
AbSciCon
2017
MESA, ARIZONA

1
00:00:12,250 --> 00:00:06,150
you

2
00:03:07,810 --> 00:00:29,130
[Music]

3
00:03:12,770 --> 00:03:10,490
ladies and gentlemen good evening I'm

4
00:03:14,930 --> 00:03:12,780
Paul Davies director of the Beyond

5
00:03:18,640 --> 00:03:14,940
Center for fundamental concepts in

6
00:03:21,860 --> 00:03:18,650
science at Arizona State University and

7
00:03:25,190 --> 00:03:21,870
welcome to this special beyond Center

8
00:03:27,650 --> 00:03:25,200
event a panel discussion before we

9
00:03:32,630 --> 00:03:27,660
proceed could you just put your cell

10
00:03:38,080 --> 00:03:32,640
phones to silent I'll give you a moment

11
00:03:41,660 --> 00:03:38,090
to do that the beyond centers motto is

12
00:03:43,160 --> 00:03:41,670
confronting the big questions and one of

13
00:03:46,130 --> 00:03:43,170

the biggest of the big questions of

14
00:03:49,610 --> 00:03:46,140
existence is are we alone in the

15
00:03:53,090 --> 00:03:49,620
universe for most of the history of

16
00:03:55,850 --> 00:03:53,100
mankind this question has remained

17
00:03:58,970 --> 00:03:55,860
firmly in the province of religion and

18
00:04:03,770 --> 00:03:58,980
philosophy but in recent decades it's

19
00:04:06,320 --> 00:04:03,780
become part of science too I've been

20
00:04:08,479 --> 00:04:06,330
interested in whether or not we are

21
00:04:11,300 --> 00:04:08,489
alone in the possibility of life beyond

22
00:04:14,240 --> 00:04:11,310
Earth ever since I was a student in a

23
00:04:17,020 --> 00:04:14,250
different century and in those days

24
00:04:19,969 --> 00:04:17,030
there was an enormous skepticism about

25
00:04:22,520 --> 00:04:19,979
the possibility of life beyond Earth

26
00:04:25,909 --> 00:04:22,530
one might as well the professor interest

27
00:04:28,730 --> 00:04:25,919
in looking for fairies Francis Crick for

28
00:04:31,070 --> 00:04:28,740
example said life seems almost a miracle

29
00:04:34,130 --> 00:04:31,080
so many of the conditions for it to get

30
00:04:36,650 --> 00:04:34,140
going manok said that weird lasts know

31
00:04:41,230 --> 00:04:36,660
that we are alone in the universe

32
00:04:43,610 --> 00:04:41,240
out of which we emerged by chance alone

33
00:04:47,330 --> 00:04:43,620
now the pendulum has swung the other way

34
00:04:50,659 --> 00:04:47,340
and so already by the 1990s Christian de

35
00:04:53,360 --> 00:04:50,669
Duve was able to write that life seems

36
00:04:55,969 --> 00:04:53,370
almost inevitable and will crop up

37
00:04:58,550 --> 00:04:55,979
wherever conditions permitted and he had

38
00:04:59,860 --> 00:04:58,560

this wonderful phrase life is a cosmic

39
00:05:02,680 --> 00:04:59,870
imperative

40
00:05:05,750 --> 00:05:02,690
but in spite of this new upbeat

41
00:05:07,970 --> 00:05:05,760
sentiment we still have no direct

42
00:05:10,850 --> 00:05:07,980
evidence for any life beyond Earth let

43
00:05:12,860 --> 00:05:10,860
alone intelligent life and we remain

44
00:05:15,080 --> 00:05:12,870
almost completely in the dark about how

45
00:05:18,230 --> 00:05:15,090
non life turned into life

46
00:05:21,620 --> 00:05:18,240
was it a bizarre chemical fluke as

47
00:05:24,140 --> 00:05:21,630
Crixus opposed in which case we will be

48
00:05:26,810 --> 00:05:24,150
unique in the universe or is it as the

49
00:05:28,970 --> 00:05:26,820
dude said a cosmic imperative well the

50
00:05:32,690 --> 00:05:28,980
best way to find out is to go and look

51
00:05:35,900 --> 00:05:32,700
and that is the agenda of the subject of

52
00:05:39,260 --> 00:05:35,910
astrobiology and we meet here because of

53
00:05:42,650 --> 00:05:39,270
the NASA Astrobiology science conference

54
00:05:47,960 --> 00:05:42,660
which this year's is hosted here in

55
00:05:52,720 --> 00:05:47,970
Mason my thanks to NASA for facilitating

56
00:05:55,850 --> 00:05:52,730
this this evenings event end to the

57
00:05:58,820 --> 00:05:55,860
coordinators of the NASA Astrobiology

58
00:06:00,620 --> 00:05:58,830
science come from sense icon so I'm

59
00:06:02,300 --> 00:06:00,630
addressing these remarks to members of

60
00:06:05,630 --> 00:06:02,310
the public who may have joined us and a

61
00:06:06,980 --> 00:06:05,640
special welcome to you otherwise the

62
00:06:10,490 --> 00:06:06,990
people you see around you I think are

63
00:06:12,350 --> 00:06:10,500

all delegates of adds icon so the way

64
00:06:15,440 --> 00:06:12,360
we're going to handle this evening's

65
00:06:17,390 --> 00:06:15,450
events is that we have over here a

66
00:06:19,190 --> 00:06:17,400
distinguished panel of experts who I

67
00:06:21,350 --> 00:06:19,200
will introduce one by one in a moment

68
00:06:23,960 --> 00:06:21,360
and they're going to come up to the

69
00:06:27,110 --> 00:06:23,970
podium and give us their five minutes

70
00:06:30,620 --> 00:06:27,120
sales pitch as to where they think we're

71
00:06:33,230 --> 00:06:30,630
going to find life beyond death and then

72
00:06:35,990 --> 00:06:33,240
when that's over we'll facilitator I'll

73
00:06:38,870 --> 00:06:36,000
facilitate some conversation between the

74
00:06:41,000 --> 00:06:38,880
panelists and when that is over we'll

75
00:06:43,250 --> 00:06:41,010
open the floor to the audience we have

76
00:06:46,280 --> 00:06:43,260
two microphones there fuser come forward

77
00:06:48,500 --> 00:06:46,290
and ask your questions so I have said so

78
00:06:52,790 --> 00:06:48,510
pretty clear and the panelists are

79
00:06:53,930 --> 00:06:52,800
sitting not not for any sexist reasons

80
00:06:55,430 --> 00:06:53,940
but they're sitting in the order in

81
00:06:57,050 --> 00:06:55,440
which they're going to speak and there's

82
00:06:59,600 --> 00:06:57,060
some logic to this because we're an

83
00:07:04,160 --> 00:06:59,610
a-star way out there and coming closer

84
00:07:07,580 --> 00:07:04,170
to home and so first up here we have

85
00:07:09,020 --> 00:07:07,590
Vicki meadows CCS at this end she's from

86
00:07:11,810 --> 00:07:09,030
the University of Washington and the

87
00:07:13,220 --> 00:07:11,820
NASA Astrobiology Institute then we have

88
00:07:18,410 --> 00:07:13,230

Brittany Schmidt

89
00:07:20,180 --> 00:07:18,420
Georgia Tech then said Lana Scalia which

90
00:07:23,390 --> 00:07:20,190
she tells me mean scholar from the

91
00:07:25,670 --> 00:07:23,400
Carnegie Institution and then next to

92
00:07:28,010 --> 00:07:25,680
her is Sarah Walker and so come all the

93
00:07:30,890 --> 00:07:28,020
way from America's largest and greatest

94
00:07:33,050 --> 00:07:30,900
university which by conscience happens

95
00:07:35,830 --> 00:07:33,060
to be right here in Arizona not far away

96
00:07:39,340 --> 00:07:35,840
it's across Arizona State University's

97
00:07:41,990 --> 00:07:39,350
let's get that plug in then we have so

98
00:07:45,530 --> 00:07:42,000
Jeb hack misra with the Blue Marble

99
00:07:48,560 --> 00:07:45,540
space Institute and last but as you will

100
00:07:50,240 --> 00:07:48,570
soon find out by no means least Charlie

101
00:07:54,380 --> 00:07:50,250
nine Weaver of the Australian National

102
00:07:56,930 --> 00:07:54,390
University and I also as I mentioned

103
00:07:59,270 --> 00:07:56,940
from Arizona State University and seeing

104
00:08:02,450 --> 00:07:59,280
as we actually have three Australians

105
00:08:05,270 --> 00:08:02,460
here on the panel it's only fitting to

106
00:08:07,480 --> 00:08:05,280
mention that today is Anzac Day if that

107
00:08:10,580 --> 00:08:07,490
means anything to people in the audience

108
00:08:13,460 --> 00:08:10,590
so without further ado I'm going to ask

109
00:08:16,100 --> 00:08:13,470
each of our panelists to brave the steps

110
00:08:18,170 --> 00:08:16,110
they've got to go down up and then back

111
00:08:21,380 --> 00:08:18,180
again without falling over so be patient

112
00:08:22,610 --> 00:08:21,390
I'm ganna call upon Vicky Meadows to get

113
00:08:31,970 --> 00:08:22,620

the show started

114
00:08:36,290 --> 00:08:31,980
thank you thank you for introduction

115
00:08:39,320 --> 00:08:36,300
applause so my my position I'm taking

116
00:08:40,790 --> 00:08:39,330
today and in this debate is to say that

117
00:08:43,160 --> 00:08:40,800
I think that that the place where we

118
00:08:44,690 --> 00:08:43,170
will find that the first find the second

119
00:08:46,790 --> 00:08:44,700
incidence of life-forms actually on

120
00:08:48,860 --> 00:08:46,800
exoplanets and that may be a crazy

121
00:08:50,810 --> 00:08:48,870
position to take because exoplanets are

122
00:08:55,430 --> 00:08:50,820
literally light-years away they're very

123
00:08:57,440 --> 00:08:55,440
very far away however that there are

124
00:08:59,150 --> 00:08:57,450
some advantages to that I'm sure many of

125
00:09:00,410 --> 00:08:59,160
my colleagues here are going to argue to

126
00:09:01,910 --> 00:09:00,420
be much better for us to actually look

127
00:09:04,130 --> 00:09:01,920
in the solar system where things are

128
00:09:06,710 --> 00:09:04,140
nearby and when we can fly by and put

129
00:09:08,240 --> 00:09:06,720
probe down and study them but exoplanets

130
00:09:10,490 --> 00:09:08,250
have the following advantage and that

131
00:09:12,380 --> 00:09:10,500
there are a lot of them we think on

132
00:09:13,880 --> 00:09:12,390
average for the most common types of

133
00:09:16,700 --> 00:09:13,890
stars in our galaxy there's probably at

134
00:09:18,200 --> 00:09:16,710
least two planets per star also it

135
00:09:19,850 --> 00:09:18,210
allows us to look for planets that are

136
00:09:21,560 --> 00:09:19,860
more earth-like terrestrial planets

137
00:09:23,270 --> 00:09:21,570
whereas we don't have any other examples

138
00:09:24,710 --> 00:09:23,280

of habitable planets in our solar system

139
00:09:25,939 --> 00:09:24,720
so we can look for planets a lot more

140
00:09:28,319 --> 00:09:25,949
like Earth

141
00:09:29,609 --> 00:09:28,329
we can also and this is at the main

142
00:09:31,619 --> 00:09:29,619
point we can look for life on the

143
00:09:33,660 --> 00:09:31,629
surface of the planet we don't have to

144
00:09:35,549 --> 00:09:33,670
worry about trying to find life clinging

145
00:09:37,949 --> 00:09:35,559
by its microbial fingernails in some

146
00:09:39,809 --> 00:09:37,959
kind of extreme environment elsewhere in

147
00:09:41,729 --> 00:09:39,819
the solar system we can look for life

148
00:09:44,549 --> 00:09:41,739
that's abundant and happy on the surface

149
00:09:46,590 --> 00:09:44,559
and so as a result that life can produce

150
00:09:48,150 --> 00:09:46,600
a pretty large signal on the planet so

151
00:09:50,699 --> 00:09:48,160
even though the planet is very distant

152
00:09:51,929 --> 00:09:50,709
the signal may be very strong and so we

153
00:09:54,359 --> 00:09:51,939
might have a very good chance of seeing

154
00:09:55,889 --> 00:09:54,369
it so if we're going to look for the

155
00:09:56,819 --> 00:09:55,899
signal of life one of the things we

156
00:09:59,429 --> 00:09:56,829
probably want to look for is

157
00:10:01,769 --> 00:09:59,439
photosynthesis so photosynthesis modern

158
00:10:04,710 --> 00:10:01,779
photosynthesis harnesses carbon dioxide

159
00:10:06,569 --> 00:10:04,720
water vapor and sunlight things that

160
00:10:09,479 --> 00:10:06,579
should be very common on the surface of

161
00:10:11,549 --> 00:10:09,489
a habitable planet elsewhere so

162
00:10:13,739 --> 00:10:11,559
essentially these organisms have been

163
00:10:15,329 --> 00:10:13,749

able to do this and to cover our entire

164
00:10:17,429 --> 00:10:15,339
planet because there's water and carbon

165
00:10:20,910 --> 00:10:17,439
dioxide and sunlight everywhere so we

166
00:10:22,710 --> 00:10:20,920
see them in lakes in oceans on lands and

167
00:10:24,739 --> 00:10:22,720
in extreme environments even hot springs

168
00:10:27,929 --> 00:10:24,749
and and the poles we find life there

169
00:10:29,369 --> 00:10:27,939
that photosynthesizes so life the

170
00:10:31,590 --> 00:10:29,379
photosynthesizers have essentially

171
00:10:35,220 --> 00:10:31,600
developed the killer app they've managed

172
00:10:36,689 --> 00:10:35,230
to turn sunlight into food and as a

173
00:10:38,819 --> 00:10:36,699
result they have taken over the entire

174
00:10:41,039 --> 00:10:38,829
planet of course you've managed to

175
00:10:42,749 --> 00:10:41,049
subjugate them in the form of salads but

176
00:10:45,509 --> 00:10:42,759
nonetheless they are a force to be

177
00:10:47,369 --> 00:10:45,519
reckoned with and so the oxygen that

178
00:10:49,259 --> 00:10:47,379
they produce over billions of years

179
00:10:51,119 --> 00:10:49,269
microbes have produced this oxygen and

180
00:10:53,519 --> 00:10:51,129
it has now dominate the atmosphere of

181
00:10:57,030 --> 00:10:53,529
our environment our planet and we can

182
00:10:58,439 --> 00:10:57,040
see it over very great distances so if

183
00:11:00,210 --> 00:10:58,449
we were to look for this oxygen from

184
00:11:01,650 --> 00:11:00,220
photosynthesis it turns out that for

185
00:11:03,869 --> 00:11:01,660
astronomers it's very easy because

186
00:11:05,850 --> 00:11:03,879
oxygen has a lot of absorption bands a

187
00:11:07,710 --> 00:11:05,860
lot of ways that we can detect it to the

188
00:11:09,929 --> 00:11:07,720

visible to near infrared region of the

189
00:11:11,069 --> 00:11:09,939
spectrum and that is the region where we

190
00:11:13,979 --> 00:11:11,079
are going to be building our first

191
00:11:16,049 --> 00:11:13,989
telescopes so that is certainly a place

192
00:11:17,489 --> 00:11:16,059
we would like to look and oxygen sits

193
00:11:20,220 --> 00:11:17,499
right there in a place that we can look

194
00:11:21,960 --> 00:11:20,230
at oxygen is also mixed very evenly

195
00:11:23,280 --> 00:11:21,970
throughout our atmosphere there's so

196
00:11:24,900 --> 00:11:23,290
much of it that you can see it even

197
00:11:26,309 --> 00:11:24,910
above the clouds and even with

198
00:11:30,299 --> 00:11:26,319
techniques that look only through the

199
00:11:33,239 --> 00:11:30,309
upper atmosphere of our planet and very

200
00:11:34,710 --> 00:11:33,249
soon in the next year in fact we're

201
00:11:35,819 --> 00:11:34,720
going to launch a very large telescope

202
00:11:37,929 --> 00:11:35,829
called the James Webb Space Telescope

203
00:11:38,999 --> 00:11:37,939
which will be able to look at planets

204
00:11:41,859 --> 00:11:39,009
passing in front of this star

205
00:11:44,019 --> 00:11:41,869
potentially habitable ones and look for

206
00:11:47,169 --> 00:11:44,029
the signals of oxygen or its sister

207
00:11:48,189 --> 00:11:47,179
products like ozone in the atmosphere we

208
00:11:49,749 --> 00:11:48,199
also are building ground-based

209
00:11:51,429 --> 00:11:49,759
telescopes that can be upgraded with

210
00:11:53,259 --> 00:11:51,439
instrumentation that will ultimately

211
00:11:55,449 --> 00:11:53,269
allow us to also look for oxygen and

212
00:11:56,259 --> 00:11:55,459
potentially ozone on planets around M

213
00:11:58,599 --> 00:11:56,269

dwarf stars

214
00:12:02,139 --> 00:11:58,609
so this is coming in the next few years

215
00:12:03,669 --> 00:12:02,149
basically we also have targets that jwst

216
00:12:06,009 --> 00:12:03,679
could look for the recent discovery of

217
00:12:09,369 --> 00:12:06,019
the Trappist one system and the LHS

218
00:12:11,139 --> 00:12:09,379
11:40 B planet have already provided to

219
00:12:14,799 --> 00:12:11,149
ask targets that we know we can look for

220
00:12:16,659 --> 00:12:14,809
with JWST so in essence we're looking

221
00:12:18,189 --> 00:12:16,669
for planets that are more earth-like

222
00:12:19,839 --> 00:12:18,199
that have strong signals on them from

223
00:12:21,729 --> 00:12:19,849
photosynthesis life that covers the

224
00:12:23,769 --> 00:12:21,739
surface of the planet we have the

225
00:12:26,139 --> 00:12:23,779
instrumentation in the next few years to

226
00:12:27,999 --> 00:12:26,149
observe this and we already have the

227
00:12:30,089 --> 00:12:28,009
targets available and so for those

228
00:12:32,229 --> 00:12:30,099
reasons that's why I think exoplanets

229
00:12:34,899 --> 00:12:32,239
oxygen and the James Webb Space

230
00:12:38,649 --> 00:12:34,909
Telescope are the reason why we will

231
00:12:46,629 --> 00:12:38,659
find life first on exoplanets perfectly

232
00:12:49,659 --> 00:12:46,639
time so next I call upon Brittany who at

233
00:12:56,649 --> 00:12:49,669
Georgia Tech is apparently known as the

234
00:13:00,339 --> 00:12:56,659
robot woman all right oh I believe we're

235
00:13:02,439 --> 00:13:00,349
really proud of the balloons huh there

236
00:13:05,799 --> 00:13:02,449
we go I hadn't realized it was that easy

237
00:13:13,659 --> 00:13:05,809
I dunno I'll tell you what we might do

238
00:13:16,569 --> 00:13:13,669

with ripping them over here I thought

239
00:13:18,249 --> 00:13:16,579
you know takes it up we're not going to

240
00:13:20,019 --> 00:13:18,259
charge you for the times by messing with

241
00:13:24,729 --> 00:13:20,029
the pollution sir thank you

242
00:13:27,549 --> 00:13:24,739
take another 30 all right well hello

243
00:13:29,139 --> 00:13:27,559
everyone so I am going to talk to you

244
00:13:31,539 --> 00:13:29,149
about the potential for discovering life

245
00:13:34,089 --> 00:13:31,549
on the ocean rolls or the icy ocean

246
00:13:36,069 --> 00:13:34,099
worlds of the outer solar system and so

247
00:13:39,789 --> 00:13:36,079
I'm how many Arizonans do we have in the

248
00:13:41,079 --> 00:13:39,799
room turns out I'm also an Arizonan so

249
00:13:43,809 --> 00:13:41,089
if you're in Arizona and you know you've

250
00:13:46,029 --> 00:13:43,819
looked out especially here in Phoenix

251
00:13:48,189 --> 00:13:46,039
and you've pretty much seen everyday

252
00:13:50,020 --> 00:13:48,199
something very familiar and when you

253
00:13:52,870 --> 00:13:50,030
look at Mars you see something

254
00:13:54,280 --> 00:13:52,880
very familiar so that that desert

255
00:13:56,260 --> 00:13:54,290
landscape is kind of something that's

256
00:13:57,880 --> 00:13:56,270
kind of human and an experience that

257
00:14:01,530 --> 00:13:57,890
we've all had and what I'm going to

258
00:14:04,300 --> 00:14:01,540
actually ask you to do is to

259
00:14:06,420 --> 00:14:04,310
unimaginative it that's covered in

260
00:14:09,010 --> 00:14:06,430
oceans and in fact the polar oceans

261
00:14:10,450 --> 00:14:09,020
which are covered in ice and so let's

262
00:14:13,420 --> 00:14:10,460
bring this home to another environment

263
00:14:17,200 --> 00:14:13,430

on the earth that's very very shall we

264
00:14:19,770 --> 00:14:17,210
say alien and so our groups perspective

265
00:14:23,350 --> 00:14:19,780
or people that work on on icy satellites

266
00:14:25,750 --> 00:14:23,360
is our we're looking at the potential of

267
00:14:28,150 --> 00:14:25,760
life in an alien ocean but in one that's

268
00:14:29,830 --> 00:14:28,160
very very much so reminiscent of the

269
00:14:31,450 --> 00:14:29,840
things that we have here on our own

270
00:14:33,790 --> 00:14:31,460
planet so we're sitting on the original

271
00:14:35,200 --> 00:14:33,800
ocean planet and if you haven't been to

272
00:14:38,080 --> 00:14:35,210
Antarctica or the Arctic perhaps you've

273
00:14:39,670 --> 00:14:38,090
never seen it totally covered in ice but

274
00:14:42,010 --> 00:14:39,680
it's really not so alien at all to

275
00:14:44,170 --> 00:14:42,020
imagine an environment like that so when

276
00:14:46,660 --> 00:14:44,180
we think specifically about which ocean

277
00:14:48,580 --> 00:14:46,670
worlds we might think about the one at

278
00:14:50,410 --> 00:14:48,590
least for me that rises to the top is

279
00:14:53,200 --> 00:14:50,420
the moon that's shown here which is

280
00:14:55,000 --> 00:14:53,210
Europa so Europa is not the largest but

281
00:14:58,660 --> 00:14:55,010
is the innermost meaning closest to

282
00:15:01,120 --> 00:14:58,670
Jupiter of the icy ocean planets that

283
00:15:03,850 --> 00:15:01,130
orbit the giant planet and so this place

284
00:15:06,400 --> 00:15:03,860
is a really remarkable world that's

285
00:15:09,460 --> 00:15:06,410
given a long-term source of energy from

286
00:15:11,500 --> 00:15:09,470
tidal activity and what we know about it

287
00:15:13,150 --> 00:15:11,510
is that it's an ice shell that covers up

288
00:15:15,610 --> 00:15:13,160

an ocean that might not be so dissimilar

289
00:15:17,890 --> 00:15:15,620
from our own and so as we start to think

290
00:15:20,260 --> 00:15:17,900
about what in the ways in which Europa

291
00:15:22,870 --> 00:15:20,270
which is about the size of our own moon

292
00:15:24,850 --> 00:15:22,880
in fact just covered with this ice shell

293
00:15:26,590 --> 00:15:24,860
and ocean might be much like our own

294
00:15:27,880 --> 00:15:26,600
planet that's what I'd like you to think

295
00:15:30,040 --> 00:15:27,890
about here so I'm going to give you kind

296
00:15:32,260 --> 00:15:30,050
of four ways that Europa and the earth

297
00:15:33,880 --> 00:15:32,270
are very similar so the first one in

298
00:15:36,010 --> 00:15:33,890
fact is water so we talked a little bit

299
00:15:38,680 --> 00:15:36,020
about water here turns out that Europa

300
00:15:40,870 --> 00:15:38,690
has something like two to three times as

301
00:15:42,400 --> 00:15:40,880
much water as the earth does and so in

302
00:15:45,100 --> 00:15:42,410
fact we're not limited in any kind of

303
00:15:46,300 --> 00:15:45,110
way turns out what makes Europa special

304
00:15:48,640 --> 00:15:46,310
amongst the ocean worlds of the outer

305
00:15:50,829 --> 00:15:48,650
planets is that in fact it's so rocky

306
00:15:53,620 --> 00:15:50,839
and so it's got what we would call the

307
00:15:55,210 --> 00:15:53,630
chemistry or the right energy inputs

308
00:15:57,220 --> 00:15:55,220
into the system and so those are the

309
00:15:59,110 --> 00:15:57,230
other parts that we think about in terms

310
00:16:00,940 --> 00:15:59,120
of the chemistry so we've got water is

311
00:16:02,740 --> 00:16:00,950
our first ingredient in terms of

312
00:16:03,550 --> 00:16:02,750
chemistry we know we've got the silicate

313
00:16:08,199 --> 00:16:03,560

interior

314
00:16:10,540 --> 00:16:08,209
the data that we have so far suggests

315
00:16:13,720 --> 00:16:10,550
that it's got an iron core it's got an

316
00:16:15,790 --> 00:16:13,730
outer silicate mantle so very much like

317
00:16:18,040 --> 00:16:15,800
the earth and very importantly because

318
00:16:20,559 --> 00:16:18,050
it has relatively less water than some

319
00:16:23,619 --> 00:16:20,569
of the other ocean worlds that water is

320
00:16:25,600 --> 00:16:23,629
in contact with the rock below and what

321
00:16:27,850 --> 00:16:25,610
might not seem apparent but is one of

322
00:16:29,319 --> 00:16:27,860
the places on earth that we think about

323
00:16:31,960 --> 00:16:29,329
for the origin of life is at that

324
00:16:34,420 --> 00:16:31,970
interface between an active interior and

325
00:16:36,999 --> 00:16:34,430
an ocean above it and so in terms of the

326
00:16:39,340 --> 00:16:37,009
the juxtaposition of the chemistry that

327
00:16:41,079 --> 00:16:39,350
we have here on on earth the ocean

328
00:16:44,699 --> 00:16:41,089
circulating through the rock below is a

329
00:16:47,019 --> 00:16:44,709
real potential source there on Europa

330
00:16:49,720 --> 00:16:47,029
finally one of the things that we also

331
00:16:51,100 --> 00:16:49,730
think about is energy so life depends on

332
00:16:52,900 --> 00:16:51,110
some source of energy whether you call

333
00:16:55,540 --> 00:16:52,910
it energy Risa call it equal

334
00:16:57,069 --> 00:16:55,550
disequilibrium but basically life is

335
00:16:59,799 --> 00:16:57,079
doing some kind of work it's stealing

336
00:17:02,079 --> 00:16:59,809
energy from another system and as doing

337
00:17:04,240 --> 00:17:02,089
that is is doing that to produce biomass

338
00:17:05,949 --> 00:17:04,250

and so when we think about planets it's

339
00:17:08,350 --> 00:17:05,959
sometimes hard to think about how that

340
00:17:10,809 --> 00:17:08,360
might operate on Europa we think about

341
00:17:13,360 --> 00:17:10,819
energy in terms of the possible

342
00:17:15,730 --> 00:17:13,370
existence of hydrothermal vents so these

343
00:17:18,579 --> 00:17:15,740
chimneys of activity where the chemistry

344
00:17:20,919 --> 00:17:18,589
and the water temperature and the energy

345
00:17:23,649 --> 00:17:20,929
are just right for life origins and

346
00:17:25,120 --> 00:17:23,659
perhaps for its sustenance and very

347
00:17:27,279 --> 00:17:25,130
importantly when we look at the surface

348
00:17:28,720 --> 00:17:27,289
of Europa it actually is a lot like

349
00:17:31,240 --> 00:17:28,730
Earth it's the only other place that

350
00:17:33,399 --> 00:17:31,250
we've seen that has potentially active

351
00:17:35,740 --> 00:17:33,409
plate tectonics right now now those are

352
00:17:37,570 --> 00:17:35,750
ice tectonics so icy plates are

353
00:17:39,909 --> 00:17:37,580
subducting down into the ocean being

354
00:17:42,039 --> 00:17:39,919
remelted and then refrozen and producing

355
00:17:43,419 --> 00:17:42,049
new crustal material but it's very very

356
00:17:45,220 --> 00:17:43,429
earth-like in that way so we've got

357
00:17:46,630 --> 00:17:45,230
water we've got chemistry we've got

358
00:17:48,549 --> 00:17:46,640
energy and I think the other thing that

359
00:17:50,919 --> 00:17:48,559
we never really talk about but we should

360
00:17:53,230 --> 00:17:50,929
on Europa is that we've got history if

361
00:17:55,779 --> 00:17:53,240
you imagine the earth and Europa

362
00:17:58,240 --> 00:17:55,789
four-and-a-half billion years ago the

363
00:17:59,860 --> 00:17:58,250

ice or the ocean Rock interphase is

364
00:18:02,710 --> 00:17:59,870
almost exactly the same

365
00:18:04,930 --> 00:18:02,720
it's a saltwater ocean it's reacting

366
00:18:07,090 --> 00:18:04,940
with a hydrothermal system to maybe

367
00:18:09,310 --> 00:18:07,100
create biochemistry to support life or

368
00:18:10,720 --> 00:18:09,320
prebiotic chemistry to support life so

369
00:18:13,330 --> 00:18:10,730
four-and-a-half billion years ago earth

370
00:18:16,180 --> 00:18:13,340
and Europa we know are very similar in

371
00:18:16,760 --> 00:18:16,190
that way and so if life god got a chance

372
00:18:18,500 --> 00:18:16,770
took a

373
00:18:20,780 --> 00:18:18,510
hold at that time I think it's got a

374
00:18:22,250 --> 00:18:20,790
real shot today and so with two

375
00:18:25,010 --> 00:18:22,260
different missions at least right now

376
00:18:27,110 --> 00:18:25,020
Europa clipper potentially a Europa

377
00:18:29,030 --> 00:18:27,120
Lander I think we've got a chance in our

378
00:18:30,710 --> 00:18:29,040
lifetime so we like to call it life in

379
00:18:33,020 --> 00:18:30,720
our lifetime right to be able to

380
00:18:34,010 --> 00:18:33,030
actually land and ask these questions so

381
00:18:47,380 --> 00:18:34,020
that's why I think your rope is our

382
00:18:50,570 --> 00:18:47,390
place maybe your lifetime Brittany her

383
00:18:53,390 --> 00:18:50,580
fence is up next and let me tell you

384
00:18:55,490 --> 00:18:53,400
that in addition to being a devotee of

385
00:18:58,150 --> 00:18:55,500
the Red Planet she extends her

386
00:19:01,610 --> 00:18:58,160
scientific expertise into the kitchen

387
00:19:03,760 --> 00:19:01,620
cooking I assume and health for dancing

388
00:19:09,110 --> 00:19:03,770

and presumably sometimes both together

389
00:19:11,900 --> 00:19:09,120
maybe maybe so I have my money placed on

390
00:19:14,080 --> 00:19:11,910
fossil life on Mars and I don't mean

391
00:19:17,690 --> 00:19:14,090
like Dino fossils I'm talking about

392
00:19:20,630 --> 00:19:17,700
microscopic microbial so bacterial life

393
00:19:24,200 --> 00:19:20,640
on Mars and I have four reasons for that

394
00:19:26,840 --> 00:19:24,210
the first reason is because of what we

395
00:19:31,340 --> 00:19:26,850
understand about the fossil record on

396
00:19:33,799 --> 00:19:31,350
earth if you counted all the carbon

397
00:19:36,470 --> 00:19:33,809
atoms that are alive and everything that

398
00:19:39,230 --> 00:19:36,480
mushrooms trees elephants everything

399
00:19:42,200 --> 00:19:39,240
that's alive today and you compare that

400
00:19:44,690 --> 00:19:42,210
to the carbon atoms of everything that's

401
00:19:47,180 --> 00:19:44,700
ever been alive and then has gotten

402
00:19:50,450 --> 00:19:47,190
fossilized and preserved in the fossil

403
00:19:54,220 --> 00:19:50,460
record you would see that the difference

404
00:19:57,830 --> 00:19:54,230
that that ratio is about 10,000 so

405
00:20:00,530 --> 00:19:57,840
10,000 more carbon atoms of everything

406
00:20:02,480 --> 00:20:00,540
that's ever been fossilized compared to

407
00:20:05,480 --> 00:20:02,490
everything that's alive today so that's

408
00:20:07,940 --> 00:20:05,490
the first clue why I think fossils are a

409
00:20:11,960 --> 00:20:07,950
better bet than looking for living life

410
00:20:14,870 --> 00:20:11,970
on Mars and we also understand a lot

411
00:20:18,080 --> 00:20:14,880
about those processes that protect those

412
00:20:21,080 --> 00:20:18,090
delicate carbon atoms and preserve them

413
00:20:23,299 --> 00:20:21,090

through the geological forces of time we

414
00:20:26,030 --> 00:20:23,309
understand what kind of mineral

415
00:20:28,600 --> 00:20:26,040
environments are favourable for the

416
00:20:31,510 --> 00:20:28,610
preservation of carbon

417
00:20:35,049 --> 00:20:31,520
organic matter on earth and so I think

418
00:20:38,260 --> 00:20:35,059
it's not unreasonable to extend those

419
00:20:40,480 --> 00:20:38,270
same principles to Mars and that brings

420
00:20:44,110 --> 00:20:40,490
me to my second reason because Mars has

421
00:20:47,440 --> 00:20:44,120
had all of the ingredients necessary not

422
00:20:50,200 --> 00:20:47,450
only to evolve life but all the

423
00:20:53,410 --> 00:20:50,210
environments the diverse environments

424
00:20:57,370 --> 00:20:53,420
necessary to preserve that life through

425
00:21:00,310 --> 00:20:57,380
geologic time we know Mars was warmer

426
00:21:02,470 --> 00:21:00,320
and wetter in its past we've all seen

427
00:21:05,200 --> 00:21:02,480
those you know those silly memes with

428
00:21:07,770 --> 00:21:05,210
the cup of water and the Mars candy bar

429
00:21:10,539 --> 00:21:07,780
underneath you know water on Mars and

430
00:21:14,620 --> 00:21:10,549
it's not funny anymore it's not cute

431
00:21:16,690 --> 00:21:14,630
anymore and the reason is because we get

432
00:21:19,000 --> 00:21:16,700
it we we get it we know there's there's

433
00:21:22,409 --> 00:21:19,010
a lot of water on Mars all the Rovers

434
00:21:25,360 --> 00:21:22,419
that have given us information about the

435
00:21:28,150 --> 00:21:25,370
habitability of the environments that

436
00:21:32,110 --> 00:21:28,160
they've explored have repeatedly

437
00:21:35,830 --> 00:21:32,120
confirmed to us that Mars had the

438
00:21:38,770 --> 00:21:35,840

conditions the ingredients for life the

439
00:21:41,260 --> 00:21:38,780
water so it was a favorable plate

440
00:21:44,530 --> 00:21:41,270
favorable place for evolving and also

441
00:21:47,950 --> 00:21:44,540
preserving life if it had evolved we

442
00:21:50,590 --> 00:21:47,960
know that those same kinds of mineral

443
00:21:54,840 --> 00:21:50,600
environments those characteristics in

444
00:21:57,039 --> 00:21:54,850
those environments like for example

445
00:21:58,870 --> 00:21:57,049
fossils tend to stay preserved in

446
00:22:01,200 --> 00:21:58,880
environments in minerals that are not

447
00:22:03,940 --> 00:22:01,210
very porous so you don't have fluids

448
00:22:07,360 --> 00:22:03,950
circulating through and degrading and

449
00:22:09,549 --> 00:22:07,370
washing away and altering the fossils

450
00:22:16,090 --> 00:22:09,559
those kinds of environments exist on

451
00:22:18,100 --> 00:22:16,100
Mars as well and my third reason is the

452
00:22:20,980 --> 00:22:18,110
reason why we know all of this about the

453
00:22:24,549 --> 00:22:20,990
environments on Mars because of the

454
00:22:28,480 --> 00:22:24,559
continuous robotic exploration of Mars

455
00:22:30,460 --> 00:22:28,490
since 1997 we of course we've been

456
00:22:33,430 --> 00:22:30,470
launching things to Mars since much

457
00:22:36,549 --> 00:22:33,440
earlier than that but we basically had

458
00:22:40,680 --> 00:22:36,559
our eyes on Mars continuously in the

459
00:22:41,750 --> 00:22:40,690
form of Rovers Landers orbiters since

460
00:22:45,320 --> 00:22:41,760
1997

461
00:22:47,420 --> 00:22:45,330
and I think the momentum is only

462
00:22:49,610 --> 00:22:47,430
building and it's and it's only going to

463
00:22:53,090 --> 00:22:49,620

get more interesting in the next decade

464
00:22:56,770 --> 00:22:53,100
I think starting in 2020 we're going to

465
00:23:00,530 --> 00:22:56,780
assure in a new era a very exciting

466
00:23:02,900 --> 00:23:00,540
exploration on Mars because in 2020

467
00:23:06,530 --> 00:23:02,910
there are going to be two Rovers that

468
00:23:09,650 --> 00:23:06,540
are going to be sent NASA's Mars 2020

469
00:23:13,700 --> 00:23:09,660
Rover and the European Space Agency's

470
00:23:18,490 --> 00:23:13,710
ExoMars Rover and these two Rovers are

471
00:23:21,590 --> 00:23:18,500
going to be designed to fully focus on

472
00:23:25,070 --> 00:23:21,600
looking for signatures of life looking

473
00:23:26,660 --> 00:23:25,080
for bio signatures on Mars and that is

474
00:23:28,400 --> 00:23:26,670
something that most most Rovers and

475
00:23:31,130 --> 00:23:28,410
ladders that have been on Mars have not

476
00:23:33,590 --> 00:23:31,140
been designed to do so stay tuned

477
00:23:35,420 --> 00:23:33,600
because some very exciting things are

478
00:23:38,720 --> 00:23:35,430
going to happen on Mars starting in 2020

479
00:23:42,830 --> 00:23:38,730
and also let's not forget the private

480
00:23:45,970 --> 00:23:42,840
SpaceX this private space sector do we

481
00:23:49,250 --> 00:23:45,980
have any SpaceX fans in the house yeah

482
00:23:51,860 --> 00:23:49,260
go SpaceX it's not unreasonable to think

483
00:23:53,630 --> 00:23:51,870
that perhaps human exploration of Mars

484
00:23:56,030 --> 00:23:53,640
which which is a possibility in the near

485
00:23:58,490 --> 00:23:56,040
future it's going to be how we're going

486
00:24:01,400 --> 00:23:58,500
to find the signs of life as opposed to

487
00:24:03,680 --> 00:24:01,410
robotic exploration and my fourth and

488
00:24:06,830 --> 00:24:03,690

final reason why I think it's going to

489
00:24:10,040 --> 00:24:06,840
be fossil life on Mars is because we

490
00:24:13,700 --> 00:24:10,050
already have lots of freebie samples

491
00:24:16,760 --> 00:24:13,710
from Mars delivered gifts gifted to us

492
00:24:19,370 --> 00:24:16,770
by nature in the form of Martian

493
00:24:21,470 --> 00:24:19,380
meteorites we have a lot of meteorites

494
00:24:25,190 --> 00:24:21,480
on earth from various places in our

495
00:24:27,520 --> 00:24:25,200
solar system and some of them a small

496
00:24:29,990 --> 00:24:27,530
percentage of them come from marks and

497
00:24:32,360 --> 00:24:30,000
the really cool thing about some of

498
00:24:37,580 --> 00:24:32,370
these Martian meteorites is that they

499
00:24:40,360 --> 00:24:37,590
contain complex carbon structures not

500
00:24:42,920 --> 00:24:40,370
necessarily formed by life but still

501
00:24:45,740 --> 00:24:42,930
carbon structures that allow us to test

502
00:24:48,740 --> 00:24:45,750
our hypotheses about for example what

503
00:24:50,140 --> 00:24:48,750
we're seeing on the rover and what we're

504
00:24:53,360 --> 00:24:50,150
going to see when we bring back samples

505
00:24:54,880 --> 00:24:53,370
from Mars to earth because on the 2020

506
00:24:56,470 --> 00:24:54,890
Rover is actually going to bring samples

507
00:24:58,210 --> 00:24:56,480
back is going to cash them and return

508
00:25:01,120 --> 00:24:58,220
them to earth for study and more

509
00:25:03,400 --> 00:25:01,130
sophisticated labs on earth and so you

510
00:25:06,370 --> 00:25:03,410
can't say that about any other planet in

511
00:25:08,830 --> 00:25:06,380
the solar system that's why I think it's

512
00:25:15,490 --> 00:25:08,840
going to be fossils on Mars thank you

513
00:25:17,890 --> 00:25:15,500

very much aisle speakers are doing very

514
00:25:21,670 --> 00:25:17,900
well nobody has tripped up yet going up

515
00:25:24,340 --> 00:25:21,680
and down set so next up is Sarah who

516
00:25:30,070 --> 00:25:24,350
many of you will know as astrobiologists

517
00:25:32,950 --> 00:25:30,080
finest stand-up comedian the world

518
00:25:36,280 --> 00:25:32,960
record to rent his delivery and she will

519
00:25:37,930 --> 00:25:36,290
explain the side okay yes I'll get to

520
00:25:40,540 --> 00:25:37,940
the slide which Paul actually made for

521
00:25:42,130 --> 00:25:40,550
me thank you very much fault

522
00:25:46,270 --> 00:25:42,140
so how many people in this room are

523
00:25:48,730 --> 00:25:46,280
alive I think everybody probably is okay

524
00:25:52,030 --> 00:25:48,740
so we definitely know there's life on

525
00:25:54,760 --> 00:25:52,040
Earth now the question is is there alien

526
00:25:56,350 --> 00:25:54,770
life on Earth and so the question that

527
00:25:59,080 --> 00:25:56,360
we're asking scientifically is not

528
00:26:01,360 --> 00:25:59,090
whether UFOs are visiting us but whether

529
00:26:03,520 --> 00:26:01,370
there's actually microbial life or some

530
00:26:05,770 --> 00:26:03,530
other kind of life-form on earth now the

531
00:26:07,090 --> 00:26:05,780
reason that's interesting is everybody

532
00:26:08,140 --> 00:26:07,100
in this room probably should have raised

533
00:26:09,370 --> 00:26:08,150
their hands when I asked if they were

534
00:26:12,190 --> 00:26:09,380
alive I guess some people weren't paying

535
00:26:15,190 --> 00:26:12,200
attention or maybe they are alive I'm

536
00:26:17,160 --> 00:26:15,200
not really sure but everything on this

537
00:26:19,360 --> 00:26:17,170
planet as far as we know is related

538
00:26:22,840 --> 00:26:19,370

biochemically so the chemistry of living

539
00:26:24,610 --> 00:26:22,850
systems has a commonality to it and so

540
00:26:27,190 --> 00:26:24,620
when we're talking about living systems

541
00:26:28,990 --> 00:26:27,200
on earth life on Earth we think all life

542
00:26:30,670 --> 00:26:29,000
on Earth is related at least all known

543
00:26:34,090 --> 00:26:30,680
life on Earth is related that we've

544
00:26:37,180 --> 00:26:34,100
discovered so far so could we actually

545
00:26:39,640 --> 00:26:37,190
find life on Earth that has a different

546
00:26:41,620 --> 00:26:39,650
chemical makeup maybe something like a

547
00:26:43,270 --> 00:26:41,630
shadow biosphere is the name that it's

548
00:26:45,340 --> 00:26:43,280
called in the scientific community and

549
00:26:50,290 --> 00:26:45,350
so this is actually a picture of shadow

550
00:26:52,120 --> 00:26:50,300
Paul and you'll notice that Paul is

551
00:26:54,400 --> 00:26:52,130
looking at himself as if he's in a

552
00:26:56,650 --> 00:26:54,410
mirror this is because one of the

553
00:27:01,870 --> 00:26:56,660
proposals for shadow life is what is

554
00:27:03,160 --> 00:27:01,880
called mirror life and so if you raise

555
00:27:04,390 --> 00:27:03,170
both your hands you'll notice that

556
00:27:06,419 --> 00:27:04,400
they're mirror images of each other

557
00:27:08,879 --> 00:27:06,429
biomolecules that are in

558
00:27:11,009 --> 00:27:08,889
your cells are also coming nearer image

559
00:27:13,169 --> 00:27:11,019
varieties but in living systems we have

560
00:27:14,879 --> 00:27:13,179
only one form of them and so one

561
00:27:18,989 --> 00:27:14,889
question could be could there be life of

562
00:27:19,649 --> 00:27:18,999
the other form living on earth so

563
00:27:21,450 --> 00:27:19,659

there's a whole bunch of different

564
00:27:23,159 --> 00:27:21,460
proposals about what kind of different

565
00:27:25,919 --> 00:27:23,169
chemistry could actually coexist on

566
00:27:28,259 --> 00:27:25,929
earth with our own biochemistry and you

567
00:27:31,710 --> 00:27:28,269
may ask well why haven't we found this

568
00:27:33,450 --> 00:27:31,720
life yet and the reason is that when

569
00:27:35,070 --> 00:27:33,460
we're looking for life on Earth we are

570
00:27:36,960 --> 00:27:35,080
not looking for things that we don't

571
00:27:39,810 --> 00:27:36,970
know we're looking for things that have

572
00:27:43,109 --> 00:27:39,820
DNA primarily most of our life detection

573
00:27:44,999 --> 00:27:43,119
actually involves DNA so why are we not

574
00:27:50,009 --> 00:27:45,009
looking for things that we don't know

575
00:27:51,269 --> 00:27:50,019
any guesses it's because we don't know

576
00:27:52,710 --> 00:27:51,279
the whole reason we have this panel

577
00:27:54,029 --> 00:27:52,720
today is because we actually don't know

578
00:27:56,519 --> 00:27:54,039
what life is so we don't know how to

579
00:27:58,680 --> 00:27:56,529
look for it we haven't found it yet and

580
00:27:59,789 --> 00:27:58,690
so one of the things I actually work on

581
00:28:01,739 --> 00:27:59,799
is trying to understand what living

582
00:28:05,129 --> 00:28:01,749
systems are what is life that's a great

583
00:28:07,710 --> 00:28:05,139
question and so my conjecture is that

584
00:28:10,379 --> 00:28:07,720
until we have an understanding of what

585
00:28:12,239 --> 00:28:10,389
life is and by that I mean an actual

586
00:28:13,649 --> 00:28:12,249
theory of life some kind of quantitative

587
00:28:15,210 --> 00:28:13,659
framework for understanding life that

588
00:28:16,710 --> 00:28:15,220

goes beyond just the chemistry of life

589
00:28:18,600 --> 00:28:16,720
that we know about is predictive of

590
00:28:20,940 --> 00:28:18,610
other chemistry's we won't be able to

591
00:28:23,129 --> 00:28:20,950
find life but when we do have such an

592
00:28:25,470 --> 00:28:23,139
understanding the easiest place for us

593
00:28:27,779 --> 00:28:25,480
to look will be on earth and we already

594
00:28:29,999 --> 00:28:27,789
know life happened here once so why not

595
00:28:38,180 --> 00:28:30,009
look and see if it happened again and

596
00:28:43,220 --> 00:28:41,600
and so now we move on to Jacob but still

597
00:28:45,470 --> 00:28:43,230
fairly close to home as you'll see from

598
00:28:48,140 --> 00:28:45,480
the picture here and I should mention

599
00:28:51,620 --> 00:28:48,150
that that in addition to his many

600
00:28:55,220 --> 00:28:51,630
talents if I got the information correct

601
00:28:58,910 --> 00:28:55,230
Jacob is setting up a lottery a lottery

602
00:29:00,650 --> 00:28:58,920
bond to fund the search for ET and if

603
00:29:02,390 --> 00:29:00,660
you asking nicely he might sell you one

604
00:29:03,980 --> 00:29:02,400
later on tonight okay

605
00:29:05,690 --> 00:29:03,990
I'm still looking for investors in there

606
00:29:09,860 --> 00:29:05,700
if you have a lot of money come and talk

607
00:29:11,300 --> 00:29:09,870
to me but we live on a planet as you can

608
00:29:14,000 --> 00:29:11,310
see from this picture that has been

609
00:29:16,550 --> 00:29:14,010
modified by technology on a global scale

610
00:29:19,460 --> 00:29:16,560
this is the black marble earths at night

611
00:29:21,110 --> 00:29:19,470
and you can see there's very small

612
00:29:22,580 --> 00:29:21,120
regions of earth that are untouched by

613
00:29:25,480 --> 00:29:22,590

civilization at this point some places

614
00:29:27,740 --> 00:29:25,490
now imagine that you are an

615
00:29:30,620 --> 00:29:27,750
extraterrestrial astronomer some

616
00:29:33,380 --> 00:29:30,630
distance away from Earth 10 20 30 40 50

617
00:29:34,720 --> 00:29:33,390
hundred light years take your pick maybe

618
00:29:37,910 --> 00:29:34,730
100 light you don't say 40 light years

619
00:29:39,170 --> 00:29:37,920
and you build a big telescope you've got

620
00:29:41,450 --> 00:29:39,180
great funding you pointed at earth

621
00:29:43,010 --> 00:29:41,460
you're going to see maybe not exactly

622
00:29:43,610 --> 00:29:43,020
this you could you're going to be able

623
00:29:46,010 --> 00:29:43,620
to TechEd

624
00:29:48,080 --> 00:29:46,020
evidence of our technology at a distance

625
00:29:49,610 --> 00:29:48,090
if you're looking right city lights if

626
00:29:51,560 --> 00:29:49,620
you look the right way you could detect

627
00:29:54,140 --> 00:29:51,570
evidence of that on the the dark

628
00:29:55,370 --> 00:29:54,150
shadowed side of a planet this is not

629
00:29:56,930 --> 00:29:55,380
the only signature that's coming across

630
00:29:58,820 --> 00:29:56,940
from our planet but it's the most

631
00:30:01,970 --> 00:29:58,830
visible one and so it's a nice one to

632
00:30:03,620 --> 00:30:01,980
start with radio waves are another

633
00:30:05,420 --> 00:30:03,630
important signal they've been emanating

634
00:30:07,610 --> 00:30:05,430
from our planet I don't have a nice

635
00:30:10,220 --> 00:30:07,620
picture like this yet of Earth from the

636
00:30:11,450 --> 00:30:10,230
radio wave length on a global scale I

637
00:30:13,790 --> 00:30:11,460
would like to someday actually they'll

638
00:30:16,190 --> 00:30:13,800

be really interesting but we've been in

639
00:30:18,740 --> 00:30:16,200
emanating radio waves for roughly 100

640
00:30:20,510 --> 00:30:18,750
some years mainly in the form of

641
00:30:23,090 --> 00:30:20,520
television carrier waves as well as

642
00:30:25,130 --> 00:30:23,100
radar mainly for military purposes all

643
00:30:26,570 --> 00:30:25,140
of these electromagnetic waves travel at

644
00:30:29,110 --> 00:30:26,580
the speed of light they're carrying

645
00:30:31,700 --> 00:30:29,120
information about our technological

646
00:30:33,740 --> 00:30:31,710
civilization to any observers that might

647
00:30:35,690 --> 00:30:33,750
be watching so now we turn the question

648
00:30:38,360 --> 00:30:35,700
around with SETI the search for

649
00:30:40,490 --> 00:30:38,370
extraterrestrial intelligence what we're

650
00:30:42,320 --> 00:30:40,500
looking for is not just intelligent

651
00:30:43,700 --> 00:30:42,330
beings but intelligent technological

652
00:30:46,490 --> 00:30:43,710
beings that we could detect at a

653
00:30:49,460 --> 00:30:46,500
distance and by anything that we could

654
00:30:51,050 --> 00:30:49,470
detect has to have to be conceivable to

655
00:30:51,630 --> 00:30:51,060
us so we're really looking for some sort

656
00:30:54,720 --> 00:30:51,640
of mirror

657
00:30:57,480 --> 00:30:54,730
of ourselves either now or sometime in

658
00:30:59,400 --> 00:30:57,490
the future so if we were to find

659
00:31:01,050 --> 00:30:59,410
something like evidence of city lights

660
00:31:03,030 --> 00:31:01,060
or evidence of strong radio

661
00:31:05,760 --> 00:31:03,040
transmissions from another part of the

662
00:31:08,010 --> 00:31:05,770
an exoplanet or a star system this would

663
00:31:10,050 --> 00:31:08,020

be very strong almost unequivocal

664
00:31:11,640 --> 00:31:10,060
evidence if you get the signal right if

665
00:31:13,730 --> 00:31:11,650
you have a strong detection this would

666
00:31:15,870 --> 00:31:13,740
be very unequivocal evidence for

667
00:31:16,470 --> 00:31:15,880
intelligent life elsewhere in the

668
00:31:18,360 --> 00:31:16,480
universe

669
00:31:20,940 --> 00:31:18,370
so what are we doing how are we looking

670
00:31:24,300 --> 00:31:20,950
for this well SETI the SETI Institute

671
00:31:27,180 --> 00:31:24,310
has been working on this since the 1960s

672
00:31:29,070 --> 00:31:27,190
1970s Frank Drake made the first

673
00:31:31,890 --> 00:31:29,080
observation of some nearby stars in

674
00:31:34,740 --> 00:31:31,900
project Ozma and obviously didn't find

675
00:31:36,330 --> 00:31:34,750
anything but what Jill tarter of SETI

676
00:31:38,580 --> 00:31:36,340
Institute like to point out is that up

677
00:31:40,620 --> 00:31:38,590
until this point SETI is is like

678
00:31:41,790 --> 00:31:40,630
swimming if you hear a boat in the

679
00:31:43,440 --> 00:31:41,800
middle of the ocean and you've got a

680
00:31:45,300 --> 00:31:43,450
drinking glass and you have to question

681
00:31:46,920 --> 00:31:45,310
are there any fish in the ocean and you

682
00:31:48,300 --> 00:31:46,930
take your drinking glass dip it in the

683
00:31:49,890 --> 00:31:48,310
water you look in your glass and you

684
00:31:51,690 --> 00:31:49,900
don't have any fish but what have you

685
00:31:53,220 --> 00:31:51,700
proven you've not proven that there are

686
00:31:54,750 --> 00:31:53,230
no fish in the ocean you've proven that

687
00:31:56,070 --> 00:31:54,760
you're one experiment is unable to

688
00:31:57,780 --> 00:31:56,080

detect life maybe you need a bigger

689
00:31:59,970 --> 00:31:57,790
glass maybe you look somewhere else in

690
00:32:02,480 --> 00:31:59,980
the ocean so the the amount of search

691
00:32:05,490 --> 00:32:02,490
space that SETI is done right now is so

692
00:32:07,170 --> 00:32:05,500
drastically small compared to the vast

693
00:32:09,150 --> 00:32:07,180
scale of the universe but here's the

694
00:32:10,650 --> 00:32:09,160
good news the good news is that there's

695
00:32:13,110 --> 00:32:10,660
recently there was a billionaire who got

696
00:32:14,670 --> 00:32:13,120
very motivated by this question yuri

697
00:32:17,130 --> 00:32:14,680
milner and some of his entrepreneur

698
00:32:19,440 --> 00:32:17,140
friends started to break through listen

699
00:32:22,350 --> 00:32:19,450
initiative which is a hundred million

700
00:32:25,140 --> 00:32:22,360
dollar initiative to do the first full

701
00:32:27,300 --> 00:32:25,150
sky survey for studies using the Green

702
00:32:30,390 --> 00:32:27,310
Bank telescope in West Virginia and the

703
00:32:32,910 --> 00:32:30,400
Parkes telescope in Australia to do a

704
00:32:34,740 --> 00:32:32,920
full radio survey of both hemispheres

705
00:32:36,420 --> 00:32:34,750
which is never before been accomplished

706
00:32:38,010 --> 00:32:36,430
in addition to that they're also going

707
00:32:40,080 --> 00:32:38,020
to be looking for little laser pulses

708
00:32:41,490 --> 00:32:40,090
which is another way if an

709
00:32:42,810 --> 00:32:41,500
extraterrestrial civilization was

710
00:32:45,360 --> 00:32:42,820
attempting to communicate or somehow

711
00:32:47,850 --> 00:32:45,370
signal their existence so these are ways

712
00:32:50,070 --> 00:32:47,860
that we know can travel through space

713
00:32:51,780 --> 00:32:50,080

relatively unfettered without losing the

714
00:32:54,300 --> 00:32:51,790
information that would give us a very

715
00:32:55,860 --> 00:32:54,310
clear signal of evidence of

716
00:32:57,780 --> 00:32:55,870
extraterrestrial intelligence so this is

717
00:32:59,160 --> 00:32:57,790
starting now you're going to be hearing

718
00:33:01,230 --> 00:32:59,170
about breakthrough listen over the next

719
00:33:02,970 --> 00:33:01,240
decade and with any luck there will be

720
00:33:04,250 --> 00:33:02,980
at least some interesting signals to

721
00:33:06,470 --> 00:33:04,260
follow up on

722
00:33:08,840 --> 00:33:06,480
other encouraging news is the SETI

723
00:33:11,060 --> 00:33:08,850
Institute their flagship array the Allen

724
00:33:12,530 --> 00:33:11,070
telescope array for a while a SETI

725
00:33:14,299 --> 00:33:12,540
Institute was struggling to fund this

726
00:33:17,240 --> 00:33:14,309
they now have a partnership with private

727
00:33:18,770 --> 00:33:17,250
industry who uses it half the time but

728
00:33:20,000 --> 00:33:18,780
fortunately they pay for it so the SETI

729
00:33:23,419 --> 00:33:20,010
Institute has a nice deal where they get

730
00:33:25,610 --> 00:33:23,429
to use this telescope every night I was

731
00:33:27,020 --> 00:33:25,620
very low cost and you get to do really

732
00:33:29,120 --> 00:33:27,030
good science and so the combination of

733
00:33:30,919 --> 00:33:29,130
the Allen telescope array and the Green

734
00:33:32,630 --> 00:33:30,929
Bank is the breakthrough listened

735
00:33:34,610 --> 00:33:32,640
initiative this is going to be the best

736
00:33:35,810 --> 00:33:34,620
attempt at searching the skies for

737
00:33:37,970 --> 00:33:35,820
evidence of extraterrestrial

738
00:33:40,070 --> 00:33:37,980

intelligence the last point is there's a

739
00:33:42,560 --> 00:33:40,080
very strong tie in to exoplanet science

740
00:33:44,270 --> 00:33:42,570
here I think doing a full Sky Survey is

741
00:33:45,260 --> 00:33:44,280
great we've never done this before it's

742
00:33:47,960 --> 00:33:45,270
going to give us a lot of information

743
00:33:50,840 --> 00:33:47,970
but I think the best way to do this is

744
00:33:53,210 --> 00:33:50,850
the the exoplanets that show strong

745
00:33:55,220 --> 00:33:53,220
signs of habitability good candidate

746
00:33:56,840 --> 00:33:55,230
planets in the habitable zone maybe even

747
00:33:58,280 --> 00:33:56,850
if we see bio signatures I think those

748
00:34:00,470 --> 00:33:58,290
are going to be the best targets to

749
00:34:01,820 --> 00:34:00,480
follow up for with SETI to listen to see

750
00:34:02,419 --> 00:34:01,830
if we're really not alone and that's why

751
00:34:03,620 --> 00:34:02,429
I think steady

752
00:34:11,040 --> 00:34:03,630
they're going to be the first discovery

753
00:34:16,560 --> 00:34:13,919
and finally we move on to Charlie

754
00:34:20,669 --> 00:34:16,570
lineweaver about him words fail me but

755
00:34:22,590 --> 00:34:20,679
they're rarely known to fail him charlie

756
00:34:24,389 --> 00:34:22,600
is I think the most disagreeing

757
00:34:26,730 --> 00:34:24,399
I didn't say disagreeable but most

758
00:34:28,050 --> 00:34:26,740
disagreeing per se no and we thought it

759
00:34:31,440 --> 00:34:28,060
would be good for him to bring out the

760
00:34:33,690 --> 00:34:31,450
rear and probably rubbish everything has

761
00:34:36,600 --> 00:34:33,700
been said so far you flattery bolts

762
00:34:39,899 --> 00:34:36,610
firing all right so my Misha's did

763
00:34:44,280 --> 00:34:39,909

describe that defend the opinion that we

764
00:34:46,409 --> 00:34:44,290
will never find life as we know it and I

765
00:34:48,119 --> 00:34:46,419
think also defend of somewhat

766
00:34:50,609 --> 00:34:48,129
schizophrenic opposite and that is I

767
00:34:53,129 --> 00:34:50,619
think we possibly have already found

768
00:34:54,990 --> 00:34:53,139
life as we don't know it now why those

769
00:34:57,330 --> 00:34:55,000
two things are not mutually exclusive is

770
00:34:59,340 --> 00:34:57,340
because we don't know what life is so

771
00:35:01,770 --> 00:34:59,350
there's a biologist about 50 years ago

772
00:35:03,600 --> 00:35:01,780
named JD Bernal who talked to iodine

773
00:35:05,730 --> 00:35:03,610
about this I'm a physicist so I always

774
00:35:07,260 --> 00:35:05,740
listen to what Einstein says and Brunel

775
00:35:09,570 --> 00:35:07,270
said that Einstein's thought about this

776
00:35:12,030 --> 00:35:09,580
a little bit and he said that that you

777
00:35:14,220 --> 00:35:12,040
know if we were ever to which we one a

778
00:35:16,800 --> 00:35:14,230
definition of life that has any chance

779
00:35:18,810 --> 00:35:16,810
of defining life elsewhere then it would

780
00:35:21,270 --> 00:35:18,820
have to include many features which we

781
00:35:24,240 --> 00:35:21,280
now consider Oh life in a very poetic

782
00:35:27,359 --> 00:35:24,250
way and I think I think we should take

783
00:35:29,550 --> 00:35:27,369
that seriously and one poetic vision or

784
00:35:31,500 --> 00:35:29,560
a kind of a weird vision is something

785
00:35:32,550 --> 00:35:31,510
that Ilya Prigogine talked about and

786
00:35:35,400 --> 00:35:32,560
that is a far from equilibrium

787
00:35:37,470 --> 00:35:35,410
dissipative system fancy words far from

788
00:35:40,470 --> 00:35:37,480

equilibrium dissipative system like a

789
00:35:43,109 --> 00:35:40,480
hurricane or a tornado or a volcano or

790
00:35:44,640 --> 00:35:43,119
convection cell or the life forms in

791
00:35:46,320 --> 00:35:44,650
this room and all of them are doing

792
00:35:48,510 --> 00:35:46,330
things are well structured in the proofs

793
00:35:50,040 --> 00:35:48,520
in entropy so that's one kind of weird

794
00:35:52,800 --> 00:35:50,050
definition of life that many people are

795
00:35:55,260 --> 00:35:52,810
uncomfortable with but I think if we

796
00:35:57,030 --> 00:35:55,270
define life that way then we have

797
00:35:58,859 --> 00:35:57,040
already found life elsewhere we find the

798
00:36:02,280 --> 00:35:58,869
Red Spot on Jupiter we found stars

799
00:36:04,950 --> 00:36:02,290
burning we found whirl winds on Mars and

800
00:36:07,530 --> 00:36:04,960
so if you're willing to take that I

801
00:36:08,880 --> 00:36:07,540
guess the poetic jump and say that's

802
00:36:12,210 --> 00:36:08,890
what life is well then we've already

803
00:36:14,370 --> 00:36:12,220
found it but so that's one vision on the

804
00:36:17,070 --> 00:36:14,380
other hand if we're looking for life as

805
00:36:19,080 --> 00:36:17,080
we we do know it I think we'll never

806
00:36:22,020 --> 00:36:19,090
find that and it's kind of like looking

807
00:36:23,370 --> 00:36:22,030
for english-speaking aliens I think most

808
00:36:24,390 --> 00:36:23,380
people say oh Allah speaking oh that's

809
00:36:24,720 --> 00:36:24,400
crazy you don't go looking for English

810
00:36:27,270 --> 00:36:24,730
speaking

811
00:36:30,900 --> 00:36:27,280
because English is so quirky but I think

812
00:36:32,970 --> 00:36:30,910
the idea that the idea that life is some

813
00:36:34,800 --> 00:36:32,980

type of generic thing is something that

814
00:36:36,930 --> 00:36:34,810
doesn't have much evidence we have one

815
00:36:38,940 --> 00:36:36,940
example here and that could very well be

816
00:36:40,680 --> 00:36:38,950
as quirky as the English language

817
00:36:42,690 --> 00:36:40,690
now why we're up here saying oh we'll

818
00:36:44,220 --> 00:36:42,700
never find english-speaking aliens most

819
00:36:46,320 --> 00:36:44,230
of you would agree but because you've

820
00:36:49,230 --> 00:36:46,330
been propagandized into thinking life is

821
00:36:52,260 --> 00:36:49,240
generic as is our most biologists then

822
00:36:53,460 --> 00:36:52,270
then you say oh we'll we'll find it

823
00:36:56,280 --> 00:36:53,470
so it really depends on whether it's

824
00:36:58,080 --> 00:36:56,290
quirky like English or its generic but

825
00:37:00,120 --> 00:36:58,090
the most generic thing that businesses

826
00:37:03,600 --> 00:37:00,130
are comfortable with is in fact far from

827
00:37:05,130 --> 00:37:03,610
equilibrium dissipative systems so you

828
00:37:07,260 --> 00:37:05,140
might say well if you if you if the

829
00:37:09,060 --> 00:37:07,270
answer to this question is so ambiguous

830
00:37:10,770 --> 00:37:09,070
depends on this on the definition of

831
00:37:13,200 --> 00:37:10,780
life well maybe Charlie you need a

832
00:37:16,200 --> 00:37:13,210
better definition of life and I would

833
00:37:18,690 --> 00:37:16,210
say no I don't think defining life is

834
00:37:21,870 --> 00:37:18,700
very helpful in 2012 a Nobel

835
00:37:24,720 --> 00:37:21,880
prize-winning biologist named Jack

836
00:37:27,630 --> 00:37:24,730
szostak wrote an article saying it's not

837
00:37:29,160 --> 00:37:27,640
helpful to try to define life one of the

838
00:37:31,350 --> 00:37:29,170

ways you can understand why it wouldn't

839
00:37:32,550 --> 00:37:31,360
be helpful is imagine try to define all

840
00:37:35,070 --> 00:37:32,560
let's look for eyeballs

841
00:37:36,630 --> 00:37:35,080
how old are eyeballs let's go back in it

842
00:37:38,670 --> 00:37:36,640
let's get in a time machine and go

843
00:37:40,530 --> 00:37:38,680
looking for eyeballs go 300 million

844
00:37:44,880 --> 00:37:40,540
years back four hundred five hundred six

845
00:37:47,610 --> 00:37:44,890
as you go back what became eyeballs gets

846
00:37:50,550 --> 00:37:47,620
deconstructed they get proto eyeballs a

847
00:37:52,530 --> 00:37:50,560
proto Pro reviled and anything that has

848
00:37:54,180 --> 00:37:52,540
evolved on this earth is the same way

849
00:37:56,040 --> 00:37:54,190
you can think of a head okay go back

850
00:37:58,140 --> 00:37:56,050
five hundred million years six seven

851
00:38:00,150 --> 00:37:58,150
hundred really head disappear

852
00:38:02,310 --> 00:38:00,160
they really get deconstructed if you go

853
00:38:04,440 --> 00:38:02,320
back in a time machine it may be the

854
00:38:07,260 --> 00:38:04,450
case I think it might be the case that

855
00:38:08,970 --> 00:38:07,270
life also gets deconstructed as we go

856
00:38:11,130 --> 00:38:08,980
further and further back and we should

857
00:38:13,110 --> 00:38:11,140
not trust our current definitions of

858
00:38:15,990 --> 00:38:13,120
what now we call life as something

859
00:38:18,450 --> 00:38:16,000
that's platonic like the like pie or two

860
00:38:19,950 --> 00:38:18,460
and it's life is not like that life two

861
00:38:22,800 --> 00:38:19,960
is something that has evolved and if

862
00:38:24,690 --> 00:38:22,810
that's the case well current versions of

863
00:38:27,900 --> 00:38:24,700

it are not something that we can trust

864
00:38:31,170 --> 00:38:27,910
in a in the early Earth and also

865
00:38:34,050 --> 00:38:31,180
elsewhere so I have of the opinion that

866
00:38:36,720 --> 00:38:34,060
we will never find life as we know it

867
00:38:38,600 --> 00:38:36,730
and we have already found life as we

868
00:38:40,620 --> 00:38:38,610
don't know

869
00:38:44,300 --> 00:38:40,630
wonderful thank you very much

870
00:38:48,150 --> 00:38:46,800
well we're going to develop one or two

871
00:38:50,220 --> 00:38:48,160
of these themes for a while before

872
00:38:53,070 --> 00:38:50,230
taking questions from the audience and

873
00:38:55,530 --> 00:38:53,080
there let me start off by saying that

874
00:38:58,260 --> 00:38:55,540
the question whether or not we are alone

875
00:39:00,750 --> 00:38:58,270
in the universe really hinges in my

876
00:39:04,080 --> 00:39:00,760
opinion on whether life has happened

877
00:39:06,060 --> 00:39:04,090
more than months and that's been the

878
00:39:08,790 --> 00:39:06,070
implication running through our remarks

879
00:39:11,880 --> 00:39:08,800
but there is a complication and svet

880
00:39:13,560 --> 00:39:11,890
mentioned it the Mars meteorites of

881
00:39:16,260 --> 00:39:13,570
which we have several in our collection

882
00:39:19,470 --> 00:39:16,270
here at Arizona State University

883
00:39:21,960 --> 00:39:19,480
if Earth and Mars exchange rocks then

884
00:39:25,080 --> 00:39:21,970
they can also exchange microorganisms

885
00:39:26,520 --> 00:39:25,090
and so this complicates the search for

886
00:39:28,500 --> 00:39:26,530
life within our solar system

887
00:39:31,440 --> 00:39:28,510
particularly for Mars because we may go

888
00:39:34,050 --> 00:39:31,450

to Mars and find life there but it'll

889
00:39:36,420 --> 00:39:34,060
just be good old boring earth life won't

890
00:39:39,510 --> 00:39:36,430
be the second sample that we all crave

891
00:39:41,790 --> 00:39:39,520
that could be a problem for the icy

892
00:39:45,960 --> 00:39:41,800
moons as well but is surely not a

893
00:39:49,920 --> 00:39:45,970
problem for Vicki's extrasolar planets

894
00:39:51,000 --> 00:39:49,930
and so what anybody like to to say this

895
00:39:53,310 --> 00:39:51,010
is not a problem

896
00:39:58,050 --> 00:39:53,320
so Sveta I'm sort of challenging your

897
00:40:00,960 --> 00:39:58,060
position would you like to say that this

898
00:40:03,030 --> 00:40:00,970
rocky panspermia isn't going to be an

899
00:40:05,400 --> 00:40:03,040
issue when it comes to looking for life

900
00:40:08,940 --> 00:40:05,410
on Mars hmm interesting

901
00:40:13,950 --> 00:40:08,950
I mean I I don't think that's a problem

902
00:40:18,120 --> 00:40:13,960
because if I would argue that whether or

903
00:40:21,620 --> 00:40:18,130
not life is the same Genesis as we found

904
00:40:26,010 --> 00:40:21,630
on earth when we find it on Mars or not

905
00:40:29,160 --> 00:40:26,020
the fact that it was prevalent the fact

906
00:40:33,960 --> 00:40:29,170
that it was preservable the fact that it

907
00:40:36,690 --> 00:40:33,970
was detectable by us is quite an

908
00:40:39,510 --> 00:40:36,700
impressive achievement and probably one

909
00:40:43,350 --> 00:40:39,520
of humanity's most amazing achievements

910
00:40:46,050 --> 00:40:43,360
and that will have huge implications so

911
00:40:46,800 --> 00:40:46,060
I don't think that's a problem too

912
00:40:50,160 --> 00:40:46,810
worried about it

913
00:40:50,790 --> 00:40:50,170

so Britney can rest rocks get to Europa

914
00:40:53,490 --> 00:40:50,800
and

915
00:40:56,250 --> 00:40:53,500
feminity we there's microbes there's a

916
00:40:58,770 --> 00:40:56,260
very yeah yeah there's a very very very

917
00:41:01,350 --> 00:40:58,780
very very small chance of that possibly

918
00:41:03,930 --> 00:41:01,360
it's very difficult to get them that far

919
00:41:06,000 --> 00:41:03,940
out it's certain that that there was

920
00:41:07,770 --> 00:41:06,010
lots of material moving around through

921
00:41:10,440 --> 00:41:07,780
the inner solar system and certainly

922
00:41:11,610 --> 00:41:10,450
through the whole solar system but the

923
00:41:14,760 --> 00:41:11,620
other thing that you have to think about

924
00:41:17,370 --> 00:41:14,770
is not just imagine the journey that

925
00:41:19,080 --> 00:41:17,380
that material is taking so you've got

926
00:41:20,880 --> 00:41:19,090
something that's been blasted off of one

927
00:41:23,010 --> 00:41:20,890
planet it's certainly that we've shown

928
00:41:24,360 --> 00:41:23,020
that that organisms tardigrades for

929
00:41:26,630 --> 00:41:24,370
instance when the most fascinating ones

930
00:41:29,580 --> 00:41:26,640
can can withstand conditions in space

931
00:41:32,610 --> 00:41:29,590
long periods of time being heated or

932
00:41:35,280 --> 00:41:32,620
frozen or relatively inactive and then

933
00:41:38,250 --> 00:41:35,290
come back to life or come back to their

934
00:41:39,660 --> 00:41:38,260
their previous activity but one of the

935
00:41:41,340 --> 00:41:39,670
things you have to think about is what

936
00:41:44,040 --> 00:41:41,350
happened to that rock to get off the

937
00:41:46,080 --> 00:41:44,050
planet finally what happens to it before

938
00:41:47,850 --> 00:41:46,090

it gets to the other planet and then

939
00:41:51,060 --> 00:41:47,860
there's a stark difference between

940
00:41:53,220 --> 00:41:51,070
surviving a set of conditions landing in

941
00:41:55,320 --> 00:41:53,230
luckily landing in conditions that

942
00:41:57,210 --> 00:41:55,330
you're capable of of not only surviving

943
00:41:59,730 --> 00:41:57,220
in and of themselves but then

944
00:42:02,520 --> 00:41:59,740
reproducing enough to then grandly

945
00:42:04,800 --> 00:42:02,530
populate an entire other planet and so I

946
00:42:06,060 --> 00:42:04,810
think between the the probability

947
00:42:07,410 --> 00:42:06,070
functions that we're talking about that

948
00:42:09,180 --> 00:42:07,420
at least for the icy world that's

949
00:42:10,680 --> 00:42:09,190
probably not very large I would argue

950
00:42:12,810 --> 00:42:10,690
it's not very large for Mars either

951
00:42:15,210 --> 00:42:12,820
because that rock you know these are

952
00:42:16,980 --> 00:42:15,220
Megaton explosions that kick a rock off

953
00:42:18,630 --> 00:42:16,990
a planet in the first place has to

954
00:42:21,180 --> 00:42:18,640
survive off the earth through its

955
00:42:23,160 --> 00:42:21,190
atmosphere come back down if your soup

956
00:42:23,790 --> 00:42:23,170
udders escape velocity on the surface of

957
00:42:25,410 --> 00:42:23,800
Europa

958
00:42:27,030 --> 00:42:25,420
I mean we're probably going to

959
00:42:28,710 --> 00:42:27,040
crash-land spacecraft there because it's

960
00:42:29,640 --> 00:42:28,720
relatively sterilizing there's no

961
00:42:31,530 --> 00:42:29,650
aerobraking

962
00:42:33,270 --> 00:42:31,540
so then the organism has to survive

963
00:42:34,980 --> 00:42:33,280

somehow in an intact rock that's

964
00:42:36,570 --> 00:42:34,990
probably going to be a plasma at this

965
00:42:38,430 --> 00:42:36,580
point in time but if it's not a plasma

966
00:42:41,670 --> 00:42:38,440
then it has to get out of that rock into

967
00:42:43,050 --> 00:42:41,680
an object that's highly oxidizing and

968
00:42:44,460 --> 00:42:43,060
then make it all the way down into an

969
00:42:46,230 --> 00:42:44,470
environment where it's no longer being

970
00:42:47,910 --> 00:42:46,240
irradiated the surface I think there's

971
00:42:49,380 --> 00:42:47,920
probably no chance I disagree with you

972
00:42:51,360 --> 00:42:49,390
behind the moderator so I'm going to

973
00:42:52,830 --> 00:42:51,370
keep read about it and presumably Vicki

974
00:42:56,250 --> 00:42:52,840
it's not too much of a problem in your

975
00:42:58,140 --> 00:42:56,260
case yeah the probability of earth life

976
00:43:02,550 --> 00:42:58,150
feeding life on Proxima Centauri B is

977
00:43:03,740 --> 00:43:02,560
probably very low once elite about site

978
00:43:05,660 --> 00:43:03,750
area do to do

979
00:43:07,400 --> 00:43:05,670
because the you have listed about what

980
00:43:10,430 --> 00:43:07,410
the question is we're trying to answer

981
00:43:12,800 --> 00:43:10,440
well the question is yes and I knew you

982
00:43:14,690 --> 00:43:12,810
would disagree with this because what

983
00:43:17,030 --> 00:43:14,700
we're really I think what makes people

984
00:43:19,130 --> 00:43:17,040
interested in is not as Bill Clinton

985
00:43:22,070 --> 00:43:19,140
said when he stood on the White House

986
00:43:23,599 --> 00:43:22,080
lawn after the Mars meteorite about if

987
00:43:26,420 --> 00:43:23,609
we discover life on Mars it will

988
00:43:28,160 --> 00:43:26,430

transform our view of the universe it

989
00:43:30,410 --> 00:43:28,170
would only do that if you could show

990
00:43:33,470 --> 00:43:30,420
that life it started independently or

991
00:43:35,510 --> 00:43:33,480
mouths but that the probability of going

992
00:43:38,450 --> 00:43:35,520
from non-life to life is not incredibly

993
00:43:39,710 --> 00:43:38,460
small because if you've got two samples

994
00:43:42,080 --> 00:43:39,720
of life in the solar system

995
00:43:45,050 --> 00:43:42,090
surely the universe is going to be full

996
00:43:46,790 --> 00:43:45,060
of it so the issue is not can life get

997
00:43:48,740 --> 00:43:46,800
from one planet to another has it

998
00:43:51,349 --> 00:43:48,750
happened once only and spread around a

999
00:43:54,050 --> 00:43:51,359
bit but is the transition from non-life

1000
00:43:56,089 --> 00:43:54,060
to life something that is quite likely

1001
00:43:58,730 --> 00:43:56,099
and therefore all those habitable

1002
00:44:02,120 --> 00:43:58,740
planets that we're discovering are as

1003
00:44:04,460 --> 00:44:02,130
potential abodes for life actually may

1004
00:44:06,410 --> 00:44:04,470
have life well the reason is reason I'm

1005
00:44:09,140 --> 00:44:06,420
asking so Svetlana answered her question

1006
00:44:11,390 --> 00:44:09,150
your question by saying well it doesn't

1007
00:44:12,290 --> 00:44:11,400
matter whether it is an independent

1008
00:44:14,089 --> 00:44:12,300
origin would still be something

1009
00:44:16,339 --> 00:44:14,099
interesting so if you're going to allow

1010
00:44:18,589 --> 00:44:16,349
that in the question when we where we

1011
00:44:20,450 --> 00:44:18,599
find life next you look in a journal

1012
00:44:22,609 --> 00:44:20,460
next week about some new species that

1013
00:44:24,380 --> 00:44:22,619

has been found by a biologist that I

1014
00:44:27,680 --> 00:44:24,390
think is definitely the answer to this

1015
00:44:29,060 --> 00:44:27,690
question we will find it in biologists

1016
00:44:30,650 --> 00:44:29,070
will find it already has found it and

1017
00:44:32,420 --> 00:44:30,660
just will be published next week that I

1018
00:44:34,280 --> 00:44:32,430
guarantee you is the answer to the

1019
00:44:36,290 --> 00:44:34,290
question if you allow that type of right

1020
00:44:38,210 --> 00:44:36,300
probably like I should she in you

1021
00:44:43,579 --> 00:44:38,220
synthetic biology and I could have I was

1022
00:44:47,000 --> 00:44:43,589
very tempted okay can I change subjects

1023
00:44:49,339 --> 00:44:47,010
totally and ask Jacob that you talked

1024
00:44:51,440 --> 00:44:49,349
about SETI and you know remote signals

1025
00:44:53,030 --> 00:44:51,450
and light-years away and so on what are

1026
00:44:55,490 --> 00:44:53,040
the chances that during its

1027
00:44:59,030 --> 00:44:55,500
four-and-a-half billion year history the

1028
00:45:00,859 --> 00:44:59,040
solar system has been visited by some

1029
00:45:01,820 --> 00:45:00,869
sort of alien technology that there was

1030
00:45:03,680 --> 00:45:01,830
alien technology

1031
00:45:07,450 --> 00:45:03,690
not necessarily the proverbial little

1032
00:45:09,859 --> 00:45:07,460
green men or there's a green person but

1033
00:45:11,839 --> 00:45:09,869
sometime of Asian technology might it

1034
00:45:13,220 --> 00:45:11,849
still be here and how much we find it

1035
00:45:16,040 --> 00:45:13,230
how will we go look

1036
00:45:17,300 --> 00:45:16,050
two alien artifacts within the circuit

1037
00:45:18,680 --> 00:45:17,310
this is a great question and then

1038
00:45:21,860 --> 00:45:18,690

something I'm pretty sure you know I've

1039
00:45:27,350 --> 00:45:21,870
thought about okay totally Alton yes so

1040
00:45:29,240 --> 00:45:27,360
um we humans have sent out probes into

1041
00:45:31,940 --> 00:45:29,250
space not for very long you know since

1042
00:45:34,610 --> 00:45:31,950
the 60s or 70s but the Voyager probes

1043
00:45:36,290 --> 00:45:34,620
Voyager 1 and 2 are basically left the

1044
00:45:39,230 --> 00:45:36,300
solar system these we've left the region

1045
00:45:40,550 --> 00:45:39,240
where the Sun has main influence and and

1046
00:45:42,500 --> 00:45:40,560
they're well on their way to becoming

1047
00:45:43,940 --> 00:45:42,510
into your stellar spacecraft now they're

1048
00:45:45,680 --> 00:45:43,950
not really going to land in another

1049
00:45:47,350 --> 00:45:45,690
solar system they're not on that kind of

1050
00:45:50,360 --> 00:45:47,360
trajectory but there's a demonstration

1051
00:45:52,100 --> 00:45:50,370
technology we can send spacecraft out to

1052
00:45:53,990 --> 00:45:52,110
another star system I mentioned yuri

1053
00:45:55,610 --> 00:45:54,000
milner breakthrough starshot is another

1054
00:45:57,890 --> 00:45:55,620
project that he's funding at 100 million

1055
00:46:00,230 --> 00:45:57,900
dollars to send graham sized probes to

1056
00:46:02,090 --> 00:46:00,240
Proxima B so we already have a plan to

1057
00:46:03,860 --> 00:46:02,100
send they're going to build a giant jet

1058
00:46:07,460 --> 00:46:03,870
laser in the desert so keep an eye on

1059
00:46:09,500 --> 00:46:07,470
this project got a lot of interest but

1060
00:46:12,080 --> 00:46:09,510
but so we know we can do this we can

1061
00:46:14,450 --> 00:46:12,090
send probe to other stars and have in

1062
00:46:16,250 --> 00:46:14,460
situ observations so there is no reason

1063
00:46:18,350 --> 00:46:16,260

in the four billion year history of the

1064
00:46:19,850 --> 00:46:18,360
Gallic of the solar system there's no

1065
00:46:21,770 --> 00:46:19,860
reason that other extraterrestrials

1066
00:46:23,780 --> 00:46:21,780
wouldn't have found interest in earth oh

1067
00:46:24,980 --> 00:46:23,790
look there's this rocky planet forming

1068
00:46:26,780 --> 00:46:24,990
in a habitable zone with some water

1069
00:46:28,250 --> 00:46:26,790
maybe they'd like guest Giants maybe was

1070
00:46:29,660 --> 00:46:28,260
like oh look there's a Jupiter with some

1071
00:46:31,640 --> 00:46:29,670
rocky moons around it we don't know what

1072
00:46:34,040 --> 00:46:31,650
they're interested in but it's very

1073
00:46:35,450 --> 00:46:34,050
conceivable that something like that

1074
00:46:37,550 --> 00:46:35,460
could be in our solar system we would

1075
00:46:39,080 --> 00:46:37,560
have very very low chance of finding

1076
00:46:41,480 --> 00:46:39,090
that now I think you would want a very

1077
00:46:43,520 --> 00:46:41,490
systematic search look at stable

1078
00:46:46,430 --> 00:46:43,530
Lagrange points or orbital places where

1079
00:46:48,740 --> 00:46:46,440
you can have have a satellite stable for

1080
00:46:50,450 --> 00:46:48,750
longer periods of time I think there's

1081
00:46:53,690 --> 00:46:50,460
there's some systematic searching you

1082
00:46:54,650 --> 00:46:53,700
can do in the solar system but I guess

1083
00:46:56,060 --> 00:46:54,660
what you have to be careful of is

1084
00:46:58,460 --> 00:46:56,070
there's a philosophical argument called

1085
00:47:00,110 --> 00:46:58,470
Russell's teapot where could I go to

1086
00:47:02,510 --> 00:47:00,120
hypothesize there's a teapot in orbit

1087
00:47:03,920 --> 00:47:02,520
between Mars and Jupiter and you go look

1088
00:47:05,330 --> 00:47:03,930

for and you come back to dig if we

1089
00:47:06,590 --> 00:47:05,340
didn't find it like oh well it's smaller

1090
00:47:08,270 --> 00:47:06,600
it's a smaller teapot you aren't looking

1091
00:47:09,680 --> 00:47:08,280
hard enough and so you have to be

1092
00:47:12,470 --> 00:47:09,690
careful yes there could be alien

1093
00:47:13,520 --> 00:47:12,480
artifact in the solar system but at some

1094
00:47:16,070 --> 00:47:13,530
point if you're looking and you don't

1095
00:47:17,150 --> 00:47:16,080
find them you can't keep insisting that

1096
00:47:18,890 --> 00:47:17,160
they're there just because you haven't

1097
00:47:20,330 --> 00:47:18,900
found them but it's totally conceivable

1098
00:47:22,460 --> 00:47:20,340
and I think we should keep looking for

1099
00:47:24,590 --> 00:47:22,470
this could I push back on that

1100
00:47:25,460 --> 00:47:24,600
what's the amazes of while you're gone I

1101
00:47:27,829 --> 00:47:25,470
forgot to mention

1102
00:47:30,140 --> 00:47:27,839
this slide here and I think I think that

1103
00:47:32,510 --> 00:47:30,150
the reason I put up that slide because I

1104
00:47:34,670 --> 00:47:32,520
think that our closest relatives in the

1105
00:47:36,559 --> 00:47:34,680
universe are here on earth and there's

1106
00:47:39,620 --> 00:47:36,569
Jane Goodall with our closest relative

1107
00:47:43,579 --> 00:47:39,630
of the species of chimpanzee and what we

1108
00:47:45,680 --> 00:47:43,589
have done with outer space has put we

1109
00:47:47,870 --> 00:47:45,690
have projected ourselves into the

1110
00:47:50,630 --> 00:47:47,880
universe and as what we see here all the

1111
00:47:53,660 --> 00:47:50,640
aliens that we have done on TV and and

1112
00:47:56,030 --> 00:47:53,670
in books and that seems silly and I've

1113
00:47:58,250 --> 00:47:56,040

tried to make it silly but it's not it's

1114
00:48:00,440 --> 00:47:58,260
also it might be silly to project

1115
00:48:02,329 --> 00:48:00,450
bacterial life that we have here and say

1116
00:48:05,240 --> 00:48:02,339
oh it too could evolve there I don't see

1117
00:48:07,940 --> 00:48:05,250
that there's a major non silliness to

1118
00:48:11,180 --> 00:48:07,950
projecting Beth terrestrial bacteria

1119
00:48:12,230 --> 00:48:11,190
elsewhere any less silly than projecting

1120
00:48:15,800 --> 00:48:12,240
this guy over here and they're right I

1121
00:48:17,780 --> 00:48:15,810
don't know who he is but so I think that

1122
00:48:19,370 --> 00:48:17,790
the Assumption behind SETI is human-like

1123
00:48:21,170 --> 00:48:19,380
intelligence is a convergent feature of

1124
00:48:23,630 --> 00:48:21,180
evolution and I see no evidence for that

1125
00:48:25,880 --> 00:48:23,640
on earth technology not going to throw

1126
00:48:27,260 --> 00:48:25,890
human-like okay the general ability to

1127
00:48:29,690 --> 00:48:27,270
build a radio transmitter a there's no

1128
00:48:32,960 --> 00:48:29,700
evidence for that on earth we had all we

1129
00:48:35,420 --> 00:48:32,970
really want is alien technology and as

1130
00:48:36,650 --> 00:48:35,430
we were talking about that Vicki let me

1131
00:48:40,339 --> 00:48:36,660
just ask you there's been a lot of

1132
00:48:43,490 --> 00:48:40,349
interest very speculative in alien

1133
00:48:45,800 --> 00:48:43,500
megastructures in other planetary

1134
00:48:49,870 --> 00:48:45,810
systems do you spare a thought for that

1135
00:48:53,690 --> 00:48:49,880
or is it just the lunatic fringe of them

1136
00:48:56,720 --> 00:48:53,700
yes so yeah we do we do think about

1137
00:48:58,160 --> 00:48:56,730
alien structures and I was actually part

1138
00:49:00,050 --> 00:48:58,170

of a project recently run by the

1139
00:49:02,059 --> 00:49:00,060
sambhoga which to see if we could see

1140
00:49:05,780 --> 00:49:02,069
them for example in terms of signals you

1141
00:49:07,880 --> 00:49:05,790
can imagine aliens are trying to give us

1142
00:49:10,160 --> 00:49:07,890
a message by putting up a particular

1143
00:49:11,540 --> 00:49:10,170
craft that have very unnatural shapes

1144
00:49:13,099 --> 00:49:11,550
like triangles for example flying

1145
00:49:15,050 --> 00:49:13,109
information or things like that that we

1146
00:49:16,760 --> 00:49:15,060
could potentially look at there's this

1147
00:49:19,520 --> 00:49:16,770
thing called tabby star which has a very

1148
00:49:21,290 --> 00:49:19,530
unusual transit signal that people are

1149
00:49:23,000 --> 00:49:21,300
looking at and one of the hypotheses is

1150
00:49:24,410 --> 00:49:23,010
that it's an alien structure some sort

1151
00:49:27,349 --> 00:49:24,420
of course there are other hypotheses

1152
00:49:28,609 --> 00:49:27,359
that are not as you know alien focused

1153
00:49:30,349 --> 00:49:28,619
for that and we're still trying to

1154
00:49:32,870 --> 00:49:30,359
figure out what that phenomenon is but

1155
00:49:34,160 --> 00:49:32,880
yeah those those are the the sort of

1156
00:49:34,880 --> 00:49:34,170
things that yeah we're always on the

1157
00:49:37,789 --> 00:49:34,890
lookout for

1158
00:49:39,769 --> 00:49:37,799
really and Luciana ganas is putting

1159
00:49:41,269 --> 00:49:39,779
together a software so the machine

1160
00:49:43,609 --> 00:49:41,279
learning software that looks for the

1161
00:49:45,529 --> 00:49:43,619
unexpected in Kepler transit signals to

1162
00:49:48,740 --> 00:49:45,539
to look for these sorts of things so

1163
00:49:53,900 --> 00:49:48,750

you've thought a bit about alien techno

1164
00:49:56,450 --> 00:49:53,910
signatures I know we should expect the

1165
00:49:58,069 --> 00:49:56,460
unexpected but do you have any any

1166
00:50:02,710 --> 00:49:58,079
thoughts about things that have not been

1167
00:50:06,950 --> 00:50:05,359
don't think we have a clue at least to

1168
00:50:09,319 --> 00:50:06,960
be honest I mean that was actually the

1169
00:50:11,779 --> 00:50:09,329
whole point of my argument technology

1170
00:50:13,519 --> 00:50:11,789
and particularly you see yeah might be a

1171
00:50:16,279 --> 00:50:13,529
techno signature that we haven't

1172
00:50:18,380 --> 00:50:16,289
discussed yet well I mean a classic one

1173
00:50:20,990 --> 00:50:18,390
that people talk about which exoplanets

1174
00:50:23,450 --> 00:50:21,000
is actually pollution I mean Jacobs

1175
00:50:26,930 --> 00:50:23,460
thought a lot about that and so you

1176
00:50:28,609 --> 00:50:26,940
might think about looking for planets

1177
00:50:31,849 --> 00:50:28,619
that are very polluted which is a very

1178
00:50:34,910 --> 00:50:31,859
bleak view of what living things are

1179
00:50:36,410 --> 00:50:34,920
doing on different worlds so I think

1180
00:50:38,299 --> 00:50:36,420
that's certainly one possibility there's

1181
00:50:39,890 --> 00:50:38,309
always classic things like Dyson spheres

1182
00:50:43,670 --> 00:50:39,900
which would be like you know really

1183
00:50:44,240 --> 00:50:43,680
massive megastructures around other

1184
00:50:46,519 --> 00:50:44,250
stars

1185
00:50:48,769 --> 00:50:46,529
you could get galactic if you wanted to

1186
00:50:50,690 --> 00:50:48,779
look for like special patterns and stars

1187
00:50:52,490 --> 00:50:50,700
if you think that like a really advanced

1188
00:50:54,559 --> 00:50:52,500

technological civilization actually

1189
00:50:56,779 --> 00:50:54,569
could move stars into the college level

1190
00:51:00,019 --> 00:50:56,789
yeah maybe like a you know a gravity

1191
00:51:01,039 --> 00:51:00,029
slingshot or something also yes yeah

1192
00:51:04,249 --> 00:51:01,049
there you go

1193
00:51:06,710 --> 00:51:04,259
pulsar GPS so so I think I think one of

1194
00:51:09,200 --> 00:51:06,720
the challenges with looking for life is

1195
00:51:11,870 --> 00:51:09,210
the way we think about it is only

1196
00:51:14,839 --> 00:51:11,880
bounded by our imagination and that

1197
00:51:17,630 --> 00:51:14,849
makes it really hard to do Astro biology

1198
00:51:19,279 --> 00:51:17,640
as a science but I think that's one I

1199
00:51:20,900 --> 00:51:19,289
think that's really incredible about the

1200
00:51:22,009 --> 00:51:20,910
field is that we managed to do it and

1201
00:51:24,380 --> 00:51:22,019
it's because there's a lot of really

1202
00:51:25,730 --> 00:51:24,390
creative scientists working on these

1203
00:51:28,160 --> 00:51:25,740
problems that are really trying to

1204
00:51:30,170 --> 00:51:28,170
figure out ways to think about these

1205
00:51:32,809 --> 00:51:30,180
things critically can I actually add

1206
00:51:34,609 --> 00:51:32,819
something to this so I like you're at

1207
00:51:36,200 --> 00:51:34,619
your comment about alien pollution and

1208
00:51:39,200 --> 00:51:36,210
take it one step further I think there

1209
00:51:40,700 --> 00:51:39,210
is one one technical signature that we

1210
00:51:43,789 --> 00:51:40,710
might find with exoplanet science and

1211
00:51:45,769 --> 00:51:43,799
that is a terraform planet next to a

1212
00:51:47,730 --> 00:51:45,779
habitable planet so if we imagine earth

1213
00:51:50,550 --> 00:51:47,740

in earth today is in the habitable zone

1214
00:51:52,859 --> 00:51:50,560
Mars is not really it's not happening

1215
00:51:54,870 --> 00:51:52,869
because it's too small but you can

1216
00:51:57,270 --> 00:51:54,880
imagine humans going to Mars and making

1217
00:51:58,650 --> 00:51:57,280
Mars raising the average surface

1218
00:52:00,000 --> 00:51:58,660
temperature of Mars by putting

1219
00:52:02,310 --> 00:52:00,010
chlorofluorocarbons of the atmosphere or

1220
00:52:04,230 --> 00:52:02,320
something like this and so Mars now

1221
00:52:05,970 --> 00:52:04,240
becomes more earth-like even though at

1222
00:52:07,920 --> 00:52:05,980
the distance it is from the Sun you

1223
00:52:09,570 --> 00:52:07,930
would calculate that it should not

1224
00:52:11,070 --> 00:52:09,580
necessarily be as warm as you observe it

1225
00:52:12,570 --> 00:52:11,080
so I think there are some technical

1226
00:52:16,230 --> 00:52:12,580
eaters then exoplanet science could get

1227
00:52:17,609 --> 00:52:16,240
change every man but planet yeah before

1228
00:52:19,200 --> 00:52:17,619
we bring in the audience I just called

1229
00:52:21,120 --> 00:52:19,210
two questions a quick one I met one that

1230
00:52:23,280 --> 00:52:21,130
maybe has been more contentious the

1231
00:52:27,359 --> 00:52:23,290
quick one is anybody here prepared to

1232
00:52:31,890 --> 00:52:27,369
speak out for Venus life on Venus what

1233
00:52:33,030 --> 00:52:31,900
you're sure sure I mean earlier since

1234
00:52:35,790 --> 00:52:33,040
you don't know what life is you can

1235
00:52:38,430 --> 00:52:35,800
mention it anyway but knows the Venus is

1236
00:52:41,400 --> 00:52:38,440
the the planet that's most what it used

1237
00:52:43,410 --> 00:52:41,410
to be the most right so it's point seven

1238
00:52:45,930 --> 00:52:43,420

eight you wear one a you know when badly

1239
00:52:48,510 --> 00:52:45,940
wrong from them uh if you call up you

1240
00:52:50,460 --> 00:52:48,520
know runaway greenhouse if you like it

1241
00:52:52,770 --> 00:52:50,470
yes maybe they did it themselves I do

1242
00:52:55,010 --> 00:52:52,780
not know so what one of you guys what

1243
00:52:57,390 --> 00:52:55,020
are the uncertainties is when Venus went

1244
00:52:58,650 --> 00:52:57,400
greenhouse I don't know whether there's

1245
00:53:00,930 --> 00:52:58,660
a build maybe Vicki would you know that

1246
00:53:03,000 --> 00:53:00,940
1 billion two billion years ago if we

1247
00:53:04,890 --> 00:53:03,010
don't really all we have is this

1248
00:53:06,570 --> 00:53:04,900
evidence that a billion years ago we

1249
00:53:08,430 --> 00:53:06,580
overturned the surface and so is it's

1250
00:53:09,450 --> 00:53:08,440
not it's not fully pinned down and I

1251
00:53:10,800 --> 00:53:09,460
know there's some people to think that

1252
00:53:12,120 --> 00:53:10,810
maybe at the point that the surface

1253
00:53:13,440 --> 00:53:12,130
overturn occurred that's when the

1254
00:53:15,089 --> 00:53:13,450
runaway occurred but it could have

1255
00:53:16,470 --> 00:53:15,099
happened a lot earlier depends was it

1256
00:53:17,730 --> 00:53:16,480
happen two billion years ago what

1257
00:53:19,470 --> 00:53:17,740
happened two billion years ago then hey

1258
00:53:21,810 --> 00:53:19,480
one two billion years which life could

1259
00:53:23,250 --> 00:53:21,820
have evolved in a very similar way to it

1260
00:53:27,060 --> 00:53:23,260
might the way it might have evolved here

1261
00:53:30,420 --> 00:53:27,070
so life on Venus is is as likely as life

1262
00:53:33,000 --> 00:53:30,430
here maybe and but it just got killed it

1263
00:53:35,190 --> 00:53:33,010

got heated up I cooked all right I'm now

1264
00:53:37,920 --> 00:53:35,200
to the to the more contentious question

1265
00:53:40,530 --> 00:53:37,930
which is and and I think has felt

1266
00:53:42,329 --> 00:53:40,540
already alluded to this that the general

1267
00:53:44,520 --> 00:53:42,339
public has the impression that nASA has

1268
00:53:47,550 --> 00:53:44,530
spent decades searching for life on Mars

1269
00:53:49,890 --> 00:53:47,560
but we all know that the last biological

1270
00:53:52,010 --> 00:53:49,900
experiment done on Mars so indeed

1271
00:53:55,130 --> 00:53:52,020
anywhere by NASA outside

1272
00:54:00,770 --> 00:53:55,140
of when outside of low-earth orbit while

1273
00:54:03,910 --> 00:54:00,780
Sir Viking in 1976 and you mentioned

1274
00:54:07,370 --> 00:54:03,920
that there are plans to actually do

1275
00:54:10,600 --> 00:54:07,380
biological experiments on Mars and maybe

1276
00:54:17,690 --> 00:54:10,610
sample return so is this kind of survive

1277
00:54:19,520 --> 00:54:17,700
the rigors of NASA quality control do

1278
00:54:22,760 --> 00:54:19,530
you think that they really are going to

1279
00:54:25,310 --> 00:54:22,770
do for example like the labeled release

1280
00:54:28,370 --> 00:54:25,320
experiments repeat that on Mars is that

1281
00:54:30,740 --> 00:54:28,380
in prospect or or it's going to be

1282
00:54:32,420 --> 00:54:30,750
pushed off for another decade yeah so

1283
00:54:36,680 --> 00:54:32,430
let's back up and first talk about

1284
00:54:40,280 --> 00:54:36,690
Viking so in the mid-70s a set of twin

1285
00:54:44,090 --> 00:54:40,290
Landers the Viking landers were the

1286
00:54:47,060 --> 00:54:44,100
first actual bio signature targeted bio

1287
00:54:48,740 --> 00:54:47,070
signature searches on Mars and there's

1288
00:54:52,310 --> 00:54:48,750

been a lot of controversy about what

1289
00:54:54,860 --> 00:54:52,320
they actually discovered the Viking

1290
00:54:58,730 --> 00:54:54,870
landers made the assumption that we were

1291
00:55:01,520 --> 00:54:58,740
looking for specifically living life on

1292
00:55:04,190 --> 00:55:01,530
Mars microbes in the soil that were

1293
00:55:06,770 --> 00:55:04,200
actively you know metabolizing actively

1294
00:55:09,290 --> 00:55:06,780
living breathing and so the actual

1295
00:55:13,460 --> 00:55:09,300
experiments were designed to measure

1296
00:55:14,840 --> 00:55:13,470
only that so that's a very strong

1297
00:55:17,690 --> 00:55:14,850
assumption to make and the other

1298
00:55:20,420 --> 00:55:17,700
assumption that was made was that we had

1299
00:55:23,540 --> 00:55:20,430
a very good understanding about the

1300
00:55:25,250 --> 00:55:23,550
chemistry of Martian soil that we knew

1301
00:55:28,070 --> 00:55:25,260
exactly what the components were of

1302
00:55:31,160 --> 00:55:28,080
Martian soil and the problem with both

1303
00:55:34,490 --> 00:55:31,170
of those assumptions was that the

1304
00:55:37,370 --> 00:55:34,500
results of Viking were kind of both ways

1305
00:55:39,680 --> 00:55:37,380
some some some of the results showed

1306
00:55:42,530 --> 00:55:39,690
that yes something's reacting in the

1307
00:55:45,340 --> 00:55:42,540
soil that looks like life like microbes

1308
00:55:49,120 --> 00:55:45,350
and some of the other experiments showed

1309
00:55:51,170 --> 00:55:49,130
now there's nothing alive in the soil so

1310
00:55:53,060 --> 00:55:51,180
what do you do with that how do you try

1311
00:55:56,570 --> 00:55:53,070
to deal with that result the community

1312
00:56:00,880 --> 00:55:56,580
argued about that and I think the more

1313
00:56:03,380 --> 00:56:00,890

accepted response the more accepted

1314
00:56:04,560 --> 00:56:03,390
result is that there was something in

1315
00:56:07,320 --> 00:56:04,570
the soil mimic

1316
00:56:09,240 --> 00:56:07,330
life that there was a component in the

1317
00:56:11,880 --> 00:56:09,250
soil that was mimicking life reaction

1318
00:56:15,000 --> 00:56:11,890
and since and since Viking we've learned

1319
00:56:17,880 --> 00:56:15,010
that that's actually true there's a

1320
00:56:20,370 --> 00:56:17,890
component in the soil oxidants or

1321
00:56:23,000 --> 00:56:20,380
specifically perchlorate chemicals that

1322
00:56:25,500 --> 00:56:23,010
are actually attacking anything

1323
00:56:27,480 --> 00:56:25,510
carbon-based or organics and they're

1324
00:56:29,720 --> 00:56:27,490
altering them and changing them in a way

1325
00:56:32,820 --> 00:56:29,730
that's really confusing our

1326
00:56:37,680 --> 00:56:32,830
interpretations so now my question is

1327
00:56:41,180 --> 00:56:37,690
less what if I can find but more well

1328
00:56:43,830 --> 00:56:41,190
NASA get over the shock of having that

1329
00:56:46,650 --> 00:56:43,840
inconclusive result and actually send

1330
00:56:49,110 --> 00:56:46,660
another biology experimental mouse yeah

1331
00:56:51,090 --> 00:56:49,120
that's as well all right so the point I

1332
00:56:53,040 --> 00:56:51,100
was trying to make with that is that we

1333
00:56:55,860 --> 00:56:53,050
made a lot of assumptions with Viking

1334
00:56:58,650 --> 00:56:55,870
that we're not making with the upcoming

1335
00:57:01,740 --> 00:56:58,660
bio signature searches the 2020 Rover

1336
00:57:03,450 --> 00:57:01,750
and the ExoMars Rover are not targeting

1337
00:57:06,030 --> 00:57:03,460
their bio signature searches to

1338
00:57:09,000 --> 00:57:06,040

specifically extend life that is

1339
00:57:11,100 --> 00:57:09,010
metabolizing we're targeting a variety

1340
00:57:12,450 --> 00:57:11,110
of organic a variety of carbon-based

1341
00:57:15,540 --> 00:57:12,460
components because we're going to have

1342
00:57:19,410 --> 00:57:15,550
instruments that are going to do laser

1343
00:57:21,650 --> 00:57:19,420
based and other chemistry based analyses

1344
00:57:24,090 --> 00:57:21,660
they're going to give us a diversity of

1345
00:57:26,820 --> 00:57:24,100
potential signatures of life and on a

1346
00:57:29,190 --> 00:57:26,830
2020 Rover we're not actually going to

1347
00:57:32,580 --> 00:57:29,200
conclude whether or not there's life on

1348
00:57:35,310 --> 00:57:32,590
Mars I would argue that you can't you

1349
00:57:36,360 --> 00:57:35,320
can't really conclusively say whether or

1350
00:57:39,420 --> 00:57:36,370
not you're going to have life on Mars

1351
00:57:41,460 --> 00:57:39,430
with a robotic rover so that is why the

1352
00:57:44,490 --> 00:57:41,470
2020 Rover is actually going to bring

1353
00:57:47,340 --> 00:57:44,500
those samples back or that is the the

1354
00:57:49,230 --> 00:57:47,350
NASA exploration strategy and when we

1355
00:57:51,480 --> 00:57:49,240
bring those back to earth

1356
00:57:53,690 --> 00:57:51,490
at a much later point in time we're

1357
00:57:56,820 --> 00:57:53,700
going to expose those samples to the

1358
00:57:58,650 --> 00:57:56,830
more sophisticated techniques that we

1359
00:58:01,470 --> 00:57:58,660
have available to us here that you can't

1360
00:58:02,940 --> 00:58:01,480
put on a rover we're not making any of

1361
00:58:05,520 --> 00:58:02,950
those assumptions that we made with

1362
00:58:07,470 --> 00:58:05,530
Viking we're going to have a much much

1363
00:58:10,050 --> 00:58:07,480

better chance and we're going to have

1364
00:58:12,780 --> 00:58:10,060
teams of people all over the world who

1365
00:58:15,840 --> 00:58:12,790
are going to get those samples and are

1366
00:58:17,290 --> 00:58:15,850
going to be able to do a variety of very

1367
00:58:19,540 --> 00:58:17,300
interesting experiments with

1368
00:58:22,060 --> 00:58:19,550
so I do need if we overcome the

1369
00:58:24,430 --> 00:58:22,070
planetary protection and legal issues or

1370
00:58:27,130 --> 00:58:24,440
if we bring them back rise that right

1371
00:58:29,620 --> 00:58:27,140
now that's not or Titans of the space

1372
00:58:30,970 --> 00:58:29,630
station now Satan yeah can I make it I

1373
00:58:33,790 --> 00:58:30,980
mean yeah I'm and then we'll bring in

1374
00:58:35,440 --> 00:58:33,800
the audio section yeah I mean this this

1375
00:58:37,030 --> 00:58:35,450
kind of emphasizes a sort of a major

1376
00:58:40,810 --> 00:58:37,040
theme in astrobiology which that it's

1377
00:58:42,070 --> 00:58:40,820
very difficult to interpret a potential

1378
00:58:43,270 --> 00:58:42,080
biosignature unless you really

1379
00:58:45,220 --> 00:58:43,280
understand what's going on in the

1380
00:58:46,210 --> 00:58:45,230
environment around it and so the Viking

1381
00:58:48,370 --> 00:58:46,220
experiments were kind of really a

1382
00:58:49,990 --> 00:58:48,380
classic example of that we were we're

1383
00:58:51,550 --> 00:58:50,000
fairly ignorant about what the the

1384
00:58:53,530 --> 00:58:51,560
chemistry of the of the Martian soul was

1385
00:58:55,390 --> 00:58:53,540
and so we weren't able to interpret our

1386
00:58:57,550 --> 00:58:55,400
results and the same thing can

1387
00:58:59,440 --> 00:58:57,560
potentially happen for exoplanets even I

1388
00:59:01,090 --> 00:58:59,450

talked about oxygen but I didn't talk

1389
00:59:02,680 --> 00:59:01,100
about the potential for false positives

1390
00:59:04,870 --> 00:59:02,690
which is ways that the environment could

1391
00:59:06,370 --> 00:59:04,880
make oxygen room fool us so this is this

1392
00:59:08,440 --> 00:59:06,380
is a big theme in astrobiology now is

1393
00:59:09,970 --> 00:59:08,450
trying to understand what in the context

1394
00:59:12,100 --> 00:59:09,980
of the environment was searching in how

1395
00:59:13,900 --> 00:59:12,110
can that environment make the thing that

1396
00:59:15,160 --> 00:59:13,910
we're looking for and how do we tell the

1397
00:59:17,020 --> 00:59:15,170
difference what would it take to

1398
00:59:19,630 --> 00:59:17,030
convince a skeptic that that really was

1399
00:59:20,920 --> 00:59:19,640
life that time I mean I'd like to bring

1400
00:59:22,990 --> 00:59:20,930
the audience in there you'll see the

1401
00:59:25,750 --> 00:59:23,000
microphones either side please don't

1402
00:59:29,740 --> 00:59:25,760
squabble form an orderly queue as we

1403
00:59:32,170 --> 00:59:29,750
would say in inland and I'll do a sort

1404
00:59:34,930 --> 00:59:32,180
of left/right approach so we'll start

1405
00:59:36,940 --> 00:59:34,940
with a gentleman over there so when I

1406
00:59:40,290 --> 00:59:36,950
was a graduate student not too many

1407
00:59:42,460 --> 00:59:40,300
decades ago we were taught that

1408
00:59:44,350 --> 00:59:42,470
exoplanets outside of the solar system

1409
00:59:47,170 --> 00:59:44,360
was exceedingly rare very hard to

1410
00:59:48,670 --> 00:59:47,180
imagine and and I think the lesson that

1411
00:59:50,230 --> 00:59:48,680
we've learned throughout astronomy is

1412
00:59:53,110 --> 00:59:50,240
that to the extent that we think we're

1413
00:59:54,760 --> 00:59:53,120

special were wrong but every time we

1414
00:59:58,300 --> 00:59:54,770
thought were special we have been wrong

1415
01:00:00,420 --> 00:59:58,310
I had two immediate responses to some of

1416
01:00:03,010 --> 01:00:00,430
the comments from a panel one of them is

1417
01:00:05,710 --> 01:00:03,020
this idea that we couldn't really

1418
01:00:08,200 --> 01:00:05,720
imagine panspermia working between

1419
01:00:10,090 --> 01:00:08,210
exoplanets but remember that the Oort

1420
01:00:13,420 --> 01:00:10,100
cloud and it's perturbations extend

1421
01:00:14,770 --> 01:00:13,430
easily between stars and comets are not

1422
01:00:17,560 --> 01:00:14,780
a bad place to imagine putting

1423
01:00:20,110 --> 01:00:17,570
biological spores I think the other

1424
01:00:21,730 --> 01:00:20,120
comment was about looking for signals on

1425
01:00:23,470 --> 01:00:21,740
exoplanets and the light signal was a

1426
01:00:26,320 --> 01:00:23,480
good place to start but actually the

1427
01:00:29,280 --> 01:00:26,330
thermodynamic signal heat generated by

1428
01:00:31,620 --> 01:00:29,290
life is ten times larger with a much

1429
01:00:34,530 --> 01:00:31,630
smaller background from the exoplanet so

1430
01:00:37,620 --> 01:00:34,540
I it's just a cautionary comment that to

1431
01:00:41,160 --> 01:00:37,630
the extent we bias our views by our own

1432
01:00:43,410 --> 01:00:41,170
experience I think we've been wrong well

1433
01:00:45,900 --> 01:00:43,420
thanks I really is a comment so I won't

1434
01:00:47,670 --> 01:00:45,910
sort of reopen the issue about that and

1435
01:00:51,750 --> 01:00:47,680
spam here because I think you gave your

1436
01:00:52,980 --> 01:00:51,760
opinions and I'll move to the question

1437
01:00:55,200 --> 01:00:52,990
from the gentleman here

1438
01:00:58,320 --> 01:00:55,210

sure thanks for being here everyone it's

1439
01:01:00,030 --> 01:00:58,330
been a fun discussion so far it kind of

1440
01:01:01,860 --> 01:01:00,040
dovetails off of the previous comment

1441
01:01:03,560 --> 01:01:01,870
over there I wanted to ask about what

1442
01:01:06,510 --> 01:01:03,570
you said about far from equilibrium

1443
01:01:08,340 --> 01:01:06,520
dissipative systems and how you said

1444
01:01:09,990 --> 01:01:08,350
that there might be many such

1445
01:01:11,430 --> 01:01:10,000
dissipative systems indeed there are in

1446
01:01:15,840 --> 01:01:11,440
the universe but life is a very

1447
01:01:17,930 --> 01:01:15,850
particular unique and rare one and so

1448
01:01:21,110 --> 01:01:17,940
the way I see it is that we've sort of

1449
01:01:24,750 --> 01:01:21,120
learned and formulated a very generic

1450
01:01:27,060 --> 01:01:24,760
story for planet formation and we think

1451
01:01:28,920 --> 01:01:27,070
that geology and geochemistry are

1452
01:01:31,050 --> 01:01:28,930
somewhat universal we see the same types

1453
01:01:33,000 --> 01:01:31,060
of minerals on Mars we think that there

1454
01:01:35,970 --> 01:01:33,010
might be hydrothermal vents in the ocean

1455
01:01:39,480 --> 01:01:35,980
world so a dissipative system that would

1456
01:01:42,270 --> 01:01:39,490
arise on a terrestrial body to tackle a

1457
01:01:44,970 --> 01:01:42,280
disequilibrium it seems like those

1458
01:01:47,190 --> 01:01:44,980
disequilibrium or barriers would be kind

1459
01:01:49,200 --> 01:01:47,200
of universal and that each terrestrial

1460
01:01:52,410 --> 01:01:49,210
planet would offer that for something

1461
01:01:54,300 --> 01:01:52,420
like life as we know it to then emerge

1462
01:01:56,190 --> 01:01:54,310
to tackle and dissipate that

1463
01:01:57,480 --> 01:01:56,200

disequilibrium well what do you think

1464
01:01:59,040 --> 01:01:57,490
about that well I agree with everything

1465
01:02:01,770 --> 01:01:59,050
you said except for the part where you

1466
01:02:04,410 --> 01:02:01,780
say that it would necessarily engender

1467
01:02:06,600 --> 01:02:04,420
the type of life that we are all

1468
01:02:09,810 --> 01:02:06,610
familiar with here now if it engendered

1469
01:02:10,770 --> 01:02:09,820
a convection cell you most people

1470
01:02:12,930 --> 01:02:10,780
wouldn't be happy because they saw

1471
01:02:14,700 --> 01:02:12,940
that's not life but so we're at we have

1472
01:02:17,310 --> 01:02:14,710
these blinkers saying we're looking for

1473
01:02:19,020 --> 01:02:17,320
terrestrial life and we always want to

1474
01:02:20,490 --> 01:02:19,030
say it's a generic feature you just

1475
01:02:22,200 --> 01:02:20,500
assumed it was a generic feature when

1476
01:02:23,580 --> 01:02:22,210
you say oh if you have these redox

1477
01:02:25,890 --> 01:02:23,590
potentials you have this thermal

1478
01:02:28,740 --> 01:02:25,900
gradients etcetera you will produce the

1479
01:02:30,690 --> 01:02:28,750
things that were at the origin of life

1480
01:02:32,760 --> 01:02:30,700
on earth but you know what English is

1481
01:02:34,980 --> 01:02:32,770
here and you could it didn't happen

1482
01:02:35,880 --> 01:02:34,990
magically at very peculiar beginnings

1483
01:02:37,860 --> 01:02:35,890
and when you're talking about biology

1484
01:02:39,660 --> 01:02:37,870
you're talking not about astronomy

1485
01:02:41,670 --> 01:02:39,670
anymore you're not talking about physics

1486
01:02:42,370 --> 01:02:41,680
and so you're not talking about to

1487
01:02:43,750 --> 01:02:42,380
determine this

1488
01:02:46,090 --> 01:02:43,760

sciences you're talking about something

1489
01:02:47,740 --> 01:02:46,100
that's very very self referential not

1490
01:02:49,750 --> 01:02:47,750
too different from a particular human

1491
01:02:50,590 --> 01:02:49,760
language and that quirkiness is

1492
01:02:53,500 --> 01:02:50,600
something that I think we should

1493
01:02:55,270 --> 01:02:53,510
entertain as a possibility for what type

1494
01:02:57,310 --> 01:02:55,280
of life we think we have here rather

1495
01:02:59,350 --> 01:02:57,320
than this propaganda it's generic

1496
01:03:01,000 --> 01:02:59,360
therefore it's out there so I don't I

1497
01:03:02,860 --> 01:03:01,010
wouldn't I would disagree with that and

1498
01:03:04,780 --> 01:03:02,870
the reason I disagree with that is two

1499
01:03:07,570 --> 01:03:04,790
things is because language you've picked

1500
01:03:09,430 --> 01:03:07,580
English but dolphins communicate right

1501
01:03:12,970 --> 01:03:09,440
so that's an example the completely

1502
01:03:15,610 --> 01:03:12,980
inhuman evolution of language or of

1503
01:03:17,470 --> 01:03:15,620
communication which we and Alton's have

1504
01:03:20,290 --> 01:03:17,480
a common ancestor but 95 million years

1505
01:03:22,000 --> 01:03:20,300
actually not anything okay and I'm

1506
01:03:23,740 --> 01:03:22,010
giving you a table you've chosen English

1507
01:03:26,140 --> 01:03:23,750
as your example and I'm giving you other

1508
01:03:27,700 --> 01:03:26,150
examples and the fact that we've evolved

1509
01:03:29,740 --> 01:03:27,710
multicellularity and multiple other

1510
01:03:31,930 --> 01:03:29,750
other opportunities but I think you're

1511
01:03:33,310 --> 01:03:31,940
oversimplifying what people are doing to

1512
01:03:35,020 --> 01:03:33,320
look for bio signatures and one of the

1513
01:03:36,610 --> 01:03:35,030

things I think is the major advance and

1514
01:03:38,770 --> 01:03:36,620
in fact perhaps it's Viking the taught

1515
01:03:40,720 --> 01:03:38,780
us this lesson was that we can't over

1516
01:03:43,000 --> 01:03:40,730
prescribe the system and we're trying to

1517
01:03:45,150 --> 01:03:43,010
use the systems that we look at from a

1518
01:03:47,920 --> 01:03:45,160
physics perspective I too am a physicist

1519
01:03:50,230 --> 01:03:47,930
from a physics perspective of what are

1520
01:03:52,510 --> 01:03:50,240
the available pieces of the puzzle that

1521
01:03:54,580 --> 01:03:52,520
we can understand and how can we make

1522
01:03:56,140 --> 01:03:54,590
them productive the generic enough that

1523
01:03:57,850 --> 01:03:56,150
we could then discover them and I think

1524
01:04:00,520 --> 01:03:57,860
some of the coolest lectures that we've

1525
01:04:03,820 --> 01:04:00,530
seen so far at apps icon are the ways to

1526
01:04:06,250 --> 01:04:03,830
make biomarker detection generic in

1527
01:04:07,630 --> 01:04:06,260
which it's not prescriptive of the types

1528
01:04:10,090 --> 01:04:07,640
of things that we do it's not ourselves

1529
01:04:12,220 --> 01:04:10,100
our DNA or any of these things so my

1530
01:04:14,080 --> 01:04:12,230
greatest hope is the work that folks

1531
01:04:15,430 --> 01:04:14,090
like Lee Cronin are doing where where

1532
01:04:17,980 --> 01:04:15,440
you're looking at the statistical

1533
01:04:18,700 --> 01:04:17,990
distribution of things that are products

1534
01:04:20,830 --> 01:04:18,710
of life

1535
01:04:24,220 --> 01:04:20,840
you're not specific specifically saying

1536
01:04:27,220 --> 01:04:24,230
we need alanine or a particular asset or

1537
01:04:28,900 --> 01:04:27,230
an amino acid or a fingerprint or a

1538
01:04:30,430 --> 01:04:28,910

filament or something like that you're

1539
01:04:32,890 --> 01:04:30,440
saying what are the things that might be

1540
01:04:34,330 --> 01:04:32,900
the generic properties of life and when

1541
01:04:37,510 --> 01:04:34,340
you look at it that way when you look at

1542
01:04:40,690 --> 01:04:37,520
planets planets have convect themselves

1543
01:04:42,070 --> 01:04:40,700
they have cores they have activity they

1544
01:04:44,800 --> 01:04:42,080
have geologic activity they have

1545
01:04:46,870 --> 01:04:44,810
atmospheres those processes if we can

1546
01:04:49,120 --> 01:04:46,880
understand those as generic I can

1547
01:04:50,470 --> 01:04:49,130
recognize a Jupiter right Viki can

1548
01:04:52,300 --> 01:04:50,480
recognize a Jupiter we don't need the

1549
01:04:54,280 --> 01:04:52,310
Great Red Spot to tell us that it's

1550
01:04:55,320 --> 01:04:54,290
stupider or it's stupid or like and so

1551
01:04:57,450 --> 01:04:55,330
in that way I think we

1552
01:04:58,850 --> 01:04:57,460
actually learning from Viking that being

1553
01:05:00,900 --> 01:04:58,860
overly prescriptive and very

1554
01:05:03,000 --> 01:05:00,910
anthropocentric does us some disservice

1555
01:05:04,860 --> 01:05:03,010
but we're trying to still go through

1556
01:05:06,840 --> 01:05:04,870
that process so I'm a bit more

1557
01:05:09,300 --> 01:05:06,850
optimistic that as you suggest that

1558
01:05:11,130 --> 01:05:09,310
these general concepts between the

1559
01:05:13,140 --> 01:05:11,140
similarities of planets and looking for

1560
01:05:15,090 --> 01:05:13,150
those fingerprints gives us a clue as to

1561
01:05:19,140 --> 01:05:15,100
what we should look for and then a way

1562
01:05:20,730 --> 01:05:19,150
to unspecified our looks at biology and

1563
01:05:21,870 --> 01:05:20,740

and the way that we're looking for

1564
01:05:23,520 --> 01:05:21,880
something because if we're looking for

1565
01:05:25,590 --> 01:05:23,530
English you're right that's not the

1566
01:05:26,600 --> 01:05:25,600
right thing to look for I agree with

1567
01:05:28,620 --> 01:05:26,610
almost everything you said except

1568
01:05:30,090 --> 01:05:28,630
non-prescriptive means looking at these

1569
01:05:32,040 --> 01:05:30,100
far from equilibrium dissipative systems

1570
01:05:33,600 --> 01:05:32,050
I oh look at that we found life yeah

1571
01:05:34,950 --> 01:05:33,610
that's very not much cryptic but that

1572
01:05:36,690 --> 01:05:34,960
what that is and that's what Mike's

1573
01:05:38,610 --> 01:05:36,700
saying here I think is that if a

1574
01:05:40,980 --> 01:05:38,620
disequilibrium exists then the maps you

1575
01:05:42,300 --> 01:05:40,990
point to go in and for for exoplanets in

1576
01:05:43,530 --> 01:05:42,310
particular it is one of the things you

1577
01:05:45,750 --> 01:05:43,540
would particularly like to look for is

1578
01:05:48,540 --> 01:05:45,760
is a disequilibrium in the system when

1579
01:05:49,770 --> 01:05:48,550
the Galileo spacecraft flew by earth it

1580
01:05:51,360 --> 01:05:49,780
was able to measure the abundance of

1581
01:05:53,010 --> 01:05:51,370
gases in the atmosphere and go wow that

1582
01:05:55,020 --> 01:05:53,020
system is not an equilibrium is clearly

1583
01:05:56,730 --> 01:05:55,030
out of equilibrium and the equilibrium

1584
01:05:59,250 --> 01:05:56,740
the disequilibrium itself is not the

1585
01:06:00,480 --> 01:05:59,260
signal it is the fact that there is a

1586
01:06:02,400 --> 01:06:00,490
disequilibrium means that there are

1587
01:06:04,230 --> 01:06:02,410
active fluxes at the surface of these

1588
01:06:05,640 --> 01:06:04,240

gases active flux is somewhere in the

1589
01:06:07,350 --> 01:06:05,650
system and that's the point at which we

1590
01:06:08,940 --> 01:06:07,360
go in and say ha we seem to have an

1591
01:06:11,040 --> 01:06:08,950
awful lot of oxygen coming another point

1592
01:06:12,180 --> 01:06:11,050
rain weapon that puncay the discussion

1593
01:06:16,260 --> 01:06:12,190
because when you get into an argument

1594
01:06:18,150 --> 01:06:16,270
early to go and then and there's people

1595
01:06:19,980 --> 01:06:18,160
patiently waiting if I'm going to take

1596
01:06:23,760 --> 01:06:19,990
the next question each me whether those

1597
01:06:25,080 --> 01:06:23,770
like hi I'm with the excuse me I'm

1598
01:06:27,510 --> 01:06:25,090
within New Mexico Museum of space

1599
01:06:30,030 --> 01:06:27,520
history and three hour drive away from

1600
01:06:31,290 --> 01:06:30,040
us of course is Roswell we know we're

1601
01:06:34,590 --> 01:06:31,300
not going to find anything like those

1602
01:06:37,770 --> 01:06:34,600
chaps on Mars but you're talking about

1603
01:06:39,930 --> 01:06:37,780
bacteria how complex might life on Mars

1604
01:06:41,550 --> 01:06:39,940
have become could it become

1605
01:06:44,310 --> 01:06:41,560
multicellular because those cells

1606
01:06:45,930 --> 01:06:44,320
started to have specialized into

1607
01:06:48,210 --> 01:06:45,940
rudimentary organs I doubt we'll find

1608
01:06:50,910 --> 01:06:48,220
anything vertebrate but how far long

1609
01:06:54,120 --> 01:06:50,920
might it have gotten how high might our

1610
01:06:56,100 --> 01:06:54,130
expectations reasonably get what what

1611
01:06:58,140 --> 01:06:56,110
answer is a truck that Carl Sagan tried

1612
01:06:59,400 --> 01:06:58,150
to put floodlights on the Vikings so you

1613
01:07:04,770 --> 01:06:59,410

could see giraffes or something to come

1614
01:07:05,870 --> 01:07:04,780
up at at night Carl Sagan actually tried

1615
01:07:08,460 --> 01:07:05,880
to characterize

1616
01:07:11,730 --> 01:07:08,470
four different types for

1617
01:07:14,790 --> 01:07:11,740
prynt ecosystem neech's of organisms

1618
01:07:17,040 --> 01:07:14,800
that were expected to be found with

1619
01:07:18,750 --> 01:07:17,050
Viking I remember reading a paper by by

1620
01:07:21,150 --> 01:07:18,760
Carl Sagan and a colleague of his right

1621
01:07:24,030 --> 01:07:21,160
before the Viking landers landed trying

1622
01:07:27,599 --> 01:07:24,040
to figure out what kind of environmental

1623
01:07:30,150 --> 01:07:27,609
conditions those very specific organisms

1624
01:07:34,140 --> 01:07:30,160
would have but if I remember they were

1625
01:07:38,190 --> 01:07:34,150
not more advanced than fungal system and

1626
01:07:40,890 --> 01:07:38,200
so the reason why many of us think that

1627
01:07:44,580 --> 01:07:40,900
whatever evolved on Mars if it evolved

1628
01:07:47,220 --> 01:07:44,590
is going to be sort of microscopic

1629
01:07:50,430 --> 01:07:47,230
microbial not too advanced just because

1630
01:07:54,060 --> 01:07:50,440
of what we know about Mars habitability

1631
01:07:57,120 --> 01:07:54,070
in the past it used to be warmer wetter

1632
01:07:59,910 --> 01:07:57,130
much like the earth abundant water

1633
01:08:01,800 --> 01:07:59,920
abundant nutrients all the ingredients

1634
01:08:06,390 --> 01:08:01,810
necessary for life and then very quickly

1635
01:08:10,050 --> 01:08:06,400
in its history the environment changed

1636
01:08:12,920 --> 01:08:10,060
the atmosphere sort of thinned out there

1637
01:08:16,680 --> 01:08:12,930
that didn't seem to be any evidence of

1638
01:08:21,090 --> 01:08:16,690

subduction for most of Mars history if

1639
01:08:26,729 --> 01:08:21,100
ever and so when the conditions changed

1640
01:08:28,829 --> 01:08:26,739
Mars became cooler not not hospitable to

1641
01:08:30,780 --> 01:08:28,839
the form to the kind of life as we

1642
01:08:32,789 --> 01:08:30,790
understand it today and as we understand

1643
01:08:35,999 --> 01:08:32,799
life evolved on earth today so if we're

1644
01:08:40,160 --> 01:08:36,009
assuming that life on Mars evolved

1645
01:08:43,650 --> 01:08:40,170
similarly like life on Earth then those

1646
01:08:46,709 --> 01:08:43,660
conditions became unhappy pretty early

1647
01:08:52,320 --> 01:08:46,719
on so that didn't leave too much time

1648
01:08:54,300 --> 01:08:52,330
for life to get very complex and if I

1649
01:08:58,769 --> 01:08:54,310
think we did I know our child is going

1650
01:09:00,840 --> 01:08:58,779
to say one of you donates fungus yes I'm

1651
01:09:03,690 --> 01:09:00,850
a bad example because it's actually

1652
01:09:07,079 --> 01:09:03,700
fairly complex but but I don't think

1653
01:09:11,039 --> 01:09:07,089
there is life on Mars at all and haven't

1654
01:09:12,420 --> 01:09:11,049
in the past I know by writing words but

1655
01:09:14,459 --> 01:09:12,430
the reason is because we're supposed to

1656
01:09:16,019 --> 01:09:14,469
be provocative but the reason is that I

1657
01:09:19,410 --> 01:09:16,029
think either life takes over an entire

1658
01:09:20,630 --> 01:09:19,420
planet or it's not there and so I think

1659
01:09:22,880 --> 01:09:20,640
to answer the

1660
01:09:24,710 --> 01:09:22,890
question you certainly wouldn't have

1661
01:09:26,450 --> 01:09:24,720
multicellular life for example because

1662
01:09:28,130 --> 01:09:26,460
that's fairly advanced life and I think

1663
01:09:30,410 --> 01:09:28,140

life would have probably covered the

1664
01:09:32,270 --> 01:09:30,420
surface of a planet and led to global

1665
01:09:34,160 --> 01:09:32,280
feedbacks and dramatically change the

1666
01:09:35,000 --> 01:09:34,170
planetary surface before you actually

1667
01:09:37,760 --> 01:09:35,010
have the evolution of multicellularity

1668
01:09:42,580 --> 01:09:37,770
and you can use the example of Earth for

1669
01:09:45,650 --> 01:09:42,590
that but even if it was microbial life

1670
01:09:46,790 --> 01:09:45,660
you might have also expected Mars to

1671
01:09:48,560 --> 01:09:46,800
look quite different because of the

1672
01:09:51,230 --> 01:09:48,570
presence of life so there's often the

1673
01:09:53,990 --> 01:09:51,240
assumption that earth is habitable

1674
01:09:55,610 --> 01:09:54,000
because it has water and it has oxygen

1675
01:09:57,050 --> 01:09:55,620
and all these nice things but most of

1676
01:09:59,360 --> 01:09:57,060
the features of the surface of this

1677
01:10:01,490 --> 01:09:59,370
planet are actually generated by life

1678
01:10:03,170 --> 01:10:01,500
and part of the continued habitability

1679
01:10:05,300 --> 01:10:03,180
of our planet is the presence of life

1680
01:10:07,700 --> 01:10:05,310
and so Mars clearly doesn't have that

1681
01:10:09,710 --> 01:10:07,710
and I would imagine that life could not

1682
01:10:12,770 --> 01:10:09,720
have gotten very far on that Jacob what

1683
01:10:14,810 --> 01:10:12,780
about an alien artifact on Mars it's

1684
01:10:16,610 --> 01:10:14,820
worth looking look on the moon look on

1685
01:10:18,080 --> 01:10:16,620
Mars but to be honest we've mapped the

1686
01:10:20,360 --> 01:10:18,090
surface of both of these bodies pretty

1687
01:10:23,270 --> 01:10:20,370
well we have I think a you snapped up

1688
01:10:25,040 --> 01:10:23,280

the pictures in enough detail so can I

1689
01:10:27,230 --> 01:10:25,050
just throw in one more what do you know

1690
01:10:30,230 --> 01:10:27,240
that yes I'm going to throw in one more

1691
01:10:32,990 --> 01:10:30,240
currently - that is rebus Mable oh yes

1692
01:10:35,150 --> 01:10:33,000
if if we think about life on Earth we

1693
01:10:38,540 --> 01:10:35,160
and the fossil record of life on Earth

1694
01:10:40,970 --> 01:10:38,550
it is largely photosynthetic so surface

1695
01:10:42,650 --> 01:10:40,980
life that is you know using energy from

1696
01:10:46,940 --> 01:10:42,660
the Sun and if we can imagine a

1697
01:10:48,650 --> 01:10:46,950
biosphere that was not photosynthetic it

1698
01:10:51,260 --> 01:10:48,660
would probably look very very different

1699
01:10:53,780 --> 01:10:51,270
on earth and it would be much less

1700
01:10:57,680 --> 01:10:53,790
abundant on earth so what if we applied

1701
01:10:58,820 --> 01:10:57,690
that to Mars and thought you know it

1702
01:11:00,400 --> 01:10:58,830
could have just been a different type of

1703
01:11:03,410 --> 01:11:00,410
metabolism it could have been just a

1704
01:11:05,870 --> 01:11:03,420
lesser a less abundant type of life and

1705
01:11:08,030 --> 01:11:05,880
so when you think about that possibility

1706
01:11:10,010 --> 01:11:08,040
maybe it's in the subsurface maybe it's

1707
01:11:12,170 --> 01:11:10,020
where we're not able to detect it at the

1708
01:11:17,690 --> 01:11:12,180
surface because we don't have the

1709
01:11:19,610 --> 01:11:17,700
technology to currently go and look you

1710
01:11:21,860 --> 01:11:19,620
know tens to hundreds of meters into the

1711
01:11:24,350 --> 01:11:21,870
subsurface where if there is liquid

1712
01:11:30,810 --> 01:11:24,360
water that's where it would be on Mars

1713
01:11:36,669 --> 01:11:34,209

all we need is a is a twenty Megaton

1714
01:11:40,660 --> 01:11:36,679
bomb we can do it we can easily get into

1715
01:11:42,939 --> 01:11:40,670
that something good idea but we we need

1716
01:11:44,439 --> 01:11:42,949
we need to speed up both the questions

1717
01:11:47,470 --> 01:11:44,449
and the answers because we thrown out of

1718
01:11:53,620 --> 01:11:47,480
here in 15 minutes max so yes you sir

1719
01:11:57,240 --> 01:11:53,630
right on exoplanet if you detect chill

1720
01:12:01,660 --> 01:11:57,250
neighbor planets on a on a solar system

1721
01:12:04,089 --> 01:12:01,670
if both have had the same hemisphere ik

1722
01:12:06,069 --> 01:12:04,099
composition or maybe temperature I don't

1723
01:12:10,810 --> 01:12:06,079
know could that be a sign of their

1724
01:12:12,790 --> 01:12:10,820
formation no of ah not terror formation

1725
01:12:16,620 --> 01:12:12,800
of one of those planets and it's kind of

1726
01:12:19,390 --> 01:12:16,630
um extraterrestrial life

1727
01:12:21,640 --> 01:12:19,400
Jacob yeah that's right I think that's

1728
01:12:24,310 --> 01:12:21,650
that's very accurate I mean I think if

1729
01:12:26,649 --> 01:12:24,320
we were to find a planet what we can do

1730
01:12:29,169 --> 01:12:26,659
with climate models and observations is

1731
01:12:30,700 --> 01:12:29,179
we can we can figure out you know what

1732
01:12:31,990 --> 01:12:30,710
the distances of the planet from the

1733
01:12:33,939 --> 01:12:32,000
star we can figure out what an

1734
01:12:35,740 --> 01:12:33,949
equilibrium surface temperature is and

1735
01:12:37,089 --> 01:12:35,750
if we've got spectra then we can

1736
01:12:39,279 --> 01:12:37,099
actually figure out what chemicals are

1737
01:12:40,299 --> 01:12:39,289
in its atmosphere and we can use models

1738
01:12:41,950 --> 01:12:40,309

that and figure out what its surface

1739
01:12:43,359 --> 01:12:41,960
temperature should be if we do that for

1740
01:12:44,830 --> 01:12:43,369
one planet you do for another planet

1741
01:12:46,209 --> 01:12:44,840
that's further out you find out the same

1742
01:12:46,629 --> 01:12:46,219
surface temperature well that's kind of

1743
01:12:51,450 --> 01:12:46,639
weird

1744
01:12:53,410 --> 01:12:51,460
if one planet is further away now just I

1745
01:12:54,910 --> 01:12:53,420
think certain chemicals would be a

1746
01:12:55,839 --> 01:12:54,920
better giveaway for terraforming than

1747
01:12:58,479 --> 01:12:55,849
others something like

1748
01:12:59,919 --> 01:12:58,489
chlorofluorocarbons are much less likely

1749
01:13:02,049 --> 01:12:59,929
you know I don't know of any abiotic

1750
01:13:04,299 --> 01:13:02,059
processes that can generate these kind

1751
01:13:06,970 --> 01:13:04,309
of things if you saw an atmosphere with

1752
01:13:08,379 --> 01:13:06,980
the dense carbon dioxide atmosphere that

1753
01:13:09,729 --> 01:13:08,389
there might be an abiotic way of

1754
01:13:11,259 --> 01:13:09,739
generating that so I think it's going to

1755
01:13:13,060 --> 01:13:11,269
be what what specifically are we seeing

1756
01:13:14,319 --> 01:13:13,070
in the atmosphere of these two planets

1757
01:13:16,299 --> 01:13:14,329
that would lead us to think one is a

1758
01:13:17,439 --> 01:13:16,309
techno signature but I think there's I

1759
01:13:18,850 --> 01:13:17,449
think there's lots of ideas

1760
01:13:20,020 --> 01:13:18,860
geoengineering is another one we're

1761
01:13:22,060 --> 01:13:20,030
thinking about doing that here putting

1762
01:13:23,770 --> 01:13:22,070
dust in the atmosphere to defy it off

1763
01:13:25,419 --> 01:13:23,780

climate change other things like that

1764
01:13:27,910 --> 01:13:25,429
you could maybe imagine seeing around

1765
01:13:29,379 --> 01:13:27,920
exoplanets I would like to create a yes

1766
01:13:31,209 --> 01:13:29,389
I'd like to agree with you on this ball

1767
01:13:33,430 --> 01:13:31,219
that you have often said that you know

1768
01:13:35,379 --> 01:13:33,440
the technological lifetime you imagine

1769
01:13:36,910 --> 01:13:35,389
terraforming now we we started to be

1770
01:13:38,259 --> 01:13:36,920
able to be terrible to do terraforming

1771
01:13:40,150 --> 01:13:38,269
what and maybe for 100 years from now

1772
01:13:41,650 --> 01:13:40,160
what you know the

1773
01:13:44,020 --> 01:13:41,660
angularities approaching the robot in my

1774
01:13:45,670 --> 01:13:44,030
over my semesters will cut soon take

1775
01:13:47,320 --> 01:13:45,680
over what we think we're in control of

1776
01:13:48,760 --> 01:13:47,330
and if that's the case they don't need

1777
01:13:50,050 --> 01:13:48,770
the temperatures or they don't need to

1778
01:13:52,810 --> 01:13:50,060
terraform anything because I live in

1779
01:13:54,280 --> 01:13:52,820
outer space and so maybe 99% of the

1780
01:13:56,710 --> 01:13:54,290
lifetime of the technological

1781
01:13:58,210 --> 01:13:56,720
civilization is doesn't need those types

1782
01:14:00,390 --> 01:13:58,220
of things and so it would be a very

1783
01:14:03,640 --> 01:14:00,400
small fraction of time that you would

1784
01:14:06,820 --> 01:14:03,650
expect to see that I question from

1785
01:14:08,260 --> 01:14:06,830
everything so you were talking about you

1786
01:14:10,090 --> 01:14:08,270
know how life might be quirky and you

1787
01:14:11,950 --> 01:14:10,100
can't say it's generic and obviously

1788
01:14:13,330 --> 01:14:11,960

like you can't just if you send

1789
01:14:15,280 --> 01:14:13,340
something to like Europa and you send

1790
01:14:17,500 --> 01:14:15,290
something down there you can't just as I

1791
01:14:19,480 --> 01:14:17,510
say I can call it when I see it about

1792
01:14:21,370 --> 01:14:19,490
life because that might not be how would

1793
01:14:23,920 --> 01:14:21,380
look like so how would you be able to

1794
01:14:26,500 --> 01:14:23,930
differentiate between some geologic

1795
01:14:29,740 --> 01:14:26,510
features saying like this unlike the sea

1796
01:14:31,570 --> 01:14:29,750
floor of Europa or between some kind of

1797
01:14:33,340 --> 01:14:31,580
organism that might be like a slime mold

1798
01:14:34,900 --> 01:14:33,350
where there's not necessarily one single

1799
01:14:36,490 --> 01:14:34,910
cell there it's like a bunch of nuclei

1800
01:14:39,570 --> 01:14:36,500
they're all part of this one organism

1801
01:14:41,830 --> 01:14:39,580
but maybe it doesn't look you know very

1802
01:14:42,900 --> 01:14:41,840
like a slime mold but more like a rock

1803
01:14:45,820 --> 01:14:42,910
like oh great right now

1804
01:14:47,920 --> 01:14:45,830
yeah can you if you get down there it's

1805
01:14:49,060 --> 01:14:47,930
slimy what are you gonna do I'd be

1806
01:14:52,360 --> 01:14:49,070
really excited if it was climbing

1807
01:14:55,560 --> 01:14:52,370
because that would be really fun but I

1808
01:14:57,490 --> 01:14:55,570
think the big question is is that we're

1809
01:14:59,920 --> 01:14:57,500
expecting to be relatively ignorant

1810
01:15:01,810 --> 01:14:59,930
right there's some systemic things that

1811
01:15:03,580 --> 01:15:01,820
life on this planet does uniquely and

1812
01:15:06,760 --> 01:15:03,590
one of those things is to make really

1813
01:15:09,100 --> 01:15:06,770

big stuff in terms of complex chemical

1814
01:15:11,260 --> 01:15:09,110
molecules and so that's one of the first

1815
01:15:12,880 --> 01:15:11,270
things that we look for is actually do

1816
01:15:15,100 --> 01:15:12,890
we have really heavy really long-chain

1817
01:15:17,200 --> 01:15:15,110
things right so there's mission concepts

1818
01:15:18,760 --> 01:15:17,210
for both Europe and for Enceladus to

1819
01:15:20,110 --> 01:15:18,770
look at materials coming out of those

1820
01:15:21,760 --> 01:15:20,120
places and look at their fractionation

1821
01:15:23,950 --> 01:15:21,770
patterns and what does that tell us

1822
01:15:25,950 --> 01:15:23,960
about the thermodynamics in which that

1823
01:15:28,660 --> 01:15:25,960
chemical system evolved and in turn

1824
01:15:30,010 --> 01:15:28,670
wasn't biology and perhaps that did it

1825
01:15:31,780 --> 01:15:30,020
now but none of those is really a

1826
01:15:33,190 --> 01:15:31,790
smoking gun it's like a warm gun or it's

1827
01:15:34,900 --> 01:15:33,200
kind of a gun over there and maybe it's

1828
01:15:37,780 --> 01:15:34,910
not a gun but it's maybe it's a water

1829
01:15:39,850 --> 01:15:37,790
gun who knows but what you want to do is

1830
01:15:42,730 --> 01:15:39,860
you want to build up a set of pieces of

1831
01:15:44,710 --> 01:15:42,740
evidence right ask many questions at the

1832
01:15:47,800 --> 01:15:44,720
same time and say what are the things

1833
01:15:49,930 --> 01:15:47,810
that life might not necessarily uniquely

1834
01:15:52,330 --> 01:15:49,940
do but what are those fingerprints of

1835
01:15:53,770 --> 01:15:52,340
that and let's test for lots of them at

1836
01:15:55,480 --> 01:15:53,780
the same time using the best

1837
01:15:57,940 --> 01:15:55,490
technology we have which is admittedly

1838
01:16:00,340 --> 01:15:57,950

needs more advancement and so the idea

1839
01:16:02,560 --> 01:16:00,350
is that you can look at the molecules

1840
01:16:04,360 --> 01:16:02,570
you can look at structures you can look

1841
01:16:06,160 --> 01:16:04,370
at the history of the inorganic system

1842
01:16:08,710 --> 01:16:06,170
and you can look at how the thing has

1843
01:16:10,510 --> 01:16:08,720
been processed or how it got there in

1844
01:16:12,910 --> 01:16:10,520
some ways and we're really looking for

1845
01:16:14,500 --> 01:16:12,920
are things that are surprising right so

1846
01:16:15,970 --> 01:16:14,510
things that are surprising not so much

1847
01:16:17,620 --> 01:16:15,980
as like oh well that's great we have

1848
01:16:19,270 --> 01:16:17,630
this chemical that we've we've never

1849
01:16:21,220 --> 01:16:19,280
seen before but things that we're

1850
01:16:22,390 --> 01:16:21,230
surprisingly out of equilibrium which

1851
01:16:24,460 --> 01:16:22,400
are the things that we've kind of talked

1852
01:16:25,810 --> 01:16:24,470
about so life is really great at

1853
01:16:27,940 --> 01:16:25,820
throwing things a little out of whack

1854
01:16:30,700 --> 01:16:27,950
and so if you're looking at something

1855
01:16:31,780 --> 01:16:30,710
like that then that gives you a really

1856
01:16:33,610 --> 01:16:31,790
good chance you're trying to check as

1857
01:16:35,140 --> 01:16:33,620
many boxes as possible because at this

1858
01:16:36,400 --> 01:16:35,150
point in time we don't have a tricorder

1859
01:16:39,100 --> 01:16:36,410
right we don't have something that's

1860
01:16:41,770 --> 01:16:39,110
like yes that thing life it shall be

1861
01:16:43,780 --> 01:16:41,780
right so we want something like that and

1862
01:16:46,330 --> 01:16:43,790
so I think the best chance is to give

1863
01:16:49,570 --> 01:16:46,340

ourselves a way to think about the

1864
01:16:50,890 --> 01:16:49,580
information that gives us a chance to

1865
01:16:52,690 --> 01:16:50,900
test in a lot of different directions

1866
01:16:53,950 --> 01:16:52,700
and it's not unique to what we're going

1867
01:16:55,540 --> 01:16:53,960
to do on your rope but right it's what

1868
01:16:56,830 --> 01:16:55,550
we're going to do with exoplanet it's

1869
01:16:58,150 --> 01:16:56,840
what we're going to do with intelligent

1870
01:16:59,950 --> 01:16:58,160
life right we wouldn't just see one

1871
01:17:01,870 --> 01:16:59,960
chemical in the atmosphere and say yes

1872
01:17:04,030 --> 01:17:01,880
absolutely there is like New York City

1873
01:17:05,650 --> 01:17:04,040
be sitting on this planet there's a lot

1874
01:17:09,190 --> 01:17:05,660
of ways to think about that I think it's

1875
01:17:10,750 --> 01:17:09,200
that's the kind of interesting power of

1876
01:17:10,990 --> 01:17:10,760
the way we think about the problem right

1877
01:17:13,900 --> 01:17:11,000
now

1878
01:17:15,880 --> 01:17:13,910
no fish on Europa hopefully writing it's

1879
01:17:17,890 --> 01:17:15,890
microbes yes

1880
01:17:19,780 --> 01:17:17,900
questions man if you're a goal were to

1881
01:17:21,820 --> 01:17:19,790
encourage the people of Earth to have a

1882
01:17:23,680 --> 01:17:21,830
grander perspective of their own planet

1883
01:17:25,660 --> 01:17:23,690
to think more long-term or to think

1884
01:17:27,520 --> 01:17:25,670
globally what kind of aster biological

1885
01:17:28,690 --> 01:17:27,530
discovery would have the best chance of

1886
01:17:30,480 --> 01:17:28,700
doing that what kind of positive or

1887
01:17:33,820 --> 01:17:30,490
negative detection would you look for

1888
01:17:35,830 --> 01:17:33,830

okay that I think and I remember Jacob

1889
01:17:39,130 --> 01:17:35,840
but then I'd like to hear from Sarah so

1890
01:17:40,810 --> 01:17:39,140
so I think a SETI detection detection of

1891
01:17:42,730 --> 01:17:40,820
a radio signal or a laser signal

1892
01:17:44,230 --> 01:17:42,740
something something that can carry

1893
01:17:46,240 --> 01:17:44,240
information you can communicate with I

1894
01:17:48,240 --> 01:17:46,250
think that would give us a much needed

1895
01:17:50,740 --> 01:17:48,250
long-term perspective if we found

1896
01:17:52,390 --> 01:17:50,750
anywhere from Proxima be to something 10

1897
01:17:54,490 --> 01:17:52,400
or 40 or a little more light-years away

1898
01:17:56,350 --> 01:17:54,500
something that we could conceivably

1899
01:17:58,360 --> 01:17:56,360
think about communicating with but

1900
01:17:59,740 --> 01:17:58,370
there's this lag you're communicating 40

1901
01:18:01,240 --> 01:17:59,750
light-years away it's going to take 40

1902
01:18:03,580 --> 01:18:01,250
light years to send that message so we

1903
01:18:04,960 --> 01:18:03,590
detect a signal we we get together as

1904
01:18:06,359 --> 01:18:04,970
humanity we figure what we want to say

1905
01:18:07,770 --> 01:18:06,369
in response how we're going to say how

1906
01:18:09,689 --> 01:18:07,780
well then we send the message now you've

1907
01:18:11,280 --> 01:18:09,699
got you've got to wait 40 years we're to

1908
01:18:13,080 --> 01:18:11,290
get there and then 40 years for to come

1909
01:18:15,180 --> 01:18:13,090
back - you know plus the time it takes

1910
01:18:16,800 --> 01:18:15,190
them to understand that message but if

1911
01:18:17,850 --> 01:18:16,810
we've already got that detection if we

1912
01:18:19,020 --> 01:18:17,860
already know they're there we're going

1913
01:18:20,430 --> 01:18:19,030

to be willing to wait we're going to

1914
01:18:23,430 --> 01:18:20,440
come up with governance structures to

1915
01:18:24,780 --> 01:18:23,440
figure out how to maintain our patients

1916
01:18:27,180 --> 01:18:24,790
so that we actually do receive this

1917
01:18:29,910 --> 01:18:27,190
reply I think that would be an

1918
01:18:32,430 --> 01:18:29,920
incredible discovery sir is there

1919
01:18:34,379 --> 01:18:32,440
anything other than the classic signal

1920
01:18:36,709 --> 01:18:34,389
from ET that might get people excited

1921
01:18:40,100 --> 01:18:36,719
enough to spend a bit more money on this

1922
01:18:43,589 --> 01:18:40,110
well that wasn't the original question I

1923
01:18:46,890 --> 01:18:43,599
mean I can answer that question I was

1924
01:18:48,570 --> 01:18:46,900
actually so I did have a I struggle with

1925
01:18:50,399 --> 01:18:48,580
the idea of like we never discover life

1926
01:18:52,290 --> 01:18:50,409
what does that mean for Humanity and I

1927
01:18:54,209 --> 01:18:52,300
don't know if that's a more pot like it

1928
01:18:55,830 --> 01:18:54,219
does that empower us more or empower us

1929
01:18:57,510 --> 01:18:55,840
less and I don't have the answer to that

1930
01:18:59,550 --> 01:18:57,520
but it's just to tick over the other

1931
01:19:00,750 --> 01:18:59,560
direction so what should we spend our

1932
01:19:04,970 --> 01:19:00,760
money on is that what you're asking well

1933
01:19:08,129 --> 01:19:04,980
no the point is that this subject

1934
01:19:10,410 --> 01:19:08,139
looking for life beyond Earth sort of

1935
01:19:12,780 --> 01:19:10,420
goes through stages where people are

1936
01:19:14,580 --> 01:19:12,790
invited and not so interested does cost

1937
01:19:16,439 --> 01:19:14,590
a fair amount of money is there some

1938
01:19:18,149 --> 01:19:16,449

discovery that would really transform

1939
01:19:20,010 --> 01:19:18,159
the field so the point where everybody

1940
01:19:22,290 --> 01:19:20,020
thought this has got to be the highest

1941
01:19:23,430 --> 01:19:22,300
priority scientific endeavor we frame

1942
01:19:24,780 --> 01:19:23,440
with a we're all villains

1943
01:19:26,939 --> 01:19:24,790
if we find english-speaking helium

1944
01:19:28,140 --> 01:19:26,949
doesn't really fit well I don't know

1945
01:19:28,709 --> 01:19:28,150
they were watching our television

1946
01:19:31,800 --> 01:19:28,719
programmes

1947
01:19:33,839 --> 01:19:31,810
I thought detecting a signal from et

1948
01:19:36,169 --> 01:19:33,849
which obviously would you knows the Holy

1949
01:19:39,450 --> 01:19:36,179
Grail there's a lot of stuff in between

1950
01:19:41,550 --> 01:19:39,460
yes I mean I'm kind of an orphan right

1951
01:19:42,870 --> 01:19:41,560
so every minute like I I have a lot of

1952
01:19:45,000 --> 01:19:42,880
disagreements with the life as

1953
01:19:46,890 --> 01:19:45,010
non-equilibrium structures and I mean

1954
01:19:48,209 --> 01:19:46,900
just equilibrium in or a lot of places

1955
01:19:50,459 --> 01:19:48,219
but one of the things that living

1956
01:19:53,399 --> 01:19:50,469
systems do that Britney already

1957
01:19:55,800 --> 01:19:53,409
mentioned is they surprised us and so I

1958
01:19:57,600 --> 01:19:55,810
think I think this thing that is really

1959
01:20:01,560 --> 01:19:57,610
hard about this endeavor is looking for

1960
01:20:03,570 --> 01:20:01,570
the unexpected and so I actually think

1961
01:20:05,580 --> 01:20:03,580
the more interesting kind of discovery

1962
01:20:08,370 --> 01:20:05,590
for alien life is not to find life on an

1963
01:20:10,830 --> 01:20:08,380

individual world but to find life and a

1964
01:20:12,689 --> 01:20:10,840
data set like a probabilistic sense that

1965
01:20:15,240 --> 01:20:12,699
we know it so so we're thinking right

1966
01:20:17,370 --> 01:20:15,250
now let's build up as many lines of

1967
01:20:18,770 --> 01:20:17,380
evidence in one location that give us a

1968
01:20:21,290 --> 01:20:18,780
conclusive

1969
01:20:23,540 --> 01:20:21,300
set of arguments that this is a

1970
01:20:25,310 --> 01:20:23,550
definitive signature of life but we

1971
01:20:26,480 --> 01:20:25,320
don't know what any of those pieces are

1972
01:20:30,230 --> 01:20:26,490
we don't know how they're going to come

1973
01:20:33,500 --> 01:20:30,240
together but what we do know is how to

1974
01:20:34,910 --> 01:20:33,510
predict in a probabilistic sense what

1975
01:20:37,220 --> 01:20:34,920
the properties of different environments

1976
01:20:38,870 --> 01:20:37,230
should be because we know the laws of

1977
01:20:42,170 --> 01:20:38,880
physics and chemistry pretty well so

1978
01:20:44,510 --> 01:20:42,180
could we actually think of ways to look

1979
01:20:46,400 --> 01:20:44,520
for life not in one location but in many

1980
01:20:48,440 --> 01:20:46,410
locations simultaneously and look for

1981
01:20:50,450 --> 01:20:48,450
anomalies and statistical datasets so

1982
01:20:52,610 --> 01:20:50,460
then you have this kind of weird paradox

1983
01:20:54,260 --> 01:20:52,620
where you've answered the question if

1984
01:20:56,030 --> 01:20:54,270
you get a positive signal that you're

1985
01:20:57,770 --> 01:20:56,040
not alone but you don't know who your

1986
01:20:59,300 --> 01:20:57,780
neighbors are right so we know there's

1987
01:21:01,220 --> 01:20:59,310
somebody or something out there

1988
01:21:04,790 --> 01:21:01,230

somewhere but we're not quite sure where

1989
01:21:06,860 --> 01:21:04,800
or what right serving God I think that

1990
01:21:08,390 --> 01:21:06,870
would motivate us so that's a sort of

1991
01:21:10,160 --> 01:21:08,400
that's something that we can do based on

1992
01:21:11,420 --> 01:21:10,170
current science now if we knew the

1993
01:21:13,490 --> 01:21:11,430
answer to that question but we didn't

1994
01:21:15,550 --> 01:21:13,500
know what that life was then were really

1995
01:21:18,650 --> 01:21:15,560
motivated to go and find out what it is

1996
01:21:21,440 --> 01:21:18,660
okay now we really are down to the life

1997
01:21:23,420 --> 01:21:21,450
thing that one question probably from

1998
01:21:24,950 --> 01:21:23,430
each side that's let's here we get your

1999
01:21:27,980 --> 01:21:24,960
question please short answers please

2000
01:21:30,320 --> 01:21:27,990
panel yes sir well there isn't a sort

2001
01:21:32,480 --> 01:21:30,330
question at this juncture here but I'll

2002
01:21:35,170 --> 01:21:32,490
ask it anywhere so here it goes

2003
01:21:38,390 --> 01:21:35,180
it's to do the daar redirect be

2004
01:21:41,360 --> 01:21:38,400
redirecting the resources and this is

2005
01:21:44,030 --> 01:21:41,370
particularly directed towards Jacob

2006
01:21:48,590 --> 01:21:44,040
obviously rest of them can Johnny if

2007
01:21:50,630 --> 01:21:48,600
they want to here's a thing and you said

2008
01:21:53,300 --> 01:21:50,640
something about the radio wave being 50

2009
01:21:55,400 --> 01:21:53,310
years old and and they're all about us

2010
01:21:58,730 --> 01:21:55,410
and other life form elsewhere in the

2011
01:22:01,190 --> 01:21:58,740
universe could actually detect us now we

2012
01:22:04,940 --> 01:22:01,200
know that for a start but we now have

2013
01:22:08,060 --> 01:22:04,950

satellite we don't have radio waves per

2014
01:22:10,880 --> 01:22:08,070
se so that means these signals are dying

2015
01:22:14,140 --> 01:22:10,890
down so now I'm all I'm now predicting

2016
01:22:17,000 --> 01:22:14,150
that let's assume that there are

2017
01:22:20,240 --> 01:22:17,010
life-forms out there which you're trying

2018
01:22:22,100 --> 01:22:20,250
to detect in order for and we also have

2019
01:22:25,280 --> 01:22:22,110
to assume that it took 4 and 1/2 billion

2020
01:22:27,440 --> 01:22:25,290
for life to evolve so that means the

2021
01:22:30,239 --> 01:22:27,450
life elsewhere in the universe has to

2022
01:22:33,000 --> 01:22:30,249
have started 9 billion years ago

2023
01:22:35,640 --> 01:22:33,010
then he moved forward to four and a half

2024
01:22:38,549 --> 01:22:35,650
billion years ago that life started on

2025
01:22:43,020 --> 01:22:38,559
that planet and that planet would

2026
01:22:45,149 --> 01:22:43,030
generate less radio waves because we're

2027
01:22:47,549 --> 01:22:45,159
in a technology so can can we move to

2028
01:22:49,529 --> 01:22:47,559
the question my question it is in the

2029
01:22:52,979 --> 01:22:49,539
next line it's next next punchline I

2030
01:22:56,729 --> 01:22:52,989
could have asked you by now right so the

2031
01:22:58,859 --> 01:22:56,739
thing is you will not be able to detect

2032
01:23:02,399 --> 01:22:58,869
because it would have taken four billion

2033
01:23:04,529 --> 01:23:02,409
years to get the radio waves to this

2034
01:23:07,200 --> 01:23:04,539
point here on planet Earth you will not

2035
01:23:09,330 --> 01:23:07,210
be able to detect it and therefore you

2036
01:23:11,160 --> 01:23:09,340
could have least redirected your

2037
01:23:14,279 --> 01:23:11,170
resources in other areas of research

2038
01:23:15,989 --> 01:23:14,289

that's my question right that's right

2039
01:23:18,419 --> 01:23:15,999
well they're looking for radio messages

2040
01:23:20,370 --> 01:23:18,429
yes just a fleeting part of that plan

2041
01:23:24,509 --> 01:23:20,380
were in history what can we look for

2042
01:23:26,969 --> 01:23:24,519
that has more longevity right so there's

2043
01:23:30,060 --> 01:23:26,979
a couple things radio you might be right

2044
01:23:31,649 --> 01:23:30,070
might be on its way down on its way out

2045
01:23:33,000 --> 01:23:31,659
but we actually have quite a bit of

2046
01:23:34,439 --> 01:23:33,010
transmission still going on even though

2047
01:23:36,239 --> 01:23:34,449
we have digital television we still have

2048
01:23:38,489 --> 01:23:36,249
digital television transmissions and so

2049
01:23:41,100 --> 01:23:38,499
there's still quite a strong radio

2050
01:23:43,109 --> 01:23:41,110
signal emanating from earth but another

2051
01:23:44,580 --> 01:23:43,119
thing to think about is we still have

2052
01:23:46,589 --> 01:23:44,590
sailboats on earth even though our

2053
01:23:49,109 --> 01:23:46,599
military no longer relies on them

2054
01:23:51,029 --> 01:23:49,119
sailboats as an example sailboats do not

2055
01:23:52,649 --> 01:23:51,039
represent the pinnacle of our current

2056
01:23:55,549 --> 01:23:52,659
technology but there's still plenty of

2057
01:23:57,930 --> 01:23:55,559
sailboat hobbyists so I imagine

2058
01:23:59,969 --> 01:23:57,940
extraterrestrials may go completely

2059
01:24:01,859 --> 01:23:59,979
digital they may be radio silent that

2060
01:24:04,500 --> 01:24:01,869
doesn't mean radio technology will be

2061
01:24:06,330 --> 01:24:04,510
gone we have ham radio operators today

2062
01:24:07,919 --> 01:24:06,340
they're going to be ham radio operators

2063
01:24:11,129 --> 01:24:07,929

100 years from now even if we're not

2064
01:24:13,950 --> 01:24:11,139
broadcasting into space so we might not

2065
01:24:16,549 --> 01:24:13,960
detect radio leakage like we would have

2066
01:24:19,410 --> 01:24:16,559
from Earth but we if there was a direct

2067
01:24:21,209 --> 01:24:19,420
beacon of some sort that is something we

2068
01:24:22,799 --> 01:24:21,219
could detect what okay I'm going to take

2069
01:24:24,120 --> 01:24:22,809
one last question from here I'm sorry

2070
01:24:26,160 --> 01:24:24,130
about the gentleman over there who was

2071
01:24:27,689 --> 01:24:26,170
waiting okay we're running out of time

2072
01:24:30,629 --> 01:24:27,699
this isn't really a question it's more

2073
01:24:33,719 --> 01:24:30,639
like you said that most of Mars has been

2074
01:24:37,589 --> 01:24:33,729
looked at great that was he right okay

2075
01:24:38,490 --> 01:24:37,599
cool um photographed yes yes Roger

2076
01:24:43,080 --> 01:24:38,500
hasn't

2077
01:24:45,360 --> 01:24:43,090
why um like Phil Christensen for example

2078
01:24:49,110 --> 01:24:45,370
I just got out of his class where he

2079
01:24:51,210 --> 01:24:49,120
talked about Mars and he said like it

2080
01:24:53,880 --> 01:24:51,220
hasn't been looked at closely at all

2081
01:24:55,680 --> 01:24:53,890
what really and we should look quick

2082
01:24:58,440 --> 01:24:55,690
yeah I really don't know how you might

2083
01:24:59,940 --> 01:24:58,450
wanna do that most of my grad students

2084
01:25:02,220 --> 01:24:59,950
just got published in science because

2085
01:25:05,370 --> 01:25:02,230
they zoomed in and they found swirly

2086
01:25:07,740 --> 01:25:05,380
lava so no yeah I definitely actually

2087
01:25:11,760 --> 01:25:07,750
you J Mars is free and you can download

2088
01:25:13,560 --> 01:25:11,770

it and you can zoom in so I agree Mikey

2089
01:25:16,200 --> 01:25:13,570
Thank You van I comment I think yeah

2090
01:25:18,270 --> 01:25:16,210
much photograph but little study I think

2091
01:25:21,180 --> 01:25:18,280
well we're talking about different

2092
01:25:23,640 --> 01:25:21,190
scales photographing it from orbit is

2093
01:25:27,480 --> 01:25:23,650
very very different than getting up

2094
01:25:29,850 --> 01:25:27,490
close to the micron level that you need

2095
01:25:32,370 --> 01:25:29,860
to detect microfossils

2096
01:25:34,470 --> 01:25:32,380
yeah but only on them like that alien

2097
01:25:36,660 --> 01:25:34,480
aspects I think very large alien

2098
01:25:38,070 --> 01:25:36,670
artifact we would have seen by now but

2099
01:25:39,570 --> 01:25:38,080
there's a threshold that's not very

2100
01:25:40,560 --> 01:25:39,580
believable that you need to do more

2101
01:25:46,020 --> 01:25:40,570
analysis to rely

2102
01:25:48,210 --> 01:25:46,030
okay if you could ask your question in

2103
01:25:51,270 --> 01:25:48,220
30 seconds if we get a 30-second break

2104
01:25:55,050 --> 01:25:51,280
and we can go with it I was thinking

2105
01:26:00,270 --> 01:25:55,060
that here on earth five star in a

2106
01:26:04,200 --> 01:26:00,280
thermal vent volcanic can move to the

2107
01:26:08,160 --> 01:26:04,210
earth to ground but all in this is their

2108
01:26:11,220 --> 01:26:08,170
assimilation can evolve so can you go

2109
01:26:16,080 --> 01:26:11,230
with that oh well I wasn't a question

2110
01:26:18,540 --> 01:26:16,090
okay I mean if I'm saying is we we

2111
01:26:21,900 --> 01:26:18,550
crawled all out of the earth at go

2112
01:26:24,120 --> 01:26:21,910
daintiness and we evolved into what we

2113
01:26:27,060 --> 01:26:24,130

are now there are so many ways of

2114
01:26:29,520 --> 01:26:27,070
evolution and you were saying the

2115
01:26:31,140 --> 01:26:29,530
evolved evolution on earth you know we

2116
01:26:34,140 --> 01:26:31,150
could have been having really smart

2117
01:26:35,520 --> 01:26:34,150
people in the in the ocean they could be

2118
01:26:37,260 --> 01:26:35,530
they could be and this is a much

2119
01:26:38,850 --> 01:26:37,270
discussed subject where you know

2120
01:26:40,710 --> 01:26:38,860
underwater world weather that could be

2121
01:26:42,990 --> 01:26:40,720
very intelligent but maybe non

2122
01:26:45,000 --> 01:26:43,000
technological alien super dolphins or

2123
01:26:47,040 --> 01:26:45,010
too many ways to go fish

2124
01:26:48,850 --> 01:26:47,050
yeah I feel that we're sorry' opening up

2125
01:26:51,390 --> 01:26:48,860
a can of worms

2126
01:26:53,770 --> 01:26:51,400
it's very late stage because unless

2127
01:26:55,840 --> 01:26:53,780
somebody is really desperate to answer

2128
01:26:57,970 --> 01:26:55,850
that question but the next and last

2129
01:27:00,280 --> 01:26:57,980
order business was going to be to take

2130
01:27:04,030 --> 01:27:00,290
advance on whether anybody actually won

2131
01:27:07,420 --> 01:27:04,040
this convention are going to overrule me

2132
01:27:09,880 --> 01:27:07,430
I just would like to see one by one a

2133
01:27:13,480 --> 01:27:09,890
show of hands starting with Vicky's

2134
01:27:15,280 --> 01:27:13,490
position that exoplanets will win this

2135
01:27:17,740 --> 01:27:15,290
way that's where we will discover life

2136
01:27:20,170 --> 01:27:17,750
beyond their set I'm not in a position

2137
01:27:22,840 --> 01:27:20,180
to be able to count right there I can

2138
01:27:32,350 --> 01:27:22,850

only count up to five but I think we're

2139
01:27:36,040 --> 01:27:32,360
all right about Britney what about the

2140
01:27:39,100 --> 01:27:36,050
ice well - who prefers that well I think

2141
01:27:41,170 --> 01:27:39,110
they're slightly ahead so far okay and

2142
01:27:43,320 --> 01:27:41,180
spent life on Mars always been my

2143
01:27:47,890 --> 01:27:43,330
favorite so I got a vote for that one

2144
01:27:50,220 --> 01:27:47,900
yeah yeah so Jacob I guess we're voting

2145
01:27:58,750 --> 01:27:50,230
for what we find

2146
01:28:00,340 --> 01:27:58,760
I'm sorry how can I forget you they come

2147
01:28:04,150 --> 01:28:00,350
to us please say oh we will we finally

2148
01:28:06,970 --> 01:28:04,160
life alien life here on earth first of

2149
01:28:10,390 --> 01:28:06,980
all okay we mean actually I preserve

2150
01:28:13,350 --> 01:28:10,400
others oh it's certainly more accessible

2151
01:28:16,000 --> 01:28:13,360
if it's here all right sorry Sarah

2152
01:28:19,330 --> 01:28:16,010
Jacob so we're voting where we find

2153
01:28:23,290 --> 01:28:19,340
basically an artifact before we find a

2154
01:28:26,410 --> 01:28:23,300
cell who would like that okay

2155
01:28:28,210 --> 01:28:26,420
all right and last but not least who

2156
01:28:30,580 --> 01:28:28,220
agrees with Charlie but it's all

2157
01:28:33,310 --> 01:28:30,590
ridiculous we're not going to find fine

2158
01:28:35,410 --> 01:28:33,320
any life as we know it but the old

2159
01:28:37,600 --> 01:28:35,420
already found or with all that it's

2160
01:28:39,010 --> 01:28:37,610
everywhere and it's a non question let's

2161
01:28:42,010 --> 01:28:39,020
say - what do you like that position

2162
01:28:42,940 --> 01:28:42,020
yeah nope not too many shall not strike

2163
01:28:46,870 --> 01:28:42,950

a move on others

2164
01:28:48,010 --> 01:28:46,880
oh I think I will join I think you're my

2165
01:28:48,850 --> 01:28:48,020
mask

2166
01:28:53,500 --> 01:28:48,860
[Applause]

2167
01:29:00,080 --> 01:28:58,340
my thanks to everybody who has come this

2168
01:29:02,810 --> 01:29:00,090
evening and particularly members of the

2169
01:29:05,780 --> 01:29:02,820
public that's always very welcome thanks

2170
01:29:09,290 --> 01:29:05,790
to to NASA the NASA Astrobiology

2171
01:29:11,840 --> 01:29:09,300
Institute and the organizers of the

2172
01:29:14,450 --> 01:29:11,850
conference and last but not least my

2173
01:29:15,390 --> 01:29:14,460
thanks to Galan panelists one more round

2174
01:29:17,880 --> 01:29:15,400
of applause