
ages: Google Earth, Huttigvulen

1
00:00:03,909 --> 00:00:02,310
nasa's jet propulsion laboratory

2
00:00:06,550 --> 00:00:03,919
presents

3
00:00:08,629 --> 00:00:06,560
the von carmen lecture a series of talks

4
00:00:11,910 --> 00:00:08,639
by scientists and engineers who are

5
00:00:26,710 --> 00:00:11,920
exploring our planet our solar system

6
00:00:30,070 --> 00:00:28,230
hey good evening everybody how's

7
00:00:32,310 --> 00:00:30,080
everyone tonight

8
00:00:34,790 --> 00:00:32,320
superb again as always thank you very

9
00:00:36,709 --> 00:00:34,800
much for coming out to join us tonight

10
00:00:38,869 --> 00:00:36,719
so the search for life elsewhere in the

11
00:00:41,110 --> 00:00:38,879
solar system has tantalized humanity for

12
00:00:42,869 --> 00:00:41,120
centuries and as much as this search has

13
00:00:44,630 --> 00:00:42,879

led us to look outward

14
00:00:46,950 --> 00:00:44,640
towards places that may have life or the

15
00:00:49,270 --> 00:00:46,960
chemical precursors for life it has also

16
00:00:50,709 --> 00:00:49,280
led us inward studying places on earth

17
00:00:53,029 --> 00:00:50,719
and recreating other worlds in the

18
00:00:54,630 --> 00:00:53,039
laboratory that can act as analog

19
00:00:56,630 --> 00:00:54,640
environments to other places that are

20
00:00:58,950 --> 00:00:56,640
far more difficult to reach

21
00:01:01,270 --> 00:00:58,960
titan a moon of saturn is an excellent

22
00:01:04,070 --> 00:01:01,280
example of a prebiotic world where a

23
00:01:05,750 --> 00:01:04,080
diverse array of organic molecules exist

24
00:01:07,990 --> 00:01:05,760
but life as we know it cannot survive on

25
00:01:09,910 --> 00:01:08,000
the surface the liquid hydrocarbon lakes

26
00:01:11,590 --> 00:01:09,920
of titan are a unique environment where

27
00:01:13,990 --> 00:01:11,600
organic molecules have the opportunity

28
00:01:16,310 --> 00:01:14,000
to interact and possibly react with each

29
00:01:17,749 --> 00:01:16,320
other by recreating titan's lakes in the

30
00:01:19,270 --> 00:01:17,759
laboratory we are discovering new

31
00:01:21,270 --> 00:01:19,280
chemical interactions that were

32
00:01:23,270 --> 00:01:21,280
previously unknown to science and which

33
00:01:24,230 --> 00:01:23,280
may help us understand how titan came to

34
00:01:26,230 --> 00:01:24,240
be

35
00:01:28,469 --> 00:01:26,240
iceland a nordic island shaped by

36
00:01:30,310 --> 00:01:28,479
volcanism and glaciers is recognized as

37
00:01:33,109 --> 00:01:30,320
an analog environment for mars due to

38
00:01:34,710 --> 00:01:33,119

its similar geochemistry and mineralogy

39
00:01:36,469 --> 00:01:34,720
two field expeditions there have

40
00:01:38,550 --> 00:01:36,479
successfully tested life detection

41
00:01:41,109 --> 00:01:38,560
techniques that may be used on future

42
00:01:43,830 --> 00:01:41,119
mars missions discovering that microbial

43
00:01:45,590 --> 00:01:43,840
diversity can vary widely even in areas

44
00:01:47,990 --> 00:01:45,600
that appear to be the same in terms of

45
00:01:50,630 --> 00:01:48,000
geology this has implications for where

46
00:01:52,630 --> 00:01:50,640
and how we might search for life on mars

47
00:01:54,389 --> 00:01:52,640
tonight's guest is a technologist in the

48
00:01:57,270 --> 00:01:54,399
instrument systems implementation and

49
00:01:58,950 --> 00:01:57,280
concepts section right here at jpl she's

50
00:02:01,190 --> 00:01:58,960
also the assistant project science

51
00:02:03,190 --> 00:02:01,200
systems engineer on the cassini mission

52
00:02:04,709 --> 00:02:03,200
which has been orbiting saturn for the

53
00:02:06,550 --> 00:02:04,719
last 10 years

54
00:02:08,550 --> 00:02:06,560
her research focuses on organic and

55
00:02:10,630 --> 00:02:08,560
biomarker detection strategies through

56
00:02:12,869 --> 00:02:10,640
both in-situ and remote sensing

57
00:02:14,550 --> 00:02:12,879
techniques while earning her phd in

58
00:02:16,710 --> 00:02:14,560
chemistry at the california institute of

59
00:02:18,790 --> 00:02:16,720
technology she designed receptor sites

60
00:02:20,710 --> 00:02:18,800
for the detection of bacterial spores

61
00:02:22,710 --> 00:02:20,720
the toughest form of life

62
00:02:25,270 --> 00:02:22,720
as a nasa postdoctoral fellow right here

63
00:02:27,910 --> 00:02:25,280

at jpl she developed novel protocols to

64
00:02:30,229 --> 00:02:27,920
analyze organics such as fatty acids

65
00:02:32,229 --> 00:02:30,239
using small portable microfluidic

66
00:02:34,390 --> 00:02:32,239
sensors she is currently working as a

67
00:02:36,630 --> 00:02:34,400
collaborator on the mapping in imaging

68
00:02:38,790 --> 00:02:36,640
spectrometer for europa an instrument

69
00:02:40,710 --> 00:02:38,800
selected for nasa's next mission to

70
00:02:42,470 --> 00:02:40,720
jupiter's icy moon europa this

71
00:02:44,470 --> 00:02:42,480
spectrometer will map europa's surface

72
00:02:46,309 --> 00:02:44,480
and search for organics salts and

73
00:02:48,070 --> 00:02:46,319
minerals ladies and gentlemen please

74
00:02:57,990 --> 00:02:48,080
help me welcome tonight's guest dr

75
00:03:02,229 --> 00:03:00,550
hello can you guys hear me all right

76
00:03:04,390 --> 00:03:02,239
all right thank you so much for coming

77
00:03:05,830 --> 00:03:04,400
tonight i'm very excited to be here to

78
00:03:07,509 --> 00:03:05,840
have you guys be here to tell you a

79
00:03:10,149 --> 00:03:07,519
little bit about some analog

80
00:03:11,830 --> 00:03:10,159
environments that we use to study the

81
00:03:15,670 --> 00:03:11,840
solar system

82
00:03:18,149 --> 00:03:15,680
so first i wanted to ask you a question

83
00:03:21,190 --> 00:03:18,159
so analog environments we are looking at

84
00:03:23,350 --> 00:03:21,200
places on earth or places that that we

85
00:03:25,910 --> 00:03:23,360
can simulate in the lab that may

86
00:03:26,790 --> 00:03:25,920
replicate places elsewhere in the solar

87
00:03:29,910 --> 00:03:26,800
system

88
00:03:31,430 --> 00:03:29,920

so is this mars or earth

89
00:03:34,149 --> 00:03:31,440
yeah this one was a little easy there

90
00:03:35,589 --> 00:03:34,159
are plants in here

91
00:03:37,910 --> 00:03:35,599
but

92
00:03:40,070 --> 00:03:37,920
this is jordan this is actually where

93
00:03:43,750 --> 00:03:40,080
the martian was filmed

94
00:03:48,949 --> 00:03:47,030
good okay you guys are doing pretty well

95
00:03:51,589 --> 00:03:48,959
what about this

96
00:03:56,869 --> 00:03:54,869
you're right this is in libya

97
00:03:58,630 --> 00:03:56,879
how about this

98
00:04:02,390 --> 00:03:58,640
you guys are really good i was hoping i

99
00:04:07,190 --> 00:04:02,400
would trick you it says salisbury peak

100
00:04:12,149 --> 00:04:10,229
oh i'm not so sure now are you

101
00:04:14,309 --> 00:04:12,159
this is iceland

102
00:04:15,110 --> 00:04:14,319
yeah so

103
00:04:17,509 --> 00:04:15,120
many

104
00:04:19,749 --> 00:04:17,519
environments on earth places like jordan

105
00:04:22,310 --> 00:04:19,759
and libya the atacama desert have been

106
00:04:24,390 --> 00:04:22,320
used by nasa as analog environments for

107
00:04:26,469 --> 00:04:24,400
places like mars for a while and iceland

108
00:04:29,110 --> 00:04:26,479
is one of these places it was actually

109
00:04:30,790 --> 00:04:29,120
used in the 50s and 60s to train apollo

110
00:04:32,469 --> 00:04:30,800
astronauts for some of their their

111
00:04:34,150 --> 00:04:32,479
activities on the moon

112
00:04:36,469 --> 00:04:34,160
the reason that we like it as an analog

113
00:04:38,629 --> 00:04:36,479

for mars is because it's very

114
00:04:41,189 --> 00:04:38,639
volcanically active right it's a land of

115
00:04:43,510 --> 00:04:41,199
fire and ice glaciers and volcanism

116
00:04:45,110 --> 00:04:43,520
a lot of those volcanic regions are very

117
00:04:46,550 --> 00:04:45,120
similar in some of their properties to

118
00:04:49,270 --> 00:04:46,560
places on mars

119
00:04:51,670 --> 00:04:49,280
it's also typically has areas that are

120
00:04:54,230 --> 00:04:51,680
desiccated so not a lot of water

121
00:04:56,469 --> 00:04:54,240
low nutrient availability just like mars

122
00:04:58,070 --> 00:04:56,479
temperature extremes and also some

123
00:05:00,550 --> 00:04:58,080
isolation from

124
00:05:02,070 --> 00:05:00,560
us from contamination that could

125
00:05:04,790 --> 00:05:02,080
fool some of our life detection

126
00:05:07,029 --> 00:05:04,800
techniques so we really like iceland as

127
00:05:09,029 --> 00:05:07,039
an analog for mars

128
00:05:10,950 --> 00:05:09,039
now i'm part of a team

129
00:05:13,029 --> 00:05:10,960
and it's a nasa team so of course we

130
00:05:16,469 --> 00:05:13,039
love our acronyms

131
00:05:18,390 --> 00:05:16,479
feldspar is a type of volcanic mineral

132
00:05:20,390 --> 00:05:18,400
and that's what we decided to name our

133
00:05:22,950 --> 00:05:20,400
team which stands for i'll only say it

134
00:05:25,350 --> 00:05:22,960
one time i promise field exploration and

135
00:05:28,230 --> 00:05:25,360
life detection sampling for planetary

136
00:05:31,430 --> 00:05:28,240
and astrobiology research

137
00:05:33,990 --> 00:05:31,440
yes feldspar go team feldspar okay

138
00:05:35,510 --> 00:05:34,000

so this is the team

139
00:05:37,189 --> 00:05:35,520
and this is all the places that we're

140
00:05:39,029 --> 00:05:37,199
from and i wanted to take a minute and

141
00:05:41,749 --> 00:05:39,039
describe how we all met because this was

142
00:05:43,270 --> 00:05:41,759
a very unique set of circumstances you

143
00:05:45,189 --> 00:05:43,280
can tell we're all from a variety of

144
00:05:47,029 --> 00:05:45,199
different places both in the u.s and

145
00:05:48,950 --> 00:05:47,039
over in europe and we met through

146
00:05:51,029 --> 00:05:48,960
something called the nasa nordic

147
00:05:53,029 --> 00:05:51,039
astrobiology summer school raise your

148
00:05:54,710 --> 00:05:53,039
hand if you've heard of this before

149
00:05:57,189 --> 00:05:54,720
okay you should all google this because

150
00:05:59,430 --> 00:05:57,199
this is an amazing program it's meant

151
00:06:01,430 --> 00:05:59,440
for early career scientists and

152
00:06:04,390 --> 00:06:01,440
engineers people interested in learning

153
00:06:06,629 --> 00:06:04,400
about astrobiology and this wait hang on

154
00:06:08,550 --> 00:06:06,639
i have a laser pointer

155
00:06:10,469 --> 00:06:08,560
okay this gentleman right here wolf

156
00:06:12,469 --> 00:06:10,479
goepper organizes the one that's in

157
00:06:14,550 --> 00:06:12,479
iceland it alternates between iceland

158
00:06:16,629 --> 00:06:14,560
and hawaii it's every i think year and a

159
00:06:18,790 --> 00:06:16,639
half and it's a wonderful program

160
00:06:20,870 --> 00:06:18,800
so as a chemist my background is in

161
00:06:24,230 --> 00:06:20,880
chemistry i went and learned about

162
00:06:25,909 --> 00:06:24,240
geology and biology and geophysics

163
00:06:27,430 --> 00:06:25,919

things that are important for the study

164
00:06:29,830 --> 00:06:27,440
of astrobiology it's a very

165
00:06:31,350 --> 00:06:29,840
interdisciplinary field and so the

166
00:06:33,270 --> 00:06:31,360
biologists would learn some chemistry

167
00:06:35,350 --> 00:06:33,280
and the geologists would too and and it

168
00:06:37,990 --> 00:06:35,360
was a great way for us to interact

169
00:06:40,070 --> 00:06:38,000
and so we went around and toured a few

170
00:06:41,909 --> 00:06:40,080
lava fields and some glaciers and other

171
00:06:44,469 --> 00:06:41,919
environments on iceland that are good

172
00:06:46,150 --> 00:06:44,479
analogs for planetary environments and a

173
00:06:48,309 --> 00:06:46,160
few of us were thinking boy

174
00:06:49,909 --> 00:06:48,319
these are some really cool places and i

175
00:06:52,230 --> 00:06:49,919
haven't found much in the literature of

176
00:06:54,629 --> 00:06:52,240
people actually using these environments

177
00:06:56,790 --> 00:06:54,639
to test things for mars maybe we should

178
00:06:58,550 --> 00:06:56,800
do something about that and so this

179
00:07:00,550 --> 00:06:58,560
smaller group i think there are 50 that

180
00:07:02,309 --> 00:07:00,560
were in the astrobiology summer school

181
00:07:04,230 --> 00:07:02,319
but a group of about 12 or 13 of us

182
00:07:06,230 --> 00:07:04,240
decided to cobble together funding from

183
00:07:08,790 --> 00:07:06,240
whatever sources we could get and put

184
00:07:10,870 --> 00:07:08,800
together an expedition so after that

185
00:07:12,469 --> 00:07:10,880
summer school the following year we were

186
00:07:13,270 --> 00:07:12,479
able to come back to iceland and do our

187
00:07:15,830 --> 00:07:13,280
own

188
00:07:18,710 --> 00:07:15,840

smaller expedition and start our

189
00:07:22,150 --> 00:07:18,720
question to inform future mars missions

190
00:07:26,309 --> 00:07:23,990
so this is not mars again this is

191
00:07:28,550 --> 00:07:26,319
iceland which so ignore the beautiful

192
00:07:30,469 --> 00:07:28,560
icelandic glaciers in the background

193
00:07:32,629 --> 00:07:30,479
and pretend like you're on mars okay

194
00:07:34,230 --> 00:07:32,639
you've landed your rover

195
00:07:36,390 --> 00:07:34,240
so there it is

196
00:07:38,870 --> 00:07:36,400
and you've used high resolution imagery

197
00:07:40,950 --> 00:07:38,880
this is actually an image of the mars

198
00:07:43,270 --> 00:07:40,960
curiosity rover can you see it

199
00:07:44,469 --> 00:07:43,280
this is uh from mars it's right there in

200
00:07:47,110 --> 00:07:44,479
the middle

201
00:07:49,430 --> 00:07:47,120
taken by highrise which is a camera

202
00:07:51,510 --> 00:07:49,440
aboard the mars reconnaissance orbiter

203
00:07:54,070 --> 00:07:51,520
so you've used your high resolution

204
00:07:56,390 --> 00:07:54,080
imagery to pick your spot that you think

205
00:07:58,070 --> 00:07:56,400
has life all right you've landed your

206
00:07:59,909 --> 00:07:58,080
rover and you've got all sorts of

207
00:08:02,070 --> 00:07:59,919
instruments

208
00:08:05,270 --> 00:08:02,080
including your life finder 3000 this is

209
00:08:07,270 --> 00:08:05,280
a future mars mars lander mars rover

210
00:08:08,950 --> 00:08:07,280
and you're ready to look for life okay

211
00:08:10,150 --> 00:08:08,960
well

212
00:08:13,830 --> 00:08:10,160
where do you look

213
00:08:15,990 --> 00:08:13,840

do you look here do you look over here

214
00:08:17,909 --> 00:08:16,000
in terms of the the really close small

215
00:08:19,749 --> 00:08:17,919
context this is the best imaging you

216
00:08:22,309 --> 00:08:19,759
have is what's coming from your rover

217
00:08:24,950 --> 00:08:22,319
and who knows the alien could be hiding

218
00:08:26,390 --> 00:08:24,960
right behind that rock that

219
00:08:28,869 --> 00:08:26,400
that you don't sample

220
00:08:31,189 --> 00:08:28,879
so our question was when you get to this

221
00:08:33,509 --> 00:08:31,199
this place and it looks uh the technical

222
00:08:35,909 --> 00:08:33,519
term would be homogeneous so it sort of

223
00:08:37,829 --> 00:08:35,919
all looks the same if you drive your

224
00:08:39,110 --> 00:08:37,839
rover over here and you collect a sample

225
00:08:41,110 --> 00:08:39,120
and then you drive your rover over here

226
00:08:42,630 --> 00:08:41,120
and collect another sample

227
00:08:44,230 --> 00:08:42,640
will they be the same

228
00:08:46,389 --> 00:08:44,240
would you find life in one and not the

229
00:08:47,670 --> 00:08:46,399
other and how do you decide

230
00:08:50,230 --> 00:08:47,680
so that was a question that we were

231
00:08:51,269 --> 00:08:50,240
trying to answer

232
00:08:52,790 --> 00:08:51,279
and so

233
00:08:55,350 --> 00:08:52,800
we have mars on the left earth on the

234
00:08:56,790 --> 00:08:55,360
right so a typical mars type exploration

235
00:08:59,350 --> 00:08:56,800
for this again you'd start with that

236
00:09:01,350 --> 00:08:59,360
remote sensing we don't have mro

237
00:09:04,470 --> 00:09:01,360
orbiting around earth so we used google

238
00:09:06,870 --> 00:09:04,480

earth to do some of our our very high

239
00:09:08,949 --> 00:09:06,880
resolution imagery of our site so this

240
00:09:10,230 --> 00:09:08,959
is one of the the lava fields that we

241
00:09:12,070 --> 00:09:10,240
visited

242
00:09:14,389 --> 00:09:12,080
now we didn't have a mars rover but we

243
00:09:17,030 --> 00:09:14,399
had a land rover which is

244
00:09:18,870 --> 00:09:17,040
what we used to go and and visit our

245
00:09:21,190 --> 00:09:18,880
various sample sites we tried to pick

246
00:09:23,350 --> 00:09:21,200
places that were sort of off the beaten

247
00:09:25,829 --> 00:09:23,360
path even in iceland it's become quite a

248
00:09:28,389 --> 00:09:25,839
tourist site and so we're trying to find

249
00:09:29,750 --> 00:09:28,399
places where we can find fresh lava but

250
00:09:31,829 --> 00:09:29,760
that doesn't have a lot of tourist

251
00:09:34,150 --> 00:09:31,839
traffic

252
00:09:35,670 --> 00:09:34,160
and just like we do on mars with the

253
00:09:37,269 --> 00:09:35,680
curiosity rover

254
00:09:39,750 --> 00:09:37,279
which has uh several techniques for

255
00:09:43,590 --> 00:09:39,760
doing standoff tech analysis things like

256
00:09:46,230 --> 00:09:43,600
the the tunable laser spectrometer tls

257
00:09:48,230 --> 00:09:46,240
or laser laser ablation types of

258
00:09:51,190 --> 00:09:48,240
experiments we also use some field

259
00:09:53,829 --> 00:09:51,200
portable instruments this is me with a

260
00:09:56,790 --> 00:09:53,839
what's called an asd spectrometer which

261
00:09:57,990 --> 00:09:56,800
is sort of strapped here and we have a

262
00:09:59,990 --> 00:09:58,000
probe that we use that we point at

263
00:10:01,910 --> 00:10:00,000

samples and this this instrument looks

264
00:10:03,269 --> 00:10:01,920
at the light that's reflected that comes

265
00:10:05,269 --> 00:10:03,279
from the sun that's reflected off the

266
00:10:07,509 --> 00:10:05,279
rocks and comes back and you can

267
00:10:08,949 --> 00:10:07,519
identify minerals this way and it's very

268
00:10:13,110 --> 00:10:08,959
similar to some instruments that we've

269
00:10:15,030 --> 00:10:13,120
included on mars rovers in the past

270
00:10:16,470 --> 00:10:15,040
so now once you've collected your sample

271
00:10:18,710 --> 00:10:16,480
a typical mars rover will bring it

272
00:10:20,470 --> 00:10:18,720
inside and interrogate it with a variety

273
00:10:22,470 --> 00:10:20,480
of different instruments well we have a

274
00:10:24,710 --> 00:10:22,480
field lab and a bunch of of my

275
00:10:26,470 --> 00:10:24,720
colleagues this is my friend elena who's

276
00:10:28,150 --> 00:10:26,480
studying she's getting her phd up at the

277
00:10:29,910 --> 00:10:28,160
university of washington

278
00:10:32,069 --> 00:10:29,920
and so she pretended to be one of the

279
00:10:35,110 --> 00:10:32,079
instruments

280
00:10:37,030 --> 00:10:35,120
um and okay so so we're doing this sort

281
00:10:39,350 --> 00:10:37,040
of thinking about what would a mars

282
00:10:41,030 --> 00:10:39,360
rover do and now what would we do

283
00:10:43,269 --> 00:10:41,040
and there are plenty of places that we

284
00:10:46,069 --> 00:10:43,279
could go on iceland it's one of the most

285
00:10:47,990 --> 00:10:46,079
volcanically active areas in on earth

286
00:10:49,829 --> 00:10:48,000
it's growing so it's it's sort of

287
00:10:51,190 --> 00:10:49,839
sandwiched between two plates and one of

288
00:10:53,750 --> 00:10:51,200

those plates is growing i think at five

289
00:10:55,910 --> 00:10:53,760
centimeters per year which is in fact is

290
00:10:57,910 --> 00:10:55,920
the same rate as your fingernails grow

291
00:10:59,509 --> 00:10:57,920
kind of cool

292
00:11:02,790 --> 00:10:59,519
okay so these are the

293
00:11:05,430 --> 00:11:02,800
the different places that we decided to

294
00:11:08,230 --> 00:11:05,440
look in order of age all right now raise

295
00:11:11,110 --> 00:11:08,240
your hand if you're icelandic

296
00:11:13,030 --> 00:11:11,120
okay so i'm apologize if i butcher any

297
00:11:15,509 --> 00:11:13,040
of the icelandic

298
00:11:17,030 --> 00:11:15,519
this is a melee fetal sander which is

299
00:11:18,710 --> 00:11:17,040
the oldest site this is sort of a

300
00:11:20,150 --> 00:11:18,720
volcanic desert

301
00:11:21,670 --> 00:11:20,160
kind of in the middle of nowhere in

302
00:11:22,630 --> 00:11:21,680
iceland which is good so not a lot of

303
00:11:24,230 --> 00:11:22,640
people

304
00:11:26,870 --> 00:11:24,240
go there this is our oldest site this is

305
00:11:28,550 --> 00:11:26,880
on the order of about 10 000 years

306
00:11:29,829 --> 00:11:28,560
uh land mana lugar which is in the

307
00:11:32,710 --> 00:11:29,839
central highlands this is from an

308
00:11:35,030 --> 00:11:32,720
eruption in the 1400s

309
00:11:37,110 --> 00:11:35,040
eldfell which is actually a relatively

310
00:11:39,030 --> 00:11:37,120
new eruption on this tiny little island

311
00:11:40,949 --> 00:11:39,040
called jaime this eruption happened in

312
00:11:42,870 --> 00:11:40,959
1973

313
00:11:45,030 --> 00:11:42,880

and that's more of a lava fisher and

314
00:11:47,990 --> 00:11:45,040
then our newest site is a femme

315
00:11:50,790 --> 00:11:48,000
volderhalls which is a new lava field do

316
00:11:52,310 --> 00:11:50,800
you guys remember back in 2010 the

317
00:11:54,630 --> 00:11:52,320
air traffic was really messed up in

318
00:11:57,670 --> 00:11:54,640
europe that was because of this

319
00:12:01,269 --> 00:11:57,680
and the the um glacier that it erupted

320
00:12:04,790 --> 00:12:03,190
don't ask me to say it again uh i've

321
00:12:06,790 --> 00:12:04,800
been practicing

322
00:12:09,269 --> 00:12:06,800
okay so uh but i'm only going to be

323
00:12:12,870 --> 00:12:09,279
talking about these two today

324
00:12:14,710 --> 00:12:12,880
so this is what the jaime eruption looks

325
00:12:16,949 --> 00:12:14,720
like you can see a couple of the other

326
00:12:18,550 --> 00:12:16,959
islands that are in this this island

327
00:12:20,310 --> 00:12:18,560
chain down off the southern coast of

328
00:12:22,470 --> 00:12:20,320
iceland it's actually funny you see that

329
00:12:23,990 --> 00:12:22,480
little white dot that's somebody's house

330
00:12:26,710 --> 00:12:24,000
he's the only guy that lives on that

331
00:12:29,030 --> 00:12:26,720
island there's one house

332
00:12:30,629 --> 00:12:29,040
but this eruption happens sort of on the

333
00:12:33,350 --> 00:12:30,639
the eastern side of the island and the

334
00:12:35,430 --> 00:12:33,360
island actually grew by about 25

335
00:12:37,590 --> 00:12:35,440
over a period of a few months as lava

336
00:12:40,230 --> 00:12:37,600
poured out this is a tiny island it's a

337
00:12:43,190 --> 00:12:40,240
it's a fishing town basically and the

338
00:12:45,990 --> 00:12:43,200

lava almost uh encroached into the the

339
00:12:47,350 --> 00:12:46,000
bay where you know all the harbor where

340
00:12:48,550 --> 00:12:47,360
the fishing boats were and they were

341
00:12:49,910 --> 00:12:48,560
really concerned that it was going to

342
00:12:51,910 --> 00:12:49,920
block it off completely and they would

343
00:12:53,750 --> 00:12:51,920
lose their livelihood so they brought in

344
00:12:56,230 --> 00:12:53,760
these boats you know the fire boats that

345
00:12:57,670 --> 00:12:56,240
shoot water and we're doing that for

346
00:12:59,430 --> 00:12:57,680
months and months and months and we're

347
00:13:01,030 --> 00:12:59,440
able to stop the flow of lava so now

348
00:13:03,030 --> 00:13:01,040
they have a more protected harbor

349
00:13:05,430 --> 00:13:03,040
because of this eruption well this is

350
00:13:08,389 --> 00:13:05,440
1973

351
00:13:10,550 --> 00:13:08,399
and this is the the more recent uh film

352
00:13:13,829 --> 00:13:10,560
volder house uh

353
00:13:15,350 --> 00:13:13,839
yokoro twice yes okay eruption

354
00:13:17,829 --> 00:13:15,360
and uh so these are the two that i'll be

355
00:13:20,550 --> 00:13:17,839
talking about today now we didn't go to

356
00:13:21,990 --> 00:13:20,560
them when they looked like this we

357
00:13:23,829 --> 00:13:22,000
when we went they look like this it's a

358
00:13:26,069 --> 00:13:23,839
little dark because it was a little a

359
00:13:28,389 --> 00:13:26,079
little cloudy when we were there let me

360
00:13:31,190 --> 00:13:28,399
see if i can play this so we also

361
00:13:34,389 --> 00:13:31,200
brought with us a quadcopter to get some

362
00:13:36,389 --> 00:13:34,399
more context imaging and you can see

363
00:13:38,710 --> 00:13:36,399

it's a little bit dim but

364
00:13:40,949 --> 00:13:38,720
beautiful landscape a lot of ice and a

365
00:13:43,590 --> 00:13:40,959
lot of lava

366
00:13:45,509 --> 00:13:43,600
and not a lot of magma right so now it's

367
00:13:46,949 --> 00:13:45,519
it's it's cooled and it's had time for

368
00:13:49,670 --> 00:13:46,959
life to gain a foothold and that's what

369
00:13:51,509 --> 00:13:49,680
we're interested in we're interested in

370
00:13:54,230 --> 00:13:51,519
how does life gain a foothold where does

371
00:13:57,110 --> 00:13:54,240
it start to colonize first

372
00:13:58,389 --> 00:13:57,120
what types of life are there

373
00:14:00,389 --> 00:13:58,399
okay so

374
00:14:01,910 --> 00:14:00,399
at these sampling sites

375
00:14:03,829 --> 00:14:01,920
we were thinking like a rover but we're

376
00:14:07,030 --> 00:14:03,839
also thinking like a sampling team here

377
00:14:08,629 --> 00:14:07,040
on earth now rovers have a very uh small

378
00:14:10,870 --> 00:14:08,639
set of samples that they can collect

379
00:14:12,629 --> 00:14:10,880
right every single sample is precious

380
00:14:14,870 --> 00:14:12,639
but for us with our team we could

381
00:14:16,790 --> 00:14:14,880
collect many samples and then go back

382
00:14:17,829 --> 00:14:16,800
and do that thought exercise of okay

383
00:14:19,269 --> 00:14:17,839
would that have been the one that we

384
00:14:21,189 --> 00:14:19,279
would have picked

385
00:14:23,350 --> 00:14:21,199
so what we did what we decided to do was

386
00:14:25,350 --> 00:14:23,360
collect samples we do it in triplicate

387
00:14:26,389 --> 00:14:25,360
which means we collect three in the same

388
00:14:28,790 --> 00:14:26,399

place

389
00:14:31,350 --> 00:14:28,800
at five centimeters depth at uh one

390
00:14:32,710 --> 00:14:31,360
meters spacing so we collect three here

391
00:14:35,990 --> 00:14:32,720
and then go one meter away and do it

392
00:14:38,150 --> 00:14:36,000
again and then we'd go 10 meters away do

393
00:14:40,310 --> 00:14:38,160
it again and then 100 meters away and do

394
00:14:43,590 --> 00:14:40,320
it again so that we could get an idea of

395
00:14:46,150 --> 00:14:43,600
scale right so orders of magnitude

396
00:14:48,550 --> 00:14:46,160
and we used as sterile of technique as

397
00:14:50,310 --> 00:14:48,560
we could so we we sterilized our our

398
00:14:52,470 --> 00:14:50,320
shovels and trowels before we collected

399
00:14:54,550 --> 00:14:52,480
the sample we approached from downwind

400
00:14:57,030 --> 00:14:54,560
all those things to try to minimize any

401
00:14:59,030 --> 00:14:57,040
anything from us contaminating this

402
00:14:59,990 --> 00:14:59,040
fresh lava field that we were trying to

403
00:15:01,750 --> 00:15:00,000
collect

404
00:15:05,750 --> 00:15:01,760
samples from to be sure that we didn't

405
00:15:09,670 --> 00:15:07,430
okay so

406
00:15:12,069 --> 00:15:09,680
here's an example of one of our sampling

407
00:15:13,670 --> 00:15:12,079
areas as you can see we collected three

408
00:15:15,590 --> 00:15:13,680
from each

409
00:15:17,430 --> 00:15:15,600
and also after we were done collecting

410
00:15:19,509 --> 00:15:17,440
the samples we would go in with our our

411
00:15:23,750 --> 00:15:19,519
standoff techniques and get some some

412
00:15:27,670 --> 00:15:25,350
once we collected the samples we brought

413
00:15:30,069 --> 00:15:27,680

them back to our field lab this is in a

414
00:15:31,910 --> 00:15:30,079
tiny town called fosvetlor which the

415
00:15:34,230 --> 00:15:31,920
headmistress was kind enough to let us

416
00:15:35,509 --> 00:15:34,240
use their school as our field lab

417
00:15:37,350 --> 00:15:35,519
because the students were out for the

418
00:15:39,269 --> 00:15:37,360
summer this was in the middle of july so

419
00:15:41,269 --> 00:15:39,279
the sun never fully set while we were

420
00:15:44,550 --> 00:15:41,279
there so we could work all day because

421
00:15:47,350 --> 00:15:44,560
there was no night um

422
00:15:50,069 --> 00:15:47,360
and but we loved it and it really was a

423
00:15:52,230 --> 00:15:50,079
was a beautiful time to to be in iceland

424
00:15:53,990 --> 00:15:52,240
so for the biology type experiments

425
00:15:55,590 --> 00:15:54,000
again we use the sterile technique but

426
00:15:57,269 --> 00:15:55,600
we split up the samples and for some of

427
00:15:59,269 --> 00:15:57,279
them we would grind them and then look

428
00:16:03,269 --> 00:15:59,279
at them with some other mineralogy

429
00:16:04,870 --> 00:16:03,279
techniques this is a raman spectrometer

430
00:16:05,910 --> 00:16:04,880
and

431
00:16:09,749 --> 00:16:05,920
so

432
00:16:13,030 --> 00:16:09,759
well one experiment that we did was

433
00:16:15,430 --> 00:16:13,040
called pcr pcr stands for polymerase

434
00:16:17,590 --> 00:16:15,440
chain reaction it's basically a fancy

435
00:16:19,269 --> 00:16:17,600
way of saying that you pick a certain

436
00:16:21,269 --> 00:16:19,279
type of dna an organism that you're

437
00:16:23,749 --> 00:16:21,279
interested in looking for and you make a

438
00:16:25,350 --> 00:16:23,759

lot of copies of its dna until you have

439
00:16:27,910 --> 00:16:25,360
enough that you can actually detect it

440
00:16:31,110 --> 00:16:27,920
and quantify it also

441
00:16:33,509 --> 00:16:31,120
and we looked for bacteria fungi and

442
00:16:35,910 --> 00:16:33,519
archaea which are the three main

443
00:16:37,670 --> 00:16:35,920
kingdoms in the tree of life and we were

444
00:16:39,590 --> 00:16:37,680
interested in seeing how much of each of

445
00:16:41,590 --> 00:16:39,600
these were were present and if that

446
00:16:44,389 --> 00:16:41,600
varied depending on where we are or

447
00:16:46,550 --> 00:16:44,399
where we were sampling

448
00:16:48,470 --> 00:16:46,560
so this is our

449
00:16:50,150 --> 00:16:48,480
fresh lava field this is the one that

450
00:16:52,069 --> 00:16:50,160
messed up the air traffic i'm just going

451
00:16:54,710 --> 00:16:52,079
to call it fim for short

452
00:16:56,470 --> 00:16:54,720
and so this is an example of that

453
00:16:58,870 --> 00:16:56,480
collection scheme i talked about where

454
00:17:01,269 --> 00:16:58,880
for every green dot that's a one sample

455
00:17:02,150 --> 00:17:01,279
site so you've got ones that are a meter

456
00:17:06,470 --> 00:17:02,160
apart

457
00:17:08,390 --> 00:17:06,480
now we don't really need the numbers

458
00:17:09,750 --> 00:17:08,400
here so i'm going to nix those for now

459
00:17:11,590 --> 00:17:09,760
but what i'm going to do is take that

460
00:17:14,150 --> 00:17:11,600
green dot and i'm going to expand it to

461
00:17:16,710 --> 00:17:14,160
the size of how much bacteria were

462
00:17:18,309 --> 00:17:16,720
present how much bacteria we found

463
00:17:19,350 --> 00:17:18,319

as soon as i hit the forward button

464
00:17:20,230 --> 00:17:19,360
there we go

465
00:17:21,750 --> 00:17:20,240
okay

466
00:17:23,669 --> 00:17:21,760
now i said that we collected things in

467
00:17:25,829 --> 00:17:23,679
triplicate so there are three circles

468
00:17:27,669 --> 00:17:25,839
for each sample site because because we

469
00:17:29,590 --> 00:17:27,679
analyzed that three times

470
00:17:32,310 --> 00:17:29,600
and what you can see is that this is the

471
00:17:34,470 --> 00:17:32,320
amount of dna of bacteria by size so

472
00:17:36,870 --> 00:17:34,480
this is a lot this is a little

473
00:17:38,549 --> 00:17:36,880
you can see even on like one meter

474
00:17:40,470 --> 00:17:38,559
differences

475
00:17:43,110 --> 00:17:40,480
the amount of bacteria that we see there

476
00:17:44,789 --> 00:17:43,120
varies a lot way more than we expected

477
00:17:46,870 --> 00:17:44,799
so that means if you were standing in

478
00:17:48,390 --> 00:17:46,880
one spot and you went three feet over

479
00:17:51,909 --> 00:17:48,400
you would see a big difference in the

480
00:17:53,830 --> 00:17:51,919
amount of life that was there now this

481
00:17:55,430 --> 00:17:53,840
means that it's very very important

482
00:17:57,590 --> 00:17:55,440
where you're looking for life that you

483
00:18:00,230 --> 00:17:57,600
have to be very clear on where you're

484
00:18:02,470 --> 00:18:00,240
sampling to be sure that you can try to

485
00:18:04,870 --> 00:18:02,480
detect life and not miss it

486
00:18:06,710 --> 00:18:04,880
so we were surprised by that and even in

487
00:18:08,310 --> 00:18:06,720
the samples that we collected three

488
00:18:10,310 --> 00:18:08,320

samples in the same spot we would have a

489
00:18:12,710 --> 00:18:10,320
lot of variation

490
00:18:14,470 --> 00:18:12,720
now this wasn't true with just bacteria

491
00:18:16,470 --> 00:18:14,480
here is fungi

492
00:18:18,230 --> 00:18:16,480
and again you can see even on the one

493
00:18:20,549 --> 00:18:18,240
meter difference

494
00:18:23,270 --> 00:18:20,559
huge or one meter uh spacing you can see

495
00:18:25,510 --> 00:18:23,280
huge differences in the amount of life

496
00:18:27,430 --> 00:18:25,520
that was there uh we find fungi

497
00:18:29,350 --> 00:18:27,440
everywhere they're likened that are a

498
00:18:31,430 --> 00:18:29,360
type of a fungus and symbiotic

499
00:18:33,270 --> 00:18:31,440
relationship with cyanobacteria that

500
00:18:34,549 --> 00:18:33,280
live in antarctica and can survive mars

501
00:18:35,430 --> 00:18:34,559
conditions we see them all over the

502
00:18:37,029 --> 00:18:35,440
place

503
00:18:39,110 --> 00:18:37,039
and it was interesting to find them here

504
00:18:40,950 --> 00:18:39,120
in this very new lava field

505
00:18:43,270 --> 00:18:40,960
but we are again surprised with how much

506
00:18:44,549 --> 00:18:43,280
variability there was just between

507
00:18:45,590 --> 00:18:44,559
these different samples that we

508
00:18:47,350 --> 00:18:45,600
collected

509
00:18:49,110 --> 00:18:47,360
and archaea was the same we didn't find

510
00:18:50,470 --> 00:18:49,120
quite as much archaea

511
00:18:51,750 --> 00:18:50,480
archaea are

512
00:18:54,150 --> 00:18:51,760
they're sort of the most primitive form

513
00:18:56,470 --> 00:18:54,160

of life unlike bacteria they don't have

514
00:18:58,710 --> 00:18:56,480
a mitochondria inside of their their

515
00:19:01,590 --> 00:18:58,720
cells and we again find these everywhere

516
00:19:03,510 --> 00:19:01,600
too they're they're really really robust

517
00:19:06,310 --> 00:19:03,520
and and we saw this this incredible

518
00:19:07,909 --> 00:19:06,320
variability

519
00:19:09,430 --> 00:19:07,919
so how does that compare to our other

520
00:19:10,950 --> 00:19:09,440
lava field remember i mentioned i was

521
00:19:12,470 --> 00:19:10,960
going to be talking about two so this is

522
00:19:15,029 --> 00:19:12,480
our younger one and this is the older

523
00:19:16,549 --> 00:19:15,039
one still not old in geology terms

524
00:19:18,710 --> 00:19:16,559
geologists think about things on like

525
00:19:20,789 --> 00:19:18,720
millions of years but but it's old in

526
00:19:22,630 --> 00:19:20,799
terms of the life that we were finding

527
00:19:24,789 --> 00:19:22,640
and we do see differences

528
00:19:26,870 --> 00:19:24,799
now i'm going to add sort of error bars

529
00:19:27,909 --> 00:19:26,880
to these so these

530
00:19:30,310 --> 00:19:27,919
blue

531
00:19:31,830 --> 00:19:30,320
sort of circles represent the errors in

532
00:19:33,270 --> 00:19:31,840
the measurements what i did was i

533
00:19:34,789 --> 00:19:33,280
averaged every single sample that we

534
00:19:37,029 --> 00:19:34,799
took from fem

535
00:19:39,029 --> 00:19:37,039
of the bacteria and that's this one here

536
00:19:40,789 --> 00:19:39,039
and everything from elderfell the the

537
00:19:42,470 --> 00:19:40,799
island sample and that's here and you

538
00:19:44,150 --> 00:19:42,480

can see for the older lava field the

539
00:19:46,070 --> 00:19:44,160
error bars the

540
00:19:49,190 --> 00:19:46,080
the blue rings are smaller they're

541
00:19:50,950 --> 00:19:49,200
thinner so these were more reproducible

542
00:19:53,350 --> 00:19:50,960
in terms of the amount of life that we

543
00:19:55,830 --> 00:19:53,360
found whereas things kind of varied much

544
00:19:57,990 --> 00:19:55,840
more for the younger lava field

545
00:19:59,830 --> 00:19:58,000
which is very interesting to us so maybe

546
00:20:01,990 --> 00:19:59,840
this means that it takes a while for

547
00:20:03,669 --> 00:20:02,000
life to stabilize things vary quite a

548
00:20:05,510 --> 00:20:03,679
bit they're more heterogeneous at first

549
00:20:08,150 --> 00:20:05,520
but then they become more homogeneous

550
00:20:10,230 --> 00:20:08,160
over time

551
00:20:12,150 --> 00:20:10,240
now that was one technique that we used

552
00:20:15,350 --> 00:20:12,160
another technique that we looked at was

553
00:20:17,909 --> 00:20:15,360
atp now atp stands for adenosine

554
00:20:20,789 --> 00:20:17,919
triphosphate it is the energy molecule

555
00:20:21,830 --> 00:20:20,799
that all life all life that we know of

556
00:20:23,510 --> 00:20:21,840
uses

557
00:20:25,669 --> 00:20:23,520
and it also doesn't hang around very

558
00:20:27,110 --> 00:20:25,679
long um in the environment once a cell

559
00:20:28,230 --> 00:20:27,120
dies so it's a really good way of

560
00:20:30,070 --> 00:20:28,240
telling you

561
00:20:31,669 --> 00:20:30,080
not just what organisms are there it

562
00:20:33,350 --> 00:20:31,679
can't tell you identify specific

563
00:20:35,430 --> 00:20:33,360

organisms because everybody uses it it's

564
00:20:37,029 --> 00:20:35,440
sort of like your energy

565
00:20:39,190 --> 00:20:37,039
but it can tell you whether or not

566
00:20:41,029 --> 00:20:39,200
they're alive like right now they're

567
00:20:42,310 --> 00:20:41,039
actively metabolizing

568
00:20:45,190 --> 00:20:42,320
like us

569
00:20:46,470 --> 00:20:45,200
so um in 2013 now we're looking at a bar

570
00:20:48,390 --> 00:20:46,480
graph but i've sort of highlighted

571
00:20:51,350 --> 00:20:48,400
things that differ on a 10 meter scale

572
00:20:53,590 --> 00:20:51,360
so so these guys differ in a meter these

573
00:20:56,310 --> 00:20:53,600
guys differ in a meter but these and

574
00:20:57,270 --> 00:20:56,320
these are 10 meters spaced apart and you

575
00:20:59,110 --> 00:20:57,280
can see that there's a lot of

576
00:21:01,270 --> 00:20:59,120
variability even things that were right

577
00:21:03,350 --> 00:21:01,280
next to each other

578
00:21:05,750 --> 00:21:03,360
vary widely in the amount of energy the

579
00:21:08,710 --> 00:21:05,760
amount of life that's active that's

580
00:21:13,510 --> 00:21:11,350
but in 2015 now this is the same lava

581
00:21:15,110 --> 00:21:13,520
field this is that young lava field now

582
00:21:16,070 --> 00:21:15,120
we start to see some patterns emerging

583
00:21:19,029 --> 00:21:16,080
right

584
00:21:20,149 --> 00:21:19,039
this grouping is all at one spatial

585
00:21:22,310 --> 00:21:20,159
scale

586
00:21:23,830 --> 00:21:22,320
of one meter apart

587
00:21:25,590 --> 00:21:23,840
and it's starting to look distinctly

588
00:21:26,549 --> 00:21:25,600

different from this grouping and this

589
00:21:28,149 --> 00:21:26,559
one

590
00:21:29,750 --> 00:21:28,159
so it seems that over time we're

591
00:21:31,830 --> 00:21:29,760
starting to get

592
00:21:34,549 --> 00:21:31,840
more predictability at least and less

593
00:21:37,830 --> 00:21:34,559
variation on these distance scales

594
00:21:42,710 --> 00:21:40,870
oh and i forgot to mention okay so so

595
00:21:44,630 --> 00:21:42,720
look at the scale here this goes up to 3

596
00:21:46,310 --> 00:21:44,640
000 this goes up to ten thousand so

597
00:21:48,630 --> 00:21:46,320
let's make them the same

598
00:21:50,549 --> 00:21:48,640
you'll also notice that uh life is

599
00:21:53,990 --> 00:21:50,559
increasing which makes sense right that

600
00:21:55,909 --> 00:21:54,000
we're over time starting to build up a

601
00:21:59,029 --> 00:21:55,919
stronger community more diverse

602
00:22:00,149 --> 00:21:59,039
hopefully microbial community here

603
00:22:02,230 --> 00:22:00,159
so this is something that we're hoping

604
00:22:03,750 --> 00:22:02,240
to monitor over time we have two

605
00:22:05,750 --> 00:22:03,760
data points in terms of uh two

606
00:22:07,830 --> 00:22:05,760
expeditions that we've been to visit and

607
00:22:09,350 --> 00:22:07,840
sample this place and we're hoping to go

608
00:22:10,830 --> 00:22:09,360
back

609
00:22:13,669 --> 00:22:10,840
so to conclude

610
00:22:15,990 --> 00:22:13,679
our when it comes to things like this

611
00:22:17,990 --> 00:22:16,000
there's no real ending to the story at

612
00:22:20,070 --> 00:22:18,000
least not yet we're just starting on

613
00:22:22,149 --> 00:22:20,080

this we've done two expeditions we just

614
00:22:24,230 --> 00:22:22,159
got funding to do four more over the

615
00:22:26,070 --> 00:22:24,240
next four years which is really exciting

616
00:22:27,909 --> 00:22:26,080
so we're going to go back to these lava

617
00:22:28,950 --> 00:22:27,919
fields that i told you about and also a

618
00:22:31,669 --> 00:22:28,960
new one

619
00:22:32,950 --> 00:22:31,679
this one is called okay

620
00:22:34,789 --> 00:22:32,960
it's up in the northern region of

621
00:22:37,430 --> 00:22:34,799
iceland which is called the

622
00:22:40,310 --> 00:22:37,440
bunga and this particular lava field is

623
00:22:42,549 --> 00:22:40,320
called uh nornachron which means witch's

624
00:22:46,149 --> 00:22:42,559
hair in icelandic which is pretty cool

625
00:22:48,149 --> 00:22:46,159
uh but this one erupted in 2014 and

626
00:22:49,990 --> 00:22:48,159
we've gotten permission to be able to to

627
00:22:51,590 --> 00:22:50,000
go up there and so this one will get

628
00:22:54,310 --> 00:22:51,600
even more of a head start at trying to

629
00:22:56,950 --> 00:22:54,320
see exactly where life starts what

630
00:22:58,630 --> 00:22:56,960
starts first and then what comes later

631
00:23:01,270 --> 00:22:58,640
so some conclusions that we've drawn

632
00:23:03,430 --> 00:23:01,280
just from our limited data so far we

633
00:23:05,510 --> 00:23:03,440
know that the older fields older lava

634
00:23:07,350 --> 00:23:05,520
fields have different types of life than

635
00:23:08,950 --> 00:23:07,360
the younger lava fields

636
00:23:10,950 --> 00:23:08,960
in the younger ones we also see that

637
00:23:13,669 --> 00:23:10,960
life abundance varies widely even at

638
00:23:15,909 --> 00:23:13,679

spatial scales of just a meter away but

639
00:23:18,549 --> 00:23:15,919
it does appear at least tentatively that

640
00:23:20,549 --> 00:23:18,559
over time patterns do emerge

641
00:23:22,870 --> 00:23:20,559
so our plan is to continue to go back

642
00:23:25,430 --> 00:23:22,880
and monitor this emergence of life in

643
00:23:27,590 --> 00:23:25,440
fresh lava fields over time

644
00:23:29,909 --> 00:23:27,600
so that's the fire and ice part

645
00:23:31,110 --> 00:23:29,919
now let's talk about the the methane

646
00:23:33,029 --> 00:23:31,120
ethane part

647
00:23:35,510 --> 00:23:33,039
so this is part two

648
00:23:37,190 --> 00:23:35,520
for mars we have analogs on earth but

649
00:23:38,950 --> 00:23:37,200
there are some places in the universe or

650
00:23:41,510 --> 00:23:38,960
in the solar system at least that are so

651
00:23:42,630 --> 00:23:41,520
weird we don't have any analogues here

652
00:23:44,710 --> 00:23:42,640
on earth

653
00:23:46,870 --> 00:23:44,720
i'd like to introduce you to titan this

654
00:23:49,110 --> 00:23:46,880
is a moon around saturn it's actually

655
00:23:51,510 --> 00:23:49,120
the largest moon in the solar system if

656
00:23:52,950 --> 00:23:51,520
you count its atmosphere yes it has an

657
00:23:55,830 --> 00:23:52,960
atmosphere it's actually thicker than

658
00:23:57,510 --> 00:23:55,840
ours about one and a half times thicker

659
00:23:58,789 --> 00:23:57,520
once you strip that atmosphere away

660
00:24:00,870 --> 00:23:58,799
though then it's a little bit smaller

661
00:24:02,149 --> 00:24:00,880
than ganymede but second place that's

662
00:24:04,549 --> 00:24:02,159
all right

663
00:24:07,350 --> 00:24:04,559

it's got an atmosphere that's about uh

664
00:24:09,750 --> 00:24:07,360
96 nitrogen a little bit of methane and

665
00:24:11,029 --> 00:24:09,760
it's thicker like i mentioned than ours

666
00:24:13,909 --> 00:24:11,039
the surface

667
00:24:16,470 --> 00:24:13,919
is this a mantle of water ice water ice

668
00:24:17,750 --> 00:24:16,480
takes the form of rock on titan it's the

669
00:24:19,269 --> 00:24:17,760
hardness of granite at these

670
00:24:21,510 --> 00:24:19,279
temperatures because it's way way out

671
00:24:22,870 --> 00:24:21,520
past the sun or far away from the sun so

672
00:24:24,630 --> 00:24:22,880
it's much colder

673
00:24:26,870 --> 00:24:24,640
and so you have this mantle of water

674
00:24:28,710 --> 00:24:26,880
icing it's coated in this veneer of

675
00:24:30,710 --> 00:24:28,720
organic molecules

676
00:24:32,549 --> 00:24:30,720
we've got dunes that are also we think

677
00:24:35,510 --> 00:24:32,559
made of those organic molecules

678
00:24:38,070 --> 00:24:35,520
and then we've got this hydrologic cycle

679
00:24:41,029 --> 00:24:38,080
but by hydro i don't mean water i mean

680
00:24:43,510 --> 00:24:41,039
hydrocarbon methane and ethane this is

681
00:24:44,789 --> 00:24:43,520
an example of a specular reflection you

682
00:24:46,870 --> 00:24:44,799
know if you're in an airplane and you

683
00:24:48,470 --> 00:24:46,880
sort of get that sun glint off of liquid

684
00:24:49,830 --> 00:24:48,480
water that's what you're seeing here

685
00:24:52,070 --> 00:24:49,840
this is off of a lake that's in the

686
00:24:53,830 --> 00:24:52,080
northern pole of titan that's made out

687
00:24:55,430 --> 00:24:53,840
of mostly methane

688
00:24:57,830 --> 00:24:55,440

so we have methane and ethane that form

689
00:25:00,230 --> 00:24:57,840
clouds and rain down onto the surface

690
00:25:02,470 --> 00:25:00,240
and we may even have some cryovolcanoes

691
00:25:04,630 --> 00:25:02,480
although this is still hotly debated uh

692
00:25:07,110 --> 00:25:04,640
in the titan community so we may have

693
00:25:09,110 --> 00:25:07,120
evidence where okay so titan just like

694
00:25:11,269 --> 00:25:09,120
europa and enceladus and all these other

695
00:25:12,950 --> 00:25:11,279
icy moons has an ocean of water

696
00:25:16,070 --> 00:25:12,960
underneath all this stuff like deeper

697
00:25:19,029 --> 00:25:16,080
down ocean of liquid water and some in

698
00:25:20,630 --> 00:25:19,039
some places for example sotra facula we

699
00:25:22,470 --> 00:25:20,640
may see some of that

700
00:25:24,310 --> 00:25:22,480
liquid water maybe mixed with some stuff

701
00:25:26,310 --> 00:25:24,320
like methanol coming up to the surface

702
00:25:28,870 --> 00:25:26,320
maybe which would be really exciting

703
00:25:31,590 --> 00:25:28,880
because then more chemistry could happen

704
00:25:33,990 --> 00:25:31,600
so titan's a fascinating place

705
00:25:36,149 --> 00:25:34,000
and it is similar to earth in some ways

706
00:25:37,830 --> 00:25:36,159
right it has clouds earth has clouds

707
00:25:39,909 --> 00:25:37,840
they're made out of different stuff but

708
00:25:43,029 --> 00:25:39,919
they both have clouds and atmospheres

709
00:25:44,870 --> 00:25:43,039
and those types of behaviors

710
00:25:46,230 --> 00:25:44,880
they both have river channels

711
00:25:48,470 --> 00:25:46,240
they are moving different things in

712
00:25:52,070 --> 00:25:48,480
those channels but uh in terms of their

713
00:25:53,510 --> 00:25:52,080

their geology they do look very similar

714
00:25:55,590 --> 00:25:53,520
they have lakes

715
00:25:58,230 --> 00:25:55,600
and this is like gmare which is in the

716
00:26:00,950 --> 00:25:58,240
north pole of titan its surface area is

717
00:26:03,669 --> 00:26:00,960
actually twice as big as lake michigan

718
00:26:04,549 --> 00:26:03,679
it's a big lake

719
00:26:07,190 --> 00:26:04,559
and

720
00:26:09,269 --> 00:26:07,200
we've got remnants of ridges other sort

721
00:26:11,590 --> 00:26:09,279
of geological features on earth we see

722
00:26:13,590 --> 00:26:11,600
echoed in titan as well the scales may

723
00:26:15,990 --> 00:26:13,600
be a little bit different but we still

724
00:26:18,230 --> 00:26:16,000
see very similar behavior

725
00:26:19,430 --> 00:26:18,240
so maybe that suggests similar processes

726
00:26:21,669 --> 00:26:19,440
even though they're made of very

727
00:26:23,669 --> 00:26:21,679
different things and the dunes which are

728
00:26:25,350 --> 00:26:23,679
crazy cool they're hundreds of

729
00:26:27,669 --> 00:26:25,360
kilometers long i think like 10

730
00:26:30,950 --> 00:26:27,679
kilometers high mike is that right 10

731
00:26:33,190 --> 00:26:30,960
kilometers ish yeah

732
00:26:35,029 --> 00:26:33,200
we're not sure if they're moving or if

733
00:26:37,590 --> 00:26:35,039
they're frozen dunes

734
00:26:39,510 --> 00:26:37,600
but we're pretty well we believe that

735
00:26:41,029 --> 00:26:39,520
they're formed by

736
00:26:43,510 --> 00:26:41,039
organic chemistry happening in the

737
00:26:45,510 --> 00:26:43,520
atmosphere so the atmosphere has just

738
00:26:47,510 --> 00:26:45,520

two things in it nitrogen and methane

739
00:26:50,149 --> 00:26:47,520
until you introduce energy now the

740
00:26:52,390 --> 00:26:50,159
energy can be uv radiation from the sun

741
00:26:54,630 --> 00:26:52,400
even though it's far away over time that

742
00:26:56,789 --> 00:26:54,640
can add up and cause chemistry you have

743
00:26:58,789 --> 00:26:56,799
these really fast moving protons and

744
00:27:00,390 --> 00:26:58,799
electrons that are accelerated by saturn

745
00:27:02,950 --> 00:27:00,400
that go slamming into these molecules

746
00:27:06,070 --> 00:27:02,960
and they break them apart and so pretty

747
00:27:07,830 --> 00:27:06,080
much any combination of carbon hydrogen

748
00:27:09,029 --> 00:27:07,840
and nitrogen that you can think of that

749
00:27:10,710 --> 00:27:09,039
you can make in your little chemistry

750
00:27:13,029 --> 00:27:10,720
set at home do you guys have chemistry

751
00:27:14,870 --> 00:27:13,039
sets at home

752
00:27:16,549 --> 00:27:14,880
anything that you can make probably

753
00:27:18,630 --> 00:27:16,559
exists on titan

754
00:27:21,430 --> 00:27:18,640
you start to form these these complex

755
00:27:23,510 --> 00:27:21,440
molecules that continue to react and

756
00:27:25,269 --> 00:27:23,520
sort of combine with each other as they

757
00:27:26,630 --> 00:27:25,279
they form these haze layers that we see

758
00:27:28,870 --> 00:27:26,640
in the atmosphere and then eventually

759
00:27:30,789 --> 00:27:28,880
they make it down to the surface and we

760
00:27:32,710 --> 00:27:30,799
think that's what is uh making up these

761
00:27:35,430 --> 00:27:32,720
dunes in addition to other surface

762
00:27:37,269 --> 00:27:35,440
features on titan

763
00:27:39,269 --> 00:27:37,279

okay so let's go back to the lakes

764
00:27:41,350 --> 00:27:39,279
because you know

765
00:27:43,350 --> 00:27:41,360
if it looks like a duck

766
00:27:44,710 --> 00:27:43,360
but in this case it's not actually

767
00:27:47,750 --> 00:27:44,720
looking like a duck i mean we do see

768
00:27:50,070 --> 00:27:47,760
some things we see bathymetry it has

769
00:27:52,310 --> 00:27:50,080
similar depth similar

770
00:27:54,870 --> 00:27:52,320
properties in terms of appearance to

771
00:27:57,190 --> 00:27:54,880
earth lakes but they're not right these

772
00:28:00,070 --> 00:27:57,200
are filled with something very different

773
00:28:01,990 --> 00:28:00,080
methane ethane a little bit of propane

774
00:28:03,909 --> 00:28:02,000
so earth we don't have a good analog

775
00:28:05,510 --> 00:28:03,919
unless we were to go and dump a lot of

776
00:28:07,029 --> 00:28:05,520
propane in a lake and i don't think

777
00:28:08,549 --> 00:28:07,039
anyone would be too happy with us if we

778
00:28:10,310 --> 00:28:08,559
did that and plus it would boil away

779
00:28:13,110 --> 00:28:10,320
because it's too hot here

780
00:28:15,110 --> 00:28:13,120
so what do we do well we go to the lab

781
00:28:17,830 --> 00:28:15,120
and we can make mini titan lakes in the

782
00:28:19,909 --> 00:28:17,840
lab using things called cryostats so we

783
00:28:22,070 --> 00:28:19,919
use liquid nitrogen which is actually a

784
00:28:24,230 --> 00:28:22,080
little bit colder than titan's surface

785
00:28:27,590 --> 00:28:24,240
titan surface is about 90 kelvin which

786
00:28:28,870 --> 00:28:27,600
is minus 183 degrees c and i don't know

787
00:28:29,750 --> 00:28:28,880
what it is in fahrenheit i should know

788
00:28:31,190 --> 00:28:29,760

that

789
00:28:33,110 --> 00:28:31,200
but it's cold

790
00:28:35,830 --> 00:28:33,120
liquid nitrogen is even colder it's

791
00:28:37,750 --> 00:28:35,840
about 77 78 kelvin so we use that as our

792
00:28:39,510 --> 00:28:37,760
bath and then we heat it up just a

793
00:28:41,669 --> 00:28:39,520
little bit about 10 or 12 degrees to get

794
00:28:43,750 --> 00:28:41,679
up to tighten temperatures

795
00:28:45,669 --> 00:28:43,760
this is what it looks like so we've got

796
00:28:47,350 --> 00:28:45,679
our dewar that's a silver thing here it

797
00:28:49,669 --> 00:28:47,360
keeps hot things hot in our case it

798
00:28:51,990 --> 00:28:49,679
keeps cold things cold we put our liquid

799
00:28:54,389 --> 00:28:52,000
nitrogen in here and then inside of this

800
00:28:57,190 --> 00:28:54,399
beaker within a beaker is a little titan

801
00:28:58,870 --> 00:28:57,200
lake that's liquid ethane in there

802
00:29:00,549 --> 00:28:58,880
and so this is what we'll use to do our

803
00:29:02,549 --> 00:29:00,559
experiments

804
00:29:05,430 --> 00:29:02,559
now there are a lot of fascinating

805
00:29:07,110 --> 00:29:05,440
things going on on titan we've got

806
00:29:08,870 --> 00:29:07,120
atmospheric chemistry

807
00:29:11,510 --> 00:29:08,880
we've got rain methane and ethane rains

808
00:29:13,669 --> 00:29:11,520
down on the surface it may be dissolving

809
00:29:15,669 --> 00:29:13,679
some things or potentially forming caves

810
00:29:18,070 --> 00:29:15,679
or other interesting types of

811
00:29:20,149 --> 00:29:18,080
geologic features it may be flowing

812
00:29:22,789 --> 00:29:20,159
things into these lakes stuff that gets

813
00:29:24,149 --> 00:29:22,799

dissolved can can move into those lakes

814
00:29:26,230 --> 00:29:24,159
and then the lakes themselves they can

815
00:29:28,389 --> 00:29:26,240
evaporate over time and so we have these

816
00:29:31,110 --> 00:29:28,399
really interesting cycles that we would

817
00:29:32,630 --> 00:29:31,120
like to study and understand better

818
00:29:33,750 --> 00:29:32,640
so let's take them one at a time and i'm

819
00:29:35,669 --> 00:29:33,760
not going to do them all i'm just doing

820
00:29:38,149 --> 00:29:35,679
two but let's look first at soluble

821
00:29:40,870 --> 00:29:38,159
material dissolution basically

822
00:29:43,029 --> 00:29:40,880
what dissolves in a titan lake

823
00:29:45,590 --> 00:29:43,039
okay this is a setup from one of my

824
00:29:47,510 --> 00:29:45,600
colleagues mike malaska put together to

825
00:29:49,830 --> 00:29:47,520
try to answer that question so again

826
00:29:51,750 --> 00:29:49,840
we've got our dewar which keeps hot

827
00:29:53,430 --> 00:29:51,760
things hot or cold things cold and a lot

828
00:29:55,590 --> 00:29:53,440
of liquid nitrogen

829
00:29:57,909 --> 00:29:55,600
now if you look at a schematic of this

830
00:29:59,830 --> 00:29:57,919
this is a figure from

831
00:30:01,750 --> 00:29:59,840
one of mike's presentations

832
00:30:03,830 --> 00:30:01,760
we'll fill it with liquid methane or

833
00:30:06,230 --> 00:30:03,840
liquid ethane and then this is our probe

834
00:30:07,669 --> 00:30:06,240
that we'll use to measure concentrations

835
00:30:09,590 --> 00:30:07,679
of things that we dissolve in there that

836
00:30:11,590 --> 00:30:09,600
we're interested in in studying to see

837
00:30:13,269 --> 00:30:11,600
how well they dissolve in this liquid

838
00:30:15,590 --> 00:30:13,279

and so we'll do what's called a flush

839
00:30:17,350 --> 00:30:15,600
and fill to sort of push things out and

840
00:30:19,190 --> 00:30:17,360
it has to come back through a filter

841
00:30:20,870 --> 00:30:19,200
before it comes back in so we don't want

842
00:30:22,950 --> 00:30:20,880
any chunks you know if you dissolve

843
00:30:24,389 --> 00:30:22,960
something like sugar in your coffee and

844
00:30:26,149 --> 00:30:24,399
you put too much sugar in there and some

845
00:30:27,350 --> 00:30:26,159
of it kind of falls to the bottom we

846
00:30:29,669 --> 00:30:27,360
don't want that to interfere with our

847
00:30:31,110 --> 00:30:29,679
measurements so we have a filter so only

848
00:30:33,909 --> 00:30:31,120
the things that are actually dissolved

849
00:30:35,190 --> 00:30:33,919
in the liquid are what we'll measure

850
00:30:36,470 --> 00:30:35,200
now a few of the things that mike has

851
00:30:39,029 --> 00:30:36,480
measured so far

852
00:30:40,149 --> 00:30:39,039
are these organic molecules here

853
00:30:42,630 --> 00:30:40,159
benzene

854
00:30:45,350 --> 00:30:42,640
naphthalene and biphenyl

855
00:30:48,230 --> 00:30:45,360
and the amounts that dissolve in a titan

856
00:30:50,149 --> 00:30:48,240
lake range from about 18 milligrams per

857
00:30:52,870 --> 00:30:50,159
liter down to much lower than that now

858
00:30:55,269 --> 00:30:52,880
to put this in context sugar dissolving

859
00:30:58,230 --> 00:30:55,279
in water at room temperature any guesses

860
00:31:00,389 --> 00:30:58,240
on how many migs per liter that is

861
00:31:02,310 --> 00:31:00,399
it's way more than 18. it's almost 2

862
00:31:03,350 --> 00:31:02,320
million actually

863
00:31:07,909 --> 00:31:03,360

so

864
00:31:10,630 --> 00:31:07,919
or ethane but this is still interesting

865
00:31:12,470 --> 00:31:10,640
for us to try to understand right

866
00:31:14,710 --> 00:31:12,480
because it's cold because it's made out

867
00:31:16,549 --> 00:31:14,720
of methane and ethane instead of water

868
00:31:18,789 --> 00:31:16,559
water is polar these things aren't so

869
00:31:21,110 --> 00:31:18,799
they behave differently and this helps

870
00:31:24,870 --> 00:31:21,120
us understand and generate models that

871
00:31:26,389 --> 00:31:24,880
we can start to to think about processes

872
00:31:28,149 --> 00:31:26,399
that have happened on titan over very

873
00:31:30,549 --> 00:31:28,159
long time scales millions or even

874
00:31:32,789 --> 00:31:30,559
billions of years

875
00:31:35,750 --> 00:31:32,799
and this can help also this can help us

876
00:31:37,909 --> 00:31:35,760
uh understand what types of processes or

877
00:31:39,350 --> 00:31:37,919
physical landforms we see on the surface

878
00:31:40,950 --> 00:31:39,360
if these are due to certain things

879
00:31:44,630 --> 00:31:40,960
dissolving and certain things being left

880
00:31:47,990 --> 00:31:45,990
and it also

881
00:31:50,149 --> 00:31:48,000
these experiments can tell us about some

882
00:31:52,230 --> 00:31:50,159
interesting features that we've seen

883
00:31:53,750 --> 00:31:52,240
for example there's something that was

884
00:31:56,470 --> 00:31:53,760
observed by

885
00:31:59,350 --> 00:31:56,480
the cassini mission happening over a

886
00:32:01,350 --> 00:31:59,360
period of many years we noticed that

887
00:32:03,350 --> 00:32:01,360
this feature which is this is again my

888
00:32:04,310 --> 00:32:03,360

gmri a lake at the northern pole of

889
00:32:06,149 --> 00:32:04,320
titan

890
00:32:08,310 --> 00:32:06,159
we saw this this uh

891
00:32:10,630 --> 00:32:08,320
bright feature appear in uh this is in

892
00:32:12,549 --> 00:32:10,640
radar datas uh synthetic aperture radar

893
00:32:14,549 --> 00:32:12,559
data and we see it appear and then

894
00:32:16,950 --> 00:32:14,559
disappear over time

895
00:32:19,029 --> 00:32:16,960
and this is called a magic island jason

896
00:32:21,430 --> 00:32:19,039
hoffgartner wrote about this recently

897
00:32:22,789 --> 00:32:21,440
and he's i saw him he's here somewhere

898
00:32:23,990 --> 00:32:22,799
there he is

899
00:32:25,750 --> 00:32:24,000
and um

900
00:32:27,430 --> 00:32:25,760
so so this was really interesting right

901
00:32:29,110 --> 00:32:27,440
what is this it's a transient feature

902
00:32:31,830 --> 00:32:29,120
right it comes and goes so is it

903
00:32:33,990 --> 00:32:31,840
something floating on methane and ethane

904
00:32:36,230 --> 00:32:34,000
it can't be methane or ethane ice unlike

905
00:32:39,190 --> 00:32:36,240
water ice that ice sinks it doesn't

906
00:32:41,269 --> 00:32:39,200
float so it can't be that could it be

907
00:32:43,029 --> 00:32:41,279
something else we don't know but we have

908
00:32:45,190 --> 00:32:43,039
a theory based on some of the

909
00:32:47,269 --> 00:32:45,200
experiments that we've been doing

910
00:32:49,190 --> 00:32:47,279
our theory is that if you have a lake

911
00:32:50,710 --> 00:32:49,200
that's rich in ethane and then you get a

912
00:32:52,549 --> 00:32:50,720
rainfall

913
00:32:54,310 --> 00:32:52,559

nitrogen which is in the atmosphere

914
00:32:56,549 --> 00:32:54,320
dissolves a little bit in both of these

915
00:32:59,110 --> 00:32:56,559
but it's much more soluble in methane

916
00:33:01,190 --> 00:32:59,120
than it is in ethane and so when this

917
00:33:03,190 --> 00:33:01,200
nitrogen saturated methane hits this

918
00:33:06,070 --> 00:33:03,200
lake it can cause some of that nitrogen

919
00:33:08,149 --> 00:33:06,080
to boil off to it's called exsolvate but

920
00:33:10,789 --> 00:33:08,159
it just means bubbles happen

921
00:33:12,710 --> 00:33:10,799
and and it can generate something maybe

922
00:33:14,070 --> 00:33:12,720
that could be an explanation for these

923
00:33:16,310 --> 00:33:14,080
magic islands

924
00:33:17,590 --> 00:33:16,320
and mike actually did an experiment in

925
00:33:19,990 --> 00:33:17,600
the lab where

926
00:33:21,509 --> 00:33:20,000
it looks like something similar could be

927
00:33:23,830 --> 00:33:21,519
happening so what you're looking at here

928
00:33:25,830 --> 00:33:23,840
this is a a glass container there's a

929
00:33:26,950 --> 00:33:25,840
stir bar that's moving around

930
00:33:30,070 --> 00:33:26,960
in here

931
00:33:32,149 --> 00:33:30,080
on the outside is a bath of methane that

932
00:33:33,669 --> 00:33:32,159
has nitrogen dissolved in it and on the

933
00:33:35,190 --> 00:33:33,679
inside he's trying to condense some

934
00:33:36,549 --> 00:33:35,200
ethane now when that happens you

935
00:33:37,750 --> 00:33:36,559
generate a little bit of heat just a

936
00:33:39,909 --> 00:33:37,760
little bit

937
00:33:41,350 --> 00:33:39,919
and it's just enough that now you can

938
00:33:43,430 --> 00:33:41,360

start to see these bubbles do you see

939
00:33:44,950 --> 00:33:43,440
these bubbles happening that's the

940
00:33:46,950 --> 00:33:44,960
nitrogen that's boiling out that's

941
00:33:49,029 --> 00:33:46,960
accelerating out

942
00:33:51,110 --> 00:33:49,039
so we see some things in the laboratory

943
00:33:53,269 --> 00:33:51,120
that maybe we can use to attribute to

944
00:33:56,070 --> 00:33:53,279
physical processes that are happening on

945
00:34:01,350 --> 00:33:58,149
alright so let's look at one more

946
00:34:03,350 --> 00:34:01,360
process that may be going on on titan

947
00:34:05,029 --> 00:34:03,360
we're interested in these lakes and what

948
00:34:07,509 --> 00:34:05,039
can happen when

949
00:34:09,430 --> 00:34:07,519
the volume of those lakes changes

950
00:34:11,589 --> 00:34:09,440
so what happens when things evaporate

951
00:34:12,629 --> 00:34:11,599
from a titan lake

952
00:34:14,389 --> 00:34:12,639
well

953
00:34:16,629 --> 00:34:14,399
we have some evidence that something

954
00:34:17,589 --> 00:34:16,639
interesting is going on from the cassini

955
00:34:20,069 --> 00:34:17,599
mission

956
00:34:23,190 --> 00:34:20,079
we've noticed that around some of these

957
00:34:25,510 --> 00:34:23,200
lakes we'll see what we sort of

958
00:34:28,230 --> 00:34:25,520
call our nickname bathtub rings they

959
00:34:30,069 --> 00:34:28,240
sort of look like evaporative deposits

960
00:34:31,589 --> 00:34:30,079
that are happening perhaps as the lake

961
00:34:33,109 --> 00:34:31,599
is evaporating away we don't know if

962
00:34:35,909 --> 00:34:33,119
that's actually the process that's just

963
00:34:37,669 --> 00:34:35,919

a guess but it is interesting and we

964
00:34:39,349 --> 00:34:37,679
started to think okay well what could

965
00:34:41,829 --> 00:34:39,359
these be made up of

966
00:34:44,230 --> 00:34:41,839
well let's go back to that that um

967
00:34:46,710 --> 00:34:44,240
solubility experiment mike did well

968
00:34:50,470 --> 00:34:46,720
benzene is not very soluble

969
00:34:52,230 --> 00:34:50,480
so if the lake liquid volume changes

970
00:34:55,030 --> 00:34:52,240
because of evaporation and it's

971
00:34:56,710 --> 00:34:55,040
dissolved to what we call to saturation

972
00:34:58,790 --> 00:34:56,720
so you put in as much benzene in that

973
00:35:01,109 --> 00:34:58,800
liquid as you possibly can if some of it

974
00:35:03,430 --> 00:35:01,119
evaporates away the liquid some of that

975
00:35:05,990 --> 00:35:03,440
benzene is going to crash out

976
00:35:07,510 --> 00:35:06,000
and precipitate out and so this could be

977
00:35:09,349 --> 00:35:07,520
something that's happening

978
00:35:11,430 --> 00:35:09,359
and so we decided to do an experiment in

979
00:35:13,030 --> 00:35:11,440
the lab to simulate this so what you're

980
00:35:15,829 --> 00:35:13,040
looking at is this is a zoomed in

981
00:35:17,510 --> 00:35:15,839
microscopic image this is a droplet of

982
00:35:19,349 --> 00:35:17,520
benzene so you're looking at the edge of

983
00:35:21,109 --> 00:35:19,359
it so this is benzene up here that's

984
00:35:23,270 --> 00:35:21,119
frozen because it's it's definitely a

985
00:35:26,069 --> 00:35:23,280
solid at time temperatures and this is

986
00:35:29,109 --> 00:35:26,079
in liquid ethane so you can imagine that

987
00:35:30,950 --> 00:35:29,119
this is sort of like um if an ethane

988
00:35:32,950 --> 00:35:30,960

lake started to evaporate away and some

989
00:35:34,870 --> 00:35:32,960
of the benzene was left behind

990
00:35:37,270 --> 00:35:34,880
now what we noticed was when we mixed

991
00:35:39,190 --> 00:35:37,280
these two together and we waited we saw

992
00:35:41,190 --> 00:35:39,200
something interesting this is something

993
00:35:43,430 --> 00:35:41,200
called recrystallization you can see how

994
00:35:45,589 --> 00:35:43,440
there are some crystals solid chunks

995
00:35:47,589 --> 00:35:45,599
here but then over here they broken up

996
00:35:49,349 --> 00:35:47,599
into tiny little bits and we didn't do

997
00:35:51,829 --> 00:35:49,359
anything we didn't touch the sample we

998
00:35:53,750 --> 00:35:51,839
just sat it there and and watched this

999
00:35:55,030 --> 00:35:53,760
happen and we saw this happen over and

1000
00:35:57,030 --> 00:35:55,040
over again

1001
00:35:58,310 --> 00:35:57,040
now in chemistry we get very excited

1002
00:36:00,390 --> 00:35:58,320
when something like this happens because

1003
00:36:02,069 --> 00:36:00,400
it tells us that something is changing

1004
00:36:03,750 --> 00:36:02,079
inside of the sample whether it's a

1005
00:36:05,190 --> 00:36:03,760
physical or chemical change it's a

1006
00:36:07,190 --> 00:36:05,200
change and it's at really cold

1007
00:36:09,349 --> 00:36:07,200
temperatures which is exciting normally

1008
00:36:11,270 --> 00:36:09,359
things slow down or even stop at very

1009
00:36:13,109 --> 00:36:11,280
low temperatures so this was something

1010
00:36:15,190 --> 00:36:13,119
we excuse me something we wanted to

1011
00:36:17,510 --> 00:36:15,200
investigate further

1012
00:36:20,790 --> 00:36:17,520
so we turned to one of our instruments

1013
00:36:22,230 --> 00:36:20,800

this is a data from a raman spectrometer

1014
00:36:25,030 --> 00:36:22,240
and essentially what you're looking at

1015
00:36:26,950 --> 00:36:25,040
is peaks that are attributed to

1016
00:36:28,550 --> 00:36:26,960
different molecules that are present in

1017
00:36:30,230 --> 00:36:28,560
our sample now we just have two things

1018
00:36:31,750 --> 00:36:30,240
in there right we've got our benzene and

1019
00:36:34,150 --> 00:36:31,760
we've got our ethane

1020
00:36:35,829 --> 00:36:34,160
and what we noticed is that once you mix

1021
00:36:38,550 --> 00:36:35,839
them and you wait for a little bit we

1022
00:36:40,310 --> 00:36:38,560
see this new peak appear over here and

1023
00:36:42,710 --> 00:36:40,320
we also see some shifts in these peaks

1024
00:36:44,630 --> 00:36:42,720
over here now this tells us this

1025
00:36:46,550 --> 00:36:44,640
particular technique not only does it

1026
00:36:48,790 --> 00:36:46,560
tell you what's there but it tells you

1027
00:36:49,670 --> 00:36:48,800
the chemical environment that it's in as

1028
00:36:51,510 --> 00:36:49,680
well

1029
00:36:53,829 --> 00:36:51,520
now this peak growing in this is one of

1030
00:36:55,990 --> 00:36:53,839
the ethane peaks this tells us that some

1031
00:36:57,910 --> 00:36:56,000
population of the ethane molecules that

1032
00:37:00,630 --> 00:36:57,920
are in our sample are in a different

1033
00:37:02,230 --> 00:37:00,640
environment than the rest of the liquid

1034
00:37:04,470 --> 00:37:02,240
so we started to try to think of what

1035
00:37:06,230 --> 00:37:04,480
that different environment could be

1036
00:37:08,550 --> 00:37:06,240
well we've got two things we've got

1037
00:37:10,630 --> 00:37:08,560
benzene and ethane how can you

1038
00:37:12,870 --> 00:37:10,640

combine them or mix them together to

1039
00:37:15,030 --> 00:37:12,880
sort of trap ethane in some kind of like

1040
00:37:16,630 --> 00:37:15,040
a co-crystal or some other

1041
00:37:18,870 --> 00:37:16,640
sort of state

1042
00:37:21,270 --> 00:37:18,880
well we turn to the literature

1043
00:37:23,829 --> 00:37:21,280
and there's a paper on a similar

1044
00:37:25,030 --> 00:37:23,839
molecular pair same with benzene but now

1045
00:37:26,790 --> 00:37:25,040
we've got a different molecule in the

1046
00:37:28,710 --> 00:37:26,800
middle called acetylene but they formed

1047
00:37:29,829 --> 00:37:28,720
this really cool sort of sandwich

1048
00:37:31,510 --> 00:37:29,839
structure

1049
00:37:33,910 --> 00:37:31,520
where the acetylene was stabilized

1050
00:37:35,750 --> 00:37:33,920
inside and so we thought okay well

1051
00:37:37,670 --> 00:37:35,760
ethane is very similar to acetylene it's

1052
00:37:39,270 --> 00:37:37,680
just got a few extra protons so maybe

1053
00:37:40,950 --> 00:37:39,280
maybe this is what's going on we did

1054
00:37:42,150 --> 00:37:40,960
some modeling that supported this as

1055
00:37:46,069 --> 00:37:42,160
well

1056
00:37:48,230 --> 00:37:46,079
we've got this friend colleague in

1057
00:37:50,550 --> 00:37:48,240
australia who has access to their

1058
00:37:53,109 --> 00:37:50,560
synchrotron so let's go down there and

1059
00:37:54,550 --> 00:37:53,119
do some cryogenic experiments

1060
00:37:57,030 --> 00:37:54,560
and so one of our colleagues went down

1061
00:37:58,069 --> 00:37:57,040
there and basically fired a bunch of

1062
00:38:00,390 --> 00:37:58,079
x-rays

1063
00:38:02,870 --> 00:38:00,400

at our sample kept it cold and when

1064
00:38:05,270 --> 00:38:02,880
x-rays bounce off of a crystal structure

1065
00:38:07,670 --> 00:38:05,280
that pattern of how the rays are are

1066
00:38:09,430 --> 00:38:07,680
bounced off and diffracted can tell you

1067
00:38:10,870 --> 00:38:09,440
what the molecule what the atoms are and

1068
00:38:12,630 --> 00:38:10,880
where they are what their specific

1069
00:38:14,310 --> 00:38:12,640
arrangement is so this can tell you what

1070
00:38:15,990 --> 00:38:14,320
the crystal structure is it's like being

1071
00:38:18,470 --> 00:38:16,000
able to zoom in and look at individual

1072
00:38:20,150 --> 00:38:18,480
atoms which is very cool

1073
00:38:22,870 --> 00:38:20,160
and so we did that and this is what we

1074
00:38:25,430 --> 00:38:22,880
saw very very different from what we

1075
00:38:27,750 --> 00:38:25,440
expected so you can see there's like a

1076
00:38:28,710 --> 00:38:27,760
ring of benzenes

1077
00:38:30,069 --> 00:38:28,720
and then

1078
00:38:31,589 --> 00:38:30,079
it's kind of hard to see but you

1079
00:38:33,030 --> 00:38:31,599
basically got this line of ethae

1080
00:38:34,470 --> 00:38:33,040
molecules that are forming sort of like

1081
00:38:36,310 --> 00:38:34,480
a tube

1082
00:38:38,870 --> 00:38:36,320
totally not what we expected really

1083
00:38:41,190 --> 00:38:38,880
wicked cool we were very excited so if

1084
00:38:42,550 --> 00:38:41,200
you sort of like drape them a cloth over

1085
00:38:44,390 --> 00:38:42,560
the benzenes you can sort of get a

1086
00:38:47,109 --> 00:38:44,400
better idea of the structure

1087
00:38:48,950 --> 00:38:47,119
we call this an inclusion compound and

1088
00:38:51,030 --> 00:38:48,960

ethanes form in these channels in

1089
00:38:52,470 --> 00:38:51,040
between the benzenes really unusual no

1090
00:38:53,910 --> 00:38:52,480
one had ever seen this before we did

1091
00:38:55,990 --> 00:38:53,920
this experiment

1092
00:38:58,470 --> 00:38:56,000
and this was really exciting for us both

1093
00:39:00,150 --> 00:38:58,480
from a chemistry perspective and from a

1094
00:39:02,150 --> 00:39:00,160
what the heck is going on on titan

1095
00:39:04,550 --> 00:39:02,160
perspective because this helps give us

1096
00:39:07,190 --> 00:39:04,560
some insight into weird processes that

1097
00:39:09,990 --> 00:39:07,200
could be happening on the surface

1098
00:39:11,990 --> 00:39:10,000
so titan surface landscape is strongly

1099
00:39:13,750 --> 00:39:12,000
influenced by this complex organic cycle

1100
00:39:15,750 --> 00:39:13,760
and we're starting to get some insights

1101
00:39:17,910 --> 00:39:15,760
through doing lab experiments

1102
00:39:19,990 --> 00:39:17,920
to try to understand what's going on

1103
00:39:21,750 --> 00:39:20,000
we know that certain molecules dissolve

1104
00:39:23,430 --> 00:39:21,760
and thanks to the work from some of our

1105
00:39:25,430 --> 00:39:23,440
colleagues we now know exactly how much

1106
00:39:28,069 --> 00:39:25,440
dissolves we know that some of them

1107
00:39:29,990 --> 00:39:28,079
precipitate or reorganize like that cool

1108
00:39:31,510 --> 00:39:30,000
crystal structure i just showed you and

1109
00:39:35,190 --> 00:39:31,520
this leads to some

1110
00:39:35,990 --> 00:39:35,200
novel solid geological materials this

1111
00:39:37,589 --> 00:39:36,000
this

1112
00:39:39,270 --> 00:39:37,599
is the equivalent of like a hydrated

1113
00:39:40,710 --> 00:39:39,280

mineral on earth

1114
00:39:41,670 --> 00:39:40,720
and so this can help us try to

1115
00:39:44,150 --> 00:39:41,680
understand

1116
00:39:46,550 --> 00:39:44,160
how things are stored how they move how

1117
00:39:48,069 --> 00:39:46,560
they interact on this really exotic

1118
00:39:49,510 --> 00:39:48,079
alien world

1119
00:39:51,510 --> 00:39:49,520
but of course this is just part of the

1120
00:39:53,510 --> 00:39:51,520
story again it doesn't have a full

1121
00:39:55,349 --> 00:39:53,520
ending yet we definitely need more lab

1122
00:39:56,950 --> 00:39:55,359
work we need future missions to go to

1123
00:39:59,030 --> 00:39:56,960
this amazing moon cassini has given us

1124
00:40:00,550 --> 00:39:59,040
an incredible wealth of data but it's

1125
00:40:02,150 --> 00:40:00,560
also given us more questions than

1126
00:40:03,430 --> 00:40:02,160
answers which a scientist is what we

1127
00:40:05,109 --> 00:40:03,440
love

1128
00:40:07,190 --> 00:40:05,119
so i'm hoping that we'll be able to go

1129
00:40:11,190 --> 00:40:07,200
back and study titan further in the

1130
00:40:13,430 --> 00:40:11,200
future to learn about what makes it tick

1131
00:40:16,069 --> 00:40:13,440
so with that i have a lot of people to

1132
00:40:17,349 --> 00:40:16,079
thank i hope i included all of them from

1133
00:40:20,069 --> 00:40:17,359
the first part for the iceland

1134
00:40:21,829 --> 00:40:20,079
expedition our feldspar team

1135
00:40:24,710 --> 00:40:21,839
funding from a variety of different

1136
00:40:26,230 --> 00:40:24,720
sources the headmistress of fosgoli

1137
00:40:27,670 --> 00:40:26,240
which the icelandic person in the

1138
00:40:30,390 --> 00:40:27,680

audience can tell me how to pronounce

1139
00:40:32,069 --> 00:40:30,400
her name the nasa nordic astrobiology

1140
00:40:33,270 --> 00:40:32,079
summer school that i mentioned google it

1141
00:40:35,349 --> 00:40:33,280
if you're interested in learning about

1142
00:40:36,550 --> 00:40:35,359
astrobiology or pursuing that as a

1143
00:40:38,870 --> 00:40:36,560
career

1144
00:40:40,950 --> 00:40:38,880
the planetary science and technology

1145
00:40:42,310 --> 00:40:40,960
from analog research program p star

1146
00:40:44,630 --> 00:40:42,320
that's what just gave us some funding to

1147
00:40:47,510 --> 00:40:44,640
go back and then for the titan lab work

1148
00:40:49,510 --> 00:40:47,520
uh rob tuan mike matthew bunch of people

1149
00:41:04,309 --> 00:40:49,520
and funding and thank you all for your

1150
00:41:08,309 --> 00:41:06,390
so i'd love to take your questions uh

1151
00:41:09,910 --> 00:41:08,319
there is a mic since this is being

1152
00:41:12,069 --> 00:41:09,920
broadcast so we can all hear your

1153
00:41:15,109 --> 00:41:12,079
questions not just me and i'll try to

1154
00:41:17,270 --> 00:41:15,119
remember to repeat them out loud too if

1155
00:41:20,069 --> 00:41:17,280
if we need to go ahead

1156
00:41:22,550 --> 00:41:20,079
hi um i was wondering you mentioned uh

1157
00:41:25,190 --> 00:41:22,560
that there's some sort of fungus that

1158
00:41:26,069 --> 00:41:25,200
could survive on mars oh this is cool

1159
00:41:28,069 --> 00:41:26,079
okay

1160
00:41:29,750 --> 00:41:28,079
i don't know exactly the authors of this

1161
00:41:31,990 --> 00:41:29,760
paper but there's this lichen that they

1162
00:41:33,710 --> 00:41:32,000
found in antarctica now lichen is it's a

1163
00:41:35,589 --> 00:41:33,720

combination of a fungus and a

1164
00:41:37,750 --> 00:41:35,599
cyanobacteria that live in this

1165
00:41:40,950 --> 00:41:37,760
symbiotic relationship they sort of need

1166
00:41:41,750 --> 00:41:40,960
each other to survive and the group took

1167
00:41:43,510 --> 00:41:41,760
that

1168
00:41:45,829 --> 00:41:43,520
lichen and then they put it into a marsh

1169
00:41:47,990 --> 00:41:45,839
chamber and they put it some of it sort

1170
00:41:49,750 --> 00:41:48,000
of under a rock kind of shielded from uv

1171
00:41:52,150 --> 00:41:49,760
radiation and then the other one was

1172
00:41:53,829 --> 00:41:52,160
exposed and then they stuck it in there

1173
00:41:56,550 --> 00:41:53,839
for i think it was a couple of months

1174
00:41:58,150 --> 00:41:56,560
and it had you know mars temperature the

1175
00:42:00,470 --> 00:41:58,160
the atmospheric conditions were correct

1176
00:42:03,109 --> 00:42:00,480
and the uv radiation and it survived

1177
00:42:04,950 --> 00:42:03,119
which is crazy so i suggest if you just

1178
00:42:07,589 --> 00:42:04,960
google something like mars antarctica

1179
00:42:09,510 --> 00:42:07,599
lichen you'll probably find the paper

1180
00:42:10,950 --> 00:42:09,520
but it's fascinating that i mean every

1181
00:42:12,710 --> 00:42:10,960
place on earth that we look for life

1182
00:42:14,630 --> 00:42:12,720
pretty much we find it and there are

1183
00:42:16,950 --> 00:42:14,640
plenty of conditions out there in the

1184
00:42:19,270 --> 00:42:16,960
solar system places like mars europa

1185
00:42:21,430 --> 00:42:19,280
enceladus where life as we know it could

1186
00:42:23,510 --> 00:42:21,440
survive and it's fun to be pushing those

1187
00:42:26,069 --> 00:42:23,520
bounds and to see exactly what could be

1188
00:42:27,510 --> 00:42:26,079

transplanted and be growing there today

1189
00:42:29,750 --> 00:42:27,520
is there anything else that we know of

1190
00:42:32,069 --> 00:42:29,760
that could survive sure there's

1191
00:42:33,910 --> 00:42:32,079
something called bacterial spores that

1192
00:42:35,430 --> 00:42:33,920
these are certain types of bacteria when

1193
00:42:37,990 --> 00:42:35,440
they're put in stressful conditions they

1194
00:42:40,790 --> 00:42:38,000
go into like this hibernation state

1195
00:42:42,390 --> 00:42:40,800
and those spores can survive in space

1196
00:42:44,390 --> 00:42:42,400
they could have survived some sort of

1197
00:42:47,190 --> 00:42:44,400
meteoritic transfer between earth and

1198
00:42:49,190 --> 00:42:47,200
mars based on modeling and stuff we

1199
00:42:51,430 --> 00:42:49,200
found some on earth in halite crystals

1200
00:42:53,750 --> 00:42:51,440
that were on the order of i believe uh

1201
00:42:55,109 --> 00:42:53,760
10 to 100 million years old really old

1202
00:42:57,030 --> 00:42:55,119
it's kind of controversial because we're

1203
00:42:58,870 --> 00:42:57,040
not sure if they were deposited when the

1204
00:42:59,829 --> 00:42:58,880
halite crystal formed or if they came in

1205
00:43:01,430 --> 00:42:59,839
later

1206
00:43:03,030 --> 00:43:01,440
we've also found spores in amber that's

1207
00:43:04,710 --> 00:43:03,040
like 50 000 years old so there are

1208
00:43:06,790 --> 00:43:04,720
things that can hang around that can

1209
00:43:09,349 --> 00:43:06,800
resist those uh conditions those

1210
00:43:11,109 --> 00:43:09,359
extremes even in space that could

1211
00:43:13,589 --> 00:43:11,119
potentially be somewhere else

1212
00:43:16,230 --> 00:43:13,599
thank you yeah thank you good questions

1213
00:43:19,510 --> 00:43:16,240

that's great yeah did the 50 million

1214
00:43:21,349 --> 00:43:19,520
year old scores did they uh regenerate

1215
00:43:23,670 --> 00:43:21,359
they reanimate i mean so the question

1216
00:43:25,589 --> 00:43:23,680
was did those 50 million year old spores

1217
00:43:27,349 --> 00:43:25,599
regenerate and they were regenerated in

1218
00:43:30,550 --> 00:43:27,359
a lab to my knowledge

1219
00:43:32,550 --> 00:43:30,560
so that was what was so exciting

1220
00:43:35,990 --> 00:43:32,560
uh do you intend to use

1221
00:43:37,990 --> 00:43:36,000
nano technologies in your analogs

1222
00:43:40,309 --> 00:43:38,000
nano technologies in the analogs like

1223
00:43:43,109 --> 00:43:40,319
like how so can you be more specific uh

1224
00:43:46,309 --> 00:43:43,119
well for example uh

1225
00:43:47,109 --> 00:43:46,319
nano carbon nano tubes

1226
00:43:50,230 --> 00:43:47,119
to

1227
00:43:51,190 --> 00:43:50,240
dissuade the radiation that comes in oh

1228
00:43:53,430 --> 00:43:51,200
sure

1229
00:43:55,349 --> 00:43:53,440
we have lots of plans for using sort of

1230
00:43:57,109 --> 00:43:55,359
up and coming technologies like that

1231
00:43:59,270 --> 00:43:57,119
some of the work that i did as a postdoc

1232
00:44:00,630 --> 00:43:59,280
was doing microfluidic

1233
00:44:02,309 --> 00:44:00,640
techniques things that can take an

1234
00:44:03,990 --> 00:44:02,319
entire lab you know biologists and

1235
00:44:06,470 --> 00:44:04,000
chemists working in a lab on a bench and

1236
00:44:08,950 --> 00:44:06,480
condense it down into a tiny little

1237
00:44:10,390 --> 00:44:08,960
chip that instead of moving like instead

1238
00:44:11,990 --> 00:44:10,400

of having wires and move electrons

1239
00:44:14,069 --> 00:44:12,000
around you have channels that move

1240
00:44:15,829 --> 00:44:14,079
liquid around and you can do an entire

1241
00:44:18,309 --> 00:44:15,839
suite of organic chemist chemical

1242
00:44:20,230 --> 00:44:18,319
analyses on a tiny little they call it a

1243
00:44:21,589 --> 00:44:20,240
lab on a chip because that's what it is

1244
00:44:24,150 --> 00:44:21,599
so there are sorts of things like that

1245
00:44:25,990 --> 00:44:24,160
that we are advancing the technology of

1246
00:44:27,510 --> 00:44:26,000
usually they have to get to a certain

1247
00:44:29,190 --> 00:44:27,520
threshold before we'll put them on a

1248
00:44:31,670 --> 00:44:29,200
mission it's called a technology

1249
00:44:33,349 --> 00:44:31,680
readiness level or trl it goes from one

1250
00:44:34,950 --> 00:44:33,359
to nine usually when you get to a six

1251
00:44:37,190 --> 00:44:34,960
they start to take you seriously for

1252
00:44:38,630 --> 00:44:37,200
planetary missions and this microfluidic

1253
00:44:40,309 --> 00:44:38,640
stuff is getting to that point i'm not

1254
00:44:41,589 --> 00:44:40,319
sure exactly about the carbon nanotube

1255
00:44:43,829 --> 00:44:41,599
stuff but i'm sure someone's pushing

1256
00:44:45,750 --> 00:44:43,839
that technology along thank you thank

1257
00:44:47,030 --> 00:44:45,760
you

1258
00:44:48,710 --> 00:44:47,040
next victim

1259
00:44:49,670 --> 00:44:48,720
um at the risk of sounding a little like

1260
00:44:50,870 --> 00:44:49,680
darwin

1261
00:44:52,870 --> 00:44:50,880
some of what you were talking about for

1262
00:44:55,589 --> 00:44:52,880
the um

1263
00:44:57,510 --> 00:44:55,599

volcanic fields the lava fields

1264
00:44:58,710 --> 00:44:57,520
sounds like the way cities organically

1265
00:45:00,069 --> 00:44:58,720
create where first they're kind of

1266
00:45:01,349 --> 00:45:00,079
esoterically populated and then

1267
00:45:03,109 --> 00:45:01,359
eventually as they reach a certain

1268
00:45:05,349 --> 00:45:03,119
critical mass they start to stabilize in

1269
00:45:07,829 --> 00:45:05,359
terms of what areas are

1270
00:45:09,589 --> 00:45:07,839
zoned for what

1271
00:45:11,109 --> 00:45:09,599
is there any am i just making that up in

1272
00:45:13,109 --> 00:45:11,119
my head or does that seem to have any

1273
00:45:15,109 --> 00:45:13,119
corollary that's a really interesting

1274
00:45:17,190 --> 00:45:15,119
point um

1275
00:45:18,950 --> 00:45:17,200
i mean we're just starting to try and

1276
00:45:20,470 --> 00:45:18,960
understand this and we're doing as many

1277
00:45:22,069 --> 00:45:20,480
measurements as we can right but more

1278
00:45:23,670 --> 00:45:22,079
data is better there could be sort of

1279
00:45:26,069 --> 00:45:23,680
micro environments happening right there

1280
00:45:28,069 --> 00:45:26,079
could be a localized uh warm patch or a

1281
00:45:29,430 --> 00:45:28,079
humid patch over here maybe

1282
00:45:31,270 --> 00:45:29,440
temperature's different because some of

1283
00:45:33,750 --> 00:45:31,280
these lava fields are still warm we were

1284
00:45:34,950 --> 00:45:33,760
having lunch near not right next to

1285
00:45:36,630 --> 00:45:34,960
because we didn't want to contaminate

1286
00:45:37,829 --> 00:45:36,640
but sort of near one of our sample sites

1287
00:45:39,430 --> 00:45:37,839
and i remember sitting on the ground

1288
00:45:41,349 --> 00:45:39,440

being like you know

1289
00:45:43,109 --> 00:45:41,359
my butt's getting a little warm and you

1290
00:45:44,550 --> 00:45:43,119
know things are still geologically

1291
00:45:46,950 --> 00:45:44,560
active in those areas and so there could

1292
00:45:48,390 --> 00:45:46,960
be small environments that we're not

1293
00:45:50,069 --> 00:45:48,400
capturing yet in our techniques that

1294
00:45:52,550 --> 00:45:50,079
we're planning on doing for future

1295
00:45:53,910 --> 00:45:52,560
expeditions but in terms of how cities

1296
00:45:55,910 --> 00:45:53,920
organize and things like that whenever

1297
00:45:58,790 --> 00:45:55,920
you get to complex

1298
00:46:01,109 --> 00:45:58,800
systems right there can be small things

1299
00:46:02,710 --> 00:46:01,119
that lead to large changes in terms of

1300
00:46:04,069 --> 00:46:02,720
how how things are distributed and

1301
00:46:05,430 --> 00:46:04,079
presented and there could be some

1302
00:46:06,870 --> 00:46:05,440
analogies there

1303
00:46:09,109 --> 00:46:06,880
absolutely

1304
00:46:11,510 --> 00:46:09,119
and then uh quickly for titan

1305
00:46:12,870 --> 00:46:11,520
is it possible that there could be

1306
00:46:14,150 --> 00:46:12,880
uh

1307
00:46:15,910 --> 00:46:14,160
not

1308
00:46:17,990 --> 00:46:15,920
environmental corollary for titan for

1309
00:46:19,750 --> 00:46:18,000
earth before the oxygen catastrophe when

1310
00:46:21,750 --> 00:46:19,760
most life wasn't

1311
00:46:24,630 --> 00:46:21,760
aerobic or i think i'm using the word

1312
00:46:26,710 --> 00:46:24,640
right yeah yes and no uh so

1313
00:46:28,790 --> 00:46:26,720

right back in earth's early history

1314
00:46:30,790 --> 00:46:28,800
there was less oxygen and there was a

1315
00:46:32,470 --> 00:46:30,800
point in time where there was some sort

1316
00:46:34,870 --> 00:46:32,480
of something magic turned on and

1317
00:46:37,349 --> 00:46:34,880
suddenly we were very oxygen rich

1318
00:46:39,109 --> 00:46:37,359
so in that sense titan can be an analog

1319
00:46:41,349 --> 00:46:39,119
but remember it's much much further away

1320
00:46:43,829 --> 00:46:41,359
from the sun it's a lot colder and so

1321
00:46:46,550 --> 00:46:43,839
certain things that would be a gas on

1322
00:46:48,069 --> 00:46:46,560
earth are liquid on titan okay so some

1323
00:46:49,990 --> 00:46:48,079
of those analogies you have to be

1324
00:46:51,030 --> 00:46:50,000
careful about how you draw them

1325
00:46:52,950 --> 00:46:51,040
one cool

1326
00:46:54,870 --> 00:46:52,960
fact that always gets me excited when i

1327
00:46:57,990 --> 00:46:54,880
think about titan is um so if you think

1328
00:46:59,670 --> 00:46:58,000
about uh what stars are most common in

1329
00:47:01,750 --> 00:46:59,680
the universe or at least in our corner

1330
00:47:04,069 --> 00:47:01,760
of the universe our star is actually not

1331
00:47:05,990 --> 00:47:04,079
the most common one red dwarfs are now

1332
00:47:07,910 --> 00:47:06,000
if you're a planet in a stable orbit

1333
00:47:11,430 --> 00:47:07,920
around a red dwarf you're not really

1334
00:47:13,349 --> 00:47:11,440
really close you're about 1au one atomic

1335
00:47:15,349 --> 00:47:13,359
or astronomical unit which is what earth

1336
00:47:17,750 --> 00:47:15,359
is from our sun you're about that far

1337
00:47:19,670 --> 00:47:17,760
away but red dwarfs are a lot dimmer

1338
00:47:22,470 --> 00:47:19,680

than our star so it turns out that if

1339
00:47:23,589 --> 00:47:22,480
you're 1au away from a red dwarf you get

1340
00:47:26,230 --> 00:47:23,599
about the same amount of light that

1341
00:47:27,829 --> 00:47:26,240
titan does so chances are just

1342
00:47:29,750 --> 00:47:27,839
statistically there are probably more

1343
00:47:31,910 --> 00:47:29,760
titans out there than earth's so if we

1344
00:47:33,589 --> 00:47:31,920
discover some new chemistry that could

1345
00:47:35,589 --> 00:47:33,599
happen that could potentially form

1346
00:47:38,069 --> 00:47:35,599
molecules important for life or support

1347
00:47:40,790 --> 00:47:38,079
life that would be a really

1348
00:47:44,710 --> 00:47:40,800
big sort of universal context discovery

1349
00:47:47,270 --> 00:47:45,430
hi

1350
00:47:49,990 --> 00:47:47,280
um

1351
00:47:51,829 --> 00:47:50,000
do we have strong reasons to believe

1352
00:47:54,550 --> 00:47:51,839
that there

1353
00:47:57,109 --> 00:47:54,560
might may be life on titan or was the

1354
00:48:00,790 --> 00:47:57,119
experiment that you did was that just to

1355
00:48:01,750 --> 00:48:00,800
investigate hydrologic uh processes

1356
00:48:03,430 --> 00:48:01,760
on them

1357
00:48:05,750 --> 00:48:03,440
yeah it's a good question it's a hard

1358
00:48:07,109 --> 00:48:05,760
question so

1359
00:48:09,349 --> 00:48:07,119
thinking from an astrobiology

1360
00:48:11,910 --> 00:48:09,359
perspective places like this with tons

1361
00:48:13,349 --> 00:48:11,920
of organic molecules are really exciting

1362
00:48:16,230 --> 00:48:13,359
right because what do we eat we eat

1363
00:48:18,230 --> 00:48:16,240

organic molecules all life needs those

1364
00:48:20,309 --> 00:48:18,240
type of building blocks to be able to

1365
00:48:22,470 --> 00:48:20,319
make the structures that they use to

1366
00:48:24,150 --> 00:48:22,480
exist at least life as we know it right

1367
00:48:26,950 --> 00:48:24,160
now titan is unique because it's got

1368
00:48:28,790 --> 00:48:26,960
these alien exotic solvents of methane

1369
00:48:30,950 --> 00:48:28,800
and ethane and it would be so cool and

1370
00:48:32,630 --> 00:48:30,960
lots of scientists are working on

1371
00:48:34,549 --> 00:48:32,640
theories of what kind of life could

1372
00:48:36,150 --> 00:48:34,559
exist in these places but you have to

1373
00:48:38,230 --> 00:48:36,160
remember that

1374
00:48:39,589 --> 00:48:38,240
these are very cold places now when

1375
00:48:41,109 --> 00:48:39,599
things are cold not a lot of stuff

1376
00:48:43,270 --> 00:48:41,119
dissolves right we've done some

1377
00:48:45,190 --> 00:48:43,280
experiments that demonstrate that

1378
00:48:48,069 --> 00:48:45,200
and life at least as we know it needs

1379
00:48:50,549 --> 00:48:48,079
large molecules in order to store and

1380
00:48:52,470 --> 00:48:50,559
transfer information like your dna like

1381
00:48:54,470 --> 00:48:52,480
your proteins those molecules have to be

1382
00:48:56,710 --> 00:48:54,480
pretty big so they can store information

1383
00:48:58,309 --> 00:48:56,720
and store function so your proteins can

1384
00:49:00,230 --> 00:48:58,319
bend and fold in certain ways to do

1385
00:49:03,430 --> 00:49:00,240
certain processes that are important for

1386
00:49:05,430 --> 00:49:03,440
your your cells to work properly

1387
00:49:07,829 --> 00:49:05,440
when it comes to methane and ethane not

1388
00:49:10,150 --> 00:49:07,839

a lot of large molecules can dissolve

1389
00:49:12,069 --> 00:49:10,160
it's just too cold and it's not as good

1390
00:49:13,750 --> 00:49:12,079
of a solvent as water now that doesn't

1391
00:49:15,750 --> 00:49:13,760
mean that life couldn't exist in a place

1392
00:49:18,470 --> 00:49:15,760
like this it just means it's harder for

1393
00:49:20,790 --> 00:49:18,480
us to come up with some good examples of

1394
00:49:23,510 --> 00:49:20,800
life at least with our earth hat on

1395
00:49:25,510 --> 00:49:23,520
thinking like we do that as life as we

1396
00:49:26,870 --> 00:49:25,520
know it but there are other solvents too

1397
00:49:28,950 --> 00:49:26,880
not just those that could exist out

1398
00:49:31,510 --> 00:49:28,960
there in the solar or in the universe

1399
00:49:33,190 --> 00:49:31,520
ammonia is a good example that can host

1400
00:49:34,710 --> 00:49:33,200
all sorts of really interesting and

1401
00:49:37,270 --> 00:49:34,720
interesting molecules

1402
00:49:39,109 --> 00:49:37,280
co2 supercritical co2 if it's under

1403
00:49:41,270 --> 00:49:39,119
pressure can dissolve things just as

1404
00:49:43,349 --> 00:49:41,280
well as water can so there are other

1405
00:49:45,430 --> 00:49:43,359
exotic forms of

1406
00:49:48,470 --> 00:49:45,440
liquids that could potentially host life

1407
00:49:50,630 --> 00:49:48,480
elsewhere in the universe

1408
00:49:52,309 --> 00:49:50,640
i i think i remember

1409
00:49:55,030 --> 00:49:52,319
hearing or reading about it somewhere

1410
00:49:57,750 --> 00:49:55,040
that like titan's atmosphere

1411
00:49:59,549 --> 00:49:57,760
the uh i guess it's nitrogen and a lot

1412
00:50:02,230 --> 00:49:59,559
of methane came from like the

1413
00:50:05,030 --> 00:50:02,240

decomposition of ammonia or something

1414
00:50:07,190 --> 00:50:05,040
like that there's an equilibrium between

1415
00:50:10,309 --> 00:50:07,200
nitrogen and ammonia that happens so

1416
00:50:12,150 --> 00:50:10,319
nitrogen n2 ammonia nh3

1417
00:50:14,069 --> 00:50:12,160
there's a relationship between those two

1418
00:50:15,109 --> 00:50:14,079
molecules and you can actually use that

1419
00:50:19,510 --> 00:50:15,119
to

1420
00:50:20,470 --> 00:50:19,520
sort of date how old things are um so

1421
00:50:22,790 --> 00:50:20,480
there

1422
00:50:24,470 --> 00:50:22,800
places like titan we we can look at that

1423
00:50:26,710 --> 00:50:24,480
and study that

1424
00:50:29,109 --> 00:50:26,720
but in terms of like the exact age i'm

1425
00:50:31,349 --> 00:50:29,119
not very uh familiar with that

1426
00:50:33,510 --> 00:50:31,359
thank you thank you very much

1427
00:50:35,109 --> 00:50:33,520
so go go ahead and use the mic please if

1428
00:50:41,910 --> 00:50:35,119
you don't mind i can also repeat your

1429
00:50:46,150 --> 00:50:43,510
thank you so you're talking about

1430
00:50:48,230 --> 00:50:46,160
organic material and life how do we go

1431
00:50:51,190 --> 00:50:48,240
from there and is there a definition of

1432
00:50:55,270 --> 00:50:51,200
life for this project

1433
00:50:57,270 --> 00:50:55,280
okay um we'd astrobiologists biologists

1434
00:50:58,230 --> 00:50:57,280
it's hard to agree on a definition of

1435
00:51:00,230 --> 00:50:58,240
life

1436
00:51:01,910 --> 00:51:00,240
uh one of the

1437
00:51:03,510 --> 00:51:01,920
things that we'll look for

1438
00:51:05,510 --> 00:51:03,520

at least when we're looking for places

1439
00:51:06,950 --> 00:51:05,520
where water is a liquid is we'll look

1440
00:51:08,549 --> 00:51:06,960
for life as we know it because it's

1441
00:51:10,230 --> 00:51:08,559
using the same solvent

1442
00:51:12,549 --> 00:51:10,240
and it's probably going to use a lot of

1443
00:51:14,790 --> 00:51:12,559
the same atoms if you just look at the

1444
00:51:17,430 --> 00:51:14,800
abundances of of elements in the

1445
00:51:19,349 --> 00:51:17,440
universe right hydrogen really abundant

1446
00:51:21,349 --> 00:51:19,359
there's a ton of hydrogen next there's

1447
00:51:23,270 --> 00:51:21,359
helium and then there are the lighter

1448
00:51:24,470 --> 00:51:23,280
elements carbon hydrogen nitrogen the

1449
00:51:26,630 --> 00:51:24,480
things we use

1450
00:51:29,670 --> 00:51:26,640
now the which star trek episode is the

1451
00:51:32,069 --> 00:51:29,680
one that had the silicon based life

1452
00:51:34,150 --> 00:51:32,079
thank you

1453
00:51:35,589 --> 00:51:34,160
nice

1454
00:51:37,430 --> 00:51:35,599
so it's not to say things like that

1455
00:51:39,750 --> 00:51:37,440
couldn't exist it's just silicon is a

1456
00:51:42,470 --> 00:51:39,760
lot less abundant than carbon and as a

1457
00:51:44,630 --> 00:51:42,480
life form you want to use things that

1458
00:51:45,589 --> 00:51:44,640
are common around you

1459
00:51:48,150 --> 00:51:45,599
right because you don't want to be

1460
00:51:49,430 --> 00:51:48,160
starved for nutrients or building blocks

1461
00:51:52,230 --> 00:51:49,440
of things that you need in your

1462
00:51:55,109 --> 00:51:52,240
molecular machinery to to continue to

1463
00:51:56,710 --> 00:51:55,119

exist so most likely life that we find

1464
00:51:58,470 --> 00:51:56,720
is probably going to be composed of some

1465
00:52:00,549 --> 00:51:58,480
of those more common elements now they

1466
00:52:03,510 --> 00:52:00,559
may be combined in ways that are very

1467
00:52:05,190 --> 00:52:03,520
alien and different and here at jpl and

1468
00:52:07,430 --> 00:52:05,200
other places when we're starting to

1469
00:52:09,349 --> 00:52:07,440
think about what the next life detection

1470
00:52:11,030 --> 00:52:09,359
experiment should be we're keeping that

1471
00:52:13,270 --> 00:52:11,040
in mind we're trying to think as broadly

1472
00:52:15,430 --> 00:52:13,280
as we can but we're still going to be

1473
00:52:17,589 --> 00:52:15,440
looking for patterns of life that may

1474
00:52:18,950 --> 00:52:17,599
contain these molecules did that answer

1475
00:52:19,990 --> 00:52:18,960
your question

1476
00:52:22,950 --> 00:52:20,000
sort of

1477
00:52:28,150 --> 00:52:25,589
going from molecule to life going from

1478
00:52:30,309 --> 00:52:28,160
molecules to life okay well amino acids

1479
00:52:32,390 --> 00:52:30,319
are present in meteorites

1480
00:52:34,790 --> 00:52:32,400
lots of meteorites life didn't put them

1481
00:52:37,430 --> 00:52:34,800
there they formed naturally from things

1482
00:52:39,670 --> 00:52:37,440
that were available in the solar system

1483
00:52:41,829 --> 00:52:39,680
in the universe things that reacted

1484
00:52:44,309 --> 00:52:41,839
because they were in gas clouds that got

1485
00:52:46,309 --> 00:52:44,319
some energy from radiation from a star

1486
00:52:48,150 --> 00:52:46,319
nearby or something like that so these

1487
00:52:50,150 --> 00:52:48,160
molecules form

1488
00:52:52,950 --> 00:52:50,160

in in the universe and when they get

1489
00:52:54,390 --> 00:52:52,960
concentrated on a place like earth

1490
00:52:55,750 --> 00:52:54,400
where they're in an environment where

1491
00:52:57,349 --> 00:52:55,760
they could potentially react and

1492
00:52:58,950 --> 00:52:57,359
interact then

1493
00:53:00,950 --> 00:52:58,960
eventually at least we have one data

1494
00:53:02,470 --> 00:53:00,960
point that says that leads to life

1495
00:53:03,510 --> 00:53:02,480
now on

1496
00:53:07,990 --> 00:53:03,520
what was i going to say i was going to

1497
00:53:10,150 --> 00:53:08,000
say something else yeah so um on titan

1498
00:53:11,829 --> 00:53:10,160
we we again have these molecules and we

1499
00:53:13,510 --> 00:53:11,839
found that there there's something you

1500
00:53:15,190 --> 00:53:13,520
can make in the lab here called tholin

1501
00:53:16,710 --> 00:53:15,200
which is our best guesses to that that

1502
00:53:18,710 --> 00:53:16,720
sort of organic muck that's on the

1503
00:53:21,270 --> 00:53:18,720
surface this sort of beautiful brownish

1504
00:53:23,510 --> 00:53:21,280
orangish stuff uh carl sagan coined the

1505
00:53:25,589 --> 00:53:23,520
term comes from the greek tholos which

1506
00:53:27,030 --> 00:53:25,599
means muddy or not clear which is kind

1507
00:53:28,790 --> 00:53:27,040
of fun because we don't know what it's

1508
00:53:31,190 --> 00:53:28,800
made of and it's sort of muddy looking

1509
00:53:33,670 --> 00:53:31,200
um but when you put that in water it

1510
00:53:35,510 --> 00:53:33,680
automatically makes amino acids like

1511
00:53:37,270 --> 00:53:35,520
right there spontaneously so all you

1512
00:53:39,109 --> 00:53:37,280
would need was liquid water and you know

1513
00:53:41,910 --> 00:53:39,119

just sit and wait and you're making some

1514
00:53:44,150 --> 00:53:41,920
prebiotic molecules that could form life

1515
00:53:45,670 --> 00:53:44,160
so it's a it's a chemistry question i

1516
00:53:47,990 --> 00:53:45,680
think more than anything else if you've

1517
00:53:49,030 --> 00:53:48,000
got the stuff there and the chemical

1518
00:53:50,549 --> 00:53:49,040
conditions are right you're going to

1519
00:53:54,069 --> 00:53:50,559
form some interesting stuff and

1520
00:53:56,150 --> 00:53:54,079
hopefully maybe life one day

1521
00:53:58,710 --> 00:53:56,160
i'd like to understand why there's a

1522
00:54:01,270 --> 00:53:58,720
variation in these life forms in the

1523
00:54:02,390 --> 00:54:01,280
area you're measuring a little more we

1524
00:54:03,109 --> 00:54:02,400
would too

1525
00:54:05,270 --> 00:54:03,119
well

1526
00:54:08,549 --> 00:54:05,280
it seems to me one way would be just the

1527
00:54:10,230 --> 00:54:08,559
transport of material which must happen

1528
00:54:12,950 --> 00:54:10,240
it comes from somewhere else when it

1529
00:54:15,670 --> 00:54:12,960
originally ends up on these fresh lava

1530
00:54:18,790 --> 00:54:15,680
fields and on the other hand the life

1531
00:54:20,549 --> 00:54:18,800
forms themselves may be propagating

1532
00:54:22,549 --> 00:54:20,559
living dying certainly they can die

1533
00:54:25,750 --> 00:54:22,559
there whether they live and grow and so

1534
00:54:28,069 --> 00:54:25,760
on is another way the concentrations can

1535
00:54:30,630 --> 00:54:28,079
vary how much do you understand about

1536
00:54:32,230 --> 00:54:30,640
what causes the variations we don't

1537
00:54:34,309 --> 00:54:32,240
understand much about what causes those

1538
00:54:36,230 --> 00:54:34,319

variations and it's it's a point of

1539
00:54:39,190 --> 00:54:36,240
consternation that i really want to to

1540
00:54:41,750 --> 00:54:39,200
know what's going on so we've we've

1541
00:54:43,670 --> 00:54:41,760
brought as many sort of

1542
00:54:45,829 --> 00:54:43,680
techniques that we can bring to bear

1543
00:54:47,109 --> 00:54:45,839
we're bringing mineralogy experiments a

1544
00:54:49,109 --> 00:54:47,119
few things that i didn't get a chance to

1545
00:54:51,030 --> 00:54:49,119
talk about today we're measuring

1546
00:54:53,270 --> 00:54:51,040
temperature relative humidity things

1547
00:54:55,270 --> 00:54:53,280
like that and we're trying to expand

1548
00:54:57,270 --> 00:54:55,280
not just looking at the the general

1549
00:54:59,030 --> 00:54:57,280
kingdoms of life that's there but

1550
00:55:01,670 --> 00:54:59,040
looking more specifically then it

1551
00:55:03,750 --> 00:55:01,680
becomes a problem of manpower that our

1552
00:55:06,790 --> 00:55:03,760
team isn't quite large enough to be able

1553
00:55:09,670 --> 00:55:06,800
to address that entire sort of area

1554
00:55:11,670 --> 00:55:09,680
sample space of of parameters right that

1555
00:55:13,270 --> 00:55:11,680
we can look for so we're trying to do as

1556
00:55:15,270 --> 00:55:13,280
much as we can in the field when we're

1557
00:55:16,710 --> 00:55:15,280
there certain things that are transient

1558
00:55:17,990 --> 00:55:16,720
uh the amount of water in the sample the

1559
00:55:19,430 --> 00:55:18,000
amount of life that's there we'll look

1560
00:55:21,190 --> 00:55:19,440
at that right away but then we're

1561
00:55:23,030 --> 00:55:21,200
bringing our samples back to do the

1562
00:55:25,270 --> 00:55:23,040
mineralogy to do things that now we can

1563
00:55:27,190 --> 00:55:25,280

take our time and study in more detail

1564
00:55:28,870 --> 00:55:27,200
and so we're we're looking for these

1565
00:55:31,030 --> 00:55:28,880
correlations like i said if there are

1566
00:55:32,630 --> 00:55:31,040
micro environments present or if maybe

1567
00:55:34,470 --> 00:55:32,640
some hiker you know came along and

1568
00:55:36,069 --> 00:55:34,480
accidentally kicked our sample site i

1569
00:55:37,829 --> 00:55:36,079
mean these places we're only there for a

1570
00:55:39,270 --> 00:55:37,839
few weeks out of the year and who knows

1571
00:55:42,150 --> 00:55:39,280
what else is going on when we're not

1572
00:55:45,109 --> 00:55:42,160
there in fact some of our sites from fem

1573
00:55:47,270 --> 00:55:45,119
from 2013 when we came back in 2015

1574
00:55:49,910 --> 00:55:47,280
iceland had had a really wet winter and

1575
00:55:51,829 --> 00:55:49,920
some of them had snow on them and so we

1576
00:55:53,670 --> 00:55:51,839
we weren't able to use those sites again

1577
00:55:55,190 --> 00:55:53,680
and we in a way we didn't want to

1578
00:55:56,950 --> 00:55:55,200
because then that's that's too wet

1579
00:55:58,630 --> 00:55:56,960
that's not really like mars anymore so

1580
00:56:01,030 --> 00:55:58,640
we're trying to be better about

1581
00:56:03,270 --> 00:56:01,040
selecting sites in sort of lower

1582
00:56:05,670 --> 00:56:03,280
altitudes that won't get a chance to

1583
00:56:07,270 --> 00:56:05,680
potentially form as much snow

1584
00:56:09,190 --> 00:56:07,280
and other things like that as well but

1585
00:56:10,630 --> 00:56:09,200
it's a hard problem and we're hoping

1586
00:56:14,150 --> 00:56:10,640
that some of the information if we're

1587
00:56:16,230 --> 00:56:14,160
able to glean an idea of okay well you

1588
00:56:18,390 --> 00:56:16,240

mars rover go over here don't go over

1589
00:56:19,910 --> 00:56:18,400
there because it has x parameter we're

1590
00:56:23,670 --> 00:56:19,920
hoping that we'll be able to do that for

1591
00:56:27,190 --> 00:56:26,150
any other questions

1592
00:56:30,390 --> 00:56:27,200
yeah

1593
00:56:34,470 --> 00:56:30,400
what evidence is there about the uh

1594
00:56:37,030 --> 00:56:34,480
the duration of existence of oceans on

1595
00:56:40,549 --> 00:56:37,040
mars and the types of

1596
00:56:42,870 --> 00:56:40,559
uh things dissolved in the oceans that

1597
00:56:44,549 --> 00:56:42,880
that you could use earth as an analog

1598
00:56:46,230 --> 00:56:44,559
for in terms of

1599
00:56:48,150 --> 00:56:46,240
how long it took life to develop in the

1600
00:56:49,670 --> 00:56:48,160
oceans on earth do you have anything to

1601
00:56:51,670 --> 00:56:49,680
say about the likelihood that it could

1602
00:56:53,349 --> 00:56:51,680
have happened on mars okay so like what

1603
00:56:55,349 --> 00:56:53,359
you know so far so the question was

1604
00:56:57,030 --> 00:56:55,359
about oceans on mars how long have they

1605
00:56:59,349 --> 00:56:57,040
existed what could have been dissolved

1606
00:57:01,430 --> 00:56:59,359
in them and how can we use analogs on

1607
00:57:02,549 --> 00:57:01,440
earth to address that and that's a very

1608
00:57:04,390 --> 00:57:02,559
good question

1609
00:57:07,030 --> 00:57:04,400
our understanding right now is that mars

1610
00:57:09,349 --> 00:57:07,040
used to be a very warm and wet place had

1611
00:57:11,190 --> 00:57:09,359
water or liquid water on its surface for

1612
00:57:13,670 --> 00:57:11,200
extended periods of time there's

1613
00:57:15,589 --> 00:57:13,680

evidence that that the ph of that water

1614
00:57:17,510 --> 00:57:15,599
wasn't as extreme as we originally

1615
00:57:19,270 --> 00:57:17,520
thought so it may be more conducive to

1616
00:57:21,349 --> 00:57:19,280
life there were probably a lot of salts

1617
00:57:24,069 --> 00:57:21,359
dissolved in that too but there are lots

1618
00:57:25,030 --> 00:57:24,079
of salts in in our ocean waters as well

1619
00:57:27,030 --> 00:57:25,040
so

1620
00:57:29,349 --> 00:57:27,040
i think there's a large sample space

1621
00:57:31,510 --> 00:57:29,359
there in terms of what concentrations of

1622
00:57:33,750 --> 00:57:31,520
things could be present that there are

1623
00:57:36,150 --> 00:57:33,760
lots of scientists working in the lab to

1624
00:57:39,109 --> 00:57:36,160
try to simulate that we're interested

1625
00:57:40,470 --> 00:57:39,119
more on okay now life has had a chance

1626
00:57:42,549 --> 00:57:40,480
to get a foothold

1627
00:57:43,430 --> 00:57:42,559
in one of these these volcanic areas on

1628
00:57:44,789 --> 00:57:43,440
mars

1629
00:57:46,630 --> 00:57:44,799
and that those are the places that we're

1630
00:57:48,069 --> 00:57:46,640
sending our rovers to now are our

1631
00:57:50,549 --> 00:57:48,079
sampling

1632
00:57:52,549 --> 00:57:50,559
planetary missions there so that's where

1633
00:57:54,710 --> 00:57:52,559
we want to try to get a handle on what

1634
00:57:56,390 --> 00:57:54,720
kind of life may still be there what is

1635
00:57:58,470 --> 00:57:56,400
what is its distribution and if

1636
00:57:59,750 --> 00:57:58,480
something looks the same everywhere is

1637
00:58:02,230 --> 00:57:59,760
it really the same everywhere and we're

1638
00:58:03,750 --> 00:58:02,240

finding no so

1639
00:58:05,510 --> 00:58:03,760
but it's a good question there are a lot

1640
00:58:07,670 --> 00:58:05,520
of labs that are doing all sorts of cool

1641
00:58:10,390 --> 00:58:07,680
work to try to address what mars used to

1642
00:58:15,030 --> 00:58:12,870
okay well we hear about life being here

1643
00:58:16,309 --> 00:58:15,040
life being there and found over here and

1644
00:58:18,470 --> 00:58:16,319
not there

1645
00:58:19,750 --> 00:58:18,480
but what's your formula

1646
00:58:24,549 --> 00:58:19,760
on

1647
00:58:27,349 --> 00:58:25,430
well

1648
00:58:29,190 --> 00:58:27,359
have you ever thought of that who does

1649
00:58:32,069 --> 00:58:29,200
that there are some people that just

1650
00:58:34,150 --> 00:58:32,079
happens by accident

1651
00:58:37,270 --> 00:58:34,160
doesn't anybody isn't there a thought

1652
00:58:38,710 --> 00:58:37,280
out there somewhere oh sure

1653
00:58:40,309 --> 00:58:38,720
there are a lot of people working on the

1654
00:58:41,990 --> 00:58:40,319
original life and it depends on who you

1655
00:58:44,470 --> 00:58:42,000
talk to there are some people who

1656
00:58:45,829 --> 00:58:44,480
believe that life originated in some

1657
00:58:49,030 --> 00:58:45,839
type of a

1658
00:58:50,309 --> 00:58:49,040
warm pool on the surface where organics

1659
00:58:51,910 --> 00:58:50,319
were able to concentrate and then you

1660
00:58:53,750 --> 00:58:51,920
had energy sources

1661
00:58:55,510 --> 00:58:53,760
from the atmosphere and things raining

1662
00:58:57,030 --> 00:58:55,520
down in there's another camp that

1663
00:58:58,870 --> 00:58:57,040

believes that life may have originated

1664
00:59:01,109 --> 00:58:58,880
in hydrothermal vents down at the ocean

1665
00:59:02,710 --> 00:59:01,119
floor now from an astrobiology

1666
00:59:04,549 --> 00:59:02,720
perspective looking out in the rest of

1667
00:59:06,630 --> 00:59:04,559
the solar system this is really exciting

1668
00:59:08,789 --> 00:59:06,640
because we have places like europa and

1669
00:59:10,789 --> 00:59:08,799
enceladus that have pretty good evidence

1670
00:59:13,030 --> 00:59:10,799
that they may have hydrothermal activity

1671
00:59:15,510 --> 00:59:13,040
down underneath their ice shell in their

1672
00:59:17,430 --> 00:59:15,520
oceans and so if life formed here in

1673
00:59:19,109 --> 00:59:17,440
those kind of conditions you know what

1674
00:59:21,030 --> 00:59:19,119
are the chances that life could also be

1675
00:59:21,829 --> 00:59:21,040
present in one of these places

1676
00:59:23,829 --> 00:59:21,839
so

1677
00:59:25,829 --> 00:59:23,839
in terms of the exact

1678
00:59:27,670 --> 00:59:25,839
molecular reactions that happen that

1679
00:59:29,670 --> 00:59:27,680
depends on a lot of different factors

1680
00:59:31,990 --> 00:59:29,680
there are certain associations that are

1681
00:59:34,710 --> 00:59:32,000
favored in certain temperature regimes

1682
00:59:36,710 --> 00:59:34,720
in under certain phs certain redox

1683
00:59:38,390 --> 00:59:36,720
gradients you know if it's oxidized or

1684
00:59:40,950 --> 00:59:38,400
reducing certain reactions will be

1685
00:59:42,470 --> 00:59:40,960
favored and they'll form certain things

1686
00:59:43,750 --> 00:59:42,480
uh there are a lot of experiments going

1687
00:59:46,549 --> 00:59:43,760
on to

1688
00:59:48,309 --> 00:59:46,559

understand exactly what um

1689
00:59:49,750 --> 00:59:48,319
you know if you have a very acidic ph

1690
00:59:51,510 --> 00:59:49,760
and you have certain concentrations of

1691
00:59:53,910 --> 00:59:51,520
things and it's reducing

1692
00:59:55,510 --> 00:59:53,920
what forms what spontaneously forms and

1693
00:59:57,109 --> 00:59:55,520
what degrades and sort of what things

1694
00:59:59,510 --> 00:59:57,119
can you make and then people looking in

1695
01:00:01,270 --> 00:59:59,520
other conditions as well so all i can

1696
01:00:02,470 --> 01:00:01,280
say is there's a lot going on and when

1697
01:00:04,150 --> 01:00:02,480
someone makes

1698
01:00:08,470 --> 01:00:04,160
life in the lab you will definitely hear

1699
01:00:13,430 --> 01:00:10,870
yeah but you know it's just like

1700
01:00:15,030 --> 01:00:13,440
let's say a computer itself represents

1701
01:00:16,789 --> 01:00:15,040
life

1702
01:00:17,910 --> 01:00:16,799
and you turn it on and there it is and

1703
01:00:20,069 --> 01:00:17,920
all of a sudden you see a bunch of

1704
01:00:23,270 --> 01:00:20,079
things on it

1705
01:00:25,990 --> 01:00:23,280
well it just doesn't happen like that

1706
01:00:27,270 --> 01:00:26,000
there has to be some kind of formula

1707
01:00:34,710 --> 01:00:27,280
to

1708
01:00:36,390 --> 01:00:34,720
fish

1709
01:00:37,829 --> 01:00:36,400
or a bear

1710
01:00:40,069 --> 01:00:37,839
or what

1711
01:00:42,230 --> 01:00:40,079
or a human being i think part of that

1712
01:00:44,789 --> 01:00:42,240
formula is chemistry right it's it's

1713
01:00:46,470 --> 01:00:44,799

entropy it's a randomness it's these

1714
01:00:49,030 --> 01:00:46,480
fundamental physical parameters that

1715
01:00:51,829 --> 01:00:49,040
define our universe uh moving things

1716
01:00:53,349 --> 01:00:51,839
from from you know order to disorder

1717
01:00:55,030 --> 01:00:53,359
that type of thing

1718
01:00:56,950 --> 01:00:55,040
energy gradients right moving things

1719
01:00:59,430 --> 01:00:56,960
from a higher energy molecule something

1720
01:01:01,190 --> 01:00:59,440
that say has high energy bonds in it to

1721
01:01:03,190 --> 01:01:01,200
lower energy bonds and gaining energy

1722
01:01:05,349 --> 01:01:03,200
from that essentially that's all life is

1723
01:01:07,349 --> 01:01:05,359
is catalysis it's getting over that

1724
01:01:09,030 --> 01:01:07,359
activation energy barrier to get to a

1725
01:01:11,589 --> 01:01:09,040
lower energetic state and using that

1726
01:01:13,750 --> 01:01:11,599
energy it's as expressed as life that's

1727
01:01:16,069 --> 01:01:13,760
what we all do right we eat food and

1728
01:01:20,390 --> 01:01:16,079
then we we breathe out co2 and we give

1729
01:01:25,270 --> 01:01:23,750
so i if there was a formula someone

1730
01:01:27,430 --> 01:01:25,280
you know it doesn't mean that there

1731
01:01:29,990 --> 01:01:27,440
doesn't exist one one doesn't exist but

1732
01:01:31,670 --> 01:01:30,000
it it is complicated we're very complex

1733
01:01:32,710 --> 01:01:31,680
systems well

1734
01:01:34,390 --> 01:01:32,720
life is

1735
01:01:36,230 --> 01:01:34,400
the motion

1736
01:01:38,470 --> 01:01:36,240
of these items

1737
01:01:41,109 --> 01:01:38,480
the question is just

1738
01:01:42,470 --> 01:01:41,119

where is this motion going to and how is

1739
01:01:44,230 --> 01:01:42,480
it going to form

1740
01:01:46,950 --> 01:01:44,240
and of course you can't answer me that

1741
01:01:47,910 --> 01:01:46,960
question thank you thank you

1742
01:01:50,950 --> 01:01:47,920
it's always good to have these

1743
01:01:56,230 --> 01:01:53,190
right i have an another strange but

1744
01:01:58,470 --> 01:01:56,240
quick question okay um you say quick but

1745
01:02:00,950 --> 01:01:58,480
let's see

1746
01:02:03,510 --> 01:02:00,960
i believe it was back like in uh may

1747
01:02:05,670 --> 01:02:03,520
10th uh when mercury was crossing across

1748
01:02:06,630 --> 01:02:05,680
the sun yeah the transit the transit

1749
01:02:07,750 --> 01:02:06,640
yeah

1750
01:02:09,510 --> 01:02:07,760
um

1751
01:02:11,910 --> 01:02:09,520
i'm not sure if this article is correct

1752
01:02:13,829 --> 01:02:11,920
and the video is what i saw but this

1753
01:02:15,349 --> 01:02:13,839
amateur astronomer by the name of paul

1754
01:02:16,710 --> 01:02:15,359
cox i believe

1755
01:02:19,030 --> 01:02:16,720
he was showing the

1756
01:02:20,549 --> 01:02:19,040
broadcast live through a solar telescope

1757
01:02:21,750 --> 01:02:20,559
i don't know it was the sleuth system or

1758
01:02:23,670 --> 01:02:21,760
what

1759
01:02:26,150 --> 01:02:23,680
and you can see

1760
01:02:27,750 --> 01:02:26,160
you mentioned red dwarf so that's why

1761
01:02:28,870 --> 01:02:27,760
i had to bring it up

1762
01:02:31,270 --> 01:02:28,880
um

1763
01:02:32,470 --> 01:02:31,280

he saw he was the sun and then murphy

1764
01:02:34,069 --> 01:02:32,480
was crossing

1765
01:02:36,069 --> 01:02:34,079
next to it was another son and there's

1766
01:02:38,309 --> 01:02:36,079
been a lot of talk about this

1767
01:02:40,230 --> 01:02:38,319
and he explained that that was uh our

1768
01:02:42,150 --> 01:02:40,240
our red dwarf that we belong to of our

1769
01:02:45,270 --> 01:02:42,160
binary system

1770
01:02:47,430 --> 01:02:45,280
and yeah you could see it clearly and um

1771
01:02:49,190 --> 01:02:47,440
there's a lot of talk about this and

1772
01:02:52,230 --> 01:02:49,200
i've seen pictures of it like in the old

1773
01:02:53,990 --> 01:02:52,240
1930s britannica encyclopedias

1774
01:02:56,789 --> 01:02:54,000
explaining that we have or we're a part

1775
01:02:57,670 --> 01:02:56,799
of a binary so we're like tatooine

1776
01:02:59,589 --> 01:02:57,680
cool

1777
01:03:01,190 --> 01:02:59,599
so do you know anything about it binary

1778
01:03:02,630 --> 01:03:01,200
star systems are a lot more common than

1779
01:03:03,990 --> 01:03:02,640
most people think i don't know the exact

1780
01:03:06,549 --> 01:03:04,000
percentage but it's a significant

1781
01:03:08,069 --> 01:03:06,559
percentage of of star systems that are

1782
01:03:08,950 --> 01:03:08,079
out there i hadn't heard anything about

1783
01:03:11,270 --> 01:03:08,960
this

1784
01:03:12,710 --> 01:03:11,280
it's interesting i think

1785
01:03:14,549 --> 01:03:12,720
in terms of all of the the mission

1786
01:03:17,029 --> 01:03:14,559
planning mission design that we do when

1787
01:03:18,470 --> 01:03:17,039
we plan trajectories for say cassini to

1788
01:03:20,470 --> 01:03:18,480

get out to the saturn system and we're

1789
01:03:21,990 --> 01:03:20,480
planning for this new europa mission

1790
01:03:24,230 --> 01:03:22,000
that's going to go

1791
01:03:25,829 --> 01:03:24,240
orbit around jupiter and visit europa we

1792
01:03:27,589 --> 01:03:25,839
have to plan those maneuvers very

1793
01:03:29,029 --> 01:03:27,599
carefully and

1794
01:03:30,789 --> 01:03:29,039
it seems to me if there was something

1795
01:03:32,870 --> 01:03:30,799
like that there that would affect our

1796
01:03:34,789 --> 01:03:32,880
spacecraft

1797
01:03:36,630 --> 01:03:34,799
but you know we we have to do orbit trim

1798
01:03:37,670 --> 01:03:36,640
maneuvers we have to modify things all

1799
01:03:40,150 --> 01:03:37,680
the time

1800
01:03:42,470 --> 01:03:40,160
we have to check for a cassini which is

1801
01:03:44,470 --> 01:03:42,480
right over there whenever we're getting

1802
01:03:46,950 --> 01:03:44,480
close to titan to do a slingshot around

1803
01:03:48,870 --> 01:03:46,960
to to continue to do some analyses of

1804
01:03:50,390 --> 01:03:48,880
the saturn system we're always checking

1805
01:03:52,470 --> 01:03:50,400
the positions of the other moons it's

1806
01:03:53,990 --> 01:03:52,480
called the ephemeris to make sure that

1807
01:03:55,109 --> 01:03:54,000
we are where we think we are and they

1808
01:03:57,190 --> 01:03:55,119
are where we think they are and

1809
01:03:58,470 --> 01:03:57,200
sometimes we have to do corrections

1810
01:04:03,430 --> 01:03:58,480
so

1811
01:04:07,990 --> 01:04:06,470
any other questions

1812
01:04:09,270 --> 01:04:08,000
all right well oh good we've got one

1813
01:04:10,789 --> 01:04:09,280

from the web

1814
01:04:12,470 --> 01:04:10,799
let's see

1815
01:04:15,829 --> 01:04:12,480
bk bkpr1

1816
01:04:16,950 --> 01:04:15,839
asks have you seen biomats on earth is

1817
01:04:18,870 --> 01:04:16,960
there anything in your research that

1818
01:04:22,390 --> 01:04:18,880
says biomats could have formed on mars

1819
01:04:24,870 --> 01:04:22,400
good question okay so we we see biomats

1820
01:04:27,430 --> 01:04:24,880
in a lot of places on earth now i'm not

1821
01:04:29,910 --> 01:04:27,440
a geochemist so i can't speak about them

1822
01:04:32,230 --> 01:04:29,920
in any detail but i know these microbial

1823
01:04:34,630 --> 01:04:32,240
mats form and we also see evidence of

1824
01:04:35,990 --> 01:04:34,640
them in the geological record too uh

1825
01:04:37,670 --> 01:04:36,000
there are things like um

1826
01:04:39,750 --> 01:04:37,680
biovermiculation

1827
01:04:40,789 --> 01:04:39,760
is one thing where you see patterns or

1828
01:04:43,029 --> 01:04:40,799
fossils

1829
01:04:45,589 --> 01:04:43,039
fossilized microbial mats

1830
01:04:47,109 --> 01:04:45,599
and there are theories that we may see

1831
01:04:49,990 --> 01:04:47,119
something like this on mars these kind

1832
01:04:51,829 --> 01:04:50,000
of communities are extensive we see them

1833
01:04:54,150 --> 01:04:51,839
all in conditions that we may consider

1834
01:04:56,470 --> 01:04:54,160
to be extreme and so one of our goals

1835
01:04:58,150 --> 01:04:56,480
with curiosity and with a lot of other

1836
01:05:00,230 --> 01:04:58,160
future missions is to try to look for

1837
01:05:02,549 --> 01:05:00,240
this kind of evidence in some of these

1838
01:05:04,789 --> 01:05:02,559

these layered rocks that we see

1839
01:05:06,630 --> 01:05:04,799
so good question we see them here we're

1840
01:05:08,470 --> 01:05:06,640
hoping to see them elsewhere who knows

1841
01:05:09,670 --> 01:05:08,480
what the equivalent of a biomat would be

1842
01:05:11,029 --> 01:05:09,680
on titan

1843
01:05:12,230 --> 01:05:11,039
i don't even know how we would look for

1844
01:05:13,910 --> 01:05:12,240
that but

1845
01:05:17,910 --> 01:05:13,920
that would be an interesting thought

1846
01:05:22,069 --> 01:05:19,829
well i appreciate you guys coming out

1847
01:05:24,309 --> 01:05:22,079
and staying late and i will hang around

1848
01:05:26,549 --> 01:05:24,319
if you have more questions but continue

1849
01:05:28,069 --> 01:05:26,559
to ask questions and remember that even

1850
01:05:30,230 --> 01:05:28,079
your backyard could be an analog

1851
01:05:41,670 --> 01:05:30,240
environment for somewhere else