:16,150 --> 00:18:14,160
why

563
00:18:19,590 --> 00:18:16,160

are some of the moons of jupiter still

564
00:18:26,230 --> 00:18:22,870
you know that's a i don't know um

565
00:18:26,630 --> 00:18:26,240
i i would i'm only guessing but i would

566
00:18:29,590 --> 00:18:26,640
guess

567
00:18:31,190 --> 00:18:29,600
that the starting point there is you got

568
00:18:35,190 --> 00:18:31,200
to decide what's the moon and

569
00:18:37,510 --> 00:18:35,200
what's just a rock right so really big

570
00:18:39,190 --> 00:18:37,520
objects orbiting jupiter pretty obvious

571
00:18:40,710 --> 00:18:39,200
we get to call the moons they've

572
00:18:42,710 --> 00:18:40,720
been discovered a long time ago and they

573
00:18:43,190 --> 00:18:42,720
all have names some of them have names

574
00:18:46,950 --> 00:18:43,200
from

575
00:18:49,190 --> 00:18:46,960
you start getting smaller

576
00:18:50,789 --> 00:18:49,200
then you know you start when you start

577
00:18:52,230 --> 00:18:50,799
into getting the objects we haven't

578
00:18:54,950 --> 00:18:52,240
discovered yet

579
00:18:56,549 --> 00:18:54,960
then those are fairly small and i would

580
00:18:57,990 --> 00:18:56,559
i'm only guessing but i would guess they

581
00:19:00,549 --> 00:18:58,000
don't have names yet because

582
00:19:01,990 --> 00:19:00,559
either they're fairly new or because

583
00:19:03,750 --> 00:19:02,000
there's some debate as to whether it's

584
00:19:05,430 --> 00:19:03,760
big enough to deserve a name as opposed

585
00:19:07,750 --> 00:19:05,440
to a number

586
00:19:08,950 --> 00:19:07,760
but as i say the truth is i have no idea

587
00:19:11,029 --> 00:19:08,960
i wasn't even really

588
00:19:12,789 --> 00:19:11,039

until you asked the question aware that

589
00:19:16,150 --> 00:19:12,799
that was a thing that there's a bunch of

590
00:19:19,830 --> 00:19:16,160
moons of jupiter that aren't named

591
00:19:21,909 --> 00:19:19,840
and i'm guessing there's smallish rocks

592
00:19:24,150 --> 00:19:21,919
i loved the first i don't know of the

593
00:19:24,870 --> 00:19:24,160
night but that's also a great transition

594
00:19:26,630 --> 00:19:24,880
question

595
00:19:28,150 --> 00:19:26,640
as we pass it over to our next speaker

596
00:19:28,870 --> 00:19:28,160
steve lindsey will come back to you with

597
00:19:31,350 --> 00:19:28,880
questions

598
00:19:33,270 --> 00:19:31,360
in just a little bit but we're going to

599
00:19:36,310 --> 00:19:33,280
move on to our planetary geologist at

600
00:19:38,950 --> 00:19:36,320
jpl who specializes in surface processes

601
00:19:40,230 --> 00:19:38,960
on icy airless bodies she is a project

602
00:19:42,070 --> 00:19:40,240
staff scientist and science

603
00:19:44,150 --> 00:19:42,080
communications lead on the europa

604
00:19:45,750 --> 00:19:44,160
clipper mission dr phillips has an

605
00:19:46,470 --> 00:19:45,760
undergraduate degree in astrophysics

606
00:19:48,470 --> 00:19:46,480
from harvard

607
00:19:50,150 --> 00:19:48,480
and a phd in planetary science from the

608
00:19:54,470 --> 00:19:50,160
university of arizona

609
00:19:56,549 --> 00:19:54,480
welcome dr cynthia phillips hi

610
00:19:58,549 --> 00:19:56,559
hi thank you so much it's it's fabulous

611
00:20:00,230 --> 00:19:58,559
to be here um and thanks to steve for

612
00:20:04,710 --> 00:20:00,240
telling us about all the amazing stuff

613
00:20:07,750 --> 00:20:06,549

we'll i'll let you ask him some

614
00:20:09,430 --> 00:20:07,760
questions here in a bit

615
00:20:10,789 --> 00:20:09,440
but i want to get your origin story we

616
00:20:13,830 --> 00:20:10,799
got steve's i want to hear

617
00:20:16,070 --> 00:20:13,840
how you got to where you are today

618
00:20:18,310 --> 00:20:16,080
sure yeah so my origin story really

619
00:20:19,510 --> 00:20:18,320
relates back to the the power of i don't

620
00:20:21,430 --> 00:20:19,520
know

621
00:20:23,750 --> 00:20:21,440
i was in high school when the voyager

622
00:20:25,990 --> 00:20:23,760
spacecraft flew past neptune

623
00:20:27,830 --> 00:20:26,000
and you know i was a persuasive kid and

624
00:20:30,149 --> 00:20:27,840
this is pre-internet and so

625
00:20:32,230 --> 00:20:30,159
the way that the team on the voyager

626
00:20:32,710 --> 00:20:32,240
spacecraft the the camera team was able

627
00:20:34,630 --> 00:20:32,720
to

628
00:20:36,710 --> 00:20:34,640
just see the pictures that were coming

629
00:20:37,750 --> 00:20:36,720
of neptune and of its moons for the very

630
00:20:39,430 --> 00:20:37,760
first time

631
00:20:40,870 --> 00:20:39,440
was they actually had to go to jpl and

632
00:20:41,830 --> 00:20:40,880
they went to the control room and they

633
00:20:43,830 --> 00:20:41,840
sat there

634
00:20:45,669 --> 00:20:43,840
and they watched as the pictures came in

635
00:20:46,310 --> 00:20:45,679
on these big monitors up in the control

636
00:20:48,710 --> 00:20:46,320
room

637
00:20:49,990 --> 00:20:48,720
and so pbs um this is you know there's

638
00:20:51,590 --> 00:20:50,000

no internet right so

639
00:20:52,789 --> 00:20:51,600
if i wanted to see the pictures you have

640
00:20:54,310 --> 00:20:52,799
to wait for them to be published in the

641
00:20:55,110 --> 00:20:54,320
newspaper or something like that it took

642
00:20:57,909 --> 00:20:55,120
forever

643
00:20:59,669 --> 00:20:57,919
so pbs had a live stream from the jpl

644
00:21:01,029 --> 00:20:59,679
control room it was called neptune all

645
00:21:02,230 --> 00:21:01,039
night and they basically just had it on

646
00:21:04,070 --> 00:21:02,240
all night and

647
00:21:05,590 --> 00:21:04,080
i was a persuasive kid and so i remember

648
00:21:07,190 --> 00:21:05,600
i persuaded my parents let me stay up

649
00:21:08,950 --> 00:21:07,200
all night and watch this thing

650
00:21:10,549 --> 00:21:08,960
um and i remember it's you know the

651
00:21:13,270 --> 00:21:10,559
middle of the night

652
00:21:14,549 --> 00:21:13,280
and there's carl sagan who of course was

653
00:21:16,549 --> 00:21:14,559
on the camera team

654
00:21:18,870 --> 00:21:16,559
and this picture comes up of one of the

655
00:21:19,909 --> 00:21:18,880
moons and carl sagan looks at it and he

656
00:21:22,470 --> 00:21:19,919
says wow

657
00:21:23,350 --> 00:21:22,480
i have no idea what that is and it

658
00:21:25,270 --> 00:21:23,360
struck me

659
00:21:27,830 --> 00:21:25,280
in that moment as a high school student

660
00:21:28,950 --> 00:21:27,840
that there are still places in the solar

661
00:21:31,190 --> 00:21:28,960
system that are

662
00:21:32,470 --> 00:21:31,200
yet to be discovered there's places that

663
00:21:35,350 --> 00:21:32,480

human eyes

664
00:21:35,990 --> 00:21:35,360
had not yet seen before and that just

665
00:21:37,750 --> 00:21:36,000
gripped me

666
00:21:39,750 --> 00:21:37,760
that there was so much that you know we

667
00:21:43,190 --> 00:21:39,760
were at the cusp of discovering and

668
00:21:44,950 --> 00:21:43,200
i wanted to be part of that well you are

669
00:21:47,110 --> 00:21:44,960
you're a big part of it now so

670
00:21:49,750 --> 00:21:47,120
what gripped you about europa why europa

671
00:21:52,070 --> 00:21:49,760
why is that a place we're looking at

672
00:21:53,430 --> 00:21:52,080
so europa is this moon of jupiter and

673
00:21:54,710 --> 00:21:53,440
and it does have a name it's one of the

674
00:21:58,230 --> 00:21:54,720
big ones so it's one of the

675
00:22:00,630 --> 00:21:58,240
the four galilean satellites um and

676
00:22:02,470 --> 00:22:00,640
what's special about europa is that it's

677
00:22:03,830 --> 00:22:02,480
about the same size as earth's moon

678
00:22:05,510 --> 00:22:03,840
but as you can see in this picture it

679
00:22:07,350 --> 00:22:05,520
looks really different

680
00:22:09,350 --> 00:22:07,360
um instead of having a surface that's

681
00:22:11,190 --> 00:22:09,360
covered over with craters

682
00:22:13,270 --> 00:22:11,200
instead of being an old kind of battered

683
00:22:16,549 --> 00:22:13,280
rocky body like our own moon is

684
00:22:18,390 --> 00:22:16,559
europa is covered with ice and we think

685
00:22:20,310 --> 00:22:18,400
that europa could actually have

686
00:22:21,430 --> 00:22:20,320
what we call the planetary ingredients

687
00:22:24,470 --> 00:22:21,440
for life

688
00:22:25,350 --> 00:22:24,480

and so those are things like liquid

689
00:22:28,470 --> 00:22:25,360
water

690
00:22:30,070 --> 00:22:28,480
a source of energy um and the right

691
00:22:30,630 --> 00:22:30,080
chemical elements for life so that's

692
00:22:32,950 --> 00:22:30,640
things like

693
00:22:34,070 --> 00:22:32,960
carbon hydrogen nitrogen phosphorous

694
00:22:36,789 --> 00:22:34,080
sulfur

695
00:22:37,669 --> 00:22:36,799
um and then as well as stability it's no

696
00:22:39,110 --> 00:22:37,679
good to have these

697
00:22:40,789 --> 00:22:39,120
to have these ingredients there if you

698
00:22:42,310 --> 00:22:40,799
don't have enough time for chemical

699
00:22:44,710 --> 00:22:42,320
reactions to take place

700
00:22:46,470 --> 00:22:44,720
that maybe could lead to life and the

701
00:22:48,390 --> 00:22:46,480
really cool thing about europa is that

702
00:22:50,070 --> 00:22:48,400
we think it's one of the best places to

703
00:22:52,710 --> 00:22:50,080
look for life beyond the earth

704
00:22:54,549 --> 00:22:52,720
because it has all of these ingredients

705
00:22:57,110 --> 00:22:54,559
so if you can go to the next slide

706
00:22:58,470 --> 00:22:57,120
um europa's surface so again it's a

707
00:23:00,390 --> 00:22:58,480
really young surface

708
00:23:02,470 --> 00:23:00,400
um it has very few craters you can see

709
00:23:04,230 --> 00:23:02,480
there's one kind of nice big crater

710
00:23:06,310 --> 00:23:04,240
um there in the bottom left of that that

711
00:23:07,990 --> 00:23:06,320
grid on the right hand side there

712
00:23:10,149 --> 00:23:08,000
and it's a young crater you see these

713
00:23:11,830 --> 00:23:10,159

bright rays of material that have spewed

714
00:23:13,590 --> 00:23:11,840
out in all directions from it

715
00:23:15,830 --> 00:23:13,600
but most of the surface is covered with

716
00:23:18,870 --> 00:23:15,840
these long linear features called

717
00:23:20,630 --> 00:23:18,880
cracks and ridges that extend for

718
00:23:22,549 --> 00:23:20,640
thousands of kilometers across the

719
00:23:24,310 --> 00:23:22,559
surface and then there's places where

720
00:23:26,070 --> 00:23:24,320
the surface has been broken up into what

721
00:23:27,510 --> 00:23:26,080
look kind of like icebergs

722
00:23:29,430 --> 00:23:27,520
and these are places where the surface

723
00:23:31,750 --> 00:23:29,440
has kind of broken up into pieces

724
00:23:32,630 --> 00:23:31,760
it's rotated it's translated it's even

725
00:23:34,310 --> 00:23:32,640
tilted

726
00:23:36,549 --> 00:23:34,320
and then it looks like it froze into

727
00:23:38,070 --> 00:23:36,559
these new positions on the surface

728
00:23:40,149 --> 00:23:38,080
and while these look like icebergs

729
00:23:41,909 --> 00:23:40,159
they're many many times bigger than any

730
00:23:43,590 --> 00:23:41,919
icebergs we have here on earth so

731
00:23:45,750 --> 00:23:43,600
the titanic wouldn't stand a chance if

732
00:23:46,630 --> 00:23:45,760
it was there um and then we have other

733
00:23:48,070 --> 00:23:46,640
features that were

734
00:23:50,230 --> 00:23:48,080
just strange looking these little

735
00:23:52,950 --> 00:23:50,240
lenticula and these are little sort of

736
00:23:55,510 --> 00:23:52,960
dark spots on the surface

737
00:23:57,269 --> 00:23:55,520
and all of these features plus other

738
00:23:58,789 --> 00:23:57,279

evidence that we got from the galileo

739
00:24:02,390 --> 00:23:58,799
spacecraft

740
00:24:03,590 --> 00:24:02,400
jupiter system in the 1990s

741
00:24:05,750 --> 00:24:03,600
and that i was fortunate enough to get

742
00:24:07,590 --> 00:24:05,760
to work on when i was in graduate school

743
00:24:09,510 --> 00:24:07,600
the galileo spacecraft took all these

744
00:24:11,029 --> 00:24:09,520
images it took information from all of

745
00:24:13,510 --> 00:24:11,039
its other instruments

746
00:24:14,390 --> 00:24:13,520
and it suggested very strongly that

747
00:24:16,950 --> 00:24:14,400
underneath

748
00:24:17,510 --> 00:24:16,960
this icy layer at the surface there's a

749
00:24:25,029 --> 00:24:17,520
ocean

750
00:24:27,269 --> 00:24:25,039
and if you go to the next slide

751
00:24:28,549 --> 00:24:27,279
basically it's really exciting to think

752
00:24:32,070 --> 00:24:28,559
that there could be an ocean here

753
00:24:33,909 --> 00:24:32,080
so far away from the sun and this really

754
00:24:35,269 --> 00:24:33,919
revolutionized our thinking about about

755
00:24:37,110 --> 00:24:35,279
the habitable zone

756
00:24:39,029 --> 00:24:37,120
about places in the solar system that

757
00:24:39,590 --> 00:24:39,039
could be inhabited by life and again

758
00:24:44,549 --> 00:24:39,600
this is

759
00:24:45,990 --> 00:24:44,559
also some crazy strange life in star

760
00:24:47,750 --> 00:24:46,000
trek that maybe we haven't figured

761
00:24:49,110 --> 00:24:47,760
out yet but you know when we're looking

762
00:24:50,470 --> 00:24:49,120
at life we just have to do the best job

763
00:24:52,070 --> 00:24:50,480

we can and that means until someone

764
00:24:53,909 --> 00:24:52,080
builds me a tricorder it's going to be

765
00:24:56,390 --> 00:24:53,919
life like we have here on earth

766
00:24:57,510 --> 00:24:56,400
that needs those those ingredients that

767
00:24:59,990 --> 00:24:57,520
i talked about

768
00:25:02,070 --> 00:25:00,000
and so here on europa we think that

769
00:25:03,269 --> 00:25:02,080
there could be this big ocean layer of

770
00:25:06,390 --> 00:25:03,279
liquid water

771
00:25:08,950 --> 00:25:06,400
and we think it could be kept liquid by

772
00:25:10,149 --> 00:25:08,960
what's called tidal heating so basically

773
00:25:13,269 --> 00:25:10,159
what happens is that

774
00:25:14,549 --> 00:25:13,279
europa goes around jupiter and

775
00:25:16,789 --> 00:25:14,559
it has about a three and a half day

776
00:25:18,310 --> 00:25:16,799
orbit and as it goes around

777
00:25:20,070 --> 00:25:18,320
sometimes it's closer to jupiter and

778
00:25:22,390 --> 00:25:20,080
sometimes it's further away

779
00:25:24,310 --> 00:25:22,400
when it's closer remember jupiter is the

780
00:25:26,549 --> 00:25:24,320
biggest planet in our solar system

781
00:25:28,070 --> 00:25:26,559
actually has more mass than all of the

782
00:25:28,549 --> 00:25:28,080
rest of the solar system except for the

783
00:25:31,350 --> 00:25:28,559
sun

784
00:25:32,870 --> 00:25:31,360
combined together so jupiter's huge its

785
00:25:35,190 --> 00:25:32,880
gravitational forces are

786
00:25:36,549 --> 00:25:35,200
massive and so when europa is a little

787
00:25:38,470 --> 00:25:36,559
bit closer to jupiter

788
00:25:40,710 --> 00:25:38,480

its surface gets tugged on it gets

789
00:25:41,430 --> 00:25:40,720
stretched and pulled and elongated a

790
00:25:42,710 --> 00:25:41,440
little bit

791
00:25:44,470 --> 00:25:42,720
and then when it moves around in its

792
00:25:46,230 --> 00:25:44,480
orbit so it's further away

793
00:25:47,909 --> 00:25:46,240
surface goes down and it's this

794
00:25:49,590 --> 00:25:47,919
stretching and pulling as it kind of

795
00:25:51,430 --> 00:25:49,600
gets squished

796
00:25:53,269 --> 00:25:51,440
that's what we think generates

797
00:25:54,070 --> 00:25:53,279
frictional heating this is called tidal

798
00:25:55,830 --> 00:25:54,080
heating

799
00:25:57,990 --> 00:25:55,840
and it's that friction that tidal

800
00:25:58,549 --> 00:25:58,000
heating that keeps this liquid water

801
00:26:02,230 --> 00:25:58,559
ocean

802
00:26:03,350 --> 00:26:02,240
have been there over the age of the

803
00:26:05,590 --> 00:26:03,360
solar system

804
00:26:07,190 --> 00:26:05,600
so four and a half billion years this

805
00:26:10,630 --> 00:26:07,200
ocean has been sitting there

806
00:26:12,710 --> 00:26:10,640
simmering and so because of this because

807
00:26:15,750 --> 00:26:12,720
of these discoveries made by the

808
00:26:17,110 --> 00:26:15,760
galileo mission back in the 1990s nasa's

809
00:26:18,549 --> 00:26:17,120
been working on a new mission called

810
00:26:21,029 --> 00:26:18,559
europa clipper

811
00:26:22,630 --> 00:26:21,039
and so in the next slide please europa

812
00:26:24,710 --> 00:26:22,640
clipper will basically

813
00:26:26,070 --> 00:26:24,720

explore europa to investigate its

814
00:26:28,070 --> 00:26:26,080
habitability

815
00:26:30,149 --> 00:26:28,080
and it has a payload of a bunch of

816
00:26:32,230 --> 00:26:30,159
different instruments shown here

817
00:26:33,909 --> 00:26:32,240
the ones that are circled in blue are

818
00:26:34,549 --> 00:26:33,919
what we call our remote sensing

819
00:26:36,630 --> 00:26:34,559
instruments

820
00:26:38,230 --> 00:26:36,640
and so that includes things like an

821
00:26:40,630 --> 00:26:38,240
ultraviolet spectrometer

822
00:26:41,750 --> 00:26:40,640
there's an imaging system there's a

823
00:26:43,590 --> 00:26:41,760
near-infrared

824
00:26:45,909 --> 00:26:43,600
mapping spectrometer there's a thermal

825
00:26:47,669 --> 00:26:45,919
imager and there's a radar instrument

826
00:26:48,950 --> 00:26:47,679
and these instruments will all let us

827
00:26:50,310 --> 00:26:48,960
study the surface

828
00:26:52,630 --> 00:26:50,320
but some of them will actually be able

829
00:26:55,669 --> 00:26:52,640
to penetrate into the subsurface

830
00:26:57,110 --> 00:26:55,679
that reason ice penetrating radar

831
00:26:58,789 --> 00:26:57,120
will be able to go through the

832
00:26:59,750 --> 00:26:58,799
subsurface ice layer go through the

833
00:27:02,390 --> 00:26:59,760
surface ice layer

834
00:27:04,310 --> 00:27:02,400
down into the subsurface and depending

835
00:27:06,470 --> 00:27:04,320
on how thick the ice layer is

836
00:27:08,710 --> 00:27:06,480
we know there's a layer about a hundred

837
00:27:11,190 --> 00:27:08,720
kilometers or so thick at the surface

838
00:27:12,549 --> 00:27:11,200

some of that layer is frozen solid ice

839
00:27:14,470 --> 00:27:12,559
some of it's liquid water

840
00:27:15,909 --> 00:27:14,480
we're not sure yet how much is frozen

841
00:27:17,669 --> 00:27:15,919
and how much is liquid

842
00:27:19,269 --> 00:27:17,679
the reason instrument maybe will be able

843
00:27:21,909 --> 00:27:19,279
to help us determine

844
00:27:23,350 --> 00:27:21,919
how thick that ice layer is and it'll

845
00:27:25,190 --> 00:27:23,360
also be able to look for

846
00:27:27,110 --> 00:27:25,200
places within the ice layer where there

847
00:27:29,990 --> 00:27:27,120
could be inclusion so

848
00:27:31,590 --> 00:27:30,000
pockets of liquid water and then we have

849
00:27:33,029 --> 00:27:31,600
another set of instruments that we call

850
00:27:35,990 --> 00:27:33,039
our in-situ instruments

851
00:27:37,430 --> 00:27:36,000
and so these are a mass spectrometer

852
00:27:38,630 --> 00:27:37,440
there's a dust detector there's a

853
00:27:40,710 --> 00:27:38,640
magnetometer

854
00:27:42,549 --> 00:27:40,720
and there's a plasma instrument and so

855
00:27:45,590 --> 00:27:42,559
these instruments will let us

856
00:27:47,830 --> 00:27:45,600
sample the composition of europa

857
00:27:48,870 --> 00:27:47,840
and that these don't do it directly so

858
00:27:50,230 --> 00:27:48,880
they're not going to we're not going to

859
00:27:51,350 --> 00:27:50,240
land on the surface of europe but not

860
00:27:53,029 --> 00:27:51,360
with this mission

861
00:27:54,549 --> 00:27:53,039
but what the mass spectrometer and the

862
00:27:56,389 --> 00:27:54,559
dust analyzer do is it's kind of like

863
00:27:58,630 --> 00:27:56,399

europa clippers sticking out its tongue

864
00:28:00,389 --> 00:27:58,640
when it goes by europa and it's

865
00:28:01,990 --> 00:28:00,399
capturing some of that material that's

866
00:28:03,990 --> 00:28:02,000
thrown off the surface

867
00:28:05,750 --> 00:28:04,000
and so if there's a plume erupting on

868
00:28:07,269 --> 00:28:05,760
europa now this is this is possible

869
00:28:08,710 --> 00:28:07,279
we've seen plumes

870
00:28:11,430 --> 00:28:08,720
erupting from the tiny little moon

871
00:28:14,070 --> 00:28:11,440
enceladus um that orbits saturn

872
00:28:15,110 --> 00:28:14,080
so we think maybe there could be plumes

873
00:28:16,950 --> 00:28:15,120
on europa

874
00:28:18,549 --> 00:28:16,960
we haven't seen them yet but if we do

875
00:28:19,990 --> 00:28:18,559
find a plume we'll be able to fly

876
00:28:21,110 --> 00:28:20,000
through it probably with the europa

877
00:28:23,510 --> 00:28:21,120
clipper spacecraft

878
00:28:25,590 --> 00:28:23,520
and sample that material directly but

879
00:28:27,190 --> 00:28:25,600
even if we don't find a plume on europa

880
00:28:28,710 --> 00:28:27,200
there's still enough material that's

881
00:28:31,029 --> 00:28:28,720
just thrown off the surface

882
00:28:32,870 --> 00:28:31,039
due to impacts from jupiter's very

883
00:28:34,789 --> 00:28:32,880
strong magnetic field that accelerates

884
00:28:36,389 --> 00:28:34,799
charged particles into the surface

885
00:28:38,310 --> 00:28:36,399
those impact the surface and they send

886
00:28:40,710 --> 00:28:38,320
off material out into space

887
00:28:41,590 --> 00:28:40,720
they make this very very thin tenuous

888
00:28:43,350 --> 00:28:41,600

atmosphere

889
00:28:45,750 --> 00:28:43,360
and as the europa clipper spacecraft

890
00:28:46,630 --> 00:28:45,760
flies by europa on its multiple close

891
00:28:48,470 --> 00:28:46,640
approaches

892
00:28:50,630 --> 00:28:48,480
you'll be able to sample that material

893
00:28:52,549 --> 00:28:50,640
and determine its composition

894
00:28:53,990 --> 00:28:52,559
and then finally we have a magnetometer

895
00:28:56,070 --> 00:28:54,000
and a plasma instrument

896
00:28:58,470 --> 00:28:56,080
that will be able to tell us more about

897
00:29:00,549 --> 00:28:58,480
the space environment surrounding europa

898
00:29:02,389 --> 00:29:00,559
and also maybe help us determine exactly

899
00:29:05,269 --> 00:29:02,399
how thick that ocean layer is by looking

900
00:29:07,510 --> 00:29:05,279
for an induced magnetic field signal

901
00:29:08,870 --> 00:29:07,520
yeah if we go to the video next we can

902
00:29:11,269 --> 00:29:08,880
see that plume you're right

903
00:29:12,789 --> 00:29:11,279
that you're talking about great yeah so

904
00:29:15,269 --> 00:29:12,799
so europa clipper

905
00:29:16,549 --> 00:29:15,279
is a it's a spacecraft that rather than

906
00:29:18,389 --> 00:29:16,559
orbiting europa

907
00:29:20,149 --> 00:29:18,399
the problem is that there's so much

908
00:29:22,149 --> 00:29:20,159
radiation around europa that we can only

909
00:29:23,510 --> 00:29:22,159
survive for a matter of matter of weeks

910
00:29:25,909 --> 00:29:23,520
in europa orbit

911
00:29:28,070 --> 00:29:25,919
but instead we'll fly will have multiple

912
00:29:29,029 --> 00:29:28,080
close flybys from jupiter orbit of

913
00:29:30,230 --> 00:29:29,039

europa

914
00:29:32,549 --> 00:29:30,240
and so here's just an artist's

915
00:29:34,149 --> 00:29:32,559
conception where if we there is a plume

916
00:29:35,590 --> 00:29:34,159
actually erupting from europa

917
00:29:37,070 --> 00:29:35,600
we'll be able to fly right through it

918
00:29:38,789 --> 00:29:37,080
and sample it and that would just be

919
00:29:40,149 --> 00:29:38,799
spectacular

920
00:29:41,909 --> 00:29:40,159
but even if there isn't a plume we'll

921
00:29:43,110 --> 00:29:41,919
still get just amazing results from

922
00:29:46,149 --> 00:29:43,120
europa clipper

923
00:29:49,909 --> 00:29:46,159
so so the the spacecraft will have

924
00:29:51,830 --> 00:29:49,919
multiple close flybys 50 or so of europa

925
00:29:53,430 --> 00:29:51,840
over the course of a couple of years um

926
00:29:54,870 --> 00:29:53,440
in the jupiter system

927
00:29:57,110 --> 00:29:54,880
and so we're really looking forward to

928
00:30:01,269 --> 00:29:57,120
these new results from europa clifford

929
00:30:02,389 --> 00:30:01,279
so stay tuned very cool

930
00:30:03,990 --> 00:30:02,399
lindsay i know there were a lot of

931
00:30:05,430 --> 00:30:04,000
questions about jupiter i imagine

932
00:30:07,750 --> 00:30:05,440
there's a lot of questions about europa

933
00:30:10,310 --> 00:30:07,760
out there too

934
00:30:10,950 --> 00:30:10,320
you are absolutely right brian so

935
00:30:13,590 --> 00:30:10,960
cynthia

936
00:30:16,310 --> 00:30:13,600
ervin on linkedin is asking how many

937
00:30:18,149 --> 00:30:16,320
instruments are flying on europa clipper

938
00:30:19,990 --> 00:30:18,159

is there an instrument that hasn't flown

939
00:30:23,830 --> 00:30:20,000
before or is very specific

940
00:30:25,590 --> 00:30:23,840
to europa uh sure so if we can go back

941
00:30:28,230 --> 00:30:25,600
two slides to the to the list of

942
00:30:28,240 --> 00:30:32,630
sorry for forward one two more

943
00:30:37,750 --> 00:30:35,990
yeah this one okay so there's

944
00:30:39,350 --> 00:30:37,760
there's a bunch of different instruments

945
00:30:41,029 --> 00:30:39,360
on europa clipper um

946
00:30:43,350 --> 00:30:41,039
it depends on how you count them whether

947
00:30:46,070 --> 00:30:43,360
or not there's nine instruments or ten

948
00:30:47,830 --> 00:30:46,080
and that's because the camera on europa

949
00:30:49,350 --> 00:30:47,840
clipper there's a narrow angle camera

950
00:30:51,110 --> 00:30:49,360
and a wide angle camera

951
00:30:52,310 --> 00:30:51,120
so sometimes we count those as two

952
00:30:54,470 --> 00:30:52,320
different instruments because you know

953
00:30:54,950 --> 00:30:54,480
technically it is two separate cameras

954
00:30:57,029 --> 00:30:54,960
but

955
00:30:58,389 --> 00:30:57,039
they're both part of the ice europa

956
00:31:01,909 --> 00:30:58,399
imaging system

957
00:31:03,590 --> 00:31:01,919
um so we've we've flown some of these

958
00:31:05,990 --> 00:31:03,600
instruments to europa before

959
00:31:07,590 --> 00:31:06,000
and some we haven't um some of the ones

960
00:31:10,710 --> 00:31:07,600
that are really special here

961
00:31:12,389 --> 00:31:10,720
are the reason the ice penetrating radar

962
00:31:14,230 --> 00:31:12,399
that's a new instrument and we've been

963
00:31:17,669 --> 00:31:14,240

using instruments like this

964
00:31:18,230 --> 00:31:17,679
um on mars to look below the the ice

965
00:31:20,870 --> 00:31:18,240
sheets

966
00:31:22,710 --> 00:31:20,880
um in the in the polls of mars and we

967
00:31:23,430 --> 00:31:22,720
also use instruments like this on the

968
00:31:28,549 --> 00:31:23,440
earth

969
00:31:29,990 --> 00:31:28,559
technology of an ice penetrating radar

970
00:31:31,509 --> 00:31:30,000
it's been tested on mars it's been

971
00:31:32,549 --> 00:31:31,519
tested on the earth but this will be the

972
00:31:33,750 --> 00:31:32,559
first time

973
00:31:35,590 --> 00:31:33,760
that we're sending an instrument like

974
00:31:37,190 --> 00:31:35,600
this to the outer solar system

975
00:31:39,110 --> 00:31:37,200
so i'd say that the reason instrument is

976
00:31:41,430 --> 00:31:39,120
one that we're all really excited

977
00:31:42,310 --> 00:31:41,440
to see what it looks like and then

978
00:31:43,830 --> 00:31:42,320
another one

979
00:31:45,830 --> 00:31:43,840
that i'm also really excited about is

980
00:31:48,230 --> 00:31:45,840
actually the ultraviolet spectrograph so

981
00:31:51,269 --> 00:31:48,240
this is the europa uvs instrument

982
00:31:53,830 --> 00:31:51,279
um the galileo spacecraft um that

983
00:31:54,950 --> 00:31:53,840
that we got most of our information from

984
00:31:57,350 --> 00:31:54,960
um

985
00:31:59,110 --> 00:31:57,360
about about europa so far uh did not

986
00:32:02,149 --> 00:31:59,120
have an ultraviolet instrument

987
00:32:03,750 --> 00:32:02,159
and so we basically we had a camera on

988
00:32:04,870 --> 00:32:03,760

galileo that went down into about the

989
00:32:06,549 --> 00:32:04,880
violet range

990
00:32:07,909 --> 00:32:06,559
but i'm really excited to see you know

991
00:32:12,070 --> 00:32:07,919
we can look for

992
00:32:14,389 --> 00:32:12,080
ultraviolet spectrograph might also be

993
00:32:15,909 --> 00:32:14,399
useful to look for plumes and so this

994
00:32:17,190 --> 00:32:15,919
will also be a really exciting

995
00:32:22,149 --> 00:32:17,200
sort of new instrument that we'll be

996
00:32:25,909 --> 00:32:24,789
thanks cynthia crimsy on youtube would

997
00:32:29,509 --> 00:32:25,919
like to know

998
00:32:33,350 --> 00:32:29,519
how deep is the ocean on europa

999
00:32:35,669 --> 00:32:33,360
and how much does that depth vary

1000
00:32:36,630 --> 00:32:35,679
that's a great question um let's see if

1001
00:32:40,070 --> 00:32:36,640
we can go back

1002
00:32:46,950 --> 00:32:43,590
so this image this image actually shows

1003
00:32:49,110 --> 00:32:46,960
that basically europa's ocean so

1004
00:32:51,110 --> 00:32:49,120
so the layer at the surface that's about

1005
00:32:52,789 --> 00:32:51,120
100 kilometers thick or so

1006
00:32:54,630 --> 00:32:52,799
you know it's 100 kilometers maybe plus

1007
00:32:56,549 --> 00:32:54,640
or minus like 30 or something

1008
00:32:58,230 --> 00:32:56,559
so you'll see people here here people

1009
00:33:00,070 --> 00:32:58,240
talking about you know it's an ocean

1010
00:33:02,470 --> 00:33:00,080
about 100 kilometers thick maybe with

1011
00:33:04,950 --> 00:33:02,480
like 30 kilometers of ice on top of it

1012
00:33:06,310 --> 00:33:04,960
the truth is that you know again this is

1013
00:33:08,470 --> 00:33:06,320

this isn't i don't know

1014
00:33:09,750 --> 00:33:08,480
but it's not quite as unbounded as some

1015
00:33:11,669 --> 00:33:09,760
of our i don't know you know

1016
00:33:13,750 --> 00:33:11,679
we do know that there definitely is a

1017
00:33:16,389 --> 00:33:13,760
layer at the surface of europa

1018
00:33:17,830 --> 00:33:16,399
um that has the density of water the

1019
00:33:20,149 --> 00:33:17,840
problem is that the density

1020
00:33:22,149 --> 00:33:20,159
of solid water ice and the density of

1021
00:33:22,789 --> 00:33:22,159
liquid water are really close to each

1022
00:33:24,789 --> 00:33:22,799
other

1023
00:33:26,950 --> 00:33:24,799
and so the gravity measurements from

1024
00:33:28,630 --> 00:33:26,960
europe from the galileo spacecraft that

1025
00:33:30,549 --> 00:33:28,640
we used to detect this layer

1026
00:33:32,070 --> 00:33:30,559
they just weren't good enough to

1027
00:33:33,750 --> 00:33:32,080
distinguish between

1028
00:33:35,590 --> 00:33:33,760
how much is solid ice and how much is

1029
00:33:37,509 --> 00:33:35,600
liquid water so

1030
00:33:39,029 --> 00:33:37,519
most of the best estimates we would say

1031
00:33:41,509 --> 00:33:39,039
are that it's about

1032
00:33:43,269 --> 00:33:41,519
you know 100 kilometers or so of water

1033
00:33:46,310 --> 00:33:43,279
maybe 80 kilometers of water and then

1034
00:33:49,590 --> 00:33:46,320
maybe 30 or so kilometers ice on top

1035
00:33:51,830 --> 00:33:49,600
um likely there is some variation um

1036
00:33:52,630 --> 00:33:51,840
but probably not a whole lot like there

1037
00:33:55,029 --> 00:33:52,640
probably aren't

1038
00:33:56,630 --> 00:33:55,039

huge sort of like you know big pointy

1039
00:33:58,149 --> 00:33:56,640
icebergy things that are there are

1040
00:34:00,230 --> 00:33:58,159
places where the ice shell is really

1041
00:34:01,590 --> 00:34:00,240
jagged at the bottom of the ice shell

1042
00:34:04,070 --> 00:34:01,600
and that's just because if there are

1043
00:34:05,350 --> 00:34:04,080
places where there's a lot of topography

1044
00:34:07,509 --> 00:34:05,360
at the bottom of the ice shelves

1045
00:34:09,030 --> 00:34:07,519
at the top of the ocean probably the

1046
00:34:10,710 --> 00:34:09,040
currents in the ocean and just the

1047
00:34:14,470 --> 00:34:10,720
temperature would kind of smooth those

1048
00:34:18,230 --> 00:34:16,869
well let's bring steve back in here

1049
00:34:19,270 --> 00:34:18,240
there are a lot of questions in this

1050
00:34:20,550 --> 00:34:19,280
chat tonight and

1051
00:34:22,069 --> 00:34:20,560
i've only heard i don't know a couple

1052
00:34:22,550 --> 00:34:22,079
times and that's pretty great um you

1053
00:34:25,270 --> 00:34:22,560
both

1054
00:34:25,589 --> 00:34:25,280
talked to me early about how proud you

1055
00:34:27,589 --> 00:34:25,599
are

1056
00:34:29,510 --> 00:34:27,599
when you get to say those that answer to

1057
00:34:31,030 --> 00:34:29,520
a question um lindsay we got time for

1058
00:34:32,869 --> 00:34:31,040
just a few more questions from our

1059
00:34:34,710 --> 00:34:32,879
audience

1060
00:34:36,869 --> 00:34:34,720
absolutely so steve this question i

1061
00:34:39,270 --> 00:34:36,879
think you can answer

1062
00:34:40,230 --> 00:34:39,280
darren on facebook would like to know

1063
00:34:42,149 --> 00:34:40,240

could the public

1064
00:34:46,829 --> 00:34:42,159
possibly be allowed to give naming

1065
00:34:53,750 --> 00:34:50,790
ah way above my pay grade so um

1066
00:34:54,470 --> 00:34:53,760
i i don't know i'm sure there is a

1067
00:34:56,790 --> 00:34:54,480
protocol

1068
00:34:57,510 --> 00:34:56,800
for deciding how to name moons of other

1069
00:35:00,230 --> 00:34:57,520
planets

1070
00:35:01,589 --> 00:35:00,240
but i don't happen to know what it is i

1071
00:35:03,750 --> 00:35:01,599
can talk about that a little bit steve

1072
00:35:05,910 --> 00:35:03,760
actually

1073
00:35:06,790 --> 00:35:05,920
um so so i've worked a little bit on on

1074
00:35:09,430 --> 00:35:06,800
yeah i've worked a little bit on

1075
00:35:11,510 --> 00:35:09,440
planetary nomenclature actually and so

1076
00:35:13,270 --> 00:35:11,520
um it really depends on what sort of

1077
00:35:15,670 --> 00:35:13,280
feature what sort of

1078
00:35:16,630 --> 00:35:15,680
object we're talking about um and so a

1079
00:35:18,390 --> 00:35:16,640
moon

1080
00:35:21,109 --> 00:35:18,400
has to fit into certain naming

1081
00:35:22,550 --> 00:35:21,119
categories and so the moons of jupiter

1082
00:35:25,030 --> 00:35:22,560
mostly come from you know greek

1083
00:35:26,790 --> 00:35:25,040
mythology um there's some other sort of

1084
00:35:28,710 --> 00:35:26,800
special cases depending on sort of

1085
00:35:31,990 --> 00:35:28,720
different clusters of moons

1086
00:35:33,670 --> 00:35:32,000
um but we have done there there have

1087
00:35:34,790 --> 00:35:33,680
been cases in the past when new moons

1088
00:35:36,230 --> 00:35:34,800

have been discovered

1089
00:35:37,670 --> 00:35:36,240
um you know you can't name a moon after

1090
00:35:39,750 --> 00:35:37,680
a person right the international

1091
00:35:41,829 --> 00:35:39,760
astronomical union has very sort of

1092
00:35:44,310 --> 00:35:41,839
strict requirements on this

1093
00:35:46,230 --> 00:35:44,320
um but the person who discovers a moon

1094
00:35:46,790 --> 00:35:46,240
does actually usually get to suggest a

1095
00:35:49,190 --> 00:35:46,800
name

1096
00:35:50,710 --> 00:35:49,200
to the international astronomical union

1097
00:35:52,710 --> 00:35:50,720
and if that name kind of

1098
00:35:55,030 --> 00:35:52,720
follows within the naming conventions

1099
00:35:56,710 --> 00:35:55,040
then sometimes that name can be adopted

1100
00:35:58,069 --> 00:35:56,720
and so yes sometimes in the past there

1101
00:36:00,790 --> 00:35:58,079
have been sort of

1102
00:36:01,510 --> 00:36:00,800
nema moons or not really contests but

1103
00:36:04,150 --> 00:36:01,520
sort of

1104
00:36:05,030 --> 00:36:04,160
public um you know periods where

1105
00:36:06,470 --> 00:36:05,040
basically

1106
00:36:08,390 --> 00:36:06,480
it's been opened to the public to sort

1107
00:36:09,349 --> 00:36:08,400
of suggest names and then help vote on

1108
00:36:10,710 --> 00:36:09,359
names

1109
00:36:13,030 --> 00:36:10,720
but the public doesn't actually get to

1110
00:36:17,109 --> 00:36:13,040
officially name any of these moons

1111
00:36:19,030 --> 00:36:17,119
so stay tuned thanks cynthia

1112
00:36:21,430 --> 00:36:19,040
laney is asking a question for her

1113
00:36:25,430 --> 00:36:21,440

daughter sloane who would like to know

1114
00:36:27,670 --> 00:36:25,440
why there are geysers on europa

1115
00:36:29,510 --> 00:36:27,680
ah that's a very good question um so

1116
00:36:30,950 --> 00:36:29,520
first we don't know whether or not there

1117
00:36:32,710 --> 00:36:30,960
are geysers on europa

1118
00:36:33,990 --> 00:36:32,720
i really like there to be geysers on

1119
00:36:35,510 --> 00:36:34,000
europa just because i think that would

1120
00:36:38,310 --> 00:36:35,520
be super super cool

1121
00:36:39,750 --> 00:36:38,320
if europa was actually ejecting material

1122
00:36:40,069 --> 00:36:39,760
out into space like this big sort of

1123
00:36:42,710 --> 00:36:40,079
like

1124
00:36:45,270 --> 00:36:42,720
space you know eruption and we do see

1125
00:36:47,270 --> 00:36:45,280
those on saturn's moon enceladus

1126
00:36:49,190 --> 00:36:47,280
and so we know that it's possible right

1127
00:36:51,589 --> 00:36:49,200
if enceladus can do it come on europa's

1128
00:36:52,870 --> 00:36:51,599
got to be able to do it too

1129
00:36:54,870 --> 00:36:52,880
part of the problem with europa is that

1130
00:36:57,190 --> 00:36:54,880
it's a lot bigger than enceladus

1131
00:36:59,510 --> 00:36:57,200
so just because we see plumes that are

1132
00:37:01,270 --> 00:36:59,520
actually being vented off of enceladus

1133
00:37:02,550 --> 00:37:01,280
if plumes did exist on europa they'd be

1134
00:37:04,550 --> 00:37:02,560
a lot smaller

1135
00:37:06,310 --> 00:37:04,560
so they wouldn't be quite as spectacular

1136
00:37:08,870 --> 00:37:06,320
as these kind of giant

1137
00:37:10,790 --> 00:37:08,880
giant jets of of gas and dust that we

1138
00:37:13,270 --> 00:37:10,800

see coming off of enceladus

1139
00:37:14,870 --> 00:37:13,280
um but if there are plumes that would be

1140
00:37:16,790 --> 00:37:14,880
really fascinating because basically

1141
00:37:17,670 --> 00:37:16,800
that would mean that somehow the liquid

1142
00:37:20,390 --> 00:37:17,680
water ocean

1143
00:37:20,950 --> 00:37:20,400
of europa made it up close enough to the

1144
00:37:22,870 --> 00:37:20,960
surface

1145
00:37:24,630 --> 00:37:22,880
that it was able to erupt and sort of

1146
00:37:26,950 --> 00:37:24,640
make it out into space

1147
00:37:29,190 --> 00:37:26,960
and so you know again we're not really

1148
00:37:31,510 --> 00:37:29,200
sure for sure how that could happen

1149
00:37:32,870 --> 00:37:31,520
but we think it could um but we won't

1150
00:37:37,190 --> 00:37:32,880
know for sure until we go there and

1151
00:37:39,190 --> 00:37:37,200
actually look for them

1152
00:37:41,030 --> 00:37:39,200
great thanks cynthia and i've been told

1153
00:37:42,550 --> 00:37:41,040
we have time for one more question and

1154
00:37:44,950 --> 00:37:42,560
so to wrap things up

1155
00:37:46,710 --> 00:37:44,960
cynthia this question's for you surety

1156
00:37:49,750 --> 00:37:46,720
from youtube would like to know

1157
00:37:51,430 --> 00:37:49,760
if europa does indeed have an ocean what

1158
00:37:52,950 --> 00:37:51,440
kind of things do you think we'll find

1159
00:37:55,349 --> 00:37:52,960
there

1160
00:37:57,270 --> 00:37:55,359
ah that's a great question um let's see

1161
00:38:00,390 --> 00:37:57,280
if we can go forward to slide

1162
00:38:04,710 --> 00:38:00,400
uh i think it's slide 32 please the one

1163
00:38:06,550 --> 00:38:04,720

that says ingredients for life

1164
00:38:08,310 --> 00:38:06,560
so one of the really cool things about

1165
00:38:09,190 --> 00:38:08,320
europa's ocean is that at the bottom of

1166
00:38:12,310 --> 00:38:09,200
that ocean

1167
00:38:12,710 --> 00:38:12,320
there's a layer of rock and in this rock

1168
00:38:13,990 --> 00:38:12,720
layer

1169
00:38:16,790 --> 00:38:14,000
it's possible there could be

1170
00:38:18,230 --> 00:38:16,800
hydrothermal vents um and on earth at

1171
00:38:21,030 --> 00:38:18,240
the bottom of earth's oceans

1172
00:38:22,710 --> 00:38:21,040
we have these hydrothermal vents and

1173
00:38:23,670 --> 00:38:22,720
most of the bottom of earth's ocean you

1174
00:38:26,069 --> 00:38:23,680
know it's kind of

1175
00:38:27,109 --> 00:38:26,079
boring right it's just kind of dusty and

1176
00:38:28,470 --> 00:38:27,119
dirty and

1177
00:38:30,470 --> 00:38:28,480
you know there's not all that much going

1178
00:38:31,990 --> 00:38:30,480
on there but if you're in a submarine

1179
00:38:33,670 --> 00:38:32,000
and you're down at the bottom of earth's

1180
00:38:35,270 --> 00:38:33,680
ocean and then you come across one of

1181
00:38:36,790 --> 00:38:35,280
these hydrothermal vents

1182
00:38:38,630 --> 00:38:36,800
these are the kinds of things you see

1183
00:38:40,310 --> 00:38:38,640
over on the right now this is this is a

1184
00:38:40,790 --> 00:38:40,320
real video but it's of earth's ocean

1185
00:38:43,670 --> 00:38:40,800
this is

1186
00:38:45,349 --> 00:38:43,680
not europa's ocean um maybe someday

1187
00:38:45,990 --> 00:38:45,359
we'll get to go there you know maybe my

1188
00:38:47,510 --> 00:38:46,000

kids or maybe

1189
00:38:49,109 --> 00:38:47,520
my kids kids will actually get to see

1190
00:38:49,829 --> 00:38:49,119
pictures from the bottom of europa's

1191
00:38:52,470 --> 00:38:49,839
ocean

1192
00:38:54,230 --> 00:38:52,480
and boy i wish they look like this but

1193
00:38:54,950 --> 00:38:54,240
here at the bottom of earth's oceans we

1194
00:38:57,750 --> 00:38:54,960
see these just

1195
00:38:59,589 --> 00:38:57,760
abundant ecosystems we see these places

1196
00:39:01,109 --> 00:38:59,599
they're like oasis for life at the

1197
00:39:03,430 --> 00:39:01,119
bottom of earth's oceans

1198
00:39:04,310 --> 00:39:03,440
and they're basically using the thermal

1199
00:39:06,630 --> 00:39:04,320
energy so that

1200
00:39:07,349 --> 00:39:06,640
the fluids the the bottom of earth's

1201
00:39:09,589 --> 00:39:07,359
ocean

1202
00:39:11,510 --> 00:39:09,599
circulates through the crust and it gets

1203
00:39:12,950 --> 00:39:11,520
heated up and so you get all these great

1204
00:39:15,589 --> 00:39:12,960
chemical materials

1205
00:39:17,349 --> 00:39:15,599
that can serve as food for an ecosystem

1206
00:39:17,990 --> 00:39:17,359
and you just find these abundant life

1207
00:39:19,910 --> 00:39:18,000
forms

1208
00:39:21,910 --> 00:39:19,920
and so i think if there's life in

1209
00:39:23,510 --> 00:39:21,920
europa's ocean

1210
00:39:26,230 --> 00:39:23,520
maybe it could exist in one of these

1211
00:39:30,630 --> 00:39:29,109
that's a great question to end on um

1212
00:39:31,750 --> 00:39:30,640
that is all the time that we have for

1213
00:39:34,470 --> 00:39:31,760

tonight

1214
00:39:35,109 --> 00:39:34,480
um if you have more questions about

1215
00:39:38,150 --> 00:39:35,119
jupiter

1216
00:39:39,270 --> 00:39:38,160
or europa you can follow these websites

1217
00:39:40,790 --> 00:39:39,280
which you're going to put at the bottom

1218
00:39:42,150 --> 00:39:40,800
of the screen you can go there and see

1219
00:39:44,550 --> 00:39:42,160
each of these missions and there's

1220
00:39:45,510 --> 00:39:44,560
all sorts of information and images and

1221
00:39:47,750 --> 00:39:45,520
multimedia

1222
00:39:48,710 --> 00:39:47,760
that you can learn but keep asking those

1223
00:39:50,630 --> 00:39:48,720
questions

1224
00:39:52,710 --> 00:39:50,640
please join us next month for our talk

1225
00:39:53,109 --> 00:39:52,720
science and art picturing discovery with

1226
00:39:55,430 --> 00:39:53,119
dr

1227
00:39:56,470 --> 00:39:55,440
morgan cable and visual strategist joby

1228
00:39:58,230 --> 00:39:56,480
harris

1229
00:40:00,870 --> 00:39:58,240
i'd like to thank our speakers dr

1230
00:40:01,750 --> 00:40:00,880
cynthia dr cynthia and steve for their

1231
00:40:03,829 --> 00:40:01,760
exuberance

1232
00:40:05,270 --> 00:40:03,839
and their knowledge um thank you to

1233
00:40:06,630 --> 00:40:05,280
lindsay and everyone behind the scenes

1234
00:40:09,910 --> 00:40:06,640
who make all this possible

1235
00:40:10,390 --> 00:40:09,920
and finally a big big thank you to all

1236
00:40:12,470 --> 00:40:10,400
of you

1237
00:40:14,470 --> 00:40:12,480
tonight who ask questions who come and

1238
00:40:16,150 --> 00:40:14,480

join us every month and watch this

1239
00:40:18,390 --> 00:40:16,160
as we keep saying it is your space

1240
00:40:22,829 --> 00:40:18,400
program so thank you for joining us

1241
00:40:25,750 --> 00:40:22,839
stay safe stay kind and we'll see you in

1242
00:40:35,030 --> 00:40:25,760
july