ASTROBIOLOGY IN THE FIELD

GREENLAND

1
00:00:02,950 --> 00:00:32,709
[Music]

2
00:00:36,470 --> 00:00:34,470
greenland

3
00:00:38,869 --> 00:00:36,480
a massive ice-covered island in the

4
00:00:41,670 --> 00:00:38,879
northern arctic a land of pristine

5
00:00:42,869 --> 00:00:41,680
waters enormous glaciers and ancient

6
00:00:44,790 --> 00:00:42,879
geology

7
00:00:47,350 --> 00:00:44,800
and for some the site of a hotly

8
00:00:49,910 --> 00:00:47,360
contested claim of the oldest signs of

9
00:00:52,869 --> 00:00:49,920
microbial life on earth

10
00:00:55,830 --> 00:00:52,879
meet dr abigail allwood astrobiologist

11
00:00:57,270 --> 00:00:55,840
at the nasa jet propulsion laboratory dr

12
00:00:59,430 --> 00:00:57,280
allwood is here in greenland to

13
00:01:01,990 --> 00:00:59,440

investigate recently published findings

14
00:01:05,429 --> 00:01:02,000
of possible stromatolites or microbial

15
00:01:05,940 --> 00:01:05,439
fossils dating back to 3.7 billion years

16
00:01:07,590 --> 00:01:05,950
ago

17
00:01:09,190 --> 00:01:07,600
[Music]

18
00:01:11,510 --> 00:01:09,200
it's always when i go and see some rocks

19
00:01:12,789 --> 00:01:11,520
and outcrops in the flesh

20
00:01:14,310 --> 00:01:12,799
it's so much

21
00:01:15,670 --> 00:01:14,320
so so much more eye opening and

22
00:01:18,149 --> 00:01:15,680
informative than it is to read about

23
00:01:19,590 --> 00:01:18,159
them in papers and absolutely the case

24
00:01:21,670 --> 00:01:19,600
with this one when i came to see them

25
00:01:23,350 --> 00:01:21,680
after that paper was published i very

26
00:01:25,749 --> 00:01:23,360
much doubted that interpretation and i

27
00:01:27,030 --> 00:01:25,759
thought well we need to do two things we

28
00:01:28,550 --> 00:01:27,040
need to put a paper out and secondly we

29
00:01:30,230 --> 00:01:28,560
need to do a workshop and bring a lot of

30
00:01:31,350 --> 00:01:30,240
people out here to

31
00:01:32,870 --> 00:01:31,360
also

32
00:01:34,469 --> 00:01:32,880
see what their opinion is be some sort

33
00:01:38,789 --> 00:01:34,479
of a consensus on

34
00:01:43,109 --> 00:01:40,630
extraordinary claims require

35
00:01:46,469 --> 00:01:43,119
extraordinary evidence and a finding

36
00:01:48,069 --> 00:01:46,479
like this requires further investigation

37
00:01:50,630 --> 00:01:48,079
dr allwood has gathered a team of

38
00:01:53,109 --> 00:01:50,640

astrobiologists and will now travel by

39
00:01:57,870 --> 00:01:53,119
helicopter into the wilderness of the

40
00:01:57,880 --> 00:02:40,229
[Music]

41
00:02:44,790 --> 00:02:42,790
so we're out here to study an outcrop

42
00:02:48,229 --> 00:02:44,800
that there is some controversy over

43
00:02:51,030 --> 00:02:48,239
there is a group of authors that has

44
00:02:52,550 --> 00:02:51,040
made a claim that there are uh uh

45
00:02:54,949 --> 00:02:52,560
biosignatures in the form of

46
00:02:57,430 --> 00:02:54,959
stromatolites in these rocks and there's

47
00:02:59,830 --> 00:02:57,440
another group of authors uh i happen to

48
00:03:02,229 --> 00:02:59,840
be one of that other group of authors uh

49
00:03:04,630 --> 00:03:02,239
that has refuted that claim so we're out

50
00:03:07,350 --> 00:03:04,640
here in greenland to study those

51
00:03:09,350 --> 00:03:07,360
outcrops in more detail and to try to

52
00:03:12,309 --> 00:03:09,360
get a sense of the

53
00:03:14,470 --> 00:03:12,319
geology that surrounds those potentially

54
00:03:16,550 --> 00:03:14,480
stromatolite bearing outcrops and try to

55
00:03:18,149 --> 00:03:16,560
get a sense for what the ancient

56
00:03:20,390 --> 00:03:18,159
environment looked like at the time that

57
00:03:21,990 --> 00:03:20,400
those rocks were forming the claim was

58
00:03:24,630 --> 00:03:22,000
such a big deal

59
00:03:28,070 --> 00:03:24,640
because if it proves to be true

60
00:03:30,869 --> 00:03:28,080
then this pushes back the earliest signs

61
00:03:33,110 --> 00:03:30,879
of life in earth's geological record by

62
00:03:35,190 --> 00:03:33,120
a couple of hundred million years

63
00:03:36,949 --> 00:03:35,200

it means that the window of opportunity

64
00:03:39,030 --> 00:03:36,959
for life to emerge doesn't have to be

65
00:03:41,110 --> 00:03:39,040
very big you know literally as the last

66
00:03:42,149 --> 00:03:41,120
bombardment is occurring that you can

67
00:03:44,149 --> 00:03:42,159
say that

68
00:03:46,390 --> 00:03:44,159
life can take hold at least our one

69
00:03:48,710 --> 00:03:46,400
example we have that life took hold go

70
00:03:49,830 --> 00:03:48,720
to mars it means that only it only also

71
00:03:51,910 --> 00:03:49,840
had to

72
00:03:53,670 --> 00:03:51,920
maintain its conditions it's sort of

73
00:03:55,270 --> 00:03:53,680
cradle of life it's you know it's

74
00:03:56,630 --> 00:03:55,280
opportunity for life to emerge for that

75
00:03:58,550 --> 00:03:56,640
short period of time it didn't have to

76
00:04:00,470 --> 00:03:58,560
sort of maintain it for a couple hundred

77
00:04:03,350 --> 00:04:00,480
million years longer

78
00:04:05,990 --> 00:04:03,360
and when you go back to those very old

79
00:04:08,949 --> 00:04:06,000
rocks they're usually altered and

80
00:04:11,270 --> 00:04:08,959
deformed and it's very difficult to find

81
00:04:13,910 --> 00:04:11,280
those signs of life but those are also

82
00:04:15,750 --> 00:04:13,920
the most interesting rocks to look at

83
00:04:17,749 --> 00:04:15,760
because we don't know when life

84
00:04:20,150 --> 00:04:17,759
originated on earth and we don't know

85
00:04:20,870 --> 00:04:20,160
what that earliest life was like

86
00:04:24,230 --> 00:04:20,880
so

87
00:04:26,150 --> 00:04:24,240
the record that we have from geology

88
00:04:28,469 --> 00:04:26,160

is in these rocks that are very

89
00:04:31,830 --> 00:04:28,479
difficult to interpret sorting out

90
00:04:35,430 --> 00:04:34,150
sampling here in greenland is

91
00:04:38,629 --> 00:04:35,440
you know it's not all that different

92
00:04:39,830 --> 00:04:38,639
from sampling anywhere else geologists

93
00:04:41,430 --> 00:04:39,840
tools are

94
00:04:44,390 --> 00:04:41,440
kind of the same no matter where you go

95
00:04:46,469 --> 00:04:44,400
you need a hammer a chisel a little you

96
00:04:49,749 --> 00:04:46,479
know hand lens to look at the rocks up

97
00:04:51,830 --> 00:04:49,759
close field notebook camera and you know

98
00:04:54,150 --> 00:04:51,840
you record your observations and when

99
00:04:56,070 --> 00:04:54,160
you think you've zeroed in on a piece of

100
00:04:58,230 --> 00:04:56,080
rock that might be worth taking back to

101
00:04:59,909 --> 00:04:58,240
the lab you get your trusty rock hammer

102
00:05:00,870 --> 00:04:59,919
out and just start banging away until

103
00:05:04,950 --> 00:05:00,880
the

104
00:05:07,510 --> 00:05:04,960
when we're looking at rocks trying to

105
00:05:08,390 --> 00:05:07,520
understand if they preserve evidence of

106
00:05:11,029 --> 00:05:08,400
life

107
00:05:14,070 --> 00:05:11,039
we look for things in the rock that

108
00:05:16,469 --> 00:05:14,080
cannot form without the influence of

109
00:05:18,710 --> 00:05:16,479
life they can change the chemistry and

110
00:05:21,189 --> 00:05:18,720
they can actually change the shape of

111
00:05:24,710 --> 00:05:21,199
the ground and they can make things like

112
00:05:26,950 --> 00:05:24,720
peaks and domes that are sometimes

113
00:05:29,110 --> 00:05:26,960

unique to the biology

114
00:05:31,270 --> 00:05:29,120
again i think here what you need to do

115
00:05:33,029 --> 00:05:31,280
is look at the context of the rocks

116
00:05:34,870 --> 00:05:33,039
around those stromatolites and try to

117
00:05:36,310 --> 00:05:34,880
get a sense for what that geology is

118
00:05:38,870 --> 00:05:36,320
telling you

119
00:05:39,990 --> 00:05:38,880
this is our sample here it came from the

120
00:05:41,670 --> 00:05:40,000
output

121
00:05:43,270 --> 00:05:41,680
that you sort of cut and polish the face

122
00:05:45,430 --> 00:05:43,280
there

123
00:05:46,550 --> 00:05:45,440
and if if it was really a cone-shaped

124
00:05:48,469 --> 00:05:46,560
structure

125
00:05:50,310 --> 00:05:48,479
then

126
00:05:51,590 --> 00:05:50,320
you shouldn't see it

127
00:05:53,350 --> 00:05:51,600
on the back of the sample you shouldn't

128
00:05:55,990 --> 00:05:53,360
see it in the back of the hole there

129
00:05:57,350 --> 00:05:56,000
that's about 14 centimeters depth hole

130
00:05:58,629 --> 00:05:57,360
and you're still seeing the structure

131
00:06:01,590 --> 00:05:58,639
there yeah

132
00:06:02,950 --> 00:06:01,600
so it's not a cone it's a it's a ridge

133
00:06:05,430 --> 00:06:02,960
if you can sort of reconstruct that in

134
00:06:07,189 --> 00:06:05,440
your mind i've got to prove the uh the

135
00:06:08,950 --> 00:06:07,199
three-dimensional morphology absolutely

136
00:06:10,150 --> 00:06:08,960
have to prove it's the same story you

137
00:06:11,749 --> 00:06:10,160
can see

138
00:06:13,110 --> 00:06:11,759

the uh the structure at the back of the

139
00:06:16,309 --> 00:06:13,120
hole there it's

140
00:06:17,510 --> 00:06:16,319
maybe 15 centimeters or so

141
00:06:19,990 --> 00:06:17,520
it was present at the front that's

142
00:06:21,510 --> 00:06:20,000
present at the back so it it's at least

143
00:06:23,430 --> 00:06:21,520
that distance

144
00:06:25,749 --> 00:06:23,440
in length

145
00:06:27,350 --> 00:06:25,759
it's not a kind shape at all

146
00:06:28,950 --> 00:06:27,360
a lot of times when you're looking for

147
00:06:32,469 --> 00:06:28,960
something that's related to earth

148
00:06:34,790 --> 00:06:32,479
history i i think of it as being

149
00:06:37,029 --> 00:06:34,800
like i'm a detective and i'm looking for

150
00:06:39,029 --> 00:06:37,039
clues but the thing is that the rocks

151
00:06:41,990 --> 00:06:39,039
that are not very good at preserving

152
00:06:44,390 --> 00:06:42,000
clues and my job as a geologist is to

153
00:06:47,270 --> 00:06:44,400
take those little bits of information

154
00:06:49,589 --> 00:06:47,280
and see if i can make a story about what

155
00:06:51,830 --> 00:06:49,599
happened in the rocks part of making

156
00:06:54,870 --> 00:06:51,840
that story though is understanding the

157
00:06:56,870 --> 00:06:54,880
uncertainty the story is never complete

158
00:06:59,270 --> 00:06:56,880
because you're always missing a lot of

159
00:07:02,550 --> 00:06:59,280
the clues because the clues have just

160
00:07:04,710 --> 00:07:02,560
been lost through time

161
00:07:06,309 --> 00:07:04,720
after investigating the site thoroughly

162
00:07:08,550 --> 00:07:06,319
the team concludes that there is

163
00:07:10,230 --> 00:07:08,560

insufficient evidence of life in these

164
00:07:12,550 --> 00:07:10,240
structures

165
00:07:17,029 --> 00:07:12,560
however there is still much to learn

166
00:07:19,830 --> 00:07:17,039
from the geology in this environment

167
00:07:22,070 --> 00:07:19,840
the rocks that we're looking at here in

168
00:07:24,469 --> 00:07:22,080
greenland are

169
00:07:26,070 --> 00:07:24,479
similar if not identical in age to the

170
00:07:28,469 --> 00:07:26,080
rocks that we're going to be exploring

171
00:07:31,029 --> 00:07:28,479
with the mars 2020 rover we'd like to

172
00:07:33,270 --> 00:07:31,039
think that we can use the

173
00:07:35,749 --> 00:07:33,280
lessons that we take from studying the

174
00:07:37,589 --> 00:07:35,759
earth's geological record and apply them

175
00:07:38,870 --> 00:07:37,599
when we start exploring the geology of

176
00:07:40,309 --> 00:07:38,880
mars

177
00:07:42,870 --> 00:07:40,319
one of the really interesting things

178
00:07:46,869 --> 00:07:42,880
about searching for life on other worlds

179
00:07:49,189 --> 00:07:46,879
is as a scientist i have to actually

180
00:07:50,950 --> 00:07:49,199
when i'm looking for life anywhere i

181
00:07:52,950 --> 00:07:50,960
have to actually have a model of what

182
00:07:55,990 --> 00:07:52,960
i'm looking for to help guide my

183
00:07:57,830 --> 00:07:56,000
observations and so by looking at these

184
00:08:00,390 --> 00:07:57,840
places that are very difficult to

185
00:08:03,029 --> 00:08:00,400
interpret on earth we get that practice

186
00:08:05,430 --> 00:08:03,039
and experience of how do we look at

187
00:08:07,510 --> 00:08:05,440
something and what are the questions

188
00:08:10,550 --> 00:08:07,520

that we need to ask and what are the

189
00:08:14,469 --> 00:08:10,560
observations we need to take to be able

190
00:08:17,510 --> 00:08:14,479
to answer them any claim that is made

191
00:08:18,790 --> 00:08:17,520
about a biosignature on mars is going to

192
00:08:19,990 --> 00:08:18,800
be

193
00:08:23,029 --> 00:08:20,000
debated

194
00:08:25,189 --> 00:08:23,039
so i think that this workshop gives us

195
00:08:27,990 --> 00:08:25,199
an opportunity to

196
00:08:30,629 --> 00:08:28,000
exercise our ability to have civil

197
00:08:32,469 --> 00:08:30,639
disagreements over uh matters of

198
00:08:33,750 --> 00:08:32,479
scientific importance because i think

199
00:08:34,949 --> 00:08:33,760
we're going to be doing

200
00:08:36,389 --> 00:08:34,959
much of that

201
00:08:39,190 --> 00:08:36,399
you know with the data that comes back

202
00:08:40,630 --> 00:08:39,200
from mars as well

203
00:08:42,550 --> 00:08:40,640
i think seeing the rocks in the fish is

204
00:08:45,190 --> 00:08:42,560
just so important you can't do that for

205
00:08:46,470 --> 00:08:45,200
many people so uh i think the next best

206
00:08:48,389 --> 00:08:46,480
thing is to try and recreate that in a

207
00:08:49,990 --> 00:08:48,399
virtual terrain sort of field trip

208
00:08:52,070 --> 00:08:50,000
company that's what we're trying to do

209
00:08:53,350 --> 00:08:52,080
so onsite is an application that we

210
00:08:55,350 --> 00:08:53,360
developed for the mars science

211
00:08:56,710 --> 00:08:55,360
laboratory mission to help the science

212
00:08:57,910 --> 00:08:56,720
team that works with the mars rover

213
00:08:59,910 --> 00:08:57,920

understand the context of the

214
00:09:00,949 --> 00:08:59,920
environment around the rover and it

215
00:09:02,630 --> 00:09:00,959
provides

216
00:09:03,829 --> 00:09:02,640
scientists the ability

217
00:09:06,389 --> 00:09:03,839
to

218
00:09:09,910 --> 00:09:06,399
basically meet on mars so it's taking

219
00:09:11,990 --> 00:09:09,920
martian data down from the the rover and

220
00:09:14,389 --> 00:09:12,000
using photogrammetry to stitch it

221
00:09:17,030 --> 00:09:14,399
together to create a 3d model of the

222
00:09:18,070 --> 00:09:17,040
outcrop and then scientists involved in

223
00:09:20,550 --> 00:09:18,080
the mission

224
00:09:24,070 --> 00:09:20,560
and engineers as well are able to use

225
00:09:25,509 --> 00:09:24,080
that 3d model enter the terrain and make

226
00:09:28,150 --> 00:09:25,519
decisions with a much better

227
00:09:30,470 --> 00:09:28,160
understanding of the context we're also

228
00:09:32,230 --> 00:09:30,480
using lidar imagery out here which is

229
00:09:34,470 --> 00:09:32,240
something not available on on mars so

230
00:09:36,389 --> 00:09:34,480
that's using a laser scanner to

231
00:09:38,389 --> 00:09:36,399
basically three-dimensionally scan

232
00:09:40,310 --> 00:09:38,399
outcrops and get uh

233
00:09:42,790 --> 00:09:40,320
higher fidelity data so that we can get

234
00:09:45,110 --> 00:09:42,800
some very accurate information yeah so

235
00:09:47,030 --> 00:09:45,120
this this is the the map of the primary

236
00:09:49,190 --> 00:09:47,040
outcrops and the laser scans this is the

237
00:09:50,870 --> 00:09:49,200
a outcrop here

238
00:09:52,870 --> 00:09:50,880

this is this this is the there's the

239
00:09:54,389 --> 00:09:52,880
flag there's the cutting block and the

240
00:09:55,670 --> 00:09:54,399
other cuts

241
00:09:57,430 --> 00:09:55,680
now on mars it's it's a different

242
00:09:59,269 --> 00:09:57,440
scenario because we're limited to the

243
00:10:00,790 --> 00:09:59,279
the instruments on board the rover uh

244
00:10:02,710 --> 00:10:00,800
the rover doesn't have lidar it'd be

245
00:10:05,110 --> 00:10:02,720
great if it did so all we have are the

246
00:10:06,870 --> 00:10:05,120
2d images to work with and 3d

247
00:10:08,630 --> 00:10:06,880
reconstruction from 2d images has been

248
00:10:09,910 --> 00:10:08,640
part of the mars missions

249
00:10:13,190 --> 00:10:09,920
all the way back to pathfinder in the

250
00:10:16,310 --> 00:10:13,200
late 90s but it's it's always been on a

251
00:10:18,949 --> 00:10:16,320
per image basis from one rover position

252
00:10:21,509 --> 00:10:18,959
so one of the innovations of

253
00:10:24,069 --> 00:10:21,519
in onsite is we started combining rover

254
00:10:25,750 --> 00:10:24,079
imagery from multiple rover positions so

255
00:10:27,190 --> 00:10:25,760
if the rover's parked next to a rock and

256
00:10:28,710 --> 00:10:27,200
the next day you drive around the rock

257
00:10:30,630 --> 00:10:28,720
you can take imagery from those two

258
00:10:32,790 --> 00:10:30,640
positions and get a more complete model

259
00:10:33,829 --> 00:10:32,800
of that rock than from any one one

260
00:10:34,949 --> 00:10:33,839
position

261
00:10:37,030 --> 00:10:34,959
on its own

262
00:10:38,790 --> 00:10:37,040
and the holy grail of this is to take

263
00:10:40,790 --> 00:10:38,800

all of the rover drives from landing to

264
00:10:43,030 --> 00:10:40,800
the current position register them all

265
00:10:44,550 --> 00:10:43,040
together so you could walk from the

266
00:10:46,389 --> 00:10:44,560
landing site to the current rover

267
00:10:48,710 --> 00:10:46,399
position seeing high quality 3d imagery

268
00:10:51,110 --> 00:10:48,720
all the way so onsite was started in the

269
00:10:53,269 --> 00:10:51,120
context of the mars river missions but

270
00:10:55,750 --> 00:10:53,279
the capability that that onsite and

271
00:10:57,190 --> 00:10:55,760
tools like it provide is really it's a

272
00:10:58,710 --> 00:10:57,200
virtual presence and situational

273
00:11:01,030 --> 00:10:58,720
awareness in an environment that's hard

274
00:11:03,030 --> 00:11:01,040
to visit mars is an extreme example of

275
00:11:05,110 --> 00:11:03,040
that but where we are today and in

276
00:11:06,949 --> 00:11:05,120
western greenland is not quite as hard

277
00:11:09,350 --> 00:11:06,959
to visit as mars but it's certainly not

278
00:11:11,030 --> 00:11:09,360
easy you can imagine geologists going

279
00:11:13,269 --> 00:11:11,040
into the field to these remote locations

280
00:11:15,910 --> 00:11:13,279
and bringing back not only their written

281
00:11:17,910 --> 00:11:15,920
field notes and photos but a 3d capture

282
00:11:20,389 --> 00:11:17,920
of the the environment that becomes kind

283
00:11:21,829 --> 00:11:20,399
of an immersive field notebook that they

284
00:11:23,910 --> 00:11:21,839
can revisit they can share with their

285
00:11:25,110 --> 00:11:23,920
colleagues and with the public and help

286
00:11:27,430 --> 00:11:25,120
to communicate

287
00:11:29,350 --> 00:11:27,440
what that environment is like in a way

288
00:11:31,190 --> 00:11:29,360

that's that's really hard to get without

289
00:11:32,790 --> 00:11:31,200
actually being there in the field so i

290
00:11:35,030 --> 00:11:32,800
don't think this technology ever really

291
00:11:37,110 --> 00:11:35,040
replaces a human in the field

292
00:11:39,430 --> 00:11:37,120
whether or not humans will go to mars is

293
00:11:41,350 --> 00:11:39,440
is uh you know not my expertise

294
00:11:43,350 --> 00:11:41,360
but if and when humans do go to mars

295
00:11:44,870 --> 00:11:43,360
only if the select few will

296
00:11:46,790 --> 00:11:44,880
go to mars but with this kind of

297
00:11:49,430 --> 00:11:46,800
technology they can bring along experts

298
00:11:50,870 --> 00:11:49,440
from earth to extend their knowledge and

299
00:11:52,470 --> 00:11:50,880
share that experience with the public so

300
00:11:53,650 --> 00:11:52,480
the whole world gets to go along you

301
00:11:55,590 --> 00:11:53,660
know for the ride

302
00:11:58,310 --> 00:11:55,600
[Music]

303
00:12:01,590 --> 00:11:58,320
so i've never been here before and the

304
00:12:04,389 --> 00:12:01,600
landscape in this environment is just i

305
00:12:06,310 --> 00:12:04,399
i could see that my mind has been blown

306
00:12:07,350 --> 00:12:06,320
being out here for a couple of days i

307
00:12:10,550 --> 00:12:07,360
mean the

308
00:12:13,670 --> 00:12:10,560
the scale of the glaciers the the the

309
00:12:15,750 --> 00:12:13,680
complete lack of vegetation in this area

310
00:12:18,230 --> 00:12:15,760
uh other than sort of you know lichens

311
00:12:19,990 --> 00:12:18,240
and moss it's just a it's kind of an

312
00:12:22,150 --> 00:12:20,000
otherworldly place

313
00:12:23,990 --> 00:12:22,160

it's really starkly beautiful i think in

314
00:12:26,470 --> 00:12:24,000
terms of why anybody should care about

315
00:12:28,550 --> 00:12:26,480
these rocks i mean they are

316
00:12:29,750 --> 00:12:28,560
they are the record of

317
00:12:33,110 --> 00:12:29,760
some of the

318
00:12:34,550 --> 00:12:33,120
oldest processes occurring on our planet

319
00:12:37,030 --> 00:12:34,560
i mean there are very few places that

320
00:12:39,590 --> 00:12:37,040
preserve rocks this old and so so

321
00:12:42,790 --> 00:12:39,600
they're really uh a precious resource

322
00:12:45,670 --> 00:12:42,800
for geologists to understand what was

323
00:12:48,470 --> 00:12:45,680
going on uh on the earth you know

324
00:12:50,829 --> 00:12:48,480
close to you know in its in its infancy

325
00:12:53,670 --> 00:12:50,839
uh so it's an important and special

326
00:12:56,069 --> 00:12:53,680
place i will gain a huge insight into

327
00:12:59,590 --> 00:12:56,079
these particular rocks but it will also

328
00:13:02,069 --> 00:12:59,600
increase my understanding of of how you

329
00:13:04,069 --> 00:13:02,079
actually demonstrate that something is

330
00:13:06,629 --> 00:13:04,079
or isn't a biosignature that i will

331
00:13:08,629 --> 00:13:06,639
apply in all my other work

332
00:13:10,949 --> 00:13:08,639
it's the ability to

333
00:13:12,629 --> 00:13:10,959
minimize the ambiguity before it even

334
00:13:15,269 --> 00:13:12,639
gets to the publication minimise the

335
00:13:16,629 --> 00:13:15,279
ambiguity and minimise the bias when it

336
00:13:18,150 --> 00:13:16,639
gets out into the press it's going to be

337
00:13:20,230 --> 00:13:18,160
that much more considered that much more

338
00:13:25,810 --> 00:13:20,240

robust i think that's what's the best