Panelists

Attendees (9)

- Hosts (1)
  - Mike Toillion
- Presenters (2)
  - Andy Burnett
  - Morgan Cable
- Participants (6)
  - Lindsay Hays
  - Max Coleman
  - MIchael New
  - Pauli Laine
  - Sheyna E. Gifford
  - Steve Vance

Open Chat (Everyone)

planetary protection, has encouraged people concerned about COSPAR protection protocols being over protective to attend the COSPAR meeting in Moscow in August.

Max Coleman: Methane is not a definitive biosignature for remote detection - there are too many abiological sources - so it is necessary to look at the whole system

--------- (01/16/2014 11:27) ---------

Pauli Laine: Steve: That's what I was refering. Trying to be there...

--------- (01/16/2014 11:29) ---------

Pauli Laine: How about culturing?

--------- (01/16/2014 11:31) ---------

Max Coleman: Is immunoassay etc suitable for Europa, Enceladus and Titan = where a second genesis of life may have occurred - which would you put your money on - more general or more specific on a mission of that cost?

--------- (01/16/2014 11:35) ---------

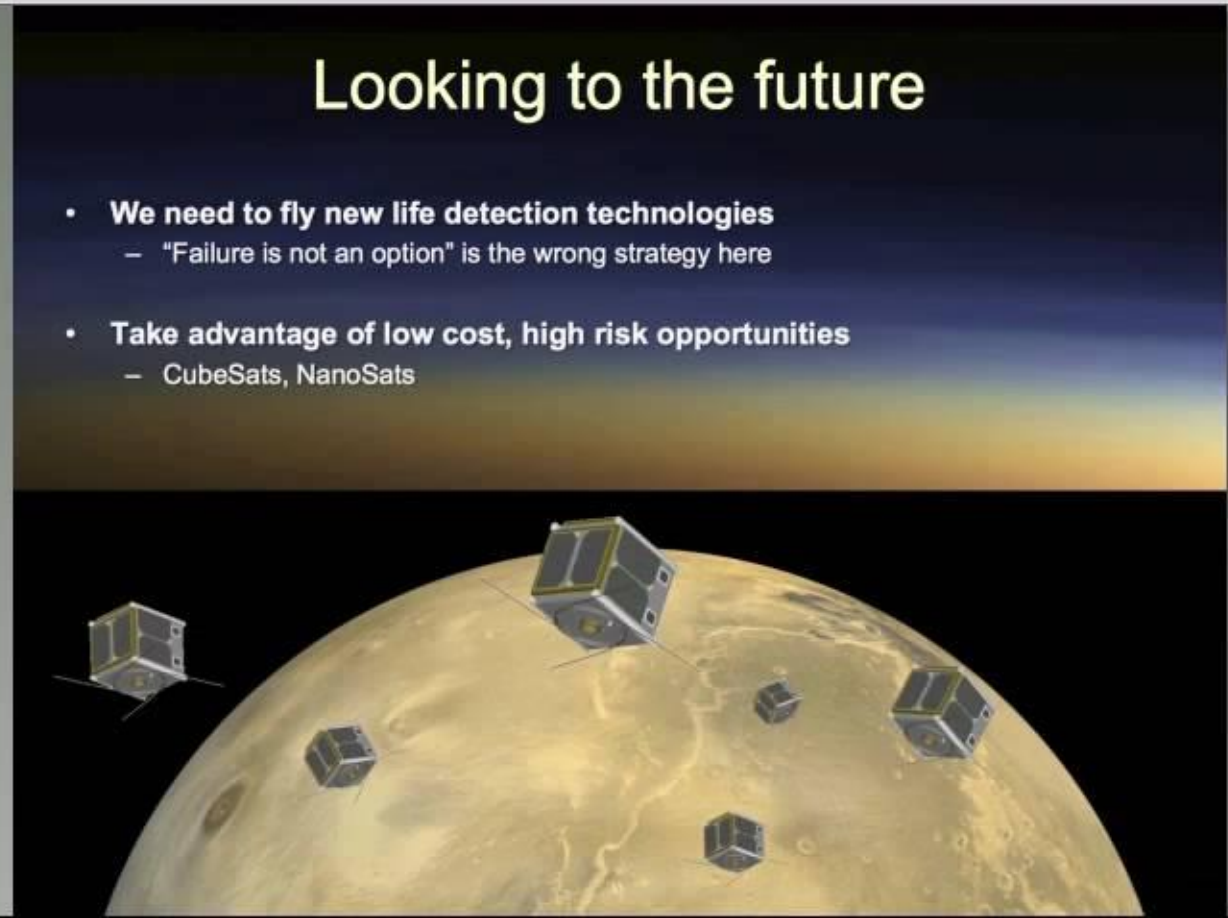
Pauli Laine: Aerogel?

Audio Instructions (Participants)

Teleconference Line: 866-692-3158
Passcode: 9109668#
Please use *6 (STAR, then 6) to MUTE your phone's mic when not speaking.
More info: https://astrobiologyfuture.org

How to Search for Life in the Solar System?

Full Screen



1
00:00:13,749 --> 00:00:10,709
good afternoon good morning everyone um

2
00:00:16,390 --> 00:00:13,759
we are on to the last

3
00:00:18,870 --> 00:00:16,400
of our astrobiology webinar as far as we

4
00:00:20,790 --> 00:00:18,880
know today's presentation is how we can

5
00:00:22,710 --> 00:00:20,800
search for life in our solar systems

6
00:00:24,950 --> 00:00:22,720
being on cable

7
00:00:28,470 --> 00:00:24,960
uh the video from

8
00:00:30,870 --> 00:00:28,480
yesterday's webinar steve moyesis uh

9
00:00:33,510 --> 00:00:30,880
will be up in the next couple of days

10
00:00:34,549 --> 00:00:33,520
and that will be added to our youtube

11
00:00:37,510 --> 00:00:34,559
stream

12
00:00:40,630 --> 00:00:37,520
the slides for today's presentation will

13
00:00:42,830 --> 00:00:40,640

be added to the event link

14
00:00:45,350 --> 00:00:42,840
and that will be up in the next hour or

15
00:00:47,270 --> 00:00:45,360
so and finally this session is being

16
00:00:49,029 --> 00:00:47,280
recorded and that covers both uh

17
00:00:51,510 --> 00:00:49,039
anything that's said and anything that's

18
00:00:53,430 --> 00:00:51,520
right in the public checked window and

19
00:00:57,510 --> 00:00:53,440
that there basically becomes publicly

20
00:01:00,069 --> 00:00:57,520
available and with that morgan

21
00:01:01,830 --> 00:01:00,079
thank you very much andy hi everyone

22
00:01:04,869 --> 00:01:01,840
thanks so much for tuning in

23
00:01:06,550 --> 00:01:04,879
so my name is morgan cable i am a staff

24
00:01:08,950 --> 00:01:06,560
scientist here at the jet propulsion

25
00:01:11,030 --> 00:01:08,960
laboratory and a part of my research

26
00:01:13,429 --> 00:01:11,040
involves astrobiology in the search for

27
00:01:15,510 --> 00:01:13,439
life and i'm very happy to be here today

28
00:01:16,789 --> 00:01:15,520
and to tell you a little bit about

29
00:01:20,390 --> 00:01:16,799
how we

30
00:01:21,190 --> 00:01:20,400
search for life and get your feedback on

31
00:01:28,990 --> 00:01:21,200
it

32
00:01:31,749 --> 00:01:29,000
there are plenty of targets

33
00:01:35,109 --> 00:01:31,759
astrobiologically in our solar system

34
00:01:36,310 --> 00:01:35,119
and nasa has certain ideas of

35
00:01:38,310 --> 00:01:36,320
which would be the best which is the

36
00:01:40,550 --> 00:01:38,320
easiest to get to

37
00:01:42,870 --> 00:01:40,560
which has the greatest potential for us

38
00:01:45,270 --> 00:01:42,880

to find life and so i wanted to start

39
00:01:46,149 --> 00:01:45,280
off with some votes some input from you

40
00:01:47,510 --> 00:01:46,159
of

41
00:01:49,429 --> 00:01:47,520
where you think

42
00:01:51,350 --> 00:01:49,439
the best potential for life might be in

43
00:01:53,510 --> 00:01:51,360
our solar system so if you look on your

44
00:01:56,230 --> 00:01:53,520
screen you should have some options for

45
00:01:59,590 --> 00:01:56,240
selecting mars europa

46
00:02:01,510 --> 00:01:59,600
titan enceladus or some other targets

47
00:02:03,350 --> 00:02:01,520
like triton which is a moon around

48
00:02:04,789 --> 00:02:03,360
neptune for example

49
00:02:06,789 --> 00:02:04,799
so if you want to take

50
00:02:09,749 --> 00:02:06,799
a few

51
00:02:11,990 --> 00:02:09,759
brief moments to to make a vote there it

52
00:02:13,270 --> 00:02:12,000
looks right now that uh europa is one of

53
00:02:15,350 --> 00:02:13,280
the main

54
00:02:17,430 --> 00:02:15,360
main contenders with enceladus in second

55
00:02:19,990 --> 00:02:17,440
place okay good so

56
00:02:22,309 --> 00:02:20,000
so you're on a similar page uh as nasa

57
00:02:23,430 --> 00:02:22,319
which is which is exciting but anytime

58
00:02:25,750 --> 00:02:23,440
that we

59
00:02:28,229 --> 00:02:25,760
we disagree or we have um different

60
00:02:29,990 --> 00:02:28,239
opinions from the community we're always

61
00:02:31,750 --> 00:02:30,000
very interested

62
00:02:33,750 --> 00:02:31,760
max has a question about expanse or

63
00:02:36,229 --> 00:02:33,760

extinct life that's a very good question

64
00:02:37,830 --> 00:02:36,239
we'll get into that a little bit in

65
00:02:39,110 --> 00:02:37,840
terms of what kind of biomarkers we

66
00:02:41,110 --> 00:02:39,120
should target

67
00:02:43,750 --> 00:02:41,120
i would say whichever has the best

68
00:02:44,869 --> 00:02:43,760
potential max so if you think we have a

69
00:02:47,030 --> 00:02:44,879
greater

70
00:02:48,830 --> 00:02:47,040
chance of finding extinct life on mars

71
00:02:51,270 --> 00:02:48,840
versus extant life on

72
00:02:52,869 --> 00:02:51,280
europa that would be something to

73
00:02:54,229 --> 00:02:52,879
consider oh and someone just changed

74
00:02:56,390 --> 00:02:54,239
their vote

75
00:02:57,750 --> 00:02:56,400
okay so so let's move forward then i'm

76
00:02:59,589 --> 00:02:57,760
just going to give

77
00:03:01,110 --> 00:02:59,599
a brief intro

78
00:03:03,190 --> 00:03:01,120
for those who don't

79
00:03:05,190 --> 00:03:03,200
live and breathe this stuff

80
00:03:06,149 --> 00:03:05,200
on some of these major targets so let's

81
00:03:09,430 --> 00:03:06,159
go

82
00:03:11,509 --> 00:03:09,440
to the next slide here so let's just

83
00:03:13,350 --> 00:03:11,519
start off with the places where

84
00:03:15,430 --> 00:03:13,360
we would like to look for life

85
00:03:17,030 --> 00:03:15,440
europa of course as that poll showed is

86
00:03:18,550 --> 00:03:17,040
one of our main

87
00:03:20,710 --> 00:03:18,560
targets for this

88
00:03:23,990 --> 00:03:20,720

it's one of the moons around jupiter it

89
00:03:24,949 --> 00:03:24,000
has an icy shell has hydrated minerals

90
00:03:27,990 --> 00:03:24,959
and

91
00:03:29,270 --> 00:03:28,000
its surface

92
00:03:32,470 --> 00:03:29,280
and more importantly it's got a

93
00:03:34,229 --> 00:03:32,480
subsurface liquid water ocean

94
00:03:36,229 --> 00:03:34,239
i believe the volume of this ocean is

95
00:03:37,750 --> 00:03:36,239
somewhere around three times greater

96
00:03:38,949 --> 00:03:37,760
than the volume of all earth's oceans

97
00:03:41,990 --> 00:03:38,959
combined

98
00:03:44,789 --> 00:03:42,000
and because of this tidal flexing that

99
00:03:46,550 --> 00:03:44,799
happens due to the gravitational forces

100
00:03:49,110 --> 00:03:46,560
of jupiter and the other galilean moons

101
00:03:50,309 --> 00:03:49,120
kind of doing tug-of-war on each other

102
00:03:53,270 --> 00:03:50,319
there could be

103
00:03:55,910 --> 00:03:53,280
a potential hydrothermal activity where

104
00:03:57,429 --> 00:03:55,920
the subsurface ocean meets the um the

105
00:03:58,390 --> 00:03:57,439
silicate crust

106
00:04:01,750 --> 00:03:58,400
of

107
00:04:03,670 --> 00:04:01,760
that

108
00:04:06,390 --> 00:04:03,680
we're very interested in looking for

109
00:04:08,229 --> 00:04:06,400
life that has analogs on earth

110
00:04:09,830 --> 00:04:08,239
at the bottom of our oceans around

111
00:04:10,869 --> 00:04:09,840
hydrothermal vents

112
00:04:12,390 --> 00:04:10,879
these are

113
00:04:14,630 --> 00:04:12,400

communities where

114
00:04:16,710 --> 00:04:14,640
hydrothermal fluid which is hot fluid

115
00:04:19,909 --> 00:04:16,720
has a lot of dissolved minerals and

116
00:04:22,310 --> 00:04:19,919
gases and and even some organics and it

117
00:04:25,189 --> 00:04:22,320
mixes with the the cold

118
00:04:26,950 --> 00:04:25,199
uh ocean water and you end up forming

119
00:04:28,790 --> 00:04:26,960
these these really intricate chimney

120
00:04:30,390 --> 00:04:28,800
structures because precipitate

121
00:04:32,070 --> 00:04:30,400
precipitation happens right because

122
00:04:33,590 --> 00:04:32,080
you've got a thermal gradient you also

123
00:04:35,350 --> 00:04:33,600
have a whole bunch of other energy

124
00:04:36,790 --> 00:04:35,360
gradients that life can use to survive

125
00:04:38,230 --> 00:04:36,800
you've got redox

126
00:04:40,870 --> 00:04:38,240
like i mentioned thermal a whole bunch

127
00:04:42,950 --> 00:04:40,880
of chemical gradients of concentration

128
00:04:45,270 --> 00:04:42,960
gradients moving along that light can

129
00:04:46,790 --> 00:04:45,280
take advantage of so

130
00:04:49,189 --> 00:04:46,800
despite the fact that there's no

131
00:04:51,749 --> 00:04:49,199
sunlight we're talking you know 3 000

132
00:04:53,030 --> 00:04:51,759
meters below the the surface of the

133
00:04:54,710 --> 00:04:53,040
ocean

134
00:04:55,830 --> 00:04:54,720
we find these thriving communities they

135
00:04:56,790 --> 00:04:55,840
have both

136
00:04:59,670 --> 00:04:56,800
micro

137
00:05:02,870 --> 00:04:59,680
organisms kind of life and also macro

138
00:05:04,790 --> 00:05:02,880

flora and fauna and so

139
00:05:06,310 --> 00:05:04,800
these types of communities may be

140
00:05:08,310 --> 00:05:06,320
something that could exist in a place

141
00:05:09,430 --> 00:05:08,320
like europa

142
00:05:10,950 --> 00:05:09,440
so let's see what do we have next we

143
00:05:13,350 --> 00:05:10,960
have mars next

144
00:05:14,310 --> 00:05:13,360
so of course mars is is dry more of a

145
00:05:16,710 --> 00:05:14,320
desert

146
00:05:19,830 --> 00:05:16,720
uh nowadays but it did have a much

147
00:05:22,790 --> 00:05:19,840
warmer wetter history and in fact recent

148
00:05:25,350 --> 00:05:22,800
evidence i believe from mro but i could

149
00:05:27,990 --> 00:05:25,360
be wrong detected these uh these linear

150
00:05:30,230 --> 00:05:28,000
that might be liquid water events

151
00:05:31,510 --> 00:05:30,240
occurring on the surface even today

152
00:05:33,749 --> 00:05:31,520
so

153
00:05:36,790 --> 00:05:33,759
mars may have the potential it may have

154
00:05:38,469 --> 00:05:36,800
had in the past to have life and may

155
00:05:41,350 --> 00:05:38,479
still today especially is that life is

156
00:05:43,670 --> 00:05:41,360
very robust to things like high salt or

157
00:05:47,029 --> 00:05:43,680
very low water activity the good earth

158
00:05:49,110 --> 00:05:47,039
analog for mars is among others is the

159
00:05:51,110 --> 00:05:49,120
atacama desert in northern chile which

160
00:05:53,590 --> 00:05:51,120
is the driest desert in the world so it

161
00:05:55,270 --> 00:05:53,600
has very low water activity

162
00:05:59,029 --> 00:05:55,280
but

163
00:06:01,270 --> 00:05:59,039

many teams at jpl other nasa centers use

164
00:06:03,110 --> 00:06:01,280
this as an analog for mars in fact i've

165
00:06:05,909 --> 00:06:03,120
been on an expedition there and we found

166
00:06:07,670 --> 00:06:05,919
all sorts of life it's not evident but a

167
00:06:09,430 --> 00:06:07,680
lot of microbial life halophilic

168
00:06:10,790 --> 00:06:09,440
organisms so things that can tolerate

169
00:06:12,550 --> 00:06:10,800
high salt

170
00:06:15,830 --> 00:06:12,560
and bacterial spores which are the

171
00:06:17,909 --> 00:06:15,840
toughest form of life we know about

172
00:06:20,070 --> 00:06:17,919
so there are plenty of

173
00:06:22,550 --> 00:06:20,080
of organisms that can even survive in in

174
00:06:24,629 --> 00:06:22,560
this type of extreme environment

175
00:06:26,710 --> 00:06:24,639
so i'm looking at a question or a

176
00:06:28,309 --> 00:06:26,720
comment from steve

177
00:06:29,510 --> 00:06:28,319
see

178
00:06:32,230 --> 00:06:29,520
tides give us a reason believe there may

179
00:06:34,390 --> 00:06:32,240
be extensive hydrothermalism

180
00:06:36,150 --> 00:06:34,400
ooh okay that's a good comment

181
00:06:37,749 --> 00:06:36,160
uh we may bring that up oh feel free to

182
00:06:39,270 --> 00:06:37,759
interrupt with questions at any point

183
00:06:41,110 --> 00:06:39,280
this is supposed to be

184
00:06:42,870 --> 00:06:41,120
more of an informal format and i'd like

185
00:06:44,710 --> 00:06:42,880
to to make this as interactive as

186
00:06:46,309 --> 00:06:44,720
possible

187
00:06:48,309 --> 00:06:46,319
i'm going to keep going but feel free to

188
00:06:50,469 --> 00:06:48,319

interrupt at any time especially if if

189
00:06:53,430 --> 00:06:50,479
you have comments that immediately to

190
00:06:56,150 --> 00:06:53,440
apply to what i'm talking about

191
00:06:57,990 --> 00:06:56,160
okay so next is uh

192
00:06:59,830 --> 00:06:58,000
one of the moons of saturn that's pretty

193
00:07:03,510 --> 00:06:59,840
near and dear to my heart i've done some

194
00:07:06,230 --> 00:07:03,520
some research on this titan so titan is

195
00:07:07,749 --> 00:07:06,240
is one of the larger moons in our solar

196
00:07:08,950 --> 00:07:07,759
system i think it's the second largest

197
00:07:10,550 --> 00:07:08,960
although if you count the atmosphere

198
00:07:11,350 --> 00:07:10,560
with the diameter technically the

199
00:07:12,230 --> 00:07:11,360
biggest

200
00:07:14,150 --> 00:07:12,240
um

201
00:07:17,510 --> 00:07:14,160
it's got a thick atmosphere thicker than

202
00:07:19,670 --> 00:07:17,520
earth about 1.5 bar at the surface and

203
00:07:21,350 --> 00:07:19,680
on earth our surface is around one bar

204
00:07:23,430 --> 00:07:21,360
so it's thicker than earth

205
00:07:24,469 --> 00:07:23,440
and it's composed of nitrogen and

206
00:07:25,830 --> 00:07:24,479
methane

207
00:07:27,110 --> 00:07:25,840
and

208
00:07:29,430 --> 00:07:27,120
charged particles from saturn's

209
00:07:31,189 --> 00:07:29,440
magnetosphere excuse me

210
00:07:33,350 --> 00:07:31,199
and uv radiation and various other

211
00:07:35,589 --> 00:07:33,360
things break up this nitrogen and

212
00:07:38,230 --> 00:07:35,599
methane and form a whole bunch of

213
00:07:41,110 --> 00:07:38,240

different organic compounds

214
00:07:43,589 --> 00:07:41,120
the hcn for example and much much larger

215
00:07:46,070 --> 00:07:43,599
species as well and these combine and

216
00:07:47,270 --> 00:07:46,080
react they form these haze layers that

217
00:07:48,950 --> 00:07:47,280
we see in the atmosphere and then they

218
00:07:52,070 --> 00:07:48,960
rain down on the surface

219
00:07:54,150 --> 00:07:52,080
so titan is a very unique mix it's got a

220
00:07:56,309 --> 00:07:54,160
water ice shell but it's coated in this

221
00:07:58,309 --> 00:07:56,319
veneer of organics and we're not sure

222
00:08:00,469 --> 00:07:58,319
how thick that layer is but there's

223
00:08:02,550 --> 00:08:00,479
there's a lot of stuff there and

224
00:08:04,869 --> 00:08:02,560
underneath all of that it also has a

225
00:08:08,790 --> 00:08:04,879
subsurface liquid water ocean just like

226
00:08:10,629 --> 00:08:08,800
europa and a lot of the other icy worlds

227
00:08:11,589 --> 00:08:10,639
in addition to that it's got hydrocarbon

228
00:08:13,990 --> 00:08:11,599
lakes

229
00:08:15,749 --> 00:08:14,000
pretty cool at the poles so mostly

230
00:08:18,550 --> 00:08:15,759
methane ethane

231
00:08:21,749 --> 00:08:18,560
lakes and like i said it's got this huge

232
00:08:23,430 --> 00:08:21,759
inventory of organic molecules so

233
00:08:25,029 --> 00:08:23,440
all the ingredients

234
00:08:26,710 --> 00:08:25,039
for life are there

235
00:08:28,790 --> 00:08:26,720
but it's very cold the surface is around

236
00:08:30,550 --> 00:08:28,800
90 kelvin so

237
00:08:32,469 --> 00:08:30,560
there are questions about the

238
00:08:34,790 --> 00:08:32,479

thermodynamics involved

239
00:08:37,190 --> 00:08:34,800
for a lot of organic chemistry reactions

240
00:08:39,589 --> 00:08:37,200
that might be necessary for life but

241
00:08:41,750 --> 00:08:39,599
it's still a really interesting place

242
00:08:44,710 --> 00:08:41,760
we don't really have a good analog for

243
00:08:46,389 --> 00:08:44,720
titan on earth although plenty of

244
00:08:48,550 --> 00:08:46,399
titan chambers have been built to

245
00:08:50,550 --> 00:08:48,560
simulate titan's environment and try to

246
00:08:52,470 --> 00:08:50,560
understand more about these organics

247
00:08:54,870 --> 00:08:52,480
that are formed in the atmosphere

248
00:08:56,230 --> 00:08:54,880
but in terms of life the closest analog

249
00:08:58,230 --> 00:08:56,240
that i can think of and that's been

250
00:09:01,750 --> 00:08:58,240
brought up in the literature before

251
00:09:03,670 --> 00:09:01,760
is hydrocarbon metabolizing bacteria so

252
00:09:05,590 --> 00:09:03,680
an example of this could be pitch lake

253
00:09:07,269 --> 00:09:05,600
which i've shown here at trinidad and

254
00:09:09,430 --> 00:09:07,279
tobago although this

255
00:09:11,910 --> 00:09:09,440
temperature regime is much higher the

256
00:09:14,070 --> 00:09:11,920
organisms that exist in this type of

257
00:09:16,870 --> 00:09:14,080
environment they're referred to as poly

258
00:09:19,350 --> 00:09:16,880
extremophiles sometimes because they

259
00:09:21,030 --> 00:09:19,360
tend to have many qualities that

260
00:09:22,870 --> 00:09:21,040
sometimes only a single extremophile

261
00:09:25,990 --> 00:09:22,880
will have for example resistance to

262
00:09:28,389 --> 00:09:26,000
either high or low temperature

263
00:09:31,350 --> 00:09:28,399

an absence or near absence of liquid

264
00:09:33,990 --> 00:09:31,360
water instead having non-polar media

265
00:09:35,750 --> 00:09:34,000
and in many cases being exposed to to

266
00:09:36,550 --> 00:09:35,760
radiation and various other things like

267
00:09:37,990 --> 00:09:36,560
that

268
00:09:40,790 --> 00:09:38,000
another example could be some of these

269
00:09:43,110 --> 00:09:40,800
deep sea oil drilling sites which also

270
00:09:44,870 --> 00:09:43,120
seem to have incredible amounts of

271
00:09:46,070 --> 00:09:44,880
bacterial life that can survive in those

272
00:09:47,509 --> 00:09:46,080
situations

273
00:09:49,670 --> 00:09:47,519
so although

274
00:09:51,990 --> 00:09:49,680
life on titan might

275
00:09:54,630 --> 00:09:52,000
if if there is any could be a little bit

276
00:09:56,470 --> 00:09:54,640
more in the on the exotic side compared

277
00:09:58,470 --> 00:09:56,480
to life on earth there are still

278
00:09:59,750 --> 00:09:58,480
potentials and that's something that we

279
00:10:01,430 --> 00:09:59,760
shouldn't um

280
00:10:04,949 --> 00:10:01,440
that we should consider when we're

281
00:10:06,310 --> 00:10:04,959
talking about astrobiology

282
00:10:08,150 --> 00:10:06,320
okay

283
00:10:10,070 --> 00:10:08,160
last but not least enceladus another

284
00:10:12,230 --> 00:10:10,080
moon around saturn this one's a bit

285
00:10:13,910 --> 00:10:12,240
further out and a bit smaller but it's

286
00:10:16,310 --> 00:10:13,920
pretty exciting especially from an

287
00:10:17,509 --> 00:10:16,320
astrobiological standpoint because it's

288
00:10:19,590 --> 00:10:17,519

spewing

289
00:10:21,110 --> 00:10:19,600
ice and and

290
00:10:23,509 --> 00:10:21,120
the water ice and i think a few other

291
00:10:25,590 --> 00:10:23,519
materials out of its south pole out of

292
00:10:27,190 --> 00:10:25,600
these tiger stripes so it's basically

293
00:10:29,269 --> 00:10:27,200
just giving us samples

294
00:10:30,870 --> 00:10:29,279
from the interior which is usually very

295
00:10:32,790 --> 00:10:30,880
difficult to access

296
00:10:35,030 --> 00:10:32,800
and so because of this

297
00:10:37,829 --> 00:10:35,040
enceladus may be a very

298
00:10:39,670 --> 00:10:37,839
interesting target for us in terms of

299
00:10:41,829 --> 00:10:39,680
some of the more difficult aspects of

300
00:10:43,590 --> 00:10:41,839
investigating astrobiology trying to

301
00:10:45,509 --> 00:10:43,600
collect a sample

302
00:10:46,630 --> 00:10:45,519
can be really challenging

303
00:10:49,190 --> 00:10:46,640
so

304
00:10:51,190 --> 00:10:49,200
enceladus just like europa titan and

305
00:10:54,310 --> 00:10:51,200
many other of the icy moons has a

306
00:10:56,550 --> 00:10:54,320
subsurface liquid water ocean

307
00:10:58,790 --> 00:10:56,560
and steve can can correct me on this i

308
00:11:01,509 --> 00:10:58,800
think he knows a bit more about the

309
00:11:04,150 --> 00:11:01,519
the size of these oceans and things of

310
00:11:05,590 --> 00:11:04,160
that nature but a good earth analog of

311
00:11:07,430 --> 00:11:05,600
course would be something like

312
00:11:08,710 --> 00:11:07,440
antarctica some of these subglacial

313
00:11:10,550 --> 00:11:08,720

ecosystems

314
00:11:12,069 --> 00:11:10,560
where you have liquid water it's very

315
00:11:14,230 --> 00:11:12,079
cold and we still have plenty of

316
00:11:16,630 --> 00:11:14,240
organisms that can survive at least on

317
00:11:18,630 --> 00:11:16,640
earth in these types of environments

318
00:11:21,190 --> 00:11:18,640
they tend to be cyclophilic which means

319
00:11:23,910 --> 00:11:21,200
cold loving or halophilic so they like

320
00:11:25,829 --> 00:11:23,920
high saline environments and as this

321
00:11:27,269 --> 00:11:25,839
image shows this is from a drill site in

322
00:11:29,590 --> 00:11:27,279
antarctica

323
00:11:32,069 --> 00:11:29,600
core you can even see some higher life

324
00:11:33,269 --> 00:11:32,079
forms like this this little shrimpy guy

325
00:11:35,350 --> 00:11:33,279
here

326
00:11:37,430 --> 00:11:35,360
so

327
00:11:39,269 --> 00:11:37,440
those are a few of the after biology

328
00:11:40,790 --> 00:11:39,279
targets and nasa really considers when

329
00:11:44,389 --> 00:11:40,800
it comes to

330
00:11:45,750 --> 00:11:44,399
looking for life in the solar system

331
00:11:48,069 --> 00:11:45,760
at this point

332
00:11:49,590 --> 00:11:48,079
it might be informative to go back to

333
00:11:51,190 --> 00:11:49,600
that question we had before where you

334
00:11:52,230 --> 00:11:51,200
were voting and ranking

335
00:11:54,230 --> 00:11:52,240
on

336
00:11:56,310 --> 00:11:54,240
where you think

337
00:12:01,829 --> 00:11:56,320
the greatest potential exists for life

338
00:12:06,230 --> 00:12:03,990

let's see if anyone has changed we've

339
00:12:07,269 --> 00:12:06,240
got let's see europa is still in the

340
00:12:09,430 --> 00:12:07,279
lead

341
00:12:11,190 --> 00:12:09,440
and we've got one vote for mars and one

342
00:12:12,470 --> 00:12:11,200
for enceladus

343
00:12:14,870 --> 00:12:12,480
no votes for titan what about the

344
00:12:17,269 --> 00:12:14,880
subsurface ocean of titan guys you could

345
00:12:20,310 --> 00:12:17,279
have organics maybe if there's some kind

346
00:12:21,430 --> 00:12:20,320
of exchange i know cryovoc volcanism

347
00:12:23,670 --> 00:12:21,440
isn't really

348
00:12:25,269 --> 00:12:23,680
as hot of a topic right now but

349
00:12:28,470 --> 00:12:25,279
there is still potential especially if

350
00:12:30,470 --> 00:12:28,480
you have ammonia that could interact

351
00:12:32,069 --> 00:12:30,480
it could change buoyancy and and

352
00:12:33,110 --> 00:12:32,079
potentially spill out on the surface of

353
00:12:34,790 --> 00:12:33,120
titan

354
00:12:37,350 --> 00:12:34,800
well there are a lot of interesting

355
00:12:39,509 --> 00:12:37,360
theories going on but i suppose

356
00:12:41,030 --> 00:12:39,519
until we have solid proof

357
00:12:41,829 --> 00:12:41,040
i'm okay with that

358
00:12:46,069 --> 00:12:41,839
so

359
00:12:48,470 --> 00:12:46,079
like enceladus now has beat out mars

360
00:12:49,829 --> 00:12:48,480
in terms of potential for life okay so

361
00:12:52,550 --> 00:12:49,839
so we've got a little bit of feedback

362
00:12:53,750 --> 00:12:52,560
that's good uh let's keep going

363
00:12:55,910 --> 00:12:53,760

mike can you close that down because

364
00:12:58,870 --> 00:12:55,920
i've got some quite a bit of text on the

365
00:12:59,829 --> 00:12:58,880
next couple of slides all right so i was

366
00:13:02,310 --> 00:12:59,839
thinking

367
00:13:04,470 --> 00:13:02,320
about how we search for life and kind of

368
00:13:06,870 --> 00:13:04,480
the best way to break it down

369
00:13:08,550 --> 00:13:06,880
and i thought to

370
00:13:10,470 --> 00:13:08,560
split it up in terms of the platform

371
00:13:12,870 --> 00:13:10,480
seemed pretty reasonable so i'm going to

372
00:13:13,670 --> 00:13:12,880
talk about each of these in turn

373
00:13:15,990 --> 00:13:13,680
so

374
00:13:17,030 --> 00:13:16,000
first there's remote observation

375
00:13:19,190 --> 00:13:17,040
right

376
00:13:22,310 --> 00:13:19,200
looking at the planet from orbit or via

377
00:13:23,509 --> 00:13:22,320
flyby or using a telescope or something

378
00:13:24,310 --> 00:13:23,519
from earth

379
00:13:25,670 --> 00:13:24,320
and

380
00:13:28,310 --> 00:13:25,680
remote observation has a lot of

381
00:13:30,150 --> 00:13:28,320
advantages for example you can study a

382
00:13:31,990 --> 00:13:30,160
really large surface area in fact you

383
00:13:34,550 --> 00:13:32,000
can get global coverage with a lot of

384
00:13:36,550 --> 00:13:34,560
these orbiters that we have today and

385
00:13:40,470 --> 00:13:36,560
you can study effects globally you can

386
00:13:46,150 --> 00:13:43,910
and get a much better idea of

387
00:13:48,389 --> 00:13:46,160
where life might exist on a body like

388
00:13:50,470 --> 00:13:48,399

europa or mars or something like that

389
00:13:52,470 --> 00:13:50,480
there are a few drawbacks for example

390
00:13:55,110 --> 00:13:52,480
resolution compared to

391
00:13:56,790 --> 00:13:55,120
if you had an image or in situ obviously

392
00:13:58,790 --> 00:13:56,800
it's not going to be as good

393
00:14:00,470 --> 00:13:58,800
and limits of detection especially when

394
00:14:03,189 --> 00:14:00,480
you're looking at things like like

395
00:14:05,110 --> 00:14:03,199
methane gas release things like that

396
00:14:07,110 --> 00:14:05,120
aren't quite as good as they would be in

397
00:14:09,509 --> 00:14:07,120
situ but you do get the global coverage

398
00:14:10,389 --> 00:14:09,519
so there's a trade-off there

399
00:14:12,389 --> 00:14:10,399
the

400
00:14:14,069 --> 00:14:12,399
second platform instead of looking at

401
00:14:15,670 --> 00:14:14,079
things remotely is to get down in the

402
00:14:17,910 --> 00:14:15,680
environment where you're trying to look

403
00:14:20,629 --> 00:14:17,920
for life and you can do this with a

404
00:14:22,629 --> 00:14:20,639
lander a rover maybe even people

405
00:14:24,230 --> 00:14:22,639
to be really nice

406
00:14:26,150 --> 00:14:24,240
to do more of that

407
00:14:27,509 --> 00:14:26,160
and there are lots of benefits right you

408
00:14:28,949 --> 00:14:27,519
can

409
00:14:30,949 --> 00:14:28,959
take images with much much higher

410
00:14:32,949 --> 00:14:30,959
resolution your limits of detection

411
00:14:35,189 --> 00:14:32,959
which vary a lot by technique but they

412
00:14:37,269 --> 00:14:35,199
tend to be much better

413
00:14:38,150 --> 00:14:37,279

but you do have a few drawbacks you

414
00:14:40,389 --> 00:14:38,160
can't

415
00:14:42,470 --> 00:14:40,399
sample everywhere right you can only

416
00:14:44,069 --> 00:14:42,480
send a lander to a very specific place

417
00:14:46,069 --> 00:14:44,079
and usually the scientists and the

418
00:14:48,150 --> 00:14:46,079
engineers tend to argue about where to

419
00:14:49,910 --> 00:14:48,160
go right the engineers want to go to the

420
00:14:51,910 --> 00:14:49,920
safe places the scientists want to go to

421
00:14:53,430 --> 00:14:51,920
the interesting places and it's very

422
00:14:54,790 --> 00:14:53,440
rare that those two actually tend to

423
00:14:57,189 --> 00:14:54,800
coincide

424
00:14:58,629 --> 00:14:57,199
so there's some risk in terms of the the

425
00:14:59,750 --> 00:14:58,639
engineering side that you have to

426
00:15:02,069 --> 00:14:59,760
consider

427
00:15:04,150 --> 00:15:02,079
there's also the issue of contamination

428
00:15:06,550 --> 00:15:04,160
which is inherent anytime you're in the

429
00:15:08,389 --> 00:15:06,560
environment you're trying to study

430
00:15:09,670 --> 00:15:08,399
and the best way to mitigate that is to

431
00:15:11,590 --> 00:15:09,680
just be very

432
00:15:13,350 --> 00:15:11,600
careful and thorough from a scientific

433
00:15:15,990 --> 00:15:13,360
standpoint that you're running the right

434
00:15:18,629 --> 00:15:16,000
controls that you're sure of the data

435
00:15:20,629 --> 00:15:18,639
you're collecting and

436
00:15:22,949 --> 00:15:20,639
and just making

437
00:15:25,430 --> 00:15:22,959
making it very clear to the scientific

438
00:15:27,269 --> 00:15:25,440

community when you report your results

439
00:15:28,550 --> 00:15:27,279
so that's in situ

440
00:15:30,389 --> 00:15:28,560
the last

441
00:15:32,230 --> 00:15:30,399
life detection strategy

442
00:15:33,189 --> 00:15:32,240
which we're getting to hopefully with

443
00:15:35,829 --> 00:15:33,199
mars

444
00:15:37,509 --> 00:15:35,839
in the near future is sample return so

445
00:15:38,629 --> 00:15:37,519
getting a sample collecting it bringing

446
00:15:40,230 --> 00:15:38,639
it back

447
00:15:41,030 --> 00:15:40,240
of course the benefits here then you

448
00:15:42,790 --> 00:15:41,040
have

449
00:15:44,949 --> 00:15:42,800
any technique

450
00:15:46,949 --> 00:15:44,959
on the planet earth that you can use to

451
00:15:48,550 --> 00:15:46,959
to analyze these even if it takes up an

452
00:15:49,829 --> 00:15:48,560
entire room or an entire building

453
00:15:50,870 --> 00:15:49,839
because you don't have to worry about

454
00:15:53,749 --> 00:15:50,880
flying it

455
00:15:54,870 --> 00:15:53,759
so you can get ultra-sensitive limits of

456
00:15:56,150 --> 00:15:54,880
detection

457
00:15:58,710 --> 00:15:56,160
and you can

458
00:16:00,470 --> 00:15:58,720
you can run analyses multiple times you

459
00:16:01,430 --> 00:16:00,480
don't have to worry quite so much about

460
00:16:03,030 --> 00:16:01,440
um

461
00:16:04,389 --> 00:16:03,040
about

462
00:16:06,470 --> 00:16:04,399
some of the things that

463
00:16:07,350 --> 00:16:06,480

you need to in terms of in situ in terms

464
00:16:08,389 --> 00:16:07,360
of

465
00:16:09,910 --> 00:16:08,399
power

466
00:16:14,230 --> 00:16:09,920
mass constraints

467
00:16:18,470 --> 00:16:15,749
there are drawbacks of course it's

468
00:16:19,749 --> 00:16:18,480
really really ridiculously expensive

469
00:16:22,310 --> 00:16:19,759
there's also a question of sample

470
00:16:23,590 --> 00:16:22,320
preservation currents models for sample

471
00:16:25,910 --> 00:16:23,600
return involve

472
00:16:27,590 --> 00:16:25,920
having these sealed samples sitting on

473
00:16:28,710 --> 00:16:27,600
mars for a while before they're brought

474
00:16:30,230 --> 00:16:28,720
back up and

475
00:16:31,990 --> 00:16:30,240
whether that thermal cycling could do

476
00:16:33,269 --> 00:16:32,000
anything to the organisms if there are

477
00:16:35,829 --> 00:16:33,279
any there

478
00:16:38,629 --> 00:16:35,839
or any biomarkers is a question that

479
00:16:39,670 --> 00:16:38,639
we're trying to address

480
00:16:41,590 --> 00:16:39,680
and then again the issue of

481
00:16:43,110 --> 00:16:41,600
contamination especially since it takes

482
00:16:45,269 --> 00:16:43,120
a while to

483
00:16:48,389 --> 00:16:45,279
go to mars and conversely bring a sample

484
00:16:51,670 --> 00:16:48,399
back so thinking in terms of how long a

485
00:16:53,509 --> 00:16:51,680
sample might be exposed to

486
00:16:56,150 --> 00:16:53,519
potential contamination

487
00:16:56,870 --> 00:16:56,160
and something to think about as well

488
00:16:58,790 --> 00:16:56,880

so

489
00:17:00,470 --> 00:16:58,800
these are the the platforms general

490
00:17:03,110 --> 00:17:00,480
platforms that you can use

491
00:17:04,949 --> 00:17:03,120
to look for life and indeed for mars

492
00:17:06,710 --> 00:17:04,959
that's basically what we've been doing

493
00:17:08,870 --> 00:17:06,720
for the last few decades we started off

494
00:17:10,870 --> 00:17:08,880
with orbiters we use those to target

495
00:17:13,110 --> 00:17:10,880
specific landing sites we thought might

496
00:17:14,949 --> 00:17:13,120
be interesting either from a geological

497
00:17:16,230 --> 00:17:14,959
or an astrobiological

498
00:17:18,309 --> 00:17:16,240
perspective

499
00:17:20,390 --> 00:17:18,319
we sent landers or rovers there and and

500
00:17:21,909 --> 00:17:20,400
eventually we'll be moving to sample

501
00:17:24,230 --> 00:17:21,919
return

502
00:17:25,669 --> 00:17:24,240
now with mars of course it's it's easier

503
00:17:28,309 --> 00:17:25,679
to do this it's cheaper right it's the

504
00:17:29,270 --> 00:17:28,319
closest closest neighbor we have

505
00:17:31,190 --> 00:17:29,280
uh

506
00:17:33,270 --> 00:17:31,200
but in terms of thinking about icy

507
00:17:35,750 --> 00:17:33,280
worlds a lot further out

508
00:17:37,990 --> 00:17:35,760
a lot of these

509
00:17:39,669 --> 00:17:38,000
these types of strategies get to be more

510
00:17:41,909 --> 00:17:39,679
challenging and we need to be thinking

511
00:17:42,870 --> 00:17:41,919
about what kind of technologies we can

512
00:17:44,470 --> 00:17:42,880
leverage

513
00:17:47,430 --> 00:17:44,480

to to

514
00:17:48,789 --> 00:17:47,440
make this more feasible in the future

515
00:17:50,070 --> 00:17:48,799
let's see i'm reading a few of the

516
00:17:51,669 --> 00:17:50,080
comments

517
00:17:52,870 --> 00:17:51,679
steve brought up a thought exercise

518
00:17:55,110 --> 00:17:52,880
about

519
00:17:56,549 --> 00:17:55,120
a rover or well-equipped person finding

520
00:17:59,350 --> 00:17:56,559
definitive signs of life in earth's

521
00:18:01,430 --> 00:17:59,360
atacama desert that's a a very good

522
00:18:03,350 --> 00:18:01,440
point a lot of teams including one that

523
00:18:04,789 --> 00:18:03,360
i was a part of as a grad student have

524
00:18:06,150 --> 00:18:04,799
tried to do that

525
00:18:08,310 --> 00:18:06,160
we try to

526
00:18:10,789 --> 00:18:08,320
take an instrument that's as close to

527
00:18:12,789 --> 00:18:10,799
what we would put on a rover and try to

528
00:18:14,310 --> 00:18:12,799
look for life and

529
00:18:15,750 --> 00:18:14,320
one challenge that we've found

530
00:18:18,950 --> 00:18:15,760
especially with

531
00:18:21,350 --> 00:18:18,960
with mars is sample handling i mean

532
00:18:23,590 --> 00:18:21,360
we're we're just breaking the surface in

533
00:18:25,510 --> 00:18:23,600
terms of handling liquids in a place

534
00:18:27,750 --> 00:18:25,520
like mars i mean there are very few

535
00:18:29,430 --> 00:18:27,760
experiments that even use uh liquids or

536
00:18:31,510 --> 00:18:29,440
solvents let's see there was the two

537
00:18:33,830 --> 00:18:31,520
viking probes had they essentially just

538
00:18:36,630 --> 00:18:33,840

had like a scoop and they dumped some

539
00:18:38,630 --> 00:18:36,640
some mars soil regalis whatever you want

540
00:18:39,990 --> 00:18:38,640
to call it and then added some water and

541
00:18:41,029 --> 00:18:40,000
then looked at what kind of gases were

542
00:18:42,630 --> 00:18:41,039
evolved

543
00:18:45,270 --> 00:18:42,640
and since then we've had let's see the

544
00:18:46,549 --> 00:18:45,280
phoenix the mecca it's a

545
00:18:49,029 --> 00:18:46,559
m i don't remember the m but

546
00:18:51,029 --> 00:18:49,039
electrochemical conductivity i believe

547
00:18:52,870 --> 00:18:51,039
for the e and the c for mecca they

548
00:18:55,430 --> 00:18:52,880
basically did the same thing they had

549
00:18:57,750 --> 00:18:55,440
these um special cells that were i think

550
00:18:59,669 --> 00:18:57,760
they're about yay big dump some soil in

551
00:19:01,750 --> 00:18:59,679
and then added some water and measured

552
00:19:03,430 --> 00:19:01,760
conductivity and other properties but it

553
00:19:04,870 --> 00:19:03,440
was still just sort of squirting water

554
00:19:06,070 --> 00:19:04,880
in seeing

555
00:19:08,390 --> 00:19:06,080
what happened

556
00:19:09,909 --> 00:19:08,400
the sam instrument of curiosity does

557
00:19:11,190 --> 00:19:09,919
something similar they have some kind of

558
00:19:13,110 --> 00:19:11,200
package that they open that has

559
00:19:14,870 --> 00:19:13,120
particular solvents and reagents that

560
00:19:16,470 --> 00:19:14,880
are supposed to react with

561
00:19:19,909 --> 00:19:16,480
certain organics if they're present or

562
00:19:21,830 --> 00:19:19,919
other species and then they look at the

563
00:19:24,630 --> 00:19:21,840

gases that are evolved

564
00:19:26,870 --> 00:19:24,640
but i think in order for us to get to a

565
00:19:28,549 --> 00:19:26,880
point where we can do definitive life

566
00:19:30,549 --> 00:19:28,559
detection and i'll get into this in a

567
00:19:33,430 --> 00:19:30,559
little bit later that we need to be able

568
00:19:35,029 --> 00:19:33,440
to handle liquids much more precisely

569
00:19:37,909 --> 00:19:35,039
maybe through microfluidics or something

570
00:19:39,830 --> 00:19:37,919
like that so we can look to analyses

571
00:19:42,789 --> 00:19:39,840
like a pcr

572
00:19:44,630 --> 00:19:42,799
dna analyses very very specific amino

573
00:19:45,590 --> 00:19:44,640
acid assays these kind of things that

574
00:19:47,750 --> 00:19:45,600
need

575
00:19:49,750 --> 00:19:47,760
liquid processing and sample handling

576
00:19:51,669 --> 00:19:49,760
more than just squirting water somewhere

577
00:19:53,750 --> 00:19:51,679
and then seeing what happens it's a good

578
00:19:55,750 --> 00:19:53,760
first step what we've done so far but we

579
00:19:58,549 --> 00:19:55,760
need to to think about advancing these

580
00:20:01,190 --> 00:19:58,559
kind of technologies in in my opinion

581
00:20:02,950 --> 00:20:01,200
to get better at addressing the life

582
00:20:04,390 --> 00:20:02,960
question

583
00:20:06,470 --> 00:20:04,400
let's see

584
00:20:09,270 --> 00:20:06,480
yeah and michael news bringing up a

585
00:20:11,190 --> 00:20:09,280
point to max coleman about that we're

586
00:20:12,870 --> 00:20:11,200
looking for trace biosignatures and

587
00:20:15,110 --> 00:20:12,880
that's a very good point

588
00:20:16,630 --> 00:20:15,120

i believe the viking limit of detection

589
00:20:19,350 --> 00:20:16,640
for life was something on the order of

590
00:20:21,350 --> 00:20:19,360
10 to the 6 or a million cells per gram

591
00:20:24,870 --> 00:20:21,360
of soil i think and someone can correct

592
00:20:27,270 --> 00:20:24,880
me if that's that's not true

593
00:20:28,630 --> 00:20:27,280
uh and really realistically we need to

594
00:20:30,789 --> 00:20:28,640
get down to the point where we can

595
00:20:32,870 --> 00:20:30,799
detect something like one

596
00:20:35,430 --> 00:20:32,880
bacterial cell per gram if we really

597
00:20:37,029 --> 00:20:35,440
want good limits of detection

598
00:20:39,029 --> 00:20:37,039
so

599
00:20:41,029 --> 00:20:39,039
these are all good points to bring up

600
00:20:43,590 --> 00:20:41,039
and good things to be talking about i'm

601
00:20:45,590 --> 00:20:43,600
going to keep moving but feel free to

602
00:20:49,110 --> 00:20:45,600
interrupt me if there are any points

603
00:20:50,149 --> 00:20:49,120
that we should talk about um let's see

604
00:20:52,390 --> 00:20:50,159
okay so

605
00:20:54,149 --> 00:20:52,400
what i i did next was just brought up a

606
00:20:55,909 --> 00:20:54,159
couple of remote sensing and then on the

607
00:20:58,230 --> 00:20:55,919
next slide in situ

608
00:21:00,630 --> 00:20:58,240
techniques that have applications for

609
00:21:02,149 --> 00:21:00,640
astrobiology

610
00:21:04,230 --> 00:21:02,159
most that have been used before but some

611
00:21:06,470 --> 00:21:04,240
that haven't yet been used and i think

612
00:21:09,909 --> 00:21:06,480
it's important for us to talk about this

613
00:21:12,070 --> 00:21:09,919

so for remote sensing one of the most uh

614
00:21:13,669 --> 00:21:12,080
powerful techniques is imaging

615
00:21:15,430 --> 00:21:13,679
spectroscopy it's also called

616
00:21:17,750 --> 00:21:15,440
hyperspectral imaging

617
00:21:19,430 --> 00:21:17,760
and these spectrometers use typically

618
00:21:21,190 --> 00:21:19,440
sunlight as a light source and they're

619
00:21:24,710 --> 00:21:21,200
measuring reflectance so surface

620
00:21:26,390 --> 00:21:24,720
reflectance based on what is absorbed

621
00:21:27,830 --> 00:21:26,400
depending on the orientation of the

622
00:21:29,909 --> 00:21:27,840
spacecraft how much light you get back

623
00:21:32,549 --> 00:21:29,919
you can determine

624
00:21:33,750 --> 00:21:32,559
the mineral basically the composition of

625
00:21:35,350 --> 00:21:33,760
the surface

626
00:21:37,590 --> 00:21:35,360
most of these spectrometers operate in

627
00:21:39,669 --> 00:21:37,600
the uv to near ir although you can get

628
00:21:41,350 --> 00:21:39,679
the thermal ir depends on how how

629
00:21:42,470 --> 00:21:41,360
sensitive and how you select your

630
00:21:43,990 --> 00:21:42,480
detector

631
00:21:46,070 --> 00:21:44,000
and this is relevant for life for a

632
00:21:48,230 --> 00:21:46,080
number of reasons you can detect for

633
00:21:50,789 --> 00:21:48,240
example the red edge of chlorophyll i

634
00:21:53,510 --> 00:21:50,799
think the best example of this was an

635
00:21:55,590 --> 00:21:53,520
experiment proposed by carl sagan where

636
00:21:56,390 --> 00:21:55,600
galileo the spacecraft that ended up

637
00:21:58,470 --> 00:21:56,400
going

638
00:21:59,830 --> 00:21:58,480

way way out to study um

639
00:22:01,750 --> 00:21:59,840
study jupiter

640
00:22:04,230 --> 00:22:01,760
as it was doing one of its gravity

641
00:22:06,390 --> 00:22:04,240
assists i think swung by earth and at a

642
00:22:09,110 --> 00:22:06,400
distance of a thousand kilometers carl

643
00:22:11,430 --> 00:22:09,120
sagan asked the question can we use our

644
00:22:14,310 --> 00:22:11,440
imaging spectrometers to look for life

645
00:22:16,470 --> 00:22:14,320
on earth and see if we can find it and

646
00:22:19,430 --> 00:22:16,480
they took spectra they weren't able to

647
00:22:21,029 --> 00:22:19,440
discern any uh any physical structures

648
00:22:22,070 --> 00:22:21,039
you know like they say you can see the

649
00:22:24,230 --> 00:22:22,080
um

650
00:22:25,990 --> 00:22:24,240
the great wall of china from orbit well

651
00:22:27,590 --> 00:22:26,000
from a thousand kilometers i guess you

652
00:22:30,149 --> 00:22:27,600
can't with the resolution of the

653
00:22:31,990 --> 00:22:30,159
spectrometer on galileo but you could

654
00:22:33,669 --> 00:22:32,000
see the red edge of chlorophyll right

655
00:22:35,350 --> 00:22:33,679
chlorophyll absorbs very strongly in the

656
00:22:37,750 --> 00:22:35,360
red it reflects in the green which is

657
00:22:40,230 --> 00:22:37,760
why grass and trees and things look

658
00:22:42,950 --> 00:22:40,240
green so we could see that we could

659
00:22:44,789 --> 00:22:42,960
detect signatures of certain gases that

660
00:22:46,390 --> 00:22:44,799
may be indicative of life

661
00:22:47,750 --> 00:22:46,400
methane that doesn't hang around in the

662
00:22:50,230 --> 00:22:47,760
atmosphere long it needs to have

663
00:22:54,710 --> 00:22:50,240

something continually producing it that

664
00:22:56,710 --> 00:22:54,720
could be life ozone things like that so

665
00:22:58,630 --> 00:22:56,720
that's a very good example and i'm so

666
00:23:01,270 --> 00:22:58,640
glad that carl sagan proposed that

667
00:23:03,590 --> 00:23:01,280
experiment because even in a place

668
00:23:05,350 --> 00:23:03,600
teeming with life like earth from a

669
00:23:07,830 --> 00:23:05,360
thousand kilometers away

670
00:23:09,430 --> 00:23:07,840
definitive detection of life

671
00:23:11,190 --> 00:23:09,440
isn't quite as straightforward as you

672
00:23:13,590 --> 00:23:11,200
think it would be

673
00:23:16,549 --> 00:23:13,600
but imaging spectrometers are a great

674
00:23:19,190 --> 00:23:16,559
tool to use for looking for all of these

675
00:23:21,430 --> 00:23:19,200
these spectroscopic signatures

676
00:23:24,470 --> 00:23:21,440
of of life or or

677
00:23:26,950 --> 00:23:24,480
byproducts of life like methane release

678
00:23:28,870 --> 00:23:26,960
another imaging not imaging but a

679
00:23:31,909 --> 00:23:28,880
spectrometer that can be used for life

680
00:23:33,029 --> 00:23:31,919
is gamma ray spectroscopy and

681
00:23:33,909 --> 00:23:33,039
yes

682
00:23:36,390 --> 00:23:33,919
yeah

683
00:23:38,310 --> 00:23:36,400
and i say spectrometer spectroscopy

684
00:23:39,990 --> 00:23:38,320
and these measure gamma ray distribution

685
00:23:41,830 --> 00:23:40,000
this isn't good for planets or moons

686
00:23:44,470 --> 00:23:41,840
with atmospheres so titan and mars are

687
00:23:47,190 --> 00:23:44,480
out but places like europa or enceladus

688
00:23:50,230 --> 00:23:47,200

with tenuous to no atmospheres you can

689
00:23:52,789 --> 00:23:50,240
use this to map the elemental and atomic

690
00:23:54,149 --> 00:23:52,799
abundances over the entire surface and

691
00:23:55,350 --> 00:23:54,159
this can be really informative

692
00:23:57,830 --> 00:23:55,360
especially

693
00:24:00,950 --> 00:23:57,840
for a place say like europa that might

694
00:24:03,270 --> 00:24:00,960
have exchanged a material from the

695
00:24:05,590 --> 00:24:03,280
ocean interior to the exterior

696
00:24:07,110 --> 00:24:05,600
periodically and if we can pinpoint

697
00:24:09,190 --> 00:24:07,120
targeted areas where this might have

698
00:24:11,750 --> 00:24:09,200
happened recently by looking at

699
00:24:13,510 --> 00:24:11,760
elemental and isotopic abundances

700
00:24:15,510 --> 00:24:13,520
that could be informative for where we

701
00:24:18,470 --> 00:24:15,520
might send a land admission

702
00:24:21,269 --> 00:24:18,480
so gamma-ray spectroscopy is good radar

703
00:24:23,830 --> 00:24:21,279
is also helpful and you can use radio

704
00:24:26,070 --> 00:24:23,840
frequency i think the cassini radar

705
00:24:27,590 --> 00:24:26,080
mapper uses microwave

706
00:24:30,230 --> 00:24:27,600
to look to peer through titan's

707
00:24:31,750 --> 00:24:30,240
atmosphere and do mapping of the surface

708
00:24:35,350 --> 00:24:31,760
and you can use this to look for water

709
00:24:37,430 --> 00:24:35,360
obviously ice versus water versus

710
00:24:38,950 --> 00:24:37,440
very dense rocks reflect

711
00:24:40,630 --> 00:24:38,960
uh in

712
00:24:43,350 --> 00:24:40,640
radio very differently and so you can

713
00:24:45,750 --> 00:24:43,360

use this to to pinpoint or conform

714
00:24:48,630 --> 00:24:45,760
areas where you may have water

715
00:24:49,750 --> 00:24:48,640
so that's another technique

716
00:24:51,990 --> 00:24:49,760
let's

717
00:24:53,590 --> 00:24:52,000
now go to in situ

718
00:24:55,590 --> 00:24:53,600
now this is

719
00:24:57,990 --> 00:24:55,600
doesn't cover by any means all

720
00:25:00,710 --> 00:24:58,000
techniques for in-situ life detection

721
00:25:03,190 --> 00:25:00,720
there are a ton but i just tried to to

722
00:25:04,390 --> 00:25:03,200
group them into three major categories

723
00:25:06,870 --> 00:25:04,400
the first one

724
00:25:09,430 --> 00:25:06,880
of course is microscopy and depending on

725
00:25:11,750 --> 00:25:09,440
your optics you can image things on the

726
00:25:13,990 --> 00:25:11,760
tens of microns even submicron level and

727
00:25:16,870 --> 00:25:14,000
you can look for evidence of either

728
00:25:18,789 --> 00:25:16,880
extinct or extant life extinct life you

729
00:25:20,630 --> 00:25:18,799
could look for microfossils things like

730
00:25:23,269 --> 00:25:20,640
stromatolites which are

731
00:25:26,549 --> 00:25:25,269
mats of microbial life that have been

732
00:25:28,230 --> 00:25:26,559
been squished and compressed and

733
00:25:29,510 --> 00:25:28,240
fossilized over time the image on the

734
00:25:31,269 --> 00:25:29,520
right here is an example of some

735
00:25:33,269 --> 00:25:31,279
stromatolites

736
00:25:35,190 --> 00:25:33,279
so we can use do that you can also look

737
00:25:37,190 --> 00:25:35,200
for things like bacterial cells so

738
00:25:39,190 --> 00:25:37,200

extent current life

739
00:25:41,029 --> 00:25:39,200
and if you bring along your own

740
00:25:42,230 --> 00:25:41,039
excitation source and your own set of

741
00:25:43,750 --> 00:25:42,240
filters you can even look at

742
00:25:45,590 --> 00:25:43,760
fluorescence

743
00:25:47,510 --> 00:25:45,600
minerals do fluoresce but they tend to

744
00:25:48,549 --> 00:25:47,520
be much more long-lived

745
00:25:50,470 --> 00:25:48,559
than

746
00:25:52,070 --> 00:25:50,480
life which typically most organic

747
00:25:54,549 --> 00:25:52,080
molecules have fluorescence on the order

748
00:25:57,029 --> 00:25:54,559
of picoseconds to nanoseconds

749
00:25:59,430 --> 00:25:57,039
most minerals fluorescence on the micro

750
00:26:01,590 --> 00:25:59,440
second to millisecond scale so if you

751
00:26:03,350 --> 00:26:01,600
have some type of a way of

752
00:26:04,950 --> 00:26:03,360
discriminating between those you could

753
00:26:07,110 --> 00:26:04,960
look for mineral fluorescence and then

754
00:26:09,510 --> 00:26:07,120
look for life

755
00:26:11,909 --> 00:26:09,520
evidence or at least evidence of organic

756
00:26:15,190 --> 00:26:11,919
molecules through fluorescence so

757
00:26:17,830 --> 00:26:15,200
microscopy is is pretty powerful

758
00:26:19,830 --> 00:26:17,840
for molecular analyses this is a big

759
00:26:21,430 --> 00:26:19,840
group i just sort of

760
00:26:23,190 --> 00:26:21,440
lop them all together

761
00:26:25,350 --> 00:26:23,200
essentially you use some kind of

762
00:26:26,789 --> 00:26:25,360
separation technique whether

763
00:26:29,269 --> 00:26:26,799

excuse me whether it's in the gas phase

764
00:26:32,789 --> 00:26:29,279
or liquid phase so you either

765
00:26:34,630 --> 00:26:32,799
desorb or or you can use heating or

766
00:26:37,669 --> 00:26:34,640
maldi some other type of laser

767
00:26:39,750 --> 00:26:37,679
desorption to get your sample into gas

768
00:26:41,190 --> 00:26:39,760
phase and then you can separate it down

769
00:26:42,950 --> 00:26:41,200
a column

770
00:26:44,310 --> 00:26:42,960
alternatively you can dissolve your

771
00:26:45,430 --> 00:26:44,320
sample of liquid do some kind of

772
00:26:47,190 --> 00:26:45,440
extraction

773
00:26:50,230 --> 00:26:47,200
and get things into the liquid phase and

774
00:26:52,870 --> 00:26:50,240
then again do a separation based on size

775
00:26:55,190 --> 00:26:52,880
charge other properties interaction with

776
00:26:56,470 --> 00:26:55,200
the substrate of the column and so you

777
00:26:58,070 --> 00:26:56,480
can separate the species you're

778
00:27:00,230 --> 00:26:58,080
interested in and then detect them

779
00:27:02,470 --> 00:27:00,240
either through something like mass spec

780
00:27:05,669 --> 00:27:02,480
you can use contactless conductivity you

781
00:27:07,269 --> 00:27:05,679
could tag these particular organics with

782
00:27:09,110 --> 00:27:07,279
a fluorescent dye and then use a

783
00:27:10,149 --> 00:27:09,120
fluorescence based technique to measure

784
00:27:11,990 --> 00:27:10,159
them

785
00:27:14,549 --> 00:27:12,000
and this is important because you can

786
00:27:17,190 --> 00:27:14,559
identify specific molecules for example

787
00:27:20,789 --> 00:27:17,200
if you're targeting amino acids or atp

788
00:27:22,230 --> 00:27:20,799

or sugars evidence of life excuse me

789
00:27:24,710 --> 00:27:22,240
um or if you have a really good mass

790
00:27:27,909 --> 00:27:24,720
spec you can do isotopic ratios so you

791
00:27:30,390 --> 00:27:27,919
can look at carbon 12 carbon 13 kind of

792
00:27:32,230 --> 00:27:30,400
things to see if

793
00:27:33,669 --> 00:27:32,240
even if you have organic compounds if

794
00:27:37,029 --> 00:27:33,679
they've been around a while or if

795
00:27:38,710 --> 00:27:37,039
they're relative or relatively recent

796
00:27:40,470 --> 00:27:38,720
and i've just touched on a few of those

797
00:27:42,950 --> 00:27:40,480
types of analyses but just to give you

798
00:27:45,669 --> 00:27:42,960
an idea of what's out there

799
00:27:48,390 --> 00:27:45,679
and then the last category which is

800
00:27:50,390 --> 00:27:48,400
yet to be applied for

801
00:27:53,190 --> 00:27:50,400
life detection elsewhere like mars but

802
00:27:54,950 --> 00:27:53,200
has a lot of potential as amino acids so

803
00:27:57,190 --> 00:27:54,960
this is targeting specific molecules

804
00:27:58,470 --> 00:27:57,200
using antibodies

805
00:28:00,870 --> 00:27:58,480
this is where you would need like i

806
00:28:04,470 --> 00:28:00,880
mentioned before some of that fluidic

807
00:28:06,070 --> 00:28:04,480
handling capability where you can't just

808
00:28:07,669 --> 00:28:06,080
squirt liquid somewhere and then call it

809
00:28:09,669 --> 00:28:07,679
good you would need to

810
00:28:12,230 --> 00:28:09,679
do very very careful treatments

811
00:28:14,870 --> 00:28:12,240
of life or of the sample in order to

812
00:28:17,350 --> 00:28:14,880
look for life for example real time pcr

813
00:28:19,669 --> 00:28:17,360

can be done in very small devices

814
00:28:22,470 --> 00:28:19,679
they're getting smaller and smaller but

815
00:28:24,149 --> 00:28:22,480
have yet to be applied to

816
00:28:26,310 --> 00:28:24,159
planetary science and looking for things

817
00:28:27,990 --> 00:28:26,320
in places like mars

818
00:28:30,149 --> 00:28:28,000
so these techniques have advantages

819
00:28:33,190 --> 00:28:30,159
because you can look for very specific

820
00:28:35,350 --> 00:28:33,200
proteins you could discriminate between

821
00:28:37,510 --> 00:28:35,360
l and d amino acids which has been

822
00:28:39,350 --> 00:28:37,520
considered the smoking gun for looking

823
00:28:41,510 --> 00:28:39,360
for life that evolved very differently

824
00:28:43,430 --> 00:28:41,520
from ours

825
00:28:45,590 --> 00:28:43,440
i hope everyone's familiar with the fact

826
00:28:48,070 --> 00:28:45,600
that all life on earth uses the l

827
00:28:49,669 --> 00:28:48,080
enantiomer of amino acids

828
00:28:51,269 --> 00:28:49,679
but there's no reason why we couldn't

829
00:28:53,669 --> 00:28:51,279
use d we just had to evolve one way or

830
00:28:55,909 --> 00:28:53,679
the other because

831
00:28:57,350 --> 00:28:55,919
from a mass and charge standpoint they

832
00:29:00,149 --> 00:28:57,360
look exactly the same but they're not

833
00:29:01,830 --> 00:29:00,159
superimposable and so

834
00:29:05,350 --> 00:29:01,840
proteins when they fold won't interact

835
00:29:07,830 --> 00:29:05,360
the same way likewise we use i believe d

836
00:29:10,149 --> 00:29:07,840
rotated so dexter rotatory the other

837
00:29:12,149 --> 00:29:10,159
type of enantiomer of sugars so if we

838
00:29:14,870 --> 00:29:12,159

find life say on mars or somewhere else

839
00:29:17,430 --> 00:29:14,880
that uses the opposite enantiomer of

840
00:29:19,830 --> 00:29:17,440
amino acid or sugar that could be a very

841
00:29:22,789 --> 00:29:19,840
very strong case for life that evolved

842
00:29:25,590 --> 00:29:22,799
differently from that on earth

843
00:29:27,750 --> 00:29:25,600
but when you do immuno immunoassays

844
00:29:29,750 --> 00:29:27,760
you're limiting yourself

845
00:29:31,750 --> 00:29:29,760
to unless you're

846
00:29:34,789 --> 00:29:31,760
you have amino acids or antibodies that

847
00:29:36,789 --> 00:29:34,799
are specific for like the d amino acid

848
00:29:37,990 --> 00:29:36,799
but normally they're they're specific

849
00:29:40,630 --> 00:29:38,000
for

850
00:29:42,389 --> 00:29:40,640
earth life so life as we know it which

851
00:29:44,149 --> 00:29:42,399
is fine i mean

852
00:29:46,070 --> 00:29:44,159
looking for dna looking for proteins

853
00:29:49,029 --> 00:29:46,080
life as we know it is good but maybe we

854
00:29:51,110 --> 00:29:49,039
should expand outside of those um

855
00:29:53,830 --> 00:29:51,120
those sort of blinder type

856
00:29:55,750 --> 00:29:53,840
life investigations too

857
00:29:57,269 --> 00:29:55,760
someone has a question about culturing

858
00:29:59,190 --> 00:29:57,279
culturing is

859
00:30:01,909 --> 00:29:59,200
challenging enough to do on earth in a

860
00:30:03,430 --> 00:30:01,919
lot of ways it'd be it'd be fun to to do

861
00:30:06,789 --> 00:30:03,440
that thought experiment to see if we

862
00:30:08,710 --> 00:30:06,799
could do that on a place like mars

863
00:30:10,310 --> 00:30:08,720

i have a friend who's a microbiologist

864
00:30:11,110 --> 00:30:10,320
and i was talking to her the other day

865
00:30:13,430 --> 00:30:11,120
and

866
00:30:15,830 --> 00:30:13,440
there are organisms that are present in

867
00:30:18,310 --> 00:30:15,840
in ocean water on earth that are

868
00:30:20,710 --> 00:30:18,320
incredibly abundant but because we

869
00:30:22,310 --> 00:30:20,720
hadn't developed the right kind of of

870
00:30:23,909 --> 00:30:22,320
agarose or the right kind of nutrient

871
00:30:26,149 --> 00:30:23,919
supply for them to grow on they weren't

872
00:30:28,389 --> 00:30:26,159
cultured in the laboratory for decades

873
00:30:30,870 --> 00:30:28,399
we didn't even know they existed because

874
00:30:33,430 --> 00:30:30,880
we had biased ourselves to looking for

875
00:30:35,590 --> 00:30:33,440
different organisms and i fear that we

876
00:30:36,950 --> 00:30:35,600
may encounter something similar

877
00:30:39,269 --> 00:30:36,960
when we're looking for life in an

878
00:30:41,669 --> 00:30:39,279
extreme environment like mars you have

879
00:30:43,750 --> 00:30:41,679
to tailor the

880
00:30:45,830 --> 00:30:43,760
selection or the

881
00:30:48,230 --> 00:30:45,840
the detection technique to what you

882
00:30:49,350 --> 00:30:48,240
think has to be there but because you're

883
00:30:51,430 --> 00:30:49,360
thinking about what has to be there

884
00:30:52,549 --> 00:30:51,440
you're sort of biasing yourself

885
00:30:53,990 --> 00:30:52,559
this is

886
00:30:55,909 --> 00:30:54,000
a very good conversation to have these

887
00:30:58,230 --> 00:30:55,919
are things that we need to be talking

888
00:30:59,750 --> 00:30:58,240

about and discussing as we move forward

889
00:31:00,789 --> 00:30:59,760
and try to think about the best

890
00:31:06,710 --> 00:31:00,799
techniques

891
00:31:08,630 --> 00:31:06,720
at least of looking of detecting life

892
00:31:09,510 --> 00:31:08,640
okay so these are just a few challenges

893
00:31:11,350 --> 00:31:09,520
that i

894
00:31:13,190 --> 00:31:11,360
i was thinking about

895
00:31:15,350 --> 00:31:13,200
not necessarily for a particular

896
00:31:16,789 --> 00:31:15,360
technique uh nothing inherent to one

897
00:31:20,149 --> 00:31:16,799
technique but just sort of more in

898
00:31:21,510 --> 00:31:20,159
general for example detection in

899
00:31:23,909 --> 00:31:21,520
in soil

900
00:31:25,590 --> 00:31:23,919
or regolith oh a couple my images didn't

901
00:31:27,909 --> 00:31:25,600
copy oh well

902
00:31:30,710 --> 00:31:27,919
for example extraction efficiency is not

903
00:31:33,350 --> 00:31:30,720
that good in soil soil tends to be

904
00:31:34,870 --> 00:31:33,360
a very porous the regolith on mars is

905
00:31:36,389 --> 00:31:34,880
most likely the same way especially

906
00:31:37,990 --> 00:31:36,399
considering how electrostatically

907
00:31:39,430 --> 00:31:38,000
charged it is how it likes to cling to

908
00:31:41,190 --> 00:31:39,440
things

909
00:31:42,789 --> 00:31:41,200
it's really good at trapping organic

910
00:31:46,470 --> 00:31:42,799
molecules in

911
00:31:48,149 --> 00:31:46,480
the the matrix of the soil and it's very

912
00:31:49,990 --> 00:31:48,159
tough to get them back out

913
00:31:51,509 --> 00:31:50,000

typical extraction efficiencies on earth

914
00:31:53,350 --> 00:31:51,519
if you're getting 10

915
00:31:54,149 --> 00:31:53,360
that's considered pretty good

916
00:31:56,149 --> 00:31:54,159
which

917
00:31:57,750 --> 00:31:56,159
is kind of disappointing

918
00:31:59,990 --> 00:31:57,760
but there are plenty of extraction

919
00:32:01,990 --> 00:32:00,000
protocols that a lot of scientists both

920
00:32:03,990 --> 00:32:02,000
at nasa and universities are working on

921
00:32:06,389 --> 00:32:04,000
to try to address this problem there's

922
00:32:08,549 --> 00:32:06,399
some critical water extraction using

923
00:32:10,549 --> 00:32:08,559
various solvents all sorts of things but

924
00:32:12,310 --> 00:32:10,559
it's a serious problem that we've been

925
00:32:13,590 --> 00:32:12,320
working on and that we need to continue

926
00:32:15,269 --> 00:32:13,600
to work on

927
00:32:17,990 --> 00:32:15,279
another problem especially in a place

928
00:32:20,070 --> 00:32:18,000
like mars is that as soon as you add

929
00:32:21,590 --> 00:32:20,080
water to this soil

930
00:32:23,750 --> 00:32:21,600
things start to happen

931
00:32:26,070 --> 00:32:23,760
stuff that was was dry and unreacted

932
00:32:29,029 --> 00:32:26,080
before is now in an environment where it

933
00:32:30,470 --> 00:32:29,039
can start to say chew up organics like

934
00:32:32,630 --> 00:32:30,480
what might be happening with all the

935
00:32:35,269 --> 00:32:32,640
perchlorates in the mars

936
00:32:37,190 --> 00:32:35,279
soil you can have

937
00:32:39,590 --> 00:32:37,200
potentially let's say uh

938
00:32:42,389 --> 00:32:39,600

acid very acidic compounds like might be

939
00:32:44,549 --> 00:32:42,399
present on europa surface if you have a

940
00:32:46,149 --> 00:32:44,559
lot of sulfates you could have sulfuric

941
00:32:48,470 --> 00:32:46,159
acid derived

942
00:32:50,310 --> 00:32:48,480
compounds that as soon as you add liquid

943
00:32:51,830 --> 00:32:50,320
water it can chew up whatever you're

944
00:32:52,710 --> 00:32:51,840
trying to detect

945
00:32:54,470 --> 00:32:52,720
so

946
00:32:56,389 --> 00:32:54,480
we have to think very carefully about

947
00:32:58,710 --> 00:32:56,399
how the intrinsic environment will

948
00:33:00,470 --> 00:32:58,720
affect the sample before we even get to

949
00:33:03,509 --> 00:33:00,480
analyze it

950
00:33:06,070 --> 00:33:03,519
so that's that's one point for titan

951
00:33:07,990 --> 00:33:06,080
this has been a bit of a problem

952
00:33:10,389 --> 00:33:08,000
we've made these stimulated titan

953
00:33:12,470 --> 00:33:10,399
aerosols on earth so you take

954
00:33:14,149 --> 00:33:12,480
methane and nitrogen essentially tighten

955
00:33:16,710 --> 00:33:14,159
atmosphere you expose it to energy and

956
00:33:18,230 --> 00:33:16,720
you get this brown gunky stuff and i

957
00:33:19,990 --> 00:33:18,240
have an image of this on the right these

958
00:33:22,070 --> 00:33:20,000
are some filaments that were

959
00:33:24,870 --> 00:33:22,080
actually made in the lab of bishon carre

960
00:33:27,350 --> 00:33:24,880
who passed away recently but he did some

961
00:33:28,870 --> 00:33:27,360
of the the initial work with carl sagan

962
00:33:30,789 --> 00:33:28,880
on these and they were the ones who came

963
00:33:33,269 --> 00:33:30,799

up with the name thulin

964
00:33:34,789 --> 00:33:33,279
excuse me it actually means um

965
00:33:37,110 --> 00:33:34,799
it comes from the greek word tholos

966
00:33:38,470 --> 00:33:37,120
which means muddy or not clear which

967
00:33:40,230 --> 00:33:38,480
totally has a double meaning right

968
00:33:42,070 --> 00:33:40,240
because muddy they're sort of brownish

969
00:33:43,350 --> 00:33:42,080
like mud but they're also not clear

970
00:33:44,310 --> 00:33:43,360
because we don't know what they're made

971
00:33:47,750 --> 00:33:44,320
of so i

972
00:33:52,549 --> 00:33:49,990
but okay so we have these solons on

973
00:33:55,430 --> 00:33:52,559
titan they're at 90 kelvin right on the

974
00:33:58,149 --> 00:33:55,440
surface it's minus 180 something degrees

975
00:34:00,230 --> 00:33:58,159
celsius really cold if you warm these up

976
00:34:02,310 --> 00:34:00,240
just to room temperature

977
00:34:05,029 --> 00:34:02,320
their composition changes we can see

978
00:34:06,389 --> 00:34:05,039
changes in the ir absorption spectra for

979
00:34:07,350 --> 00:34:06,399
example

980
00:34:09,829 --> 00:34:07,360
and when they're supposed to liquid

981
00:34:11,909 --> 00:34:09,839
water they change even more so

982
00:34:12,950 --> 00:34:11,919
how do you interrogate such a complex

983
00:34:14,710 --> 00:34:12,960
sample

984
00:34:16,310 --> 00:34:14,720
without changing it

985
00:34:18,230 --> 00:34:16,320
it's been a big challenge and that's

986
00:34:20,710 --> 00:34:18,240
something we're still trying to address

987
00:34:22,389 --> 00:34:20,720
even using the simulated aerosols that

988
00:34:23,829 --> 00:34:22,399

might be very different from what's

989
00:34:25,909 --> 00:34:23,839
present on titan but we're pretty sure

990
00:34:27,669 --> 00:34:25,919
they're kind of close

991
00:34:30,629 --> 00:34:27,679
okay let's see what else a radiation on

992
00:34:32,869 --> 00:34:30,639
europa on the surface of europa a human

993
00:34:34,710 --> 00:34:32,879
would get a lethal dose within somewhere

994
00:34:36,230 --> 00:34:34,720
along five to twenty minutes depending

995
00:34:38,950 --> 00:34:36,240
on who you talk to

996
00:34:40,790 --> 00:34:38,960
and we've discussed this radiation

997
00:34:42,470 --> 00:34:40,800
environment in terms of electronics but

998
00:34:43,669 --> 00:34:42,480
when we're talking about

999
00:34:45,990 --> 00:34:43,679
life

1000
00:34:47,669 --> 00:34:46,000
detection if we want to bring along say

1001
00:34:49,589 --> 00:34:47,679
an immunoassay or something like that

1002
00:34:51,190 --> 00:34:49,599
how is this going to affect how is the

1003
00:34:52,310 --> 00:34:51,200
radiation going to affect this

1004
00:34:53,589 --> 00:34:52,320
experiment

1005
00:34:55,349 --> 00:34:53,599
things like that that we need to

1006
00:34:56,869 --> 00:34:55,359
consider also

1007
00:34:59,030 --> 00:34:56,879
and then finally on a place like

1008
00:35:01,349 --> 00:34:59,040
enceladus

1009
00:35:02,950 --> 00:35:01,359
sure it's it's spewing out sample all we

1010
00:35:04,230 --> 00:35:02,960
have to do is go and get it seems very

1011
00:35:05,510 --> 00:35:04,240
simple right

1012
00:35:08,470 --> 00:35:05,520
but not really especially when you

1013
00:35:09,910 --> 00:35:08,480

consider that most spacecraft flybys

1014
00:35:12,310 --> 00:35:09,920
they're they're qualified on the order

1015
00:35:14,950 --> 00:35:12,320
of kilometers per second

1016
00:35:17,190 --> 00:35:14,960
it's really fast and so if you're flying

1017
00:35:19,270 --> 00:35:17,200
through this this shower of icy

1018
00:35:22,390 --> 00:35:19,280
crystalline particles that have been

1019
00:35:24,230 --> 00:35:22,400
spewed out of enceladus south pole

1020
00:35:26,550 --> 00:35:24,240
um you're going to be encountering those

1021
00:35:28,870 --> 00:35:26,560
at tremendous speeds and how do you

1022
00:35:30,390 --> 00:35:28,880
capture them how do you collect them in

1023
00:35:32,550 --> 00:35:30,400
a way where they're not just going to

1024
00:35:34,470 --> 00:35:32,560
kind of explode into

1025
00:35:35,670 --> 00:35:34,480
individual monomers or have some type of

1026
00:35:37,589 --> 00:35:35,680
chemically

1027
00:35:39,829 --> 00:35:37,599
related tribal chemical reaction where

1028
00:35:41,190 --> 00:35:39,839
it's just based on their impact

1029
00:35:42,630 --> 00:35:41,200
they form something else that wasn't

1030
00:35:44,069 --> 00:35:42,640
there originally

1031
00:35:45,510 --> 00:35:44,079
things like that are important to think

1032
00:35:47,030 --> 00:35:45,520
about

1033
00:35:49,270 --> 00:35:47,040
uh let's see

1034
00:35:50,310 --> 00:35:49,280
oh and i've this is my last slide

1035
00:35:53,750 --> 00:35:50,320
this

1036
00:35:55,910 --> 00:35:53,760
talk i was thinking about what the

1037
00:35:57,349 --> 00:35:55,920
future of life detection technologies

1038
00:36:00,230 --> 00:35:57,359

could mean

1039
00:36:03,190 --> 00:36:00,240
and nasa has constantly adopted this

1040
00:36:05,750 --> 00:36:03,200
mantra of failure is not an option and

1041
00:36:07,670 --> 00:36:05,760
for flagship missions for human-based

1042
00:36:09,270 --> 00:36:07,680
exploration of course that's that's what

1043
00:36:12,230 --> 00:36:09,280
we should focus on but when it comes to

1044
00:36:14,790 --> 00:36:12,240
trying out new technologies for

1045
00:36:15,670 --> 00:36:14,800
astrobiology pushing the boundaries of

1046
00:36:18,630 --> 00:36:15,680
of

1047
00:36:21,670 --> 00:36:18,640
our our capabilities into technology and

1048
00:36:23,829 --> 00:36:21,680
engineering in in science being able to

1049
00:36:25,510 --> 00:36:23,839
to get these limits of detection to a

1050
00:36:27,589 --> 00:36:25,520
place where we can be confident that

1051
00:36:30,230 --> 00:36:27,599
we're actually looking for life that we

1052
00:36:31,910 --> 00:36:30,240
were sure that we found it or not

1053
00:36:34,230 --> 00:36:31,920
i think that's the wrong strategy the

1054
00:36:37,109 --> 00:36:34,240
failure is an option i think we should

1055
00:36:39,109 --> 00:36:37,119
go back to the beginning of jpl when we

1056
00:36:41,430 --> 00:36:39,119
could take risks we could operate things

1057
00:36:44,230 --> 00:36:41,440
that were high risk low cost but we

1058
00:36:46,310 --> 00:36:44,240
learned a lot from them and i think

1059
00:36:49,349 --> 00:36:46,320
learning more about a technique whether

1060
00:36:51,349 --> 00:36:49,359
it'll work or not whether

1061
00:36:52,069 --> 00:36:51,359
whether it's feasible

1062
00:36:56,150 --> 00:36:52,079
and

1063
00:36:58,470 --> 00:36:56,160

investing in something else that has a

1064
00:36:59,430 --> 00:36:58,480
lot more potential it might make more

1065
00:37:00,550 --> 00:36:59,440
sense

1066
00:37:02,870 --> 00:37:00,560
and

1067
00:37:04,630 --> 00:37:02,880
granted the planetary protection folks

1068
00:37:07,589 --> 00:37:04,640
might not be too excited about us trying

1069
00:37:08,710 --> 00:37:07,599
to send say a fleet of cubesats to mars

1070
00:37:10,630 --> 00:37:08,720
trying out a whole bunch of different

1071
00:37:13,829 --> 00:37:10,640
techniques all over but something like

1072
00:37:15,589 --> 00:37:13,839
that i could envision might be a

1073
00:37:17,990 --> 00:37:15,599
realistic future of

1074
00:37:19,750 --> 00:37:18,000
doing this smaller missions maybe

1075
00:37:21,510 --> 00:37:19,760
sending a fleet of instruments

1076
00:37:23,829 --> 00:37:21,520
in different spacecraft instead of just

1077
00:37:25,190 --> 00:37:23,839
one one landed platform so if you lose a

1078
00:37:27,349 --> 00:37:25,200
couple it's not a big deal because

1079
00:37:29,270 --> 00:37:27,359
you've got five more that kind of thing

1080
00:37:30,390 --> 00:37:29,280
might be something that we should talk

1081
00:37:32,150 --> 00:37:30,400
about

1082
00:37:34,630 --> 00:37:32,160
and i think

1083
00:37:38,790 --> 00:37:34,640
that's all i had yeah so i'd like to to

1084
00:37:44,630 --> 00:37:42,390
thanks morgan um just so we're clear i

1085
00:37:46,710 --> 00:37:44,640
suspect everybody has been through

1086
00:37:49,829 --> 00:37:46,720
enough of these webinars now to know the

1087
00:37:53,270 --> 00:37:49,839
process but the audio lines are open if

1088
00:37:55,349 --> 00:37:53,280

you want to speak um if we find it

1089
00:37:57,589 --> 00:37:55,359
people are crashing over each other you

1090
00:37:59,109 --> 00:37:57,599
can certainly use the little raise your

1091
00:38:02,950 --> 00:37:59,119
hand button

1092
00:38:05,829 --> 00:38:02,960
at the top and equally feel free to um

1093
00:38:07,670 --> 00:38:05,839
to uh type straight into the text box

1094
00:38:08,950 --> 00:38:07,680
and morgan as you can see mike is just

1095
00:38:10,950 --> 00:38:08,960
asking whether you want to bring any of

1096
00:38:13,510 --> 00:38:10,960
your polls back

1097
00:38:15,030 --> 00:38:13,520
oh okay yeah so i had a couple others

1098
00:38:17,270 --> 00:38:15,040
and i didn't get a chance to talk about

1099
00:38:19,030 --> 00:38:17,280
if i got distracted um that happens

1100
00:38:21,990 --> 00:38:19,040
sometimes when i get excited about stuff

1101
00:38:23,589 --> 00:38:22,000
okay so mike do you want to bring up the

1102
00:38:25,510 --> 00:38:23,599
let's see actually the third one the

1103
00:38:28,230 --> 00:38:25,520
third question would be something i

1104
00:38:30,390 --> 00:38:28,240
think that could incite some discussion

1105
00:38:32,550 --> 00:38:30,400
so and someone brought this up in the in

1106
00:38:34,950 --> 00:38:32,560
the open chat forum about looking for

1107
00:38:35,829 --> 00:38:34,960
extant versus extinct life

1108
00:38:38,150 --> 00:38:35,839
obviously there are different

1109
00:38:40,230 --> 00:38:38,160
biosignatures we could focus on

1110
00:38:42,470 --> 00:38:40,240
um extinct life includes things like the

1111
00:38:44,550 --> 00:38:42,480
microfossils the stromatolites certain

1112
00:38:47,750 --> 00:38:44,560
chemical signatures things like opanoids

1113
00:38:49,750 --> 00:38:47,760

or sterols that

1114
00:38:51,510 --> 00:38:49,760
are chemically modified from things that

1115
00:38:53,670 --> 00:38:51,520
were originally present in cells but can

1116
00:38:55,190 --> 00:38:53,680
be good indicators that life existed

1117
00:38:58,230 --> 00:38:55,200
there in the past

1118
00:38:59,270 --> 00:38:58,240
that versus the extant life looking for

1119
00:39:06,790 --> 00:38:59,280
in

1120
00:39:09,430 --> 00:39:06,800
that

1121
00:39:11,270 --> 00:39:09,440
uh it looks like yes i agree uh we

1122
00:39:12,790 --> 00:39:11,280
should be looking for both

1123
00:39:14,390 --> 00:39:12,800
uh but it depends a lot on the

1124
00:39:16,710 --> 00:39:14,400
environment right i mean

1125
00:39:19,510 --> 00:39:16,720
let's say mars of course we want to look

1126
00:39:20,710 --> 00:39:19,520
more in the regalis for microfossils and

1127
00:39:23,670 --> 00:39:20,720
things like that but what about the

1128
00:39:25,430 --> 00:39:23,680
poles of mars places where some of these

1129
00:39:27,349 --> 00:39:25,440
other organics might have been preserved

1130
00:39:30,069 --> 00:39:27,359
for extended periods of time i mean

1131
00:39:31,670 --> 00:39:30,079
bacterial spores can hang around for

1132
00:39:33,910 --> 00:39:31,680
potentially hundreds of millions of

1133
00:39:36,870 --> 00:39:33,920
years there's a study out that found

1134
00:39:37,910 --> 00:39:36,880
spores and halite crystals on earth

1135
00:39:40,710 --> 00:39:37,920
excuse me

1136
00:39:43,910 --> 00:39:42,630
halite crystals on earth that i believe

1137
00:39:45,589 --> 00:39:43,920
the halite crystals were something on

1138
00:39:46,630 --> 00:39:45,599

the order of 100 million years old and

1139
00:39:48,790 --> 00:39:46,640
there were

1140
00:39:51,510 --> 00:39:48,800
um bacterial spores trapped inside that

1141
00:39:53,589 --> 00:39:51,520
then they could culture and make growing

1142
00:39:54,950 --> 00:39:53,599
metabolizing cells out of those it's a

1143
00:39:56,630 --> 00:39:54,960
bit controversial because we're not sure

1144
00:39:58,470 --> 00:39:56,640
if the spores were

1145
00:40:00,390 --> 00:39:58,480
trapped in there when the halite crystal

1146
00:40:01,750 --> 00:40:00,400
was formed or if they were introduced

1147
00:40:04,390 --> 00:40:01,760
later but

1148
00:40:05,829 --> 00:40:04,400
in theory there's nothing to limit

1149
00:40:07,349 --> 00:40:05,839
something like a bacterial spore from

1150
00:40:08,790 --> 00:40:07,359
hanging around that long which means

1151
00:40:11,109 --> 00:40:08,800
that it would

1152
00:40:13,190 --> 00:40:11,119
it would have a lot of its organic um

1153
00:40:16,710 --> 00:40:13,200
compounds still present things like

1154
00:40:18,870 --> 00:40:16,720
dipiclinic acid dna nucleic acids um

1155
00:40:21,510 --> 00:40:18,880
some of the the phospholipid fatty acids

1156
00:40:24,470 --> 00:40:21,520
or things that that um comprise the

1157
00:40:26,550 --> 00:40:24,480
bacterial spore coat stuff like that

1158
00:40:29,030 --> 00:40:26,560
so

1159
00:40:32,150 --> 00:40:29,040
yeah i agree that both is important but

1160
00:40:33,829 --> 00:40:32,160
it depends a lot on where you go

1161
00:40:36,230 --> 00:40:33,839
let's see plfa does anyone need a

1162
00:40:37,589 --> 00:40:36,240
definition of plfa phospholipid fatty

1163
00:40:39,270 --> 00:40:37,599

acids

1164
00:40:41,109 --> 00:40:39,280
and again a lot of the things i've

1165
00:40:43,190 --> 00:40:41,119
brought up are just touching on the

1166
00:40:44,950 --> 00:40:43,200
surface of a few of these techniques i

1167
00:40:47,109 --> 00:40:44,960
didn't want to get too in-depth there

1168
00:40:49,589 --> 00:40:47,119
are so many and they're advancing so

1169
00:40:51,670 --> 00:40:49,599
quickly it would take a long long time

1170
00:40:55,030 --> 00:40:51,680
to do that thorough literature search to

1171
00:40:58,150 --> 00:40:56,550
does anyone have any comments i'd like

1172
00:41:02,230 --> 00:40:58,160
to say

1173
00:41:07,430 --> 00:41:04,470
the only conclusive evidence steve said

1174
00:41:08,710 --> 00:41:07,440
will be a body a better life hopefully a

1175
00:41:10,870 --> 00:41:08,720
self

1176
00:41:12,870 --> 00:41:10,880
is what you're talking about yeah

1177
00:41:16,950 --> 00:41:12,880
i agree i also think i wasn't talking

1178
00:41:19,670 --> 00:41:18,550
well it's going to be challenging right

1179
00:41:21,670 --> 00:41:19,680
to convince

1180
00:41:24,150 --> 00:41:21,680
not just the science community here but

1181
00:41:25,510 --> 00:41:24,160
everyone in general that we've really

1182
00:41:27,349 --> 00:41:25,520
found something

1183
00:41:29,109 --> 00:41:27,359
okay life life is one thing life is

1184
00:41:31,190 --> 00:41:29,119
exciting for us but extraterrestrial

1185
00:41:33,349 --> 00:41:31,200
life life that we can prove

1186
00:41:34,550 --> 00:41:33,359
evolved separately from life on earth i

1187
00:41:36,710 --> 00:41:34,560
think that's

1188
00:41:38,630 --> 00:41:36,720

that's incredibly exciting right how do

1189
00:41:39,589 --> 00:41:38,640
we prove that well

1190
00:41:41,829 --> 00:41:39,599
i mean

1191
00:41:43,910 --> 00:41:41,839
ultimately the only way to do that

1192
00:41:46,790 --> 00:41:43,920
assuming that it's similar to life on

1193
00:41:49,109 --> 00:41:46,800
earth would be dna right proving that it

1194
00:41:50,870 --> 00:41:49,119
branched off much much earlier than than

1195
00:41:54,390 --> 00:41:50,880
our life did i know can anyone else

1196
00:41:57,990 --> 00:41:56,790
that we could we could use to

1197
00:41:59,910 --> 00:41:58,000
clearly

1198
00:42:01,990 --> 00:41:59,920
distinguish and of course chris mckay's

1199
00:42:04,630 --> 00:42:02,000
whole l versus d amino acid thing

1200
00:42:06,069 --> 00:42:04,640
there's that too

1201
00:42:09,349 --> 00:42:06,079
but looking we're still trying to

1202
00:42:11,190 --> 00:42:09,359
develop very small compact portable ways

1203
00:42:13,750 --> 00:42:11,200
to discriminate between

1204
00:42:15,270 --> 00:42:13,760
enantiomers of amino acids

1205
00:42:16,710 --> 00:42:15,280
so i think there's a lot of room for

1206
00:42:18,630 --> 00:42:16,720
advancement there and i hope that

1207
00:42:20,069 --> 00:42:18,640
technology gets

1208
00:42:21,349 --> 00:42:20,079
gets invested in

1209
00:42:25,190 --> 00:42:21,359
for future

1210
00:42:27,589 --> 00:42:25,200
mars and related investigations

1211
00:42:29,829 --> 00:42:27,599
it'd be so much fun to see a cell

1212
00:42:32,150 --> 00:42:29,839
like bring a really nice microscope to

1213
00:42:34,790 --> 00:42:32,160

mars or enceladus or europa and then

1214
00:42:37,510 --> 00:42:34,800
find a cell just boom right there be

1215
00:42:41,270 --> 00:42:39,109
um whilst people are thinking about

1216
00:42:43,270 --> 00:42:41,280
their questions let me just mention that

1217
00:42:46,150 --> 00:42:43,280
uh the documents

1218
00:42:48,470 --> 00:42:46,160
that this presentation is based on is

1219
00:42:51,270 --> 00:42:48,480
linked to on the front of the website

1220
00:42:53,910 --> 00:42:51,280
and it's now being flipped over so that

1221
00:42:55,910 --> 00:42:53,920
everyone can make comments on it you're

1222
00:42:58,150 --> 00:42:55,920
not editing the document directly you're

1223
00:43:00,710 --> 00:42:58,160
just adding your comments to any parts

1224
00:43:02,790 --> 00:43:00,720
of that so uh whilst the conversation in

1225
00:43:05,109 --> 00:43:02,800
the chat log is extremely useful and on

1226
00:43:07,109 --> 00:43:05,119
the phone lines uh it's also really

1227
00:43:09,190 --> 00:43:07,119
helpful to the authors if you can go to

1228
00:43:11,829 --> 00:43:09,200
the document and just add thoughts

1229
00:43:14,069 --> 00:43:11,839
references questions directly in that to

1230
00:43:15,190 --> 00:43:14,079
help them strengthen the document as

1231
00:43:17,430 --> 00:43:15,200
well

1232
00:43:19,829 --> 00:43:17,440
oh i totally forgot to talk about one

1233
00:43:21,589 --> 00:43:19,839
thing okay so there's one other thing

1234
00:43:23,910 --> 00:43:21,599
and lindsay just brought up something

1235
00:43:26,150 --> 00:43:23,920
that reminded me about this so when

1236
00:43:28,150 --> 00:43:26,160
you're talking about biotic versus

1237
00:43:32,069 --> 00:43:28,160
abiotic

1238
00:43:34,150 --> 00:43:32,079

production of say a suite of organic

1239
00:43:37,829 --> 00:43:34,160
compounds like amino acids

1240
00:43:40,630 --> 00:43:37,839
they tend to be produced in sort of a

1241
00:43:42,309 --> 00:43:40,640
very broad sense there's no specificity

1242
00:43:44,309 --> 00:43:42,319
so you'll get a whole

1243
00:43:46,470 --> 00:43:44,319
slew of organics that are all kind of

1244
00:43:48,870 --> 00:43:46,480
very similar let's take let's take fatty

1245
00:43:50,950 --> 00:43:48,880
acids this is a good example so we found

1246
00:43:52,870 --> 00:43:50,960
fatty acids in meteorites

1247
00:43:54,710 --> 00:43:52,880
so fatty acids are they're some similar

1248
00:43:56,630 --> 00:43:54,720
to phospholipid fatty acids but you just

1249
00:43:58,390 --> 00:43:56,640
cut off the phospholipid parts so you've

1250
00:43:59,990 --> 00:43:58,400
got a long aliphatic chain lots of

1251
00:44:01,750 --> 00:44:00,000
carbons and at the end you have a

1252
00:44:03,510 --> 00:44:01,760
carboxylic acid

1253
00:44:05,670 --> 00:44:03,520
and these can hang around for a while

1254
00:44:07,030 --> 00:44:05,680
and we found plenty of these in

1255
00:44:10,150 --> 00:44:07,040
meteorites

1256
00:44:11,829 --> 00:44:10,160
up to a carbon length of c30 now your

1257
00:44:14,069 --> 00:44:11,839
cells in your body bacterial cells

1258
00:44:17,109 --> 00:44:14,079
typically use carbon link chains of

1259
00:44:19,109 --> 00:44:17,119
those fatty acids of like 16 or 18

1260
00:44:20,950 --> 00:44:19,119
but they they do them very specifically

1261
00:44:24,470 --> 00:44:20,960
so you'll see for example if you have

1262
00:44:28,150 --> 00:44:24,480
life you'll see a huge spike of c16 16

1263
00:44:31,349 --> 00:44:28,160

carpets long and c18 and c20 you don't

1264
00:44:33,750 --> 00:44:31,359
tend to see many of the c19 and c21s

1265
00:44:35,990 --> 00:44:33,760
because it turns out that the way

1266
00:44:37,589 --> 00:44:36,000
life makes these fatty acids they make

1267
00:44:38,950 --> 00:44:37,599
them where they add on the carbons in

1268
00:44:41,190 --> 00:44:38,960
sets of two

1269
00:44:43,349 --> 00:44:41,200
so one of the things that we can do when

1270
00:44:45,349 --> 00:44:43,359
we're looking for signatures of life is

1271
00:44:47,430 --> 00:44:45,359
not just look for fatty acids but look

1272
00:44:50,390 --> 00:44:47,440
for patterns do we see in these

1273
00:44:52,309 --> 00:44:50,400
meteorites if it's abiotic we'll see all

1274
00:44:54,069 --> 00:44:52,319
the way from carbon say 10 to 30 and

1275
00:44:55,430 --> 00:44:54,079
we'll sort of see an even distribution

1276
00:44:57,589 --> 00:44:55,440
of all of them

1277
00:45:00,870 --> 00:44:57,599
but if it was from life we might see

1278
00:45:02,870 --> 00:45:00,880
these spikes at c18 at c20 c22 i think

1279
00:45:04,470 --> 00:45:02,880
is fungus stuff like that

1280
00:45:06,230 --> 00:45:04,480
and we can trace those back to

1281
00:45:08,150 --> 00:45:06,240
particular kinds of life too that's

1282
00:45:09,910 --> 00:45:08,160
another story but the point is

1283
00:45:12,390 --> 00:45:09,920
to look for for

1284
00:45:15,270 --> 00:45:12,400
asymmetric distributions look for spikes

1285
00:45:17,910 --> 00:45:15,280
of things that if it was produced

1286
00:45:19,910 --> 00:45:17,920
abiotically you wouldn't expect to see

1287
00:45:21,990 --> 00:45:19,920
so looking for a whole suite of

1288
00:45:23,510 --> 00:45:22,000

compounds is important and looking for

1289
00:45:25,109 --> 00:45:23,520
their distributions

1290
00:45:27,910 --> 00:45:25,119
relative to each other is really

1291
00:45:29,270 --> 00:45:27,920
important so detection and quantitation

1292
00:45:31,870 --> 00:45:29,280
we've got to find out how much of the

1293
00:45:33,990 --> 00:45:31,880
stuff is there can help us a lot in this

1294
00:45:37,430 --> 00:45:34,000
discriminating between

1295
00:45:43,190 --> 00:45:39,349
let's see i'm going to just look at a

1296
00:45:47,670 --> 00:45:44,870
okay right this is a good point the

1297
00:45:50,309 --> 00:45:47,680
radiation issue on mars so the

1298
00:45:52,390 --> 00:45:50,319
atmosphere of mars is thin we end up

1299
00:45:54,390 --> 00:45:52,400
sterilizing the first it looks like a

1300
00:45:55,670 --> 00:45:54,400
meter or two oh i was hoping it was

1301
00:45:58,150 --> 00:45:55,680
centimeters

1302
00:46:00,390 --> 00:45:58,160
okay we end up sterilizing a lot of the

1303
00:46:02,470 --> 00:46:00,400
topsoil right because of uv radiation

1304
00:46:03,829 --> 00:46:02,480
and things so if we want to find life

1305
00:46:06,230 --> 00:46:03,839
yes i agree

1306
00:46:09,750 --> 00:46:06,240
we have to drill the um

1307
00:46:11,349 --> 00:46:09,760
the ins in sight mission which is a

1308
00:46:12,790 --> 00:46:11,359
lander that

1309
00:46:15,030 --> 00:46:12,800
is going to mars can't remember what

1310
00:46:17,190 --> 00:46:15,040
year maybe steve can help me out soon

1311
00:46:19,270 --> 00:46:17,200
he's going to drill down two meters

1312
00:46:20,950 --> 00:46:19,280
and that will be our first test of a

1313
00:46:23,190 --> 00:46:20,960

drill that can approach those types of

1314
00:46:24,950 --> 00:46:23,200
magnitudes it'd be so much fun to put in

1315
00:46:26,630 --> 00:46:24,960
organic experiments on the end of that

1316
00:46:27,829 --> 00:46:26,640
drill but right now they're doing just

1317
00:46:29,589 --> 00:46:27,839
proof of concept i think they're going

1318
00:46:31,430 --> 00:46:29,599
to look for the planting centers and

1319
00:46:32,390 --> 00:46:31,440
looking for um

1320
00:46:33,829 --> 00:46:32,400
for

1321
00:46:36,150 --> 00:46:33,839
geology

1322
00:46:39,430 --> 00:46:36,160
oh exomors is a 2 meter drill i did not

1323
00:46:41,829 --> 00:46:39,440
know that thank you paulie

1324
00:46:43,109 --> 00:46:41,839
you can say polly do you want to come on

1325
00:46:48,950 --> 00:46:43,119
the line and say a little bit about the

1326
00:46:52,870 --> 00:46:50,470
or someone else who knows a bit more

1327
00:46:53,750 --> 00:46:52,880
about exomars i'm afraid the only

1328
00:46:55,349 --> 00:46:53,760
uh

1329
00:46:58,069 --> 00:46:55,359
instrument package i'm familiar with for

1330
00:46:59,430 --> 00:46:58,079
exomars is that life marker tip that

1331
00:47:00,870 --> 00:46:59,440
looks pretty exciting it's got some

1332
00:47:02,230 --> 00:47:00,880
antibodies that

1333
00:47:03,750 --> 00:47:02,240
they're targeting for a whole bunch of

1334
00:47:05,670 --> 00:47:03,760
different organic molecules including

1335
00:47:09,430 --> 00:47:05,680
hopanes i think or hopinoids one of

1336
00:47:13,190 --> 00:47:09,440
those extinct life biomarkers

1337
00:47:15,270 --> 00:47:13,200
oh poor mike okay no worries polly

1338
00:47:17,109 --> 00:47:15,280

maybe you can make some comments on the

1339
00:47:19,109 --> 00:47:17,119
uh the word documents that andy

1340
00:47:22,790 --> 00:47:19,119
mentioned that would be really helpful

1341
00:47:24,870 --> 00:47:22,800
for us we don't want to miss anything

1342
00:47:26,390 --> 00:47:24,880
cool thanks

1343
00:47:29,030 --> 00:47:26,400
steve do you want to chime in on any of

1344
00:47:31,589 --> 00:47:29,040
these upcoming missions and

1345
00:47:33,990 --> 00:47:31,599
the issue with radiation on mars and

1346
00:47:36,630 --> 00:47:34,000
sterilization looking for life deeper

1347
00:47:41,349 --> 00:47:39,750
uh yeah sure um thanks by the way morgan

1348
00:47:42,950 --> 00:47:41,359
for this really nice presentation i

1349
00:47:45,270 --> 00:47:42,960
think you um

1350
00:47:47,829 --> 00:47:45,280
gave a real nicely organized uh

1351
00:47:50,230 --> 00:47:47,839
presentation

1352
00:47:54,230 --> 00:47:52,790
i'm sorry i'm pasting a comment here

1353
00:47:55,910 --> 00:47:54,240
which has been my my mode of

1354
00:47:58,630 --> 00:47:55,920
communication so far

1355
00:48:02,950 --> 00:48:00,950
yeah yeah so so for europa at least in

1356
00:48:03,829 --> 00:48:02,960
terms of the radiation

1357
00:48:05,990 --> 00:48:03,839
um

1358
00:48:08,870 --> 00:48:06,000
just below the surface

1359
00:48:10,470 --> 00:48:08,880
you might find pristine material

1360
00:48:11,750 --> 00:48:10,480
if you need to get into the ocean that's

1361
00:48:13,990 --> 00:48:11,760
that's a different problem in this

1362
00:48:16,790 --> 00:48:14,000
you're talking about kilometers of ice

1363
00:48:18,390 --> 00:48:16,800

that's why i think the the putative

1364
00:48:20,950 --> 00:48:18,400
finding of plumes from europa is

1365
00:48:23,030 --> 00:48:20,960
particularly exciting uh and of course

1366
00:48:28,230 --> 00:48:23,040
that's one reason why

1367
00:48:30,230 --> 00:48:28,240
enceladus are really exciting as well

1368
00:48:31,510 --> 00:48:30,240
yeah so i i do have a question steve i

1369
00:48:32,790 --> 00:48:31,520
heard

1370
00:48:34,870 --> 00:48:32,800
from a

1371
00:48:36,870 --> 00:48:34,880
mechanistic standpoint that because it's

1372
00:48:38,790 --> 00:48:36,880
so cold on europa the hardness of the

1373
00:48:39,829 --> 00:48:38,800
ice on the surface is on the order of

1374
00:48:41,030 --> 00:48:39,839
granite

1375
00:48:43,030 --> 00:48:41,040
on earth so

1376
00:48:45,670 --> 00:48:43,040
even 10 centimeters getting that far in

1377
00:48:47,430 --> 00:48:45,680
could be a challenge do you know of any

1378
00:48:49,750 --> 00:48:47,440
any drill or

1379
00:48:51,670 --> 00:48:49,760
other types of mechanical

1380
00:48:54,630 --> 00:48:51,680
proposals that have gone in to try to

1381
00:48:58,069 --> 00:48:54,640
get down below that

1382
00:48:59,430 --> 00:48:58,079
um well so the europa lander concept

1383
00:49:01,349 --> 00:48:59,440
that was published in astrobiology

1384
00:49:03,670 --> 00:49:01,359
recently included a drill and that was

1385
00:49:06,790 --> 00:49:03,680
based on the this is

1386
00:49:08,790 --> 00:49:06,800
sorry the phoenix trail is that right um

1387
00:49:10,630 --> 00:49:08,800
but i i in those discussions it wasn't

1388
00:49:11,990 --> 00:49:10,640

seen as a problem getting through cold

1389
00:49:15,270 --> 00:49:12,000
ice

1390
00:49:17,030 --> 00:49:15,280
so it was not not an intractable problem

1391
00:49:19,270 --> 00:49:17,040
okay excellent that's good to hear what

1392
00:49:20,470 --> 00:49:19,280
about oh boy you'd have to be

1393
00:49:22,790 --> 00:49:20,480
how would you

1394
00:49:24,150 --> 00:49:22,800
so as soon as you expose that to the

1395
00:49:27,030 --> 00:49:24,160
radiation environment you've got to

1396
00:49:28,870 --> 00:49:27,040
collect those organics really fast or do

1397
00:49:30,710 --> 00:49:28,880
something

1398
00:49:33,109 --> 00:49:30,720
and so there was a specific protocol

1399
00:49:34,950 --> 00:49:33,119
again described in the paper for

1400
00:49:37,030 --> 00:49:34,960
uh collecting the material in such a way

1401
00:49:38,790 --> 00:49:37,040
that you didn't compromise your sample

1402
00:49:40,069 --> 00:49:38,800
and that include because there was a

1403
00:49:42,150 --> 00:49:40,079
gcms

1404
00:49:43,750 --> 00:49:42,160
on the the model payload uh that

1405
00:49:45,109 --> 00:49:43,760
included melting it in such a way that

1406
00:49:47,750 --> 00:49:45,119
you didn't

1407
00:49:49,030 --> 00:49:47,760
mix different portions of the drilled

1408
00:49:50,870 --> 00:49:49,040
sample

1409
00:49:52,630 --> 00:49:50,880
as the the upper the upper portion that

1410
00:49:54,230 --> 00:49:52,640
was radiated so you want to sample both

1411
00:49:55,190 --> 00:49:54,240
compare them

1412
00:50:00,710 --> 00:49:55,200
right

1413
00:50:04,790 --> 00:50:00,720

cool okay uh let's see any other

1414
00:50:06,630 --> 00:50:04,800
comments shouldn't have to dig too far

1415
00:50:08,390 --> 00:50:06,640
oh michael new hosted yeah that's

1416
00:50:10,710 --> 00:50:08,400
another thing guys if you have links

1417
00:50:13,430 --> 00:50:10,720
like steve if you could look up the that

1418
00:50:16,390 --> 00:50:13,440
astrobiology paper and put a link either

1419
00:50:18,470 --> 00:50:16,400
here or in the the word document

1420
00:50:20,069 --> 00:50:18,480
and similarly with this this workshop

1421
00:50:21,990 --> 00:50:20,079
that michael knew hosted if we could put

1422
00:50:23,670 --> 00:50:22,000
links for that that would be really nice

1423
00:50:27,910 --> 00:50:23,680
so then we can all kind of

1424
00:50:33,430 --> 00:50:31,430
oh thank you paulie i think i might have

1425
00:50:35,829 --> 00:50:33,440
read that paper i did a lot of

1426
00:50:37,270 --> 00:50:35,839
literature searches in the past few days

1427
00:50:41,349 --> 00:50:37,280
just trying to

1428
00:50:43,990 --> 00:50:41,359
to get a more broader scope idea uh when

1429
00:50:45,349 --> 00:50:44,000
i was preparing this talk and i think i

1430
00:50:48,069 --> 00:50:45,359
i might have skimmed that one i'll go

1431
00:50:50,390 --> 00:50:48,079
back and check so thank you for that

1432
00:50:51,430 --> 00:50:50,400
probably uh brought up a paper

1433
00:50:52,710 --> 00:50:51,440
oh

1434
00:50:54,870 --> 00:50:52,720
morgan

1435
00:50:58,309 --> 00:50:54,880
yes hello

1436
00:51:01,510 --> 00:50:58,319
hi this is mary voytech um the the

1437
00:51:04,390 --> 00:51:01,520
report that lindsay was referring to was

1438
00:51:07,109 --> 00:51:04,400

a report out from a workshop that we

1439
00:51:09,829 --> 00:51:07,119
held in august and actually it's not out

1440
00:51:13,670 --> 00:51:09,839
yet so um i'm not sure what stage it's

1441
00:51:16,790 --> 00:51:13,680
in but um there's a resource there to be

1442
00:51:17,670 --> 00:51:16,800
had um with that we should consider if

1443
00:51:21,750 --> 00:51:17,680
you're going to have any kind of

1444
00:51:25,109 --> 00:51:21,760
discussion about technology needs or

1445
00:51:27,109 --> 00:51:25,119
accessing important environments

1446
00:51:28,950 --> 00:51:27,119
great okay thanks

1447
00:51:32,309 --> 00:51:28,960
well can you let us know when that does

1448
00:51:34,829 --> 00:51:34,069
absolutely

1449
00:51:37,270 --> 00:51:34,839
thank

1450
00:51:39,910 --> 00:51:37,280
you okay i'm going to scroll up and just

1451
00:51:42,309 --> 00:51:39,920
see if there are any other questions

1452
00:51:43,430 --> 00:51:42,319
that we haven't addressed yet

1453
00:51:44,309 --> 00:51:43,440
and i did

1454
00:51:46,710 --> 00:51:44,319
have

1455
00:51:48,470 --> 00:51:46,720
one more poll although it's kind of

1456
00:51:50,549 --> 00:51:48,480
kind of obvious but maybe mike we could

1457
00:51:52,470 --> 00:51:50,559
bring up that question number two about

1458
00:51:53,670 --> 00:51:52,480
the yeah

1459
00:51:58,390 --> 00:51:53,680
so

1460
00:51:59,670 --> 00:51:58,400
what would be necessary to convince you

1461
00:52:01,750 --> 00:51:59,680
that we'd found life somewhere else

1462
00:52:05,190 --> 00:52:01,760
would you be okay with us just staying

1463
00:52:06,549 --> 00:52:05,200

let's say we had a orbiting spacecraft

1464
00:52:07,990 --> 00:52:06,559
and we saw a definitive release of

1465
00:52:09,750 --> 00:52:08,000
methane that

1466
00:52:11,109 --> 00:52:09,760
at least to our best understanding

1467
00:52:12,790 --> 00:52:11,119
couldn't be explained by a geology

1468
00:52:14,710 --> 00:52:12,800
that's just an example would that be

1469
00:52:16,950 --> 00:52:14,720
enough to convince you or would you need

1470
00:52:18,710 --> 00:52:16,960
some kind of in-situ detection as long

1471
00:52:21,190 --> 00:52:18,720
as we could confidently say it wasn't

1472
00:52:23,990 --> 00:52:21,200
from contamination if we found some

1473
00:52:26,790 --> 00:52:24,000
example of of extant life or extinct

1474
00:52:29,190 --> 00:52:26,800
life that i just gave one example there

1475
00:52:30,230 --> 00:52:29,200
or would you really need sample return

1476
00:52:31,430 --> 00:52:30,240
to earth

1477
00:52:32,950 --> 00:52:31,440
where we could

1478
00:52:34,710 --> 00:52:32,960
fully

1479
00:52:37,510 --> 00:52:34,720
uh analyze the the heck out of the

1480
00:52:39,589 --> 00:52:37,520
sample with all of our really really um

1481
00:52:41,829 --> 00:52:39,599
you know ultra sensitive and best of the

1482
00:52:43,829 --> 00:52:41,839
best techniques what would you need to

1483
00:52:46,710 --> 00:52:43,839
definitively say

1484
00:52:49,109 --> 00:52:46,720
that you found life

1485
00:52:51,670 --> 00:52:49,119
okay that's interesting see i would have

1486
00:52:53,270 --> 00:52:51,680
voted for the sample return to earth for

1487
00:52:55,270 --> 00:52:53,280
the truly

1488
00:52:57,349 --> 00:52:55,280

ultimate like we absolutely have found

1489
00:52:58,710 --> 00:52:57,359
life not only we found it but we can

1490
00:53:00,390 --> 00:52:58,720
show you when it's

1491
00:53:02,549 --> 00:53:00,400
branched off from life on earth that

1492
00:53:04,470 --> 00:53:02,559
kind of thing

1493
00:53:06,390 --> 00:53:04,480
that's interesting

1494
00:53:07,990 --> 00:53:06,400
cool good that means we don't need to

1495
00:53:09,910 --> 00:53:08,000
invest too much in sample return we

1496
00:53:11,910 --> 00:53:09,920
should focus more on in situ detection

1497
00:53:17,910 --> 00:53:11,920
i'm more excited about that because

1498
00:53:22,069 --> 00:53:19,589
can you guys see me i had to restart my

1499
00:53:23,430 --> 00:53:22,079
webcam and mike sent a note but it's not

1500
00:53:24,950 --> 00:53:23,440
time stamp

1501
00:53:27,270 --> 00:53:24,960
yep okay

1502
00:53:31,510 --> 00:53:27,280
just checking so we're into our last

1503
00:53:34,390 --> 00:53:31,520
just a few minutes of the webinar um

1504
00:53:36,630 --> 00:53:34,400
are there any last questions that people

1505
00:53:38,230 --> 00:53:36,640
want to raise if you're on the phone

1506
00:53:41,829 --> 00:53:38,240
line and you want to talk that's great

1507
00:53:49,589 --> 00:53:41,839
and if not just um

1508
00:53:49,599 --> 00:53:54,069
give people a moment to ponder equally

1509
00:53:58,390 --> 00:53:56,230
yeah this is one of those questions that

1510
00:54:00,790 --> 00:53:58,400
i think motivated most of us to get into

1511
00:54:02,870 --> 00:54:00,800
this kind of research is are we alone

1512
00:54:03,589 --> 00:54:02,880
and could there be life somewhere else

1513
00:54:06,470 --> 00:54:03,599

and

1514
00:54:08,870 --> 00:54:06,480
um jonathan mooneen i think i had a

1515
00:54:10,790 --> 00:54:08,880
discussion with him a few months ago we

1516
00:54:12,549 --> 00:54:10,800
were talking about how

1517
00:54:14,150 --> 00:54:12,559
on a place like earth everywhere you

1518
00:54:16,309 --> 00:54:14,160
look for life you find it it's

1519
00:54:17,510 --> 00:54:16,319
ubiquitous right and you look at the

1520
00:54:20,549 --> 00:54:17,520
bottom of the ocean you look in

1521
00:54:22,950 --> 00:54:20,559
antarctica everywhere we find life

1522
00:54:24,230 --> 00:54:22,960
and so why don't we see this anywhere

1523
00:54:25,990 --> 00:54:24,240
else i mean there are organisms that

1524
00:54:27,990 --> 00:54:26,000
could survive

1525
00:54:29,910 --> 00:54:28,000
granted not on the surface of europa or

1526
00:54:32,230 --> 00:54:29,920
the surface of mars but probably pretty

1527
00:54:33,430 --> 00:54:32,240
close to a point where if life were

1528
00:54:35,349 --> 00:54:33,440
ubiquitous

1529
00:54:37,750 --> 00:54:35,359
would we see signs and so that's another

1530
00:54:40,710 --> 00:54:37,760
very interesting question of

1531
00:54:42,549 --> 00:54:40,720
if there is life somewhere else

1532
00:54:44,950 --> 00:54:42,559
why is it not ubiquitous like it would

1533
00:54:47,190 --> 00:54:44,960
be like it is on earth um

1534
00:54:48,950 --> 00:54:47,200
could it be that it evolved more slowly

1535
00:54:50,150 --> 00:54:48,960
could it be that it's migrated down

1536
00:54:52,069 --> 00:54:50,160
underground

1537
00:54:52,950 --> 00:54:52,079
maybe on mars this could be an example

1538
00:54:56,069 --> 00:54:52,960

of that

1539
00:54:58,230 --> 00:54:56,079
uh and will we find ubiquitous life

1540
00:55:01,510 --> 00:54:58,240
somewhere else all of these these um

1541
00:55:03,270 --> 00:55:01,520
exoplanets observations with are better

1542
00:55:03,990 --> 00:55:03,280
and better of more improving telescopes

1543
00:55:06,470 --> 00:55:04,000
are

1544
00:55:08,790 --> 00:55:06,480
really really exciting from this aspect

1545
00:55:11,589 --> 00:55:08,800
so i believe that we will find life

1546
00:55:13,349 --> 00:55:11,599
somewhere else in our lifetime

1547
00:55:16,069 --> 00:55:13,359
i really do especially if we keep

1548
00:55:20,790 --> 00:55:16,079
advancing the way we are and that's a

1549
00:55:25,109 --> 00:55:23,349
so perhaps that can be our closing

1550
00:55:27,349 --> 00:55:25,119
comment um

1551
00:55:31,589 --> 00:55:27,359
morgan thank you very much

1552
00:55:34,630 --> 00:55:31,599
uh just to remind everyone um please go

1553
00:55:37,270 --> 00:55:34,640
and uh add any thoughts you've got to

1554
00:55:39,190 --> 00:55:37,280
the the paper um you'll also find on the

1555
00:55:42,069 --> 00:55:39,200
front of the website um

1556
00:55:44,549 --> 00:55:42,079
the yesterday's paper is the the link on

1557
00:55:47,270 --> 00:55:44,559
the first two links are there so if you

1558
00:55:49,670 --> 00:55:47,280
didn't have a chance please go and uh

1559
00:55:51,349 --> 00:55:49,680
pop your comments in there and with that

1560
00:55:54,069 --> 00:55:51,359
thank you very much hope to see you all

1561
00:55:55,270 --> 00:55:54,079
next week for our next two webinars