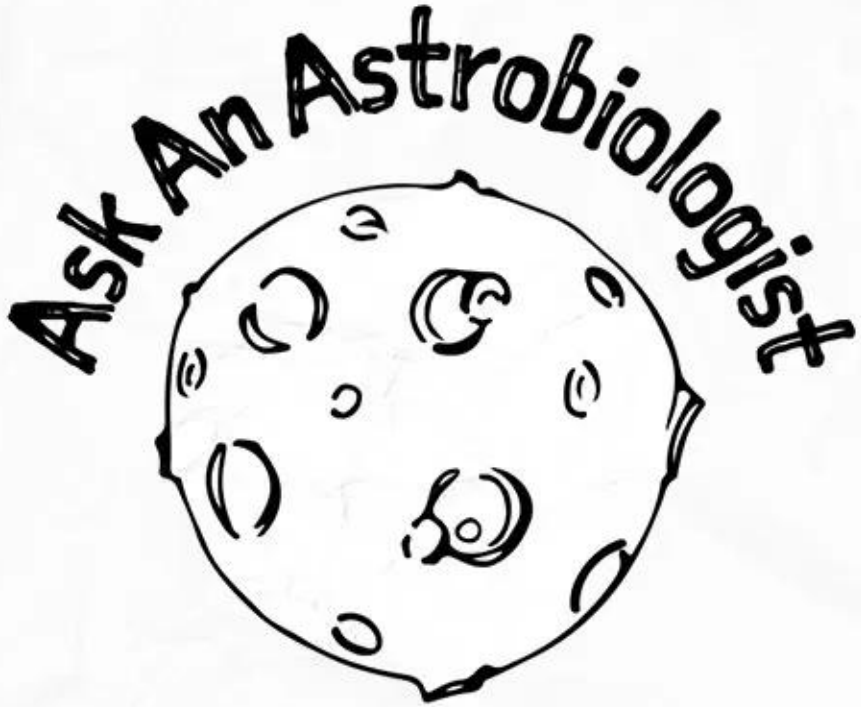

Episode 24: September 24th, 2019

Dr. Bruce Damer

NASA Astrobiology Program

1
00:00:00,690 --> 00:00:29,580
[Music]

2
00:00:34,170 --> 00:00:31,819
greetings to all of our friends of

3
00:00:36,780 --> 00:00:34,180
astrobiology and welcome to ask an

4
00:00:39,260 --> 00:00:36,790
astrobiologist the show that celebrates

5
00:00:41,700 --> 00:00:39,270
the science and the scientists of

6
00:00:44,160 --> 00:00:41,710
astrobiology we're brought to you by

7
00:00:47,340 --> 00:00:44,170
Sagan net org and the NASA Astrobiology

8
00:00:49,860 --> 00:00:47,350
program I'm dr. Graham Lau your co-host

9
00:00:52,350 --> 00:00:49,870
this month normally you see Sanjoy Somme

10
00:00:53,790 --> 00:00:52,360
but now you get me I'm very excited for

11
00:00:56,460 --> 00:00:53,800
today's episode we have a wonderful

12
00:00:58,140 --> 00:00:56,470
guest in house but first we have a few

13
00:01:01,319 --> 00:00:58,150

little things to get through for our

14
00:01:03,270 --> 00:01:01,329
show as usual first off is our

15
00:01:05,369 --> 00:01:03,280
background quiz that we do every single

16
00:01:07,200 --> 00:01:05,379
month you might notice right now behind

17
00:01:09,840 --> 00:01:07,210
me is a pretty cool-looking picture of

18
00:01:11,960 --> 00:01:09,850
some place here on the planet that has

19
00:01:14,250 --> 00:01:11,970
some aster of biological relevancy

20
00:01:15,990 --> 00:01:14,260
relevancy to our search for

21
00:01:17,429 --> 00:01:16,000
extraterrestrial life and the quest to

22
00:01:19,890 --> 00:01:17,439
better understand the nature of life in

23
00:01:21,719 --> 00:01:19,900
the cosmos well last month's picture

24
00:01:23,940 --> 00:01:21,729
that was behind song joy which you're

25
00:01:27,090 --> 00:01:23,950
gonna see now on your screen is a

26
00:01:28,770 --> 00:01:27,100
picture from Turkmenistan and we put

27
00:01:30,990 --> 00:01:28,780
this quiz out for people to answer and

28
00:01:32,850 --> 00:01:31,000
this month we had a winner who is Teja L

29
00:01:34,739 --> 00:01:32,860
Acharya and they apologize when

30
00:01:36,539 --> 00:01:34,749
pronouncing that wrong page well my

31
00:01:38,789 --> 00:01:36,549
pronunciation isn't always the best but

32
00:01:40,230 --> 00:01:38,799
our winner who selected at random from

33
00:01:42,870 --> 00:01:40,240
all of those who have the right answer

34
00:01:45,059 --> 00:01:42,880
gets some of our NASA stickers and some

35
00:01:47,760 --> 00:01:45,069
of the graphic history comic books from

36
00:01:50,399 --> 00:01:47,770
NASA Astrobiology now the cool thing

37
00:01:52,739 --> 00:01:50,409
about that Darwaza gas crater in that

38
00:01:55,559 --> 00:01:52,749

picture is that it's actually not a

39
00:01:57,630 --> 00:01:55,569
natural site this is a site that had a

40
00:02:00,379 --> 00:01:57,640
lot of methane or natural gas coming out

41
00:02:03,120 --> 00:02:00,389
of it back in the late 1960s early 1970s

42
00:02:04,919 --> 00:02:03,130
and some scientists who were working

43
00:02:07,169 --> 00:02:04,929
there some geo scientists wanted to look

44
00:02:09,210 --> 00:02:07,179
for natural gas and happened to have

45
00:02:11,430 --> 00:02:09,220
this crater collapse right below where

46
00:02:13,020 --> 00:02:11,440
they were doing some research well they

47
00:02:14,190 --> 00:02:13,030
saw all this methane coming out and

48
00:02:16,110 --> 00:02:14,200
decided to set it on fire

49
00:02:19,800 --> 00:02:16,120
thinking that would burn the natural gas

50
00:02:21,990 --> 00:02:19,810
away well that was in 1971 we think when

51
00:02:25,020 --> 00:02:22,000
it first was lit and has been burning

52
00:02:26,550 --> 00:02:25,030
continuously since then now so far we

53
00:02:28,980 --> 00:02:26,560
know of one person who's gone down into

54
00:02:30,180 --> 00:02:28,990
the crater to sample for microbes to see

55
00:02:31,949 --> 00:02:30,190
what kind of things are living down

56
00:02:33,780 --> 00:02:31,959
there and this kind of research can be

57
00:02:36,150 --> 00:02:33,790
an important for understanding organisms

58
00:02:38,160 --> 00:02:36,160
that live in not just hot environments

59
00:02:40,610 --> 00:02:38,170
but environments with burning materials

60
00:02:42,650 --> 00:02:40,620
around them and lots of natural gas

61
00:02:44,960 --> 00:02:42,660
so congratulations to tej well for

62
00:02:47,150 --> 00:02:44,970
winning our contest for this month we

63
00:02:49,430 --> 00:02:47,160

also have our ambassador of the month to

64
00:02:52,730 --> 00:02:49,440
announce again and this month is

65
00:02:56,720 --> 00:02:52,740
actually a two-timer so user Astro bio

66
00:02:59,090 --> 00:02:56,730
Kosh or Kashi sheesh naath has won yet

67
00:03:01,550 --> 00:02:59,100
again he tweeted I think five or six

68
00:03:04,370 --> 00:03:01,560
times about our show going into this

69
00:03:05,990 --> 00:03:04,380
month so Kashi thank you very much for

70
00:03:07,940 --> 00:03:06,000
all your support thank you to our

71
00:03:10,220 --> 00:03:07,950
dedicated audience who watch our show

72
00:03:11,570 --> 00:03:10,230
who tune in and ask questions promote us

73
00:03:14,000 --> 00:03:11,580
through Twitter and Facebook and

74
00:03:15,410 --> 00:03:14,010
Instagram and LinkedIn and all over the

75
00:03:18,680 --> 00:03:15,420
interwebs we really really appreciate

76
00:03:20,270 --> 00:03:18,690
that so that's all the fun stuff now we

77
00:03:21,290 --> 00:03:20,280
can actually get to the real meat of our

78
00:03:24,680 --> 00:03:21,300
episode

79
00:03:26,479 --> 00:03:24,690
today's guest is dr. Bruce Damer who's

80
00:03:28,790 --> 00:03:26,489
actually joining me right now from NASA

81
00:03:30,830 --> 00:03:28,800
Astrobiology Institute headquarters at

82
00:03:32,840 --> 00:03:30,840
the NASA Ames Research Center

83
00:03:37,370 --> 00:03:32,850
so dr. Damon hi and welcome to ask an

84
00:03:38,930 --> 00:03:37,380
astrobiologist hello gram that's it's

85
00:03:41,120 --> 00:03:38,940
it's great to have you here I have to

86
00:03:43,760 --> 00:03:41,130
admit and getting ready for today's

87
00:03:46,490 --> 00:03:43,770
episode I listen to episodes of your

88
00:03:47,660 --> 00:03:46,500

podcast levity zone I listen to other

89
00:03:49,430 --> 00:03:47,670
episodes you've been in I've watched

90
00:03:51,979 --> 00:03:49,440
videos and read articles about you and

91
00:03:54,050 --> 00:03:51,989
you've done so many amazing things and

92
00:03:56,690 --> 00:03:54,060
studying the origin of life and using

93
00:03:58,970 --> 00:03:56,700
computers to simulate ideas about how

94
00:04:00,949 --> 00:03:58,980
good life can originate and evolve

95
00:04:04,330 --> 00:04:00,959
you've worked on spacecraft design so

96
00:04:06,590 --> 00:04:04,340
many things but I think for our audience

97
00:04:07,940 --> 00:04:06,600
we should jump back just a little bit

98
00:04:10,520 --> 00:04:07,950
and I just wonder if you could give our

99
00:04:11,780 --> 00:04:10,530
audience a little bit of an idea of who

100
00:04:13,280 --> 00:04:11,790
you are and where you've come from and

101
00:04:19,190 --> 00:04:13,290
what things drove you to become a

102
00:04:21,860 --> 00:04:19,200
scientist I was a rambunctious dreamy

103
00:04:24,830 --> 00:04:21,870
teenager in Canada and Kamloops British

104
00:04:26,719 --> 00:04:24,840
Columbia Canada and when I was 14 I had

105
00:04:28,540 --> 00:04:26,729
a flash inspiration to work on the

106
00:04:30,920 --> 00:04:28,550
origin of life I thought this

107
00:04:31,940 --> 00:04:30,930
self-assembly of molecules like tinker

108
00:04:35,000 --> 00:04:31,950
toy or Meccano

109
00:04:37,969 --> 00:04:35,010
which we all played with was a strange

110
00:04:40,010 --> 00:04:37,979
and interesting problem and so I started

111
00:04:42,200 --> 00:04:40,020
kind of doing thought experiments and I

112
00:04:46,670 --> 00:04:42,210
wrote programs and then I met David

113
00:04:48,800 --> 00:04:46,680

Deamer at UCS UCSC and I had developed a

114
00:04:50,839 --> 00:04:48,810
complete model by that point and then we

115
00:04:51,470 --> 00:04:50,849
placed the model into the chemistry and

116
00:04:55,280 --> 00:04:51,480
then into

117
00:04:57,590 --> 00:04:55,290
geo geological environment and the what

118
00:04:59,660 --> 00:04:57,600
the models working now testing in the

119
00:05:01,570 --> 00:04:59,670
lab and out in the field it's an amazing

120
00:05:04,930 --> 00:05:01,580
thing from a 14-year old all the way to

121
00:05:07,640 --> 00:05:04,940
getting something that actually tests

122
00:05:10,940 --> 00:05:07,650
yeah that's absolutely incredible to

123
00:05:12,320 --> 00:05:10,950
have that that kind of ambition at 14

124
00:05:15,320 --> 00:05:12,330
years old that really kind of drove you

125
00:05:17,120 --> 00:05:15,330
on a career path because you studied

126
00:05:18,800 --> 00:05:17,130
computer science I believe originally

127
00:05:21,740 --> 00:05:18,810
and then eventually came back that's a

128
00:05:23,840 --> 00:05:21,750
first-year PhD is that correct yeah I I

129
00:05:26,300 --> 00:05:23,850
did computer science and it was too soon

130
00:05:29,120 --> 00:05:26,310
literally in 1985 wanted to use

131
00:05:31,730 --> 00:05:29,130
computers to simulate an origin of life

132
00:05:34,850 --> 00:05:31,740
or emergent phenomena with cellular

133
00:05:37,100 --> 00:05:34,860
automata and then I discovered in 1985

134
00:05:38,690 --> 00:05:37,110
it was too soon I was like I was like

135
00:05:41,210 --> 00:05:38,700
back to the future I was like Marty

136
00:05:41,870 --> 00:05:41,220
McFly you know I needed to go into the

137
00:05:44,750 --> 00:05:41,880
future

138
00:05:47,240 --> 00:05:44,760

so 22 years later I finished my PhD in

139
00:05:50,120 --> 00:05:47,250
this very topic which provided the

140
00:05:54,080 --> 00:05:50,130
statistical basis for this new hot

141
00:05:56,570 --> 00:05:54,090
spring origin scenario wow that's

142
00:05:58,010 --> 00:05:56,580
incredible so let's let's talk about the

143
00:05:59,990 --> 00:05:58,020
scenario than this hypothesis that

144
00:06:02,990 --> 00:06:00,000
you've developed with David Deamer at

145
00:06:05,510 --> 00:06:03,000
UCSC so what is the this this new

146
00:06:07,130 --> 00:06:05,520
hypothesis for the origin of life and

147
00:06:09,020 --> 00:06:07,140
why is it's a very strong model you

148
00:06:12,140 --> 00:06:09,030
think for how it might have started

149
00:06:14,870 --> 00:06:12,150
right here on earth well until recently

150
00:06:17,030 --> 00:06:14,880
a lot of science has focused on

151
00:06:20,300 --> 00:06:17,040
hydrothermal vents and the deep in the

152
00:06:22,640 --> 00:06:20,310
oceans as a place where life might start

153
00:06:26,510 --> 00:06:22,650
but it was only a proposal it's never

154
00:06:28,130 --> 00:06:26,520
worked actually in testing ie if you

155
00:06:31,280 --> 00:06:28,140
define an origin of life as the

156
00:06:33,680 --> 00:06:31,290
formation of long enough polymers to

157
00:06:37,040 --> 00:06:33,690
then either fold or serve as data stores

158
00:06:40,340 --> 00:06:37,050
or information and that those polymers

159
00:06:42,020 --> 00:06:40,350
have to be selected in vast numbers to

160
00:06:44,930 --> 00:06:42,030
be able to pull what's called molecular

161
00:06:46,730 --> 00:06:44,940
evolution forward toward life you just

162
00:06:48,350 --> 00:06:46,740
can't do it in the hydrothermal vent in

163
00:06:50,930 --> 00:06:48,360

the ocean because water simply breaks

164
00:06:53,540 --> 00:06:50,940
everything up and you can't form

165
00:06:56,450 --> 00:06:53,550
membranous compartments in that

166
00:06:59,050 --> 00:06:56,460
environment made of lipids whereas

167
00:07:01,490 --> 00:06:59,060
coming from space for example here's a

168
00:07:04,350 --> 00:07:01,500
ground-up powder of the Marie Marie

169
00:07:06,600 --> 00:07:04,360
meteorite which fell on earth

170
00:07:09,300 --> 00:07:06,610
which was the similar to the material

171
00:07:12,330 --> 00:07:09,310
that was falling on earth 4.5 billion

172
00:07:14,749 --> 00:07:12,340
years 4.2 billion years ago and if I

173
00:07:17,640 --> 00:07:14,759
smell it I can smell organic compounds

174
00:07:20,670 --> 00:07:17,650
amino acids in this case polycyclic

175
00:07:22,710 --> 00:07:20,680
aromatic compounds nucleobases fatty

176
00:07:25,770 --> 00:07:22,720
acids the building blocks of membranes

177
00:07:28,589 --> 00:07:25,780
and this material is falling on the land

178
00:07:30,659 --> 00:07:28,599
and if it fell in the ocean would be to

179
00:07:33,300 --> 00:07:30,669
dilute so the falls on land it goes into

180
00:07:36,480 --> 00:07:33,310
little ponds and the little ponds can

181
00:07:40,140 --> 00:07:36,490
concentrate it enough to form the

182
00:07:42,270 --> 00:07:40,150
vesicular protocells and then what Dave

183
00:07:46,020 --> 00:07:42,280
Deemer had discovered is that if those

184
00:07:48,379 --> 00:07:46,030
ponds undergo wet dry cycling with the

185
00:07:50,550 --> 00:07:48,389
filling of hot springs are due or

186
00:07:52,800 --> 00:07:50,560
condensation but basically hot springs

187
00:07:55,920 --> 00:07:52,810
give you that regularity then you can

188
00:07:59,459 --> 00:07:55,930

actually grow polymers the polymers will

189
00:08:02,219 --> 00:07:59,469
form naturally without enzymes in

190
00:08:04,350 --> 00:08:02,229
between layers of the lipid could form a

191
00:08:07,200 --> 00:08:04,360
kind of bathtub ring slurry on the

192
00:08:09,540 --> 00:08:07,210
bottom and so the wet dried cycling that

193
00:08:11,370 --> 00:08:09,550
was featured this is our Scientific

194
00:08:14,670 --> 00:08:11,380
American article from a couple of years

195
00:08:17,969 --> 00:08:14,680
ago it's a cycle that simply goes around

196
00:08:19,890 --> 00:08:17,979
wet and dry wet and dry and through that

197
00:08:23,159 --> 00:08:19,900
you have an engine sort of a Genesis

198
00:08:26,309 --> 00:08:23,169
engine that can pull molecular functions

199
00:08:27,870 --> 00:08:26,319
or polymers to function and then you get

200
00:08:31,290 --> 00:08:27,880
these little things called proto cells

201
00:08:33,269 --> 00:08:31,300
that have increasing functional utility

202
00:08:35,519 --> 00:08:33,279
that make them more robust you get more

203
00:08:37,680 --> 00:08:35,529
of them you get a bigger sludge and that

204
00:08:40,889 --> 00:08:37,690
sludge forms the unit called the Pro

205
00:08:43,139 --> 00:08:40,899
Jeannot t' which is but basically we

206
00:08:47,069 --> 00:08:43,149
proposed the common ancestor of mike all

207
00:08:49,079 --> 00:08:47,079
microbial communities and we're testing

208
00:08:51,420 --> 00:08:49,089
this now in the field in Yellowstone

209
00:08:54,170 --> 00:08:51,430
National Park in Rotorua and New Zealand

210
00:08:58,170 --> 00:08:54,180
forming these protocells from this

211
00:09:01,829 --> 00:08:58,180
prebiotic meteoritic material basically

212
00:09:06,420 --> 00:09:01,839
simulants of it and it's we're growing

213
00:09:09,329 --> 00:09:06,430

very long polymers of RNA hundreds of

214
00:09:12,210 --> 00:09:09,339
bases long and now increasingly other

215
00:09:14,280 --> 00:09:12,220
groups are doing peptides and dep c

216
00:09:16,530 --> 00:09:14,290
peptides and other other polymers you

217
00:09:18,270 --> 00:09:16,540
would need to start life through wet dry

218
00:09:21,750 --> 00:09:18,280
cycling in a surface pool

219
00:09:24,210 --> 00:09:21,760
and that's so incredible I know in the

220
00:09:25,860 --> 00:09:24,220
geological sciences there is some debate

221
00:09:27,660 --> 00:09:25,870
currently about when continents first

222
00:09:31,650 --> 00:09:27,670
formed and when there would have been

223
00:09:32,820 --> 00:09:31,660
dry land mass on the early Earth so for

224
00:09:35,420 --> 00:09:32,830
this model it really does require that

225
00:09:37,800 --> 00:09:35,430
there were continents very very early on

226
00:09:39,000 --> 00:09:37,810
if those continents really were there

227
00:09:41,220 --> 00:09:39,010
where do you think that that material

228
00:09:44,460 --> 00:09:41,230
ended up becoming in our modern world

229
00:09:47,220 --> 00:09:44,470
where are those old rocks have gone well

230
00:09:50,070 --> 00:09:47,230
the interesting thing is if you look at

231
00:09:52,080 --> 00:09:50,080
the post planet formation when the

232
00:09:54,570 --> 00:09:52,090
oceans formed there would have been a

233
00:09:57,450 --> 00:09:54,580
huge amount of cooling of the crust of

234
00:10:00,390 --> 00:09:57,460
the mantle forming basically large

235
00:10:02,580 --> 00:10:00,400
volcanic proto continents so prior to

236
00:10:05,310 --> 00:10:02,590
the existence of plate tectonics or

237
00:10:08,070 --> 00:10:05,320
actual true continents you would have

238
00:10:11,160 --> 00:10:08,080

had a lot of volcanic land masses which

239
00:10:13,830 --> 00:10:11,170
is ideal no similar to say New Zealand

240
00:10:16,290 --> 00:10:13,840
it's ideal for the formation of these

241
00:10:18,870 --> 00:10:16,300
hot spring environments and in fact the

242
00:10:23,070 --> 00:10:18,880
entire Earth was a huge hydrothermal

243
00:10:25,290 --> 00:10:23,080
system with a lot of hot water going

244
00:10:27,690 --> 00:10:25,300
through rock everywhere under the oceans

245
00:10:31,140 --> 00:10:27,700
in these volcanic land masses so there's

246
00:10:33,570 --> 00:10:31,150
copious dry land that we predict would

247
00:10:36,780 --> 00:10:33,580
have been there doot-doot-doot to just

248
00:10:39,150 --> 00:10:36,790
this simple amount of volcanism that's

249
00:10:40,490 --> 00:10:39,160
possible do you think then with this

250
00:10:42,870 --> 00:10:40,500
model that there could have also been

251
00:10:44,850 --> 00:10:42,880
multiple forms of origins kind of

252
00:10:46,170 --> 00:10:44,860
happening in these different places with

253
00:10:48,120 --> 00:10:46,180
each of these cycles of wetting and

254
00:10:49,380 --> 00:10:48,130
drying kind of bringing around these

255
00:10:50,400 --> 00:10:49,390
these probably all these different

256
00:10:51,630 --> 00:10:50,410
protein oh it's that kind of came

257
00:10:53,610 --> 00:10:51,640
together then they're really formed the

258
00:10:56,400 --> 00:10:53,620
first material or do you think it all

259
00:10:59,820 --> 00:10:56,410
will happen in just one place that's a

260
00:11:02,880 --> 00:10:59,830
great question in fact what we think is

261
00:11:04,500 --> 00:11:02,890
just like life today life gets started

262
00:11:07,410 --> 00:11:04,510
in local environments and then can go

263
00:11:09,870 --> 00:11:07,420

extinct but as long as it can distribute

264
00:11:13,950 --> 00:11:09,880
seeds or spores it can distribute itself

265
00:11:16,320 --> 00:11:13,960
it avoids going extinct altogether so

266
00:11:18,360 --> 00:11:16,330
even in the progeny inand this period

267
00:11:20,430 --> 00:11:18,370
we're calling the progeny and where it's

268
00:11:23,040 --> 00:11:20,440
the boot out phase of life that the

269
00:11:25,020 --> 00:11:23,050
proto cellular masses the fact that

270
00:11:27,120 --> 00:11:25,030
they're transportable either being

271
00:11:29,370 --> 00:11:27,130
washing from one pool to the next or

272
00:11:31,140 --> 00:11:29,380
blown as a dry film which is a way

273
00:11:32,240 --> 00:11:31,150
microbial communities still distribute

274
00:11:34,490 --> 00:11:32,250
today

275
00:11:36,050 --> 00:11:34,500
they have a coverage across the

276
00:11:38,900 --> 00:11:36,060
landscape so all the eggs aren't in one

277
00:11:41,300 --> 00:11:38,910
basket and we think that that's the

278
00:11:44,630 --> 00:11:41,310
mechanism for the proto genomic

279
00:11:46,850 --> 00:11:44,640
distribution the incensed the horizontal

280
00:11:48,740 --> 00:11:46,860
gene transfer of all those innovations

281
00:11:52,520 --> 00:11:48,750
across the landscape so that when one

282
00:11:54,440 --> 00:11:52,530
area becomes enviable things go extinct

283
00:11:57,230 --> 00:11:54,450
meaning they're not alive yet they just

284
00:11:59,330 --> 00:11:57,240
simply stop working other pools and

285
00:12:00,860 --> 00:11:59,340
other areas can support the continued

286
00:12:04,540 --> 00:12:00,870
evolutions you have this grid you have a

287
00:12:07,820 --> 00:12:04,550
network effect and that's really cool I

288
00:12:09,200 --> 00:12:07,830

mean this is incredible research and it

289
00:12:11,360 --> 00:12:09,210
feels like we're at a really important

290
00:12:13,700 --> 00:12:11,370
time right now in astrobiology but also

291
00:12:14,900 --> 00:12:13,710
for Humanity where we're learning more

292
00:12:16,520 --> 00:12:14,910
and more about how it might have

293
00:12:17,990 --> 00:12:16,530
actually happened here on earth

294
00:12:20,060 --> 00:12:18,000
and we're also learning more and more

295
00:12:21,950 --> 00:12:20,070
about where else it might have happened

296
00:12:23,710 --> 00:12:21,960
in our solar system or even going beyond

297
00:12:26,720 --> 00:12:23,720
now that we know thousands of exoplanets

298
00:12:28,010 --> 00:12:26,730
I'm wondering if you have any worlds in

299
00:12:29,780 --> 00:12:28,020
our solar system you think are very

300
00:12:31,940 --> 00:12:29,790
likely candidates for life outside of

301
00:12:33,760 --> 00:12:31,950
Earth or other worlds you think are

302
00:12:37,610 --> 00:12:33,770
likely outside of our solar system

303
00:12:40,220 --> 00:12:37,620
primarily we're looking at Mars because

304
00:12:42,050 --> 00:12:40,230
the the amazing thing about Mars is the

305
00:12:45,230 --> 00:12:42,060
Spirit and Opportunity mission the mer

306
00:12:47,630 --> 00:12:45,240
missions spirit driving toward the end

307
00:12:50,120 --> 00:12:47,640
of its mission had a basically one of

308
00:12:52,040 --> 00:12:50,130
its wheels stopped turning and they

309
00:12:53,840 --> 00:12:52,050
actually then use it as a trenching tool

310
00:12:55,430 --> 00:12:53,850
and they trenched into the area at

311
00:12:57,950 --> 00:12:55,440
Columbia Hills that were driving through

312
00:13:00,650 --> 00:12:57,960
turned up a white powder that was

313
00:13:03,530 --> 00:13:00,660

opaline silica so they realized we have

314
00:13:07,280 --> 00:13:03,540
happened upon by accident an old yellow

315
00:13:10,520 --> 00:13:07,290
stone type environment preserved 3.5 3.7

316
00:13:12,620 --> 00:13:10,530
billion years old just as old as the as

317
00:13:15,020 --> 00:13:12,630
the stromatolite environments that we

318
00:13:18,470 --> 00:13:15,030
find these in Australia and Western

319
00:13:21,290 --> 00:13:18,480
Australia and so suddenly they realized

320
00:13:24,110 --> 00:13:21,300
all these rocks around us are maybe

321
00:13:26,030 --> 00:13:24,120
these digitate silicon modules that

322
00:13:28,940 --> 00:13:26,040
might contain evidence for life because

323
00:13:30,440 --> 00:13:28,950
we know that old hot springs hot springs

324
00:13:32,480 --> 00:13:30,450
on earth always have life and they

325
00:13:34,910 --> 00:13:32,490
always preserve evidence for life very

326
00:13:37,250 --> 00:13:34,920
well so we think that Columbia Hills

327
00:13:39,890 --> 00:13:37,260
where Spirit is is a good place for

328
00:13:43,040 --> 00:13:39,900
returning to Mars and doing a sample

329
00:13:45,079 --> 00:13:43,050
return mission on the other hand our

330
00:13:48,049 --> 00:13:45,089
colleagues that are looking at the

331
00:13:51,039 --> 00:13:48,059
coming off of the through the ice sheets

332
00:13:53,809 --> 00:13:51,049
of the ice crust of Enceladus

333
00:13:56,179 --> 00:13:53,819
environments like Titan may not be so

334
00:13:59,209 --> 00:13:56,189
conducive because they don't have

335
00:14:01,489 --> 00:13:59,219
wet/dry cycling in fact the energy

336
00:14:03,829 --> 00:14:01,499
available in the ocean even if there is

337
00:14:06,889 --> 00:14:03,839
a hydrothermal activity the energy flux

338
00:14:10,129 --> 00:14:06,899

is so low in those environments without

339
00:14:12,649 --> 00:14:10,139
access to sunlight and with with the the

340
00:14:13,879 --> 00:14:12,659
coldness and the the limited scale that

341
00:14:16,729 --> 00:14:13,889
there might be hydrothermal activity

342
00:14:21,619 --> 00:14:16,739
that life just can't get started in an

343
00:14:22,999 --> 00:14:21,629
ocean an icy ocean world you know so it

344
00:14:24,619 --> 00:14:23,009
sounds like Mars could then been a good

345
00:14:26,989 --> 00:14:24,629
target especially if life could start in

346
00:14:29,419 --> 00:14:26,999
some of these siliceous sinter kind of

347
00:14:31,339 --> 00:14:29,429
areas I wonder what you think about

348
00:14:33,709 --> 00:14:31,349
Venus then long ago in the early solar

349
00:14:35,839 --> 00:14:33,719
system obviously we don't know right now

350
00:14:39,379 --> 00:14:35,849
what early venus was exactly like but

351
00:14:42,739 --> 00:14:39,389
even last week I think at a VPS meeting

352
00:14:44,749 --> 00:14:42,749
in Europe another paper came out talking

353
00:14:46,849 --> 00:14:44,759
about the potential for Venus being

354
00:14:48,409 --> 00:14:46,859
habitable for life as we know it in its

355
00:14:50,509 --> 00:14:48,419
early history maybe for a long period of

356
00:14:52,549 --> 00:14:50,519
time do you think there could have been

357
00:14:55,099 --> 00:14:52,559
life on Venus especially with this

358
00:14:56,719 --> 00:14:55,109
wedding drawing a cyclical structure in

359
00:14:59,749 --> 00:14:56,729
hydrothermal environments or geothermal

360
00:15:01,189 --> 00:14:59,759
environments long ago well certainly you

361
00:15:03,709 --> 00:15:01,199
know I saw that article too and

362
00:15:05,509 --> 00:15:03,719
certainly there could have and it's a

363
00:15:09,649 --> 00:15:05,519

chilling tale or literally a heating

364
00:15:11,629 --> 00:15:09,659
tale for us that Venus is oceans it was

365
00:15:13,159 --> 00:15:11,639
essentially went out of habitability in

366
00:15:15,799 --> 00:15:13,169
the oceans evaporated into the

367
00:15:18,469 --> 00:15:15,809
atmosphere and then the hydrogen was

368
00:15:21,979 --> 00:15:18,479
stripped off leaving a co2 90 bar

369
00:15:22,999 --> 00:15:21,989
atmosphere if life started on Venus just

370
00:15:25,969 --> 00:15:23,009
as in Mars

371
00:15:28,189 --> 00:15:25,979
if life started there then perhaps the

372
00:15:31,759 --> 00:15:28,199
only place it could could survive is

373
00:15:34,549 --> 00:15:31,769
seeking refuge in the rocks so hot wet

374
00:15:37,099 --> 00:15:34,559
rocks and you know if we do it's

375
00:15:39,649 --> 00:15:37,109
difficult enough to drill in má on Mars

376
00:15:42,739 --> 00:15:39,659
to find evidence of active microbial

377
00:15:44,839 --> 00:15:42,749
activity we see some methane release but

378
00:15:47,869 --> 00:15:44,849
Venus they would have to be surely in

379
00:15:50,239 --> 00:15:47,879
the rocks the chilling part of all this

380
00:15:52,639 --> 00:15:50,249
is that planets don't necessarily

381
00:15:53,449 --> 00:15:52,649
maintain liquid water for four billion

382
00:15:56,029 --> 00:15:53,459
years

383
00:15:58,550 --> 00:15:56,039
it's not a given and in fact it may be a

384
00:16:00,769 --> 00:15:58,560
very rare case and it may be that

385
00:16:03,679 --> 00:16:00,779
just got extremely lucky maybe perhaps

386
00:16:07,009 --> 00:16:03,689
with the moon that we have the exact

387
00:16:09,350 --> 00:16:07,019
size of that moon or some factor kept

388
00:16:12,050 --> 00:16:09,360

liquid water on our surface long enough

389
00:16:14,179 --> 00:16:12,060
for complex life to rise so it is truly

390
00:16:17,569 --> 00:16:14,189
a chilling tale that we may be

391
00:16:19,939 --> 00:16:17,579
extraordinarily rare not for microbial

392
00:16:22,759 --> 00:16:19,949
life to arise but for complex life few

393
00:16:25,699 --> 00:16:22,769
arrives interesting the kind ran through

394
00:16:27,699 --> 00:16:25,709
the rare earth hypothesis from Peter

395
00:16:29,809 --> 00:16:27,709
Ward and Don Brownlee some years back

396
00:16:31,340 --> 00:16:29,819
considering you know all these various

397
00:16:32,720 --> 00:16:31,350
factors that we have to think about with

398
00:16:35,540 --> 00:16:32,730
our earth and our position right now in

399
00:16:37,369 --> 00:16:35,550
the cosmos and how rare all worlds like

400
00:16:39,079 --> 00:16:37,379
ours might be not for life as you

401
00:16:40,819 --> 00:16:39,089
mentioned but for more advanced to life

402
00:16:42,319 --> 00:16:40,829
to form more more intellectual life that

403
00:16:45,139 --> 00:16:42,329
can look back on itself and realize it

404
00:16:46,429 --> 00:16:45,149
it is alive and there's so many cool

405
00:16:48,559 --> 00:16:46,439
things we can keep talking about an

406
00:16:50,449 --> 00:16:48,569
Origin life stuff I do want to jump a

407
00:16:52,790 --> 00:16:50,459
little bit now I know you've had some

408
00:16:56,360 --> 00:16:52,800
background in developing spacecraft and

409
00:16:58,939 --> 00:16:56,370
more recently in working on spacecrafts

410
00:17:00,769 --> 00:16:58,949
for harvesting resources from asteroids

411
00:17:03,199 --> 00:17:00,779
I wonder if you can talk a bit about

412
00:17:04,549 --> 00:17:03,209
that that that work that you've done and

413
00:17:07,189 --> 00:17:04,559

what you think the future holds for

414
00:17:10,159 --> 00:17:07,199
sending spacecraft out to do some of

415
00:17:13,189 --> 00:17:10,169
this work of harvesting resources yeah

416
00:17:15,470 --> 00:17:13,199
it was about six or seven years ago that

417
00:17:18,289 --> 00:17:15,480
NASA had the asteroid redirect program

418
00:17:20,689 --> 00:17:18,299
people may have remembered that our team

419
00:17:23,689 --> 00:17:20,699
Peter Jenniskens and Julie and not

420
00:17:26,090 --> 00:17:23,699
Peters from SETI Institute Julianne's an

421
00:17:28,850 --> 00:17:26,100
independent balloon designer we've came

422
00:17:31,789 --> 00:17:28,860
up with this idea that if you came up to

423
00:17:34,039 --> 00:17:31,799
the asteroid matched its orbit extended

424
00:17:36,409 --> 00:17:34,049
a regular helium balloon structure that

425
00:17:38,750 --> 00:17:36,419
you sealed the end of introduced a

426
00:17:40,970 --> 00:17:38,760
controlling gas it would actually stop

427
00:17:43,279 --> 00:17:40,980
the tumbling of the asteroid and you

428
00:17:45,560 --> 00:17:43,289
would be able to direct it with a flow

429
00:17:48,860 --> 00:17:45,570
of gas and put Delta V which is the

430
00:17:51,049 --> 00:17:48,870
changing of orbit and then drive along

431
00:17:52,820 --> 00:17:51,059
as a coupled unit without touching the

432
00:17:54,500 --> 00:17:52,830
surface you can't touch these object

433
00:17:56,450 --> 00:17:54,510
can't wrap cables around them and mind

434
00:17:58,940 --> 00:17:56,460
them as people have proposed in the past

435
00:18:01,130 --> 00:17:58,950
they're potentially loosely consolidated

436
00:18:03,380 --> 00:18:01,140
rubble piles but then we could literally

437
00:18:06,010 --> 00:18:03,390
move asteroids so we could get to lunar

438
00:18:08,690 --> 00:18:06,020

orbit release one for geological

439
00:18:11,419 --> 00:18:08,700
sampling for people like you would love

440
00:18:14,909 --> 00:18:11,429
to go with a rock hammer and sample it

441
00:18:17,090 --> 00:18:14,919
with a backpack but also then we

442
00:18:19,980 --> 00:18:17,100
realized we could extract volatiles

443
00:18:21,750 --> 00:18:19,990
water would come off and can condense

444
00:18:24,180 --> 00:18:21,760
into tanks and we could turn that into

445
00:18:26,700 --> 00:18:24,190
fueling stations we could also use the

446
00:18:29,250 --> 00:18:26,710
Mond process of electro forming to

447
00:18:31,799 --> 00:18:29,260
extract nickel and iron with an electric

448
00:18:34,260 --> 00:18:31,809
field and plate large object in space to

449
00:18:35,940 --> 00:18:34,270
build these big space habitats that Jeff

450
00:18:38,520 --> 00:18:35,950
Bezos is talking about the O'Neill

451
00:18:41,880 --> 00:18:38,530
colonies and the last thing we could

452
00:18:44,190 --> 00:18:41,890
turn a 50 percent water ice potentially

453
00:18:47,070 --> 00:18:44,200
with carbonaceous asteroid into a

454
00:18:49,500 --> 00:18:47,080
globule that would support a biosphere

455
00:18:51,659 --> 00:18:49,510
to feed people on space so the three of

456
00:18:54,360 --> 00:18:51,669
us realize that this shepherd idea we

457
00:18:56,370 --> 00:18:54,370
call it Shepherd could be the single

458
00:18:58,890 --> 00:18:56,380
technology and effect like a sailing

459
00:19:01,350 --> 00:18:58,900
ship in space a single technology to

460
00:19:03,720 --> 00:19:01,360
open the solar system and do incredible

461
00:19:05,970 --> 00:19:03,730
science that's awesome

462
00:19:07,409 --> 00:19:05,980
and when I was when I was first posting

463
00:19:09,090 --> 00:19:07,419

some stuff to try to get people

464
00:19:11,100 --> 00:19:09,100
interested in this episode I mentioned

465
00:19:13,530 --> 00:19:11,110
spacecraft design and asked some people

466
00:19:15,930 --> 00:19:13,540
what their favorite spacecraft were from

467
00:19:18,210 --> 00:19:15,940
science fiction and from reality and we

468
00:19:21,240 --> 00:19:18,220
had NASA respond back with loving the

469
00:19:24,480 --> 00:19:21,250
SLS the upcoming mission rocket to take

470
00:19:26,070 --> 00:19:24,490
us with Artemis back to the moon there

471
00:19:29,310 --> 00:19:26,080
were some other responses including from

472
00:19:31,799 --> 00:19:29,320
me for instance I love the idea of

473
00:19:34,200 --> 00:19:31,809
organic being ships or ships that are

474
00:19:35,640 --> 00:19:34,210
like slightly organic so for instance

475
00:19:37,669 --> 00:19:35,650
one of my favorite episodes of Star Trek

476
00:19:40,770 --> 00:19:37,679
The Next Generation had a character

477
00:19:44,400 --> 00:19:40,780
named Tom - who himself was a spaceship

478
00:19:46,020 --> 00:19:44,410
and who could interact with his crew and

479
00:19:47,909 --> 00:19:46,030
so I wonder for from your side of it

480
00:19:50,460 --> 00:19:47,919
what are your favorite spacecraft from

481
00:19:54,720 --> 00:19:50,470
science fiction or from reality and why

482
00:19:56,159 --> 00:19:54,730
I really liked Verner von braun's and

483
00:19:58,740 --> 00:19:56,169
Chesley von Estelle's

484
00:20:00,810 --> 00:19:58,750
descriptions in the 1950s in the early

485
00:20:03,930 --> 00:20:00,820
50s which really launched the Space Age

486
00:20:05,700 --> 00:20:03,940
now they have the rotating colony they

487
00:20:09,480 --> 00:20:05,710
design spacesuits they had winged

488
00:20:11,730 --> 00:20:09,490

spacecraft they had gum shaped Landers

489
00:20:14,100 --> 00:20:11,740
they really nailed it right and it's an

490
00:20:17,370 --> 00:20:14,110
amazing thing but what they missed or

491
00:20:19,680 --> 00:20:17,380
fabric were fabric enclosures so my

492
00:20:22,409 --> 00:20:19,690
favorites are of course shepherds of

493
00:20:24,060 --> 00:20:22,419
fabric spacecraft but I liked echo 1 the

494
00:20:25,120 --> 00:20:24,070
first telecommunications satellite in

495
00:20:29,140 --> 00:20:25,130
the 60s

496
00:20:31,320 --> 00:20:29,150
Bigelow's work in the a330 and the Biman

497
00:20:33,880 --> 00:20:31,330
station it's this breathtakingly

498
00:20:36,100 --> 00:20:33,890
interesting work because suddenly you

499
00:20:39,190 --> 00:20:36,110
can launch an entire station on a single

500
00:20:42,310 --> 00:20:39,200
lift and you to go to Mars you have an

501
00:20:44,500 --> 00:20:42,320
envelope a couple of meters with water

502
00:20:46,510 --> 00:20:44,510
that you get from asteroids and you have

503
00:20:49,750 --> 00:20:46,520
the radiation shielding problem solved

504
00:20:52,990 --> 00:20:49,760
and so I think inflatables if they call

505
00:20:54,490 --> 00:20:53,000
them are the future that's awesome yeah

506
00:20:56,230 --> 00:20:54,500
I think a lot of us would love that to

507
00:20:57,730 --> 00:20:56,240
be a future for us to go into low-earth

508
00:21:00,970 --> 00:20:57,740
orbit and just have a chance to see the

509
00:21:02,380 --> 00:21:00,980
Earth from space honestly so before we

510
00:21:04,060 --> 00:21:02,390
open up the questions and just a

511
00:21:05,980 --> 00:21:04,070
reminder for our audience those of you

512
00:21:07,570 --> 00:21:05,990
watching on según net and on the NASA

513
00:21:09,820 --> 00:21:07,580

Astrobiology Facebook you can ask

514
00:21:11,409 --> 00:21:09,830
questions in the chat there you can also

515
00:21:14,110 --> 00:21:11,419
ask us questions on Twitter using

516
00:21:16,000 --> 00:21:14,120
hashtag ask Astro bio and if you're

517
00:21:17,770 --> 00:21:16,010
watching this after the fact on YouTube

518
00:21:19,240 --> 00:21:17,780
feel free to leave some questions on

519
00:21:21,669 --> 00:21:19,250
YouTube as well I come through and I

520
00:21:23,169 --> 00:21:21,679
answer those and if I can I'll also

521
00:21:25,270 --> 00:21:23,179
shoot them along to Bruce and our other

522
00:21:28,149 --> 00:21:25,280
guests who are in the YouTube videos as

523
00:21:30,460 --> 00:21:28,159
well so before we open up the questions

524
00:21:33,640 --> 00:21:30,470
I want to chat a bit then dr. de mer

525
00:21:36,039 --> 00:21:33,650
about your work as a storyteller you've

526
00:21:37,870 --> 00:21:36,049
done a lot in going out to the community

527
00:21:40,659 --> 00:21:37,880
to the public and speaking with people

528
00:21:42,190 --> 00:21:40,669
of various backgrounds about science and

529
00:21:44,529 --> 00:21:42,200
about the origin of life and about your

530
00:21:46,630 --> 00:21:44,539
research and telling poetry and giving

531
00:21:48,310 --> 00:21:46,640
talks at Burning Man and I wonder if you

532
00:21:50,740 --> 00:21:48,320
could just speak to us about what really

533
00:21:53,169 --> 00:21:50,750
resonates for you and makes you feel the

534
00:21:54,060 --> 00:21:53,179
drive to go share your science in that

535
00:21:56,740 --> 00:21:54,070
way

536
00:21:58,930 --> 00:21:56,750
what resonates for me is of course that

537
00:22:01,870 --> 00:21:58,940
the next generation you might call them

538
00:22:03,970 --> 00:22:01,880

Millennials and or I James I people

539
00:22:06,880 --> 00:22:03,980
arbitrarily named generations they are

540
00:22:10,330 --> 00:22:06,890
our future so if they are passionately

541
00:22:13,570 --> 00:22:10,340
excited about science down to their core

542
00:22:16,299 --> 00:22:13,580
like I was when I was 14 I think almost

543
00:22:21,130 --> 00:22:16,309
as a spiritual quest not just sort of a

544
00:22:23,289 --> 00:22:21,140
career choice that I was completely to

545
00:22:25,720 --> 00:22:23,299
me science isn't the most amazing story

546
00:22:28,270 --> 00:22:25,730
that humans have ever told that we're

547
00:22:30,460 --> 00:22:28,280
unfolding the story of truth the story

548
00:22:33,280 --> 00:22:30,470
of measurable and testable reality and

549
00:22:34,990 --> 00:22:33,290
that the cosmos and the the birth of

550
00:22:38,649 --> 00:22:35,000
complex life on Earth is the most

551
00:22:42,599 --> 00:22:38,659
awe-inspiring line

552
00:22:45,549 --> 00:22:42,609
lowing story that's ever occurred and so

553
00:22:47,619 --> 00:22:45,559
taking young people back into that

554
00:22:49,899 --> 00:22:47,629
progeny in period back to that period

555
00:22:52,799 --> 00:22:49,909
where you have fragile protocells that

556
00:22:56,680 --> 00:22:52,809
don't have a ribosome that don't have a

557
00:22:58,359 --> 00:22:56,690
nucleus that have bare-bones metabolic

558
00:23:01,960 --> 00:22:58,369
processes and you put them into that

559
00:23:04,960 --> 00:23:01,970
suit you say these little fellows are

560
00:23:08,259 --> 00:23:04,970
the ones that carried us all the way to

561
00:23:10,509 --> 00:23:08,269
complex life and watching how quickly

562
00:23:13,719 --> 00:23:10,519
they fail it's almost an emotional

563
00:23:17,499 --> 00:23:13,729

connection with that world of my gosh

564
00:23:19,989 --> 00:23:17,509
this is how improbable we are this is

565
00:23:22,419 --> 00:23:19,999
the process where it started passively

566
00:23:25,450 --> 00:23:22,429
and then it became active and the

567
00:23:28,239 --> 00:23:25,460
mind-blowing this of how an earth did

568
00:23:30,549 --> 00:23:28,249
this happen but it did and we are here

569
00:23:32,919 --> 00:23:30,559
and were the beneficiaries of that for

570
00:23:35,799 --> 00:23:32,929
me that's a spiritual quest and so if I

571
00:23:37,960 --> 00:23:35,809
can bring that to audiences like at

572
00:23:40,570 --> 00:23:37,970
Burning Man or the festival's everyone's

573
00:23:43,089 --> 00:23:40,580
dressed up on a funny outfit we've got

574
00:23:45,369 --> 00:23:43,099
live painting of artists like Android

575
00:23:47,320 --> 00:23:45,379
Jones going where we're reaching them

576
00:23:48,969 --> 00:23:47,330
and the medium that they care about it

577
00:23:51,729 --> 00:23:48,979
it's the most powerful storytelling

578
00:23:55,229 --> 00:23:51,739
medium for science that we think that we

579
00:23:58,419 --> 00:23:55,239
can create for this next generation and

580
00:24:00,879 --> 00:23:58,429
then they get excited they join master

581
00:24:03,219 --> 00:24:00,889
biology groups once one of the young

582
00:24:06,339 --> 00:24:03,229
people and vessel joined our lab and did

583
00:24:08,019 --> 00:24:06,349
fundamentally important work they just

584
00:24:10,810 --> 00:24:08,029
get excited so they don't get led astray

585
00:24:12,820 --> 00:24:10,820
by flat earths and things like this

586
00:24:16,599 --> 00:24:12,830
which are a little dangerous to our

587
00:24:18,789 --> 00:24:16,609
society you know we we we risk losing

588
00:24:21,389 --> 00:24:18,799

science we list screws losing all this

589
00:24:24,369 --> 00:24:21,399
progress if people can't discern between

590
00:24:28,180 --> 00:24:24,379
made up stuff and conspiracy theories

591
00:24:30,879 --> 00:24:28,190
and this quest for truth and I think

592
00:24:33,399 --> 00:24:30,889
they get that but you have to put that

593
00:24:35,649 --> 00:24:33,409
out in front of them say this is this is

594
00:24:38,889 --> 00:24:35,659
why this is the most exciting story and

595
00:24:39,580 --> 00:24:38,899
thing to work on that we know of that's

596
00:24:41,249 --> 00:24:39,590
incredible

597
00:24:43,629 --> 00:24:41,259
I really inspires me just hearing that

598
00:24:45,369 --> 00:24:43,639
as a scientist and science communicator

599
00:24:47,469 --> 00:24:45,379
myself and I think I was one of those

600
00:24:49,029 --> 00:24:47,479
young people who was impressionable and

601
00:24:50,229 --> 00:24:49,039
loved hearing these tales from people

602
00:24:52,240 --> 00:24:50,239
who she cared to share them so that's

603
00:24:53,710 --> 00:24:52,250
that's wonderful

604
00:24:55,090 --> 00:24:53,720
one more thing before you open it up to

605
00:24:59,740 --> 00:24:55,100
the to the audience questions I promise

606
00:25:01,270 --> 00:24:59,750
I get there soon so Google and the SETI

607
00:25:02,560 --> 00:25:01,280
Institute have worked with NASA with the

608
00:25:04,690 --> 00:25:02,570
frontier development lab something

609
00:25:05,830 --> 00:25:04,700
called FDL I know you've spoken there

610
00:25:07,660 --> 00:25:05,840
before

611
00:25:09,460 --> 00:25:07,670
about the future of artificial

612
00:25:11,950 --> 00:25:09,470
intelligence of machine learning and

613
00:25:13,570 --> 00:25:11,960

we're computing will take us I wonder if

614
00:25:16,060 --> 00:25:13,580
you can speak it just a little bit about

615
00:25:18,610 --> 00:25:16,070
the future of astrobiology maybe even

616
00:25:20,230 --> 00:25:18,620
the future of science right now through

617
00:25:21,700 --> 00:25:20,240
artificial intelligence through machine

618
00:25:24,520 --> 00:25:21,710
learning and what you see coming down

619
00:25:26,920 --> 00:25:24,530
them down the pipeline here I think that

620
00:25:29,050 --> 00:25:26,930
AI and machine learning are the greatest

621
00:25:30,910 --> 00:25:29,060
tools we have for this century from

622
00:25:33,190 --> 00:25:30,920
everything from telemedicine to

623
00:25:35,710 --> 00:25:33,200
self-driving cars to figure out

624
00:25:38,800 --> 00:25:35,720
solutions for climate change shocks that

625
00:25:42,010 --> 00:25:38,810
are coming and after my presentation at

626
00:25:43,960 --> 00:25:42,020
FDL where I showed our origin model but

627
00:25:46,180 --> 00:25:43,970
when you abstract the origin model it

628
00:25:49,300 --> 00:25:46,190
comes out as three parts probability

629
00:25:51,520 --> 00:25:49,310
shaping interconnection or interactivity

630
00:25:53,830 --> 00:25:51,530
and memory writing and reading we just

631
00:25:55,690 --> 00:25:53,840
abstracted our chemistry of protocells

632
00:25:57,910 --> 00:25:55,700
to those three things and then it

633
00:25:59,800 --> 00:25:57,920
suddenly occurred to me one night that

634
00:26:01,600 --> 00:25:59,810
could be the general principle of

635
00:26:05,260 --> 00:26:01,610
emergent systems which is what I've been

636
00:26:07,210 --> 00:26:05,270
after since I was a teenager and so the

637
00:26:09,730 --> 00:26:07,220
fellow from Google put his hand up and

638
00:26:11,770 --> 00:26:09,740

said dad is fascinating we want to be

639
00:26:14,350 --> 00:26:11,780
involved so we've been having meetings

640
00:26:17,920 --> 00:26:14,360
with them about how to ingest

641
00:26:20,650 --> 00:26:17,930
or inject biology and genes and

642
00:26:23,140 --> 00:26:20,660
evolution into AI itself because right

643
00:26:24,760 --> 00:26:23,150
now yeah is just a great big neural nets

644
00:26:27,640 --> 00:26:24,770
that you have to train and train and

645
00:26:29,740 --> 00:26:27,650
train manually what if it could evolve

646
00:26:31,870 --> 00:26:29,750
and learn on its own through genetics

647
00:26:33,850 --> 00:26:31,880
and through the principles of life so

648
00:26:36,520 --> 00:26:33,860
urgent that we could have a truly

649
00:26:39,700 --> 00:26:36,530
powerful new generation of AI for the

650
00:26:41,890 --> 00:26:39,710
tools that we need in this century yeah

651
00:26:44,380 --> 00:26:41,900
that's awesome so we both open up to our

652
00:26:46,570 --> 00:26:44,390
to our audience now once again sagging

653
00:26:48,070 --> 00:26:46,580
net NASA Astrobiology Facebook please

654
00:26:50,530 --> 00:26:48,080
ask us questions we'll get them into the

655
00:26:52,150 --> 00:26:50,540
queue here for dr. de mer if you're

656
00:26:55,270 --> 00:26:52,160
using Twitter feel free to hit us with

657
00:26:57,160 --> 00:26:55,280
hashtag ask Astor bio our first question

658
00:27:01,060 --> 00:26:57,170
actually comes from one of our longtime

659
00:27:02,020 --> 00:27:01,070
fans of the show Maryanne Denton Mary

660
00:27:03,400 --> 00:27:02,030
Ann asks

661
00:27:06,610 --> 00:27:03,410
and she has a term here they absolutely

662
00:27:09,190 --> 00:27:06,620
love she says if the wet-dry in warm

663
00:27:11,410 --> 00:27:09,200

little ponds hypothesis is necessary for

664
00:27:14,980 --> 00:27:11,420
the development of polymers or as she

665
00:27:16,690 --> 00:27:14,990
phrases it life's Legos is it possible

666
00:27:18,310 --> 00:27:16,700
that those long-chain molecules could

667
00:27:21,070 --> 00:27:18,320
have migrated via weathering or

668
00:27:24,520 --> 00:27:21,080
volcanism to to hydrothermal vents in

669
00:27:26,560 --> 00:27:24,530
the ocean for finishing so and then her

670
00:27:28,480 --> 00:27:26,570
real question here is does it have to be

671
00:27:31,480 --> 00:27:28,490
one or the other could it be some

672
00:27:33,310 --> 00:27:31,490
mixture of both we've had a lot of

673
00:27:35,020 --> 00:27:33,320
conversations with our colleagues on

674
00:27:37,000 --> 00:27:35,030
this including the late the latest

675
00:27:40,420 --> 00:27:37,010
astrobiology science conference in

676
00:27:43,450 --> 00:27:40,430
Washington and we've really determined

677
00:27:46,390 --> 00:27:43,460
that it is one or the other if you have

678
00:27:48,310 --> 00:27:46,400
a polymer that ends up in a liquid

679
00:27:49,810 --> 00:27:48,320
environment like an ocean environment

680
00:27:51,910 --> 00:27:49,820
it's going to breakdown due to high

681
00:27:54,610 --> 00:27:51,920
light hydrolytic degradation pretty

682
00:27:57,880 --> 00:27:54,620
quickly so you really have to have

683
00:27:59,830 --> 00:27:57,890
access to surficial environments and the

684
00:28:02,830 --> 00:27:59,840
atmosphere to make this the chemistry

685
00:28:07,210 --> 00:28:02,840
work so in the oceans you have just a

686
00:28:10,450 --> 00:28:07,220
mineral interface with rock and a water

687
00:28:15,340 --> 00:28:10,460
interface on the surface you have the

688
00:28:17,950 --> 00:28:15,350

mineral water mineral air air water it's

689
00:28:20,490 --> 00:28:17,960
just that much more complex and rich and

690
00:28:23,980 --> 00:28:20,500
environment and you have many more ph's

691
00:28:26,230 --> 00:28:23,990
Rock weathering products and access to

692
00:28:29,530 --> 00:28:26,240
that important exogenous meteoritic

693
00:28:31,270 --> 00:28:29,540
material so the difference between the

694
00:28:33,910 --> 00:28:31,280
surficial environment and the oceanic

695
00:28:36,810 --> 00:28:33,920
environment is profound there really are

696
00:28:39,400 --> 00:28:36,820
two regimes so what we think is that as

697
00:28:41,350 --> 00:28:39,410
protocells became living cells and

698
00:28:43,450 --> 00:28:41,360
living microbial communities those

699
00:28:46,390 --> 00:28:43,460
communities would adapt to salty ocean

700
00:28:48,940 --> 00:28:46,400
water later down in the estuaries it

701
00:28:52,060 --> 00:28:48,950
would flow downhill and have to develop

702
00:28:55,330 --> 00:28:52,070
the active pores to equilibrate all that

703
00:28:59,050 --> 00:28:55,340
salt out of the cells which cells do

704
00:29:00,670 --> 00:28:59,060
today and then only many many maybe

705
00:29:02,800 --> 00:29:00,680
hundreds of millions of years later

706
00:29:04,980 --> 00:29:02,810
after adapting to the marine shoreline

707
00:29:08,230 --> 00:29:04,990
you may find extremophiles organisms

708
00:29:10,540 --> 00:29:08,240
adapting to hydrothermal vents in the

709
00:29:12,880 --> 00:29:10,550
submarine environment which are truly

710
00:29:16,190 --> 00:29:12,890
extreme environments so that's that's

711
00:29:18,149 --> 00:29:16,200
the path that we believe life took

712
00:29:19,919 --> 00:29:18,159
interesting yes so starting on land then

713
00:29:21,990 --> 00:29:19,929

kind of spreading out to these tidal

714
00:29:23,460 --> 00:29:22,000
zones then down into the oceans and then

715
00:29:27,269 --> 00:29:23,470
evolving later to come back up around

716
00:29:28,529 --> 00:29:27,279
again right that's really intriguing our

717
00:29:30,060 --> 00:29:28,539
next question I actually own a preface

718
00:29:31,980 --> 00:29:30,070
first I heard you speaking to Michael

719
00:29:34,440 --> 00:29:31,990
Phillip in a podcast from some years ago

720
00:29:36,450 --> 00:29:34,450
and I heard you mentioned in the podcast

721
00:29:39,720 --> 00:29:36,460
that you don't really buy into the ideas

722
00:29:41,399 --> 00:29:39,730
of the technological singularity and

723
00:29:43,049 --> 00:29:41,409
technological dystopias and some of

724
00:29:47,129 --> 00:29:43,059
these ideas from cyberpunk the kind of

725
00:29:50,519 --> 00:29:47,139
are in our culture now so Jean Griffith

726
00:29:52,799 --> 00:29:50,529
on Sagan net wants to know which of the

727
00:29:54,750 --> 00:29:52,809
great filters you think might most be

728
00:29:57,690 --> 00:29:54,760
likely to stop intelligent life from

729
00:30:00,509 --> 00:29:57,700
being everywhere and if it could be that

730
00:30:03,330 --> 00:30:00,519
the power of an individual or our

731
00:30:05,700 --> 00:30:03,340
technology really could be really what

732
00:30:09,210 --> 00:30:05,710
drives the the end of a civilization

733
00:30:11,190 --> 00:30:09,220
I think the filter you know that fit

734
00:30:14,039 --> 00:30:11,200
that because the filter theory there's

735
00:30:16,860 --> 00:30:14,049
so many that that prevent intelligent

736
00:30:17,700 --> 00:30:16,870
life one of them being which is crazy to

737
00:30:21,210 --> 00:30:17,710
think about it

738
00:30:23,909 --> 00:30:21,220

according to primate biologists apes

739
00:30:25,950 --> 00:30:23,919
you know primates were going extinct at

740
00:30:28,769 --> 00:30:25,960
the time when Africa split down the

741
00:30:29,850 --> 00:30:28,779
middle and put our ancestors into the

742
00:30:32,190 --> 00:30:29,860
dry savanna

743
00:30:36,120 --> 00:30:32,200
so apes were going extinct because

744
00:30:37,620 --> 00:30:36,130
monkeys were much better foragers even

745
00:30:40,080 --> 00:30:37,630
though they had smaller brains but they

746
00:30:42,480 --> 00:30:40,090
worked as a communal unit and so our

747
00:30:44,639 --> 00:30:42,490
ancestors were going out anyway and

748
00:30:47,639 --> 00:30:44,649
probably wouldn't have survived so the

749
00:30:49,289 --> 00:30:47,649
big brain thing that apes had wasn't a

750
00:30:52,230 --> 00:30:49,299
selective advantage in the end

751
00:30:55,049 --> 00:30:52,240
potentially but we were just cast out of

752
00:30:57,299 --> 00:30:55,059
Eden into this drying savanna on that

753
00:30:59,310 --> 00:30:57,309
the monkeys weren't there and that we

754
00:31:01,649 --> 00:30:59,320
had to adapt quickly and in the sense we

755
00:31:03,000 --> 00:31:01,659
are creatures of climate change one of

756
00:31:05,549 --> 00:31:03,010
the things that occurred to me last week

757
00:31:08,220 --> 00:31:05,559
is that as these climate change shocks

758
00:31:10,500 --> 00:31:08,230
are coming we were made by climate

759
00:31:12,899 --> 00:31:10,510
change if you look throughout the

760
00:31:14,909 --> 00:31:12,909
evolution when humans walked out of

761
00:31:17,190 --> 00:31:14,919
Africa they walk straight into advancing

762
00:31:20,759 --> 00:31:17,200
glaciers in Europe and Asia

763
00:31:24,930 --> 00:31:20,769

so we perhaps are evolved by climate

764
00:31:27,419 --> 00:31:24,940
shocks so we may be pre adapted to deal

765
00:31:29,230 --> 00:31:27,429
with this global climate change shocks

766
00:31:32,190 --> 00:31:29,240
that may be coming but

767
00:31:35,680 --> 00:31:32,200
the second part of the the question was

768
00:31:38,049 --> 00:31:35,690
how do we go forward I think we have to

769
00:31:40,720 --> 00:31:38,059
go forward by the same way that life

770
00:31:43,570 --> 00:31:40,730
rose we have to link together into

771
00:31:46,180 --> 00:31:43,580
strong community again we can't allow

772
00:31:50,260 --> 00:31:46,190
ourselves to be isolated and separated

773
00:31:52,750 --> 00:31:50,270
by our own processes and dialogue it's

774
00:31:56,470 --> 00:31:52,760
really together we will get through this

775
00:31:59,230 --> 00:31:56,480
thing so we can't afford this sort of

776
00:32:01,690 --> 00:31:59,240
stories of anxiety and separation we

777
00:32:04,990 --> 00:32:01,700
have to be very positive very gear heady

778
00:32:07,480 --> 00:32:05,000
and go ahead and build our solutions for

779
00:32:11,470 --> 00:32:07,490
the future as a community as a global

780
00:32:13,180 --> 00:32:11,480
community that's really incredible it's

781
00:32:15,250 --> 00:32:13,190
weird to think of us as you know being

782
00:32:16,330 --> 00:32:15,260
driven by it by climate change to

783
00:32:19,090 --> 00:32:16,340
actually be able to adapt to climate

784
00:32:21,310 --> 00:32:19,100
change very quickly and we are certainly

785
00:32:22,870 --> 00:32:21,320
now children of the Anthropocene so it's

786
00:32:24,039 --> 00:32:22,880
interesting to think about what a global

787
00:32:25,919 --> 00:32:24,049
consciousness what a global awareness

788
00:32:28,899 --> 00:32:25,929

could really do for us moving forward

789
00:32:31,240 --> 00:32:28,909
our next question comes from to us from

790
00:32:34,090 --> 00:32:31,250
Twitter from our ambassador of the month

791
00:32:36,970 --> 00:32:34,100
Kosh sheesh as asked the question he's

792
00:32:38,500 --> 00:32:36,980
asked according to theories of Mars and

793
00:32:41,320 --> 00:32:38,510
earth formed pretty much around the same

794
00:32:44,560 --> 00:32:41,330
time and if it's true that Mars has

795
00:32:45,820 --> 00:32:44,570
fossil life on it from back then what

796
00:32:48,549 --> 00:32:45,830
could have made the life on Mars

797
00:32:52,870 --> 00:32:48,559
developed so fast and then also end so

798
00:32:54,880 --> 00:32:52,880
fast so if Mars had similar conditions

799
00:32:58,000 --> 00:32:54,890
in the noachian period into the HISP

800
00:33:00,669 --> 00:32:58,010
Irian period where it had oceans shallow

801
00:33:02,830 --> 00:33:00,679
seas but it had precipitation and

802
00:33:04,750 --> 00:33:02,840
hydrological cycling it would have had a

803
00:33:07,899 --> 00:33:04,760
lot of hot springs as well because it

804
00:33:10,330 --> 00:33:07,909
had volcanic activity but unfortunately

805
00:33:12,789 --> 00:33:10,340
for Mars it did not have a big enough

806
00:33:14,649 --> 00:33:12,799
protective magnetic field so the

807
00:33:17,980 --> 00:33:14,659
atmosphere got stripped away rather

808
00:33:20,529 --> 00:33:17,990
quickly our colleagues at SETI think

809
00:33:22,810 --> 00:33:20,539
that maybe Mars was out of habitability

810
00:33:25,149 --> 00:33:22,820
of the surface by 400 million years into

811
00:33:27,159 --> 00:33:25,159
its history others say about by a

812
00:33:30,970 --> 00:33:27,169
billion years but certainly surface

813
00:33:32,740 --> 00:33:30,980

habitability was lost so that's actually

814
00:33:35,440 --> 00:33:32,750
another argument for it it's not a good

815
00:33:37,930 --> 00:33:35,450
idea try to settle Mars because it it's

816
00:33:42,159 --> 00:33:37,940
definitely a sterilizing sink

817
00:33:42,880 --> 00:33:42,169
environment but life if it started there

818
00:33:45,250 --> 00:33:42,890
could have

819
00:33:47,440 --> 00:33:45,260
started rapidly we just don't know that

820
00:33:49,360 --> 00:33:47,450
that's sort of an inference that now

821
00:33:51,370 --> 00:33:49,370
that we know that hydrothermal pools can

822
00:33:53,200 --> 00:33:51,380
cycle systems and that polymers have to

823
00:33:55,270 --> 00:33:53,210
grow at a certain rate and be

824
00:33:57,940 --> 00:33:55,280
resynthesized at a certain rate to stay

825
00:34:00,340 --> 00:33:57,950
in that kinetic trap that we we could

826
00:34:02,980 --> 00:34:00,350
say well then life must start quickly

827
00:34:05,230 --> 00:34:02,990
however that's an assumption it may be

828
00:34:06,820 --> 00:34:05,240
that there was many starts and failures

829
00:34:10,030 --> 00:34:06,830
of the system before it found a

830
00:34:12,639 --> 00:34:10,040
combinatorial way through to robust safe

831
00:34:17,110 --> 00:34:12,649
phototrophic cells that were finally

832
00:34:18,940 --> 00:34:17,120
more autonomous so lice start may not

833
00:34:20,950 --> 00:34:18,950
have been quickly in it and it may not

834
00:34:23,320 --> 00:34:20,960
have been quick rather and it may be

835
00:34:25,360 --> 00:34:23,330
that to get to robust life to the life

836
00:34:28,090 --> 00:34:25,370
that uses ribosomal translate

837
00:34:31,540 --> 00:34:28,100
translational machinery that may be a

838
00:34:34,149 --> 00:34:31,550

very circuitous path so is the life on

839
00:34:37,120 --> 00:34:34,159
Mars robust enough to use sunlight to

840
00:34:40,360 --> 00:34:37,130
leave stromatolites to leave a fossil

841
00:34:43,480 --> 00:34:40,370
record may perhaps not we just don't

842
00:34:47,409 --> 00:34:43,490
know that this is a great area for

843
00:34:48,639 --> 00:34:47,419
thought experiments that's awesome yeah

844
00:34:49,899 --> 00:34:48,649
it also seems a great reason to keep

845
00:34:50,980 --> 00:34:49,909
going back and keep searching the

846
00:34:54,580 --> 00:34:50,990
profile for some of these potential

847
00:34:56,460 --> 00:34:54,590
signs of past life with new robots and I

848
00:34:59,230 --> 00:34:56,470
guess I'm with my own question out then

849
00:35:00,550 --> 00:34:59,240
so you did mention with Gusev maybe

850
00:35:02,500 --> 00:35:00,560
sending a mission back there for a quick

851
00:35:04,330 --> 00:35:02,510
sample return or sorry Columbia Hills

852
00:35:07,360 --> 00:35:04,340
and bringing some material that material

853
00:35:09,990 --> 00:35:07,370
back if you had the ability with no

854
00:35:12,220 --> 00:35:10,000
budget limit to send a mission to Mars

855
00:35:15,580 --> 00:35:12,230
where would you send it what would do

856
00:35:18,520 --> 00:35:15,590
and why is that important well the

857
00:35:21,270 --> 00:35:18,530
amazing thing sometimes nature throws

858
00:35:25,270 --> 00:35:21,280
you a ringer it's row that throws you a

859
00:35:27,670 --> 00:35:25,280
wonderful chance and with spirit coming

860
00:35:30,190 --> 00:35:27,680
into Columbia Hills at the end of its

861
00:35:33,340 --> 00:35:30,200
mission up to the home plate formation

862
00:35:36,070 --> 00:35:33,350
then finishing the mission there what it

863
00:35:37,990 --> 00:35:36,080

imaged were these little digitate rocks

864
00:35:40,390 --> 00:35:38,000
these silicon nodules all over the

865
00:35:43,480 --> 00:35:40,400
surface plus the outcrop plus the

866
00:35:46,240 --> 00:35:43,490
opaline silica that was trenched up to

867
00:35:48,640 --> 00:35:46,250
get some of those nodules they look like

868
00:35:51,250 --> 00:35:48,650
the nodules that the maori call and

869
00:35:56,740 --> 00:35:51,260
coral in new zealand they look like the

870
00:35:58,930 --> 00:35:56,750
the structures in el tatio in chile so

871
00:36:01,390 --> 00:35:58,940
to actually return those just on their

872
00:36:05,950 --> 00:36:01,400
own would be of huge astrobiological

873
00:36:07,360 --> 00:36:05,960
value awesome yeah it seems that we have

874
00:36:08,920 --> 00:36:07,370
so many good reasons to code to go back

875
00:36:12,460 --> 00:36:08,930
and take more samples but also to do

876
00:36:13,900 --> 00:36:12,470
sample return at some point soon our

877
00:36:17,500 --> 00:36:13,910
next question comes to us from another

878
00:36:19,210 --> 00:36:17,510
long-term fan of the show dr. Jim Paz is

879
00:36:22,230 --> 00:36:19,220
the president of the Astro sociology

880
00:36:25,330 --> 00:36:22,240
Research Institute he's asked on Twitter

881
00:36:26,710 --> 00:36:25,340
what social and cultural impacts does

882
00:36:30,100 --> 00:36:26,720
the search for extraterrestrial life

883
00:36:31,600 --> 00:36:30,110
produce here on earth even though we

884
00:36:33,310 --> 00:36:31,610
really haven't located yet any

885
00:36:36,490 --> 00:36:33,320
definitive proof that there is excess

886
00:36:38,410 --> 00:36:36,500
rest real life you know that's a gym

887
00:36:40,270 --> 00:36:38,420
that's a really good question and I I

888
00:36:42,730 --> 00:36:40,280

know you were just recently out in the

889
00:36:44,950 --> 00:36:42,740
Pilbara and Western Australia and I hope

890
00:36:49,480 --> 00:36:44,960
you were able to bring some of this

891
00:36:52,390 --> 00:36:49,490
stromatolite home for your desk but it

892
00:36:55,900 --> 00:36:52,400
has the search for a life has a huge

893
00:36:59,770 --> 00:36:55,910
impact I think on our species for

894
00:37:01,930 --> 00:36:59,780
example what if and if we if we can't

895
00:37:04,630 --> 00:37:01,940
find evidence for like life outside the

896
00:37:07,480 --> 00:37:04,640
earth but we can do something secondary

897
00:37:09,670 --> 00:37:07,490
we can set up science such that we can

898
00:37:12,190 --> 00:37:09,680
see the first projet notes in the

899
00:37:14,530 --> 00:37:12,200
laboratory they're undergoing the first

900
00:37:17,050 --> 00:37:14,540
evolutionary steps toward life not

901
00:37:19,240 --> 00:37:17,060
anywhere close to life but we see pores

902
00:37:21,340 --> 00:37:19,250
and metabolic functions and stabilizing

903
00:37:24,250 --> 00:37:21,350
polymers be selected in molecular

904
00:37:27,460 --> 00:37:24,260
evolution and the mass of progeny grows

905
00:37:29,590 --> 00:37:27,470
in size we hit it with some kind of a

906
00:37:31,930 --> 00:37:29,600
stress it shrinks and crashes and then

907
00:37:34,510 --> 00:37:31,940
grows again and that'll be the Turing

908
00:37:36,730 --> 00:37:34,520
test or whether something is going

909
00:37:39,130 --> 00:37:36,740
toward the living world and I think the

910
00:37:40,900 --> 00:37:39,140
images of that happening in the lab will

911
00:37:43,840 --> 00:37:40,910
be as powerful as seeing earth from

912
00:37:46,510 --> 00:37:43,850
space from Apollo 8 the first those

913
00:37:48,190 --> 00:37:46,520

first wonderful pictures and so it's

914
00:37:51,070 --> 00:37:48,200
something we could actually even

915
00:37:54,040 --> 00:37:51,080
anticipate or prepare for that science

916
00:37:56,170 --> 00:37:54,050
could say plot that this is a plausible

917
00:37:58,900 --> 00:37:56,180
we don't know and we never will know how

918
00:38:02,080 --> 00:37:58,910
really how life this is a plausible

919
00:38:05,620 --> 00:38:02,090
argument for a mechanism for life to

920
00:38:08,740 --> 00:38:05,630
start on a world and then of course

921
00:38:10,420 --> 00:38:08,750
tunes our search in exoplanets for which

922
00:38:13,390 --> 00:38:10,430
worlds could support this

923
00:38:16,180 --> 00:38:13,400
and it will be a very big innocence

924
00:38:17,140 --> 00:38:16,190
spiritual impact or philosophical impact

925
00:38:19,840 --> 00:38:17,150
on our species

926
00:38:23,770 --> 00:38:19,850
it'll be perhaps the first if you will

927
00:38:25,390 --> 00:38:23,780
alien that we meet we make but it's not

928
00:38:26,620 --> 00:38:25,400
that alien in the sense it's a

929
00:38:32,410 --> 00:38:26,630
laboratory

930
00:38:35,560 --> 00:38:32,420
it won't look like what the true

931
00:38:37,690 --> 00:38:35,570
brochure notes were back 4.1 4.2 billion

932
00:38:40,270 --> 00:38:37,700
years ago it'll be I'm taking a

933
00:38:42,700 --> 00:38:40,280
different path is no Carl Sagan or

934
00:38:44,380 --> 00:38:42,710
Stephen Jay Gould zai dia of rewinding

935
00:38:48,190 --> 00:38:44,390
the tape and then going forward and you

936
00:38:49,630 --> 00:38:48,200
get a different version every time it

937
00:38:51,730 --> 00:38:49,640
seems powerful the idea too that we

938
00:38:54,130 --> 00:38:51,740

could be the creators of life in the

939
00:38:55,510 --> 00:38:54,140
laboratory while attempting to

940
00:38:57,370 --> 00:38:55,520
understand how we came to be in the

941
00:39:00,130 --> 00:38:57,380
first place that seems like a very

942
00:39:01,750 --> 00:39:00,140
powerful moment for us as a species and

943
00:39:03,910 --> 00:39:01,760
our next question I think you've kind of

944
00:39:06,040 --> 00:39:03,920
already answered so I'm gonna add to it

945
00:39:09,460 --> 00:39:06,050
a little bit this is from G s heard on

946
00:39:12,190 --> 00:39:09,470
Sagan net he asked have you guys started

947
00:39:14,230 --> 00:39:12,200
a lab simulation as well as the work in

948
00:39:15,700 --> 00:39:14,240
Yellowstone and I'd like to go a little

949
00:39:16,930 --> 00:39:15,710
bit further than to ask you know what's

950
00:39:18,970 --> 00:39:16,940
actually going on in the laboratory

951
00:39:21,430 --> 00:39:18,980
that's allowing us to test these models

952
00:39:24,070 --> 00:39:21,440
and what kind of timeframe do you think

953
00:39:25,780 --> 00:39:24,080
that we're looking at scientifically for

954
00:39:26,890 --> 00:39:25,790
laboratory simulation is to actually

955
00:39:29,320 --> 00:39:26,900
bring us to the point where we think we

956
00:39:31,960 --> 00:39:29,330
might have our minds around how it could

957
00:39:34,780 --> 00:39:31,970
happen you know this is a wonderful

958
00:39:37,120 --> 00:39:34,790
shout out to everyone out here because

959
00:39:40,120 --> 00:39:37,130
I'm fundamentally trained as a computer

960
00:39:41,920 --> 00:39:40,130
scientist I came into this hoping that

961
00:39:43,980 --> 00:39:41,930
computers would be able to do a

962
00:39:46,330 --> 00:39:43,990
simulation would guard the chemistry

963
00:39:47,800 --> 00:39:46,340

found that the computers weren't fast

964
00:39:50,050 --> 00:39:47,810
enough where we didn't understand the

965
00:39:51,610 --> 00:39:50,060
chemistry jumped into the chemistry

966
00:39:54,070 --> 00:39:51,620
working with Dave Deemer and our

967
00:39:56,860 --> 00:39:54,080
colleagues getting the chemistry now to

968
00:39:59,530 --> 00:39:56,870
work we can reverse the thing and make

969
00:40:01,990 --> 00:39:59,540
computer science models of these

970
00:40:04,300 --> 00:40:02,000
polymers of these selection criteria

971
00:40:06,070 --> 00:40:04,310
we've done it for the kinetic trap to

972
00:40:08,020 --> 00:40:06,080
show that that that's real and

973
00:40:10,630 --> 00:40:08,030
characterize how polymers grow and and

974
00:40:12,940 --> 00:40:10,640
continue to grow in length and continue

975
00:40:14,230 --> 00:40:12,950
to work in this in this kinetic trap

976
00:40:17,170 --> 00:40:14,240
away from equilibrium

977
00:40:19,930 --> 00:40:17,180
what about protocells somebody out there

978
00:40:22,210 --> 00:40:19,940
right a simulation of protocells even

979
00:40:23,660 --> 00:40:22,220
low fidelity that would show us the

980
00:40:26,089 --> 00:40:23,670
likelihood of the emergence

981
00:40:28,099 --> 00:40:26,099
the first pour for example the first

982
00:40:30,530 --> 00:40:28,109
passive pour and how that would affect

983
00:40:33,140 --> 00:40:30,540
the unit's I think it's a great PhD

984
00:40:36,230 --> 00:40:33,150
project it's a great at-home type

985
00:40:38,539 --> 00:40:36,240
project to simulate our laboratory and

986
00:40:40,460 --> 00:40:38,549
field work conditions that are that are

987
00:40:42,349 --> 00:40:40,470
working that are creating emergent

988
00:40:44,539 --> 00:40:42,359

phenomena because then the computing

989
00:40:47,270 --> 00:40:44,549
will get so good and maybe you can throw

990
00:40:49,309 --> 00:40:47,280
it all into a huge cloud-based system

991
00:40:51,200 --> 00:40:49,319
that will guide future chemistry and we

992
00:40:54,349 --> 00:40:51,210
can do it like this we can stack up the

993
00:40:57,620 --> 00:40:54,359
efforts and accelerate that's awesome

994
00:40:59,059 --> 00:40:57,630
and I I guess I also wonder then if you

995
00:41:00,710 --> 00:40:59,069
had to give advice to anyone right now

996
00:41:02,210 --> 00:41:00,720
listening at home or watching our show

997
00:41:04,910 --> 00:41:02,220
or listening to out the podcast version

998
00:41:06,319 --> 00:41:04,920
of it who wants to be involved if there

999
00:41:08,210 --> 00:41:06,329
are a high school student or a college

1000
00:41:09,380 --> 00:41:08,220
student or there they're a professional

1001
00:41:11,990 --> 00:41:09,390
working somewhere else but want to be

1002
00:41:13,510 --> 00:41:12,000
involved in the computer simulations or

1003
00:41:15,650 --> 00:41:13,520
the lab simulations or the fieldwork

1004
00:41:17,510 --> 00:41:15,660
what would your advice be to those

1005
00:41:20,710 --> 00:41:17,520
people to get involved in this kind of

1006
00:41:23,450 --> 00:41:20,720
work I think that become a

1007
00:41:25,730 --> 00:41:23,460
multi-disciplinarian in that in the

1008
00:41:27,440 --> 00:41:25,740
field of astrobiology usually each

1009
00:41:29,420 --> 00:41:27,450
person in the field has least two

1010
00:41:31,760 --> 00:41:29,430
disciplines but maybe get four or five

1011
00:41:35,450 --> 00:41:31,770
so study complexity science study

1012
00:41:37,579 --> 00:41:35,460
membrane biophysics study organic

1013
00:41:40,370 --> 00:41:37,589

chemistry polymerization or polymers

1014
00:41:43,490 --> 00:41:40,380
study how cells work then study some

1015
00:41:44,839 --> 00:41:43,500
geology go out and sit next to the hot

1016
00:41:47,059 --> 00:41:44,849
spring environments and you know as a

1017
00:41:51,170 --> 00:41:47,069
geologist that it's such a great teacher

1018
00:41:53,000 --> 00:41:51,180
that you can see at the lakeshore or the

1019
00:41:55,280 --> 00:41:53,010
or next to a pond or something you can

1020
00:41:56,720 --> 00:41:55,290
see all this complexity that the natural

1021
00:41:58,819 --> 00:41:56,730
environment provides you can only do

1022
00:42:00,680 --> 00:41:58,829
that by going to the field become

1023
00:42:02,539 --> 00:42:00,690
fascinated in all those things and

1024
00:42:04,910 --> 00:42:02,549
you'll start having kind of visionary

1025
00:42:06,589 --> 00:42:04,920
downloads of how they all connect then

1026
00:42:08,900 --> 00:42:06,599
you might want to go the geology route

1027
00:42:11,359 --> 00:42:08,910
or the chemistry route but you may want

1028
00:42:13,940 --> 00:42:11,369
to go the computing route or collaborate

1029
00:42:15,740 --> 00:42:13,950
and create these multidisciplinary teams

1030
00:42:18,020 --> 00:42:15,750
and then build your own little

1031
00:42:20,930 --> 00:42:18,030
laboratory instrument that is a rocker

1032
00:42:23,630 --> 00:42:20,940
plate going back and forth putting fluid

1033
00:42:26,089 --> 00:42:23,640
over a mineral with the lipids and with

1034
00:42:28,819 --> 00:42:26,099
the monomers of the polymers and just

1035
00:42:31,490 --> 00:42:28,829
build something at home and then scrape

1036
00:42:33,440 --> 00:42:31,500
that off and and do sequencing on that

1037
00:42:35,000 --> 00:42:33,450
and see what you can see and you could

1038
00:42:36,829 --> 00:42:35,010

build your own experiment and then

1039
00:42:37,490 --> 00:42:36,839
effectively Dave and I have sometimes

1040
00:42:40,339 --> 00:42:37,500
done

1041
00:42:44,809 --> 00:42:40,349
our experiments in tests in on frying

1042
00:42:45,440 --> 00:42:44,819
pans on stove tops in the kitchen that's

1043
00:42:46,880 --> 00:42:45,450
awesome

1044
00:42:49,010 --> 00:42:46,890
kinda makes me think just just weirdly

1045
00:42:50,240 --> 00:42:49,020
about like biohacking and how there's a

1046
00:42:52,309 --> 00:42:50,250
lot of folks right now who are like

1047
00:42:54,440 --> 00:42:52,319
taking their their materials back at

1048
00:42:56,420 --> 00:42:54,450
home and trying to like learn how to

1049
00:42:58,700 --> 00:42:56,430
hack through genes and genetically

1050
00:42:59,900 --> 00:42:58,710
engineer cells it'd be pretty cool if we

1051
00:43:02,329 --> 00:42:59,910
had a bunch of people who are also

1052
00:43:03,680 --> 00:43:02,339
trying to do origin of life hacking at

1053
00:43:05,960 --> 00:43:03,690
home in that manner that's that's a

1054
00:43:08,240 --> 00:43:05,970
pretty awesome idea we do have a bunch

1055
00:43:11,780 --> 00:43:08,250
more questions I'm promised to get it to

1056
00:43:14,180 --> 00:43:11,790
as many as I can here our next question

1057
00:43:17,870 --> 00:43:14,190
is from Tom Caruso who's a longtime fan

1058
00:43:20,240 --> 00:43:17,880
of the show Tom asks us on Facebook is

1059
00:43:23,660 --> 00:43:20,250
it possible for you to apply the wet/dry

1060
00:43:26,030 --> 00:43:23,670
cycles to the internal cores of icy

1061
00:43:28,430 --> 00:43:26,040
moons covered by deep oceans such as

1062
00:43:30,260 --> 00:43:28,440
Enceladus and Europa the premise being

1063
00:43:32,900 --> 00:43:30,270

that gas is produced from serpentine

1064
00:43:34,940 --> 00:43:32,910
reactions and orbital oscillations

1065
00:43:37,400 --> 00:43:34,950
allowing a loosely bound rocky core to

1066
00:43:39,650 --> 00:43:37,410
stretch and relax could possibly produce

1067
00:43:41,540 --> 00:43:39,660
the dry environment and then mechanical

1068
00:43:46,220 --> 00:43:41,550
driving force to alternate between wet

1069
00:43:48,319 --> 00:43:46,230
and dry we've looked at that with our

1070
00:43:50,900 --> 00:43:48,329
colleagues and our colleagues in

1071
00:43:53,059 --> 00:43:50,910
geochemistry have basically said that in

1072
00:43:55,309 --> 00:43:53,069
any environment which is under the

1073
00:43:57,680 --> 00:43:55,319
pressure of a water column there is no

1074
00:44:00,280 --> 00:43:57,690
way to have reduced water activity so

1075
00:44:02,569 --> 00:44:00,290
there'd be a gel a temporary cavity

1076
00:44:04,190 --> 00:44:02,579
you're always going to have the presence

1077
00:44:05,930 --> 00:44:04,200
of water so you cannot do the

1078
00:44:08,870 --> 00:44:05,940
condensation reactions that we're doing

1079
00:44:10,790 --> 00:44:08,880
with wet/dry cycling so then you might

1080
00:44:13,150 --> 00:44:10,800
say well maybe within the ice that

1081
00:44:15,770 --> 00:44:13,160
there's a pocket that there's some air

1082
00:44:17,839 --> 00:44:15,780
that is contained so there could be some

1083
00:44:19,609 --> 00:44:17,849
drying the problem is the ice is gonna

1084
00:44:21,800 --> 00:44:19,619
be so cold it's not going to have enough

1085
00:44:24,650 --> 00:44:21,810
activation energy for the chemistry and

1086
00:44:26,599 --> 00:44:24,660
then if you had say a few polymers

1087
00:44:28,819 --> 00:44:26,609
forming there's nowhere for them to go

1088
00:44:31,099 --> 00:44:28,829

and you also need access to the

1089
00:44:33,050 --> 00:44:31,109
membranous lipid material which isn't

1090
00:44:34,339 --> 00:44:33,060
going to be prebiotic ly plausible in

1091
00:44:36,290 --> 00:44:34,349
that environment to create the

1092
00:44:39,410 --> 00:44:36,300
compartments to crowd everything enough

1093
00:44:41,540 --> 00:44:39,420
to make the chemistry work so if someone

1094
00:44:44,120 --> 00:44:41,550
can build an environment in the lab that

1095
00:44:46,670 --> 00:44:44,130
shows that this is possible in an icy

1096
00:44:48,200 --> 00:44:46,680
and watery environment all power to them

1097
00:44:50,540 --> 00:44:48,210
but if you just look at the

1098
00:44:51,440 --> 00:44:50,550
thermodynamics the barriers are just

1099
00:44:53,720 --> 00:44:51,450
extremely

1100
00:44:57,259 --> 00:44:53,730
- any of that working in a watery or a

1101
00:44:58,970 --> 00:44:57,269
cooler environment and it's awesome so

1102
00:45:00,920 --> 00:44:58,980
that's a good answer I wonder what tom

1103
00:45:03,079 --> 00:45:00,930
thinks about that to talk with him later

1104
00:45:05,779 --> 00:45:03,089
about that our next question comes from

1105
00:45:08,660 --> 00:45:05,789
user Vern Emmerich on Twitter

1106
00:45:10,490 --> 00:45:08,670
Vern wants to know since all of life on

1107
00:45:13,509 --> 00:45:10,500
Earth appears to have evolved from a

1108
00:45:15,980 --> 00:45:13,519
single common ancestor or a proto note

1109
00:45:19,880 --> 00:45:15,990
shouldn't that same dynamic be true for

1110
00:45:21,440 --> 00:45:19,890
a galaxy so in other words once an

1111
00:45:23,960 --> 00:45:21,450
organism achieves some level of

1112
00:45:25,400 --> 00:45:23,970
homeostasis needed to traverse through

1113
00:45:28,660 --> 00:45:25,410

sterile environments traverse the galaxy

1114
00:45:31,160 --> 00:45:28,670
and then it starts to spread and evolve

1115
00:45:33,019 --> 00:45:31,170
would it become that that organism kind

1116
00:45:34,910 --> 00:45:33,029
of becomes that universal organism as

1117
00:45:36,440 --> 00:45:34,920
well it spreads faster than other

1118
00:45:39,620 --> 00:45:36,450
organisms that might be arising in other

1119
00:45:42,579 --> 00:45:39,630
places you know that's that's a very

1120
00:45:45,920 --> 00:45:42,589
good hypothesis it's sort of an extended

1121
00:45:48,190 --> 00:45:45,930
panspermia hypothesis so for example if

1122
00:45:50,420 --> 00:45:48,200
we could catch up to an extraterrestrial

1123
00:45:53,839 --> 00:45:50,430
extrasolar object coming through the

1124
00:45:56,390 --> 00:45:53,849
solar system get it sample it find bugs

1125
00:45:59,029 --> 00:45:56,400
on it effectively sequence them and see

1126
00:46:00,740 --> 00:45:59,039
if it has the same genetic code and so

1127
00:46:03,349 --> 00:46:00,750
ours on earth it would answer one of

1128
00:46:05,420 --> 00:46:03,359
Chris McKay's big chart questions of

1129
00:46:07,400 --> 00:46:05,430
where a life can start ends at common

1130
00:46:09,620 --> 00:46:07,410
origin did you need to have a

1131
00:46:12,859 --> 00:46:09,630
hydrosphere of a galaxy to

1132
00:46:14,569 --> 00:46:12,869
combinatorially start life and and then

1133
00:46:17,480 --> 00:46:14,579
it just seeds through this rocky

1134
00:46:21,559 --> 00:46:17,490
transfer these desiccated you know low

1135
00:46:24,410 --> 00:46:21,569
metabolism transits my my approach is

1136
00:46:27,170 --> 00:46:24,420
that that's a complicated solution that

1137
00:46:30,289 --> 00:46:27,180
perhaps life since it's so exquisitely

1138
00:46:33,319 --> 00:46:30,299

evolved hand in glove to the earth

1139
00:46:36,259 --> 00:46:33,329
environment it probably did start here

1140
00:46:38,870 --> 00:46:36,269
it could have started on Mars and come

1141
00:46:41,599 --> 00:46:38,880
through in a transit deposited on the

1142
00:46:43,430 --> 00:46:41,609
earth but it doesn't it really pushes

1143
00:46:46,299 --> 00:46:43,440
the question of where life's origins

1144
00:46:48,799 --> 00:46:46,309
would occur back to some other location

1145
00:46:51,049 --> 00:46:48,809
and I don't think it changes really the

1146
00:46:53,210 --> 00:46:51,059
nature of the questions you still have

1147
00:46:54,529 --> 00:46:53,220
to form long chain polymers in an

1148
00:46:56,150 --> 00:46:54,539
aqueous environment you still have to

1149
00:46:58,579 --> 00:46:56,160
encapsulate them in a cell size

1150
00:47:01,339 --> 00:46:58,589
compartment as far as we know that's the

1151
00:47:03,530 --> 00:47:01,349
only way to get function to come out of

1152
00:47:06,380 --> 00:47:03,540
matter

1153
00:47:08,570 --> 00:47:06,390
interesting I wonder if my own question

1154
00:47:11,510 --> 00:47:08,580
in there if you've heard of Leo si

1155
00:47:14,260 --> 00:47:11,520
Chen's dark forest hypothesis from his

1156
00:47:16,940 --> 00:47:14,270
science fiction works and this idea that

1157
00:47:18,470 --> 00:47:16,950
say you're alone in the jungle at night

1158
00:47:20,960 --> 00:47:18,480
and you want to know if other other

1159
00:47:22,760 --> 00:47:20,970
people are out there you could call out

1160
00:47:25,280 --> 00:47:22,770
into the into the forest into the dark

1161
00:47:27,080 --> 00:47:25,290
forest but you might be attracting the

1162
00:47:29,720 --> 00:47:27,090
the leopards and jaguars and things that

1163
00:47:31,420 --> 00:47:29,730

might eat you and the idea is should we

1164
00:47:33,350 --> 00:47:31,430
be sending messages out into space

1165
00:47:35,570 --> 00:47:33,360
because we don't know who might be

1166
00:47:37,310 --> 00:47:35,580
listening even if we think that we might

1167
00:47:38,600 --> 00:47:37,320
be looking for a friend out there I

1168
00:47:40,250 --> 00:47:38,610
wonder what you think about the

1169
00:47:41,630 --> 00:47:40,260
potential for other extraterrestrial

1170
00:47:43,880 --> 00:47:41,640
intelligence out there listening to us

1171
00:47:47,930 --> 00:47:43,890
and whether they might be benevolent or

1172
00:47:49,640 --> 00:47:47,940
malevolent I feel that complex

1173
00:47:51,830 --> 00:47:49,650
intelligent life is probably so

1174
00:47:55,840 --> 00:47:51,840
incredibly rare that if they got a

1175
00:47:59,000 --> 00:47:55,850
signal it would be as profound a

1176
00:48:01,310 --> 00:47:59,010
philosophical impact on them as it would

1177
00:48:03,410 --> 00:48:01,320
be for us and they would be quite

1178
00:48:05,480 --> 00:48:03,420
humbled because they would have probably

1179
00:48:08,420 --> 00:48:05,490
done this kind of thinking about their

1180
00:48:10,850 --> 00:48:08,430
own origins realize how difficult it is

1181
00:48:13,400 --> 00:48:10,860
to get to intelligence and been grateful

1182
00:48:16,820 --> 00:48:13,410
that it occurred somewhere else and

1183
00:48:18,920 --> 00:48:16,830
certainly you know we don't have much to

1184
00:48:20,930 --> 00:48:18,930
offer I don't think that the effort

1185
00:48:22,910 --> 00:48:20,940
needed to mount a nurse teller

1186
00:48:26,570 --> 00:48:22,920
expedition to come to little old earth

1187
00:48:29,990 --> 00:48:26,580
and you know pick up a burger at the

1188
00:48:32,150 --> 00:48:30,000

local burger joint is going to satisfy

1189
00:48:34,580 --> 00:48:32,160
what they're gonna be asked after it's

1190
00:48:36,470 --> 00:48:34,590
philosophical inquiry what is our

1191
00:48:38,300 --> 00:48:36,480
science they're gonna be very very open

1192
00:48:41,060 --> 00:48:38,310
they're not going to be for dating on us

1193
00:48:44,060 --> 00:48:41,070
there's nothing of value materially here

1194
00:48:46,180 --> 00:48:44,070
but our knowledge our science our arts

1195
00:48:47,990 --> 00:48:46,190
are what they would be fascinated by

1196
00:48:50,330 --> 00:48:48,000
interesting yeah and trying to share

1197
00:48:51,950 --> 00:48:50,340
culturally that's awesome our next

1198
00:48:54,980 --> 00:48:51,960
question is from Ramon Rockets here on

1199
00:48:57,980 --> 00:48:54,990
Twitter which is an awesome username ra

1200
00:49:00,800 --> 00:48:57,990
you ramona asks with the fragmented

1201
00:49:02,600 --> 00:49:00,810
magnetic field on mars is one region

1202
00:49:06,470 --> 00:49:02,610
marginally more protected than another

1203
00:49:08,860 --> 00:49:06,480
from radiation effects for life i don't

1204
00:49:12,440 --> 00:49:08,870
really have any idea it's not my area

1205
00:49:13,790 --> 00:49:12,450
okay no worries okay you can skip past

1206
00:49:16,680 --> 00:49:13,800
that one Ramon I'll reach out to you

1207
00:49:20,430 --> 00:49:16,690
later we can chat James Mullins on

1208
00:49:22,920 --> 00:49:20,440
has asked how can this theory for the

1209
00:49:25,920 --> 00:49:22,930
origin of life help us develop our

1210
00:49:28,220 --> 00:49:25,930
technology for terraforming new planets

1211
00:49:31,020 --> 00:49:28,230
potentially is an interesting question

1212
00:49:33,359 --> 00:49:31,030
yeah I think that the concept of

1213
00:49:36,599 --> 00:49:33,369

terraforming new planets is probably

1214
00:49:40,589 --> 00:49:36,609
beyond us like I can't really imagine if

1215
00:49:43,020 --> 00:49:40,599
you drop two full comet on to Mars it's

1216
00:49:44,839 --> 00:49:43,030
liquid water would simply be absorbed in

1217
00:49:47,640 --> 00:49:44,849
the environment and continue to be lost

1218
00:49:50,910 --> 00:49:47,650
so Mars being really the only candidate

1219
00:49:53,160 --> 00:49:50,920
I think it's you know I would dare say

1220
00:49:55,890 --> 00:49:53,170
it's a pipe dream I think to terraform a

1221
00:49:58,530 --> 00:49:55,900
place like that I think that we can

1222
00:49:59,099 --> 00:49:58,540
build biospheres like with our shepherd

1223
00:50:01,980 --> 00:49:59,109
idea

1224
00:50:04,980 --> 00:50:01,990
the O'Neal colonies are much more viable

1225
00:50:07,079 --> 00:50:04,990
a kind of terraforming by building by

1226
00:50:09,930 --> 00:50:07,089
building new terrestrial environments

1227
00:50:13,050 --> 00:50:09,940
you know give you an example if you took

1228
00:50:15,510 --> 00:50:13,060
a cruise ship down to Antarctica which

1229
00:50:18,030 --> 00:50:15,520
you can you might get off that cruise

1230
00:50:20,160 --> 00:50:18,040
ship and goes sea Shackleton's Hut and

1231
00:50:21,900 --> 00:50:20,170
whatnot but you'd be in a big hurry to

1232
00:50:23,940 --> 00:50:21,910
get back to the cruise ship to have your

1233
00:50:26,490 --> 00:50:23,950
hamburgers or your veggie burgers for

1234
00:50:28,550 --> 00:50:26,500
lunch because it's not habitable for

1235
00:50:32,309 --> 00:50:28,560
humans to be in Antarctica without this

1236
00:50:34,559 --> 00:50:32,319
extensive resupply and housing and I

1237
00:50:37,260 --> 00:50:34,569
think that that that that says a

1238
00:50:40,079 --> 00:50:37,270

metaphor for Mars Mars even worse the

1239
00:50:41,880 --> 00:50:40,089
moon's even worse so we're going to be

1240
00:50:44,250 --> 00:50:41,890
building cruise ships we're gonna be

1241
00:50:46,770 --> 00:50:44,260
building hopefully not the axiom where

1242
00:50:49,020 --> 00:50:46,780
we all get too big on milkshakes but

1243
00:50:51,210 --> 00:50:49,030
we're gonna be building structures in

1244
00:50:54,420 --> 00:50:51,220
space I think that to try to terraform

1245
00:50:57,720 --> 00:50:54,430
any surface is far too much effort and

1246
00:50:59,640 --> 00:50:57,730
probably beyond our capacity interesting

1247
00:51:00,990 --> 00:50:59,650
I wonder what you think then about some

1248
00:51:02,670 --> 00:51:01,000
ideas with science fiction that have

1249
00:51:05,430 --> 00:51:02,680
happened in the past and I know Carl

1250
00:51:07,079 --> 00:51:05,440
Sagan wrote on this Eric Vernon Quist

1251
00:51:10,290 --> 00:51:07,089
made a beautiful film called Wanderers

1252
00:51:13,079 --> 00:51:10,300
that has really great imaging of this in

1253
00:51:15,300 --> 00:51:13,089
video but the idea of us may be taking

1254
00:51:17,640 --> 00:51:15,310
asteroids and building building

1255
00:51:19,220 --> 00:51:17,650
spacecraft and habitats out of asteroids

1256
00:51:22,520 --> 00:51:19,230
and hollowing them out and building our

1257
00:51:25,130 --> 00:51:22,530
habitats inside of them how feasible do

1258
00:51:26,720 --> 00:51:25,140
you think that is for Humanity maybe in

1259
00:51:28,460 --> 00:51:26,730
the next hundred or a thousand or ten

1260
00:51:30,890 --> 00:51:28,470
thousand years I

1261
00:51:33,500 --> 00:51:30,900
I personally I'm not an expert in

1262
00:51:35,240 --> 00:51:33,510
asteroids but I've studied them through

1263
00:51:38,270 --> 00:51:35,250

the work of Peter Jenniskens I think

1264
00:51:40,790 --> 00:51:38,280
it's infeasible because mostly they're

1265
00:51:43,160 --> 00:51:40,800
consolidated rubble piles they're

1266
00:51:46,430 --> 00:51:43,170
geotechnical properties I don't think

1267
00:51:47,990 --> 00:51:46,440
would allow you to heat them or core

1268
00:51:50,090 --> 00:51:48,000
them out and you're dealing in a low

1269
00:51:51,560 --> 00:51:50,100
gravity or no virtually no gravity

1270
00:51:52,310 --> 00:51:51,570
environment so materials going

1271
00:51:54,340 --> 00:51:52,320
everywhere

1272
00:51:57,410 --> 00:51:54,350
very hard to operate in that environment

1273
00:51:59,480 --> 00:51:57,420
with all this dangers basically large

1274
00:52:01,940 --> 00:51:59,490
boulders moving around if they come

1275
00:52:03,830 --> 00:52:01,950
loose I think it's more likely that

1276
00:52:06,290 --> 00:52:03,840
we're going to extract perhaps of the

1277
00:52:09,440 --> 00:52:06,300
gas like we're talking about in in

1278
00:52:11,120 --> 00:52:09,450
Shepard pure metal ions and then we'll

1279
00:52:13,340 --> 00:52:11,130
plate them into the parts we need

1280
00:52:15,650 --> 00:52:13,350
because asteroids are hazardous they're

1281
00:52:17,420 --> 00:52:15,660
hazardous to deal with that's why our

1282
00:52:20,359 --> 00:52:17,430
design we don't touch them we handle

1283
00:52:24,260 --> 00:52:20,369
them gently with gas they're not exactly

1284
00:52:25,270 --> 00:52:24,270
a safe place to operate that's

1285
00:52:27,560 --> 00:52:25,280
intriguing

1286
00:52:30,530 --> 00:52:27,570
we have another question here from Bruno

1287
00:52:32,380 --> 00:52:30,540
pavlovic from Sagan net soberness we

1288
00:52:35,270 --> 00:52:32,390

talked earlier about this potential for

1289
00:52:36,980 --> 00:52:35,280
life to start in the dry/wet cycles and

1290
00:52:39,440 --> 00:52:36,990
these geothermal environments and then

1291
00:52:43,040 --> 00:52:39,450
maybe migrate to intertidal regions and

1292
00:52:44,900 --> 00:52:43,050
beyond so Bruno wants to know how long

1293
00:52:47,450 --> 00:52:44,910
you think these first preacher notes are

1294
00:52:49,460 --> 00:52:47,460
these for these life-forms should evolve

1295
00:52:52,099 --> 00:52:49,470
before they can begin begin spreading

1296
00:52:55,490 --> 00:52:52,109
out from that point of origin to then

1297
00:52:57,800 --> 00:52:55,500
start inhabiting other other places this

1298
00:53:00,710 --> 00:52:57,810
is an excellent question that we'll

1299
00:53:04,609 --> 00:53:00,720
never know precisely but we can make

1300
00:53:08,840 --> 00:53:04,619
some guesses so for example at 3.5

1301
00:53:10,370 --> 00:53:08,850
billion years ago a 2.48 in this piece

1302
00:53:12,890 --> 00:53:10,380
of hot stirring stone stromatolite

1303
00:53:15,680 --> 00:53:12,900
discovered by Tyra jock itch and Martin

1304
00:53:18,440 --> 00:53:15,690
Van cran and on you can see clear

1305
00:53:21,020 --> 00:53:18,450
evidence of a microbial ecosystem here

1306
00:53:22,940 --> 00:53:21,030
in this geyser right or on the layers on

1307
00:53:24,530 --> 00:53:22,950
either side of the guys alright so

1308
00:53:27,440 --> 00:53:24,540
that's three point four eight there's

1309
00:53:29,570 --> 00:53:27,450
some evidence that may be at 3.7 we see

1310
00:53:32,520 --> 00:53:29,580
stromatolites in Greenland that's

1311
00:53:35,010 --> 00:53:32,530
disputed there's some

1312
00:53:37,420 --> 00:53:35,020
chemical evidence that we might see life

1313
00:53:39,510 --> 00:53:37,430

evidence for life existing before four

1314
00:53:42,760 --> 00:53:39,520
billion years ago then on the other side

1315
00:53:45,040 --> 00:53:42,770
oceans formed by perhaps about 4.3

1316
00:53:48,340 --> 00:53:45,050
billion years ago so there's a two

1317
00:53:51,910 --> 00:53:48,350
hundred a seven hundred million year gap

1318
00:53:54,250 --> 00:53:51,920
in there to get to when you get to this

1319
00:53:56,290 --> 00:53:54,260
you have Modern Life these this is

1320
00:53:58,360 --> 00:53:56,300
there's really these leave the same

1321
00:54:00,130 --> 00:53:58,370
telltale textures in the rock as you'll

1322
00:54:03,490 --> 00:54:00,140
see in New Zealand for example they are

1323
00:54:06,280 --> 00:54:03,500
tough this is way past Luca past a

1324
00:54:08,410 --> 00:54:06,290
common ancestor so it's hundreds of

1325
00:54:11,530 --> 00:54:08,420
millions of years perhaps maybe tens of

1326
00:54:13,750 --> 00:54:11,540
millions I think from the progeny nor

1327
00:54:15,850 --> 00:54:13,760
the approach and out to the microbial

1328
00:54:18,910 --> 00:54:15,860
mat will never have fossil evidence of

1329
00:54:20,920 --> 00:54:18,920
that period in the laboratory we Mabel

1330
00:54:23,050 --> 00:54:20,930
to simulate the first few steps and make

1331
00:54:25,290 --> 00:54:23,060
some guesses but it's it's always gonna

1332
00:54:27,820 --> 00:54:25,300
be this guesswork about time frames

1333
00:54:29,800 --> 00:54:27,830
interesting yeah and why once told some

1334
00:54:31,390 --> 00:54:29,810
geochemistry students that may be the

1335
00:54:32,950 --> 00:54:31,400
only way we'll ever know for sure is if

1336
00:54:34,480 --> 00:54:32,960
they were intelligent aliens watching us

1337
00:54:38,040 --> 00:54:34,490
from afar and they they have some videos

1338
00:54:40,450 --> 00:54:38,050

in the library somewhere for us to watch

1339
00:54:41,410 --> 00:54:40,460
there is one other thing if we find

1340
00:54:44,260 --> 00:54:41,420
rocks on the moon

1341
00:54:46,660 --> 00:54:44,270
from that period right if we find

1342
00:54:48,730 --> 00:54:46,670
exogenous material on the lunar surface

1343
00:54:51,370 --> 00:54:48,740
or probably not Mars but the moon it

1344
00:54:53,200 --> 00:54:51,380
would be great preservation of perhaps

1345
00:54:55,540 --> 00:54:53,210
something containing evidence of

1346
00:54:57,010 --> 00:54:55,550
stromatolites or micro fossils yeah

1347
00:54:58,150 --> 00:54:57,020
that's a really good point I mean it's

1348
00:55:01,330 --> 00:54:58,160
been hypothesized that there could be

1349
00:55:03,280 --> 00:55:01,340
you know once now extinct materials from

1350
00:55:04,600 --> 00:55:03,290
life from early life on earth just

1351
00:55:06,040 --> 00:55:04,610
sitting on the moon for us to go find

1352
00:55:09,190 --> 00:55:06,050
which could be a good reason to go back

1353
00:55:12,040 --> 00:55:09,200
yeah our next question is from Ben

1354
00:55:13,780 --> 00:55:12,050
Pierce on Twitter hi Ben he says do you

1355
00:55:15,810 --> 00:55:13,790
think it's necessarily RNA filled

1356
00:55:18,040 --> 00:55:15,820
protocells that made up the first life

1357
00:55:19,930 --> 00:55:18,050
and then what do you think about other

1358
00:55:23,230 --> 00:55:19,940
information pollen or polymers being

1359
00:55:24,730 --> 00:55:23,240
first perhaps outside of RNA DNA I know

1360
00:55:26,980 --> 00:55:24,740
recently a paper came out suggesting an

1361
00:55:29,760 --> 00:55:26,990
rna-dna hybrid what about other

1362
00:55:32,980 --> 00:55:29,770
potential genetic information systems

1363
00:55:35,760 --> 00:55:32,990

yeah in fact there's talk of the many

1364
00:55:39,430 --> 00:55:35,770
potential systems like origamis between

1365
00:55:42,250 --> 00:55:39,440
RNA nucleic acid like polymers and

1366
00:55:45,520 --> 00:55:42,260
peptide possibly he we had access to

1367
00:55:46,030 --> 00:55:45,530
amino acids more so than the nucleotides

1368
00:55:49,210 --> 00:55:46,040
that

1369
00:55:50,830 --> 00:55:49,220
works on at McMaster University so could

1370
00:55:53,110 --> 00:55:50,840
we have something that's a close cousin

1371
00:55:55,450 --> 00:55:53,120
that still provides informational

1372
00:55:58,300 --> 00:55:55,460
there's been work on TNA work with ROM

1373
00:56:00,580 --> 00:55:58,310
Krishnamurti it's scripts work at the

1374
00:56:03,130 --> 00:56:00,590
chemical Center for chemical evolution

1375
00:56:07,810 --> 00:56:03,140
in Georgia Tech on and in other places

1376
00:56:10,000 --> 00:56:07,820
on these non-canonical bases also it in

1377
00:56:13,540 --> 00:56:10,010
India our colleagues at Pune and India

1378
00:56:17,050 --> 00:56:13,550
so yes that that is a feel ripe for

1379
00:56:19,300 --> 00:56:17,060
exploration and we ought to extend our

1380
00:56:21,700 --> 00:56:19,310
range of what we're using in our

1381
00:56:23,530 --> 00:56:21,710
experiments that to convince more of our

1382
00:56:27,790 --> 00:56:23,540
colleagues that this is prebiotic ly

1383
00:56:30,010 --> 00:56:27,800
plausible mmm it's awesome our next

1384
00:56:31,890 --> 00:56:30,020
question kind of business back to where

1385
00:56:34,300 --> 00:56:31,900
we were a little earlier considering

1386
00:56:36,070 --> 00:56:34,310
potential or no potential for having

1387
00:56:39,250 --> 00:56:36,080
life start in Europe are Enceladus as

1388
00:56:41,500 --> 00:56:39,260

oceans pritho Jay Paul on Sagan net has

1389
00:56:43,000 --> 00:56:41,510
asked if you think that the this

1390
00:56:46,030 --> 00:56:43,010
concentrated pool theory for the origin

1391
00:56:47,830 --> 00:56:46,040
of life or the wet/dry cycles strictly

1392
00:56:49,960 --> 00:56:47,840
pertained to conditions on early Earth

1393
00:56:52,390 --> 00:56:49,970
and the question that kind of comes down

1394
00:56:54,250 --> 00:56:52,400
to do you think that there's other ways

1395
00:56:56,380 --> 00:56:54,260
that origins of life could occur in

1396
00:56:58,270 --> 00:56:56,390
different kinds of environments on other

1397
00:57:02,820 --> 00:56:58,280
places and other other worlds in the

1398
00:57:04,780 --> 00:57:02,830
universe okay it's it all comes down to

1399
00:57:07,360 --> 00:57:04,790
definitions again and of course years

1400
00:57:09,690 --> 00:57:07,370
ago NASA held a conference that tried to

1401
00:57:12,430 --> 00:57:09,700
come up with a definition for a life

1402
00:57:14,860 --> 00:57:12,440
what we're doing now in our field is

1403
00:57:17,730 --> 00:57:14,870
coming up with what we call a crucial

1404
00:57:21,040 --> 00:57:17,740
experiment this is from John Platts

1405
00:57:23,830 --> 00:57:21,050
ideas of strong inference from the 1960s

1406
00:57:26,230 --> 00:57:23,840
that we need to have a single sentence

1407
00:57:28,900 --> 00:57:26,240
or a couple sentence long description of

1408
00:57:30,490 --> 00:57:28,910
how life can begin that's abstract and

1409
00:57:33,370 --> 00:57:30,500
I've been recently talking to Laurie

1410
00:57:35,470 --> 00:57:33,380
barge at JPL and circulating this around

1411
00:57:37,270 --> 00:57:35,480
all of our colleagues and they're kind

1412
00:57:40,570 --> 00:57:37,280
of coming to agreement that we need a

1413
00:57:42,190 --> 00:57:40,580

non enzymatic process to create polymers

1414
00:57:44,260 --> 00:57:42,200
long enough that they have catalytic

1415
00:57:46,510 --> 00:57:44,270
function getting together and set

1416
00:57:48,580 --> 00:57:46,520
somehow so they can undergo a

1417
00:57:51,190 --> 00:57:48,590
large-scale combinatorial selection

1418
00:57:53,170 --> 00:57:51,200
which sets up molecular evolution and

1419
00:57:55,570 --> 00:57:53,180
you have to be able to keep the polymers

1420
00:57:57,760 --> 00:57:55,580
around and resynthesize them and I think

1421
00:57:59,890 --> 00:57:57,770
that we're kind of coming to agreement

1422
00:58:02,620 --> 00:57:59,900
that that's what's needed for an orange

1423
00:58:04,809 --> 00:58:02,630
of life so if you look at Titan if you

1424
00:58:06,789 --> 00:58:04,819
look at other environments you have to

1425
00:58:09,579 --> 00:58:06,799
be able to do that so you can propose a

1426
00:58:11,349 --> 00:58:09,589
chemistry that as long as it meets that

1427
00:58:13,599 --> 00:58:11,359
crucial experiment it's a testable

1428
00:58:15,370 --> 00:58:13,609
hypothesis and so that's what we're

1429
00:58:17,740 --> 00:58:15,380
putting out to our field a new article

1430
00:58:18,930 --> 00:58:17,750
coming out in astrobiology in a few

1431
00:58:20,799 --> 00:58:18,940
months

1432
00:58:23,109 --> 00:58:20,809
awesome we look forward to it and we'll

1433
00:58:24,760 --> 00:58:23,119
share it through second next Twitter and

1434
00:58:26,529 --> 00:58:24,770
Facebook through Blue Marble space

1435
00:58:29,289 --> 00:58:26,539
through NASA Astrobiology through my own

1436
00:58:30,640 --> 00:58:29,299
social media of course so we are running

1437
00:58:32,109 --> 00:58:30,650
out of time now so I want to say to all

1438
00:58:34,029 --> 00:58:32,119

of our viewers who are watching right

1439
00:58:36,789 --> 00:58:34,039
now on second thought I'll work on the

1440
00:58:39,069 --> 00:58:36,799
NASA Astrobiology Facebook page and on

1441
00:58:41,260 --> 00:58:39,079
the livestream thanks so much for

1442
00:58:42,549 --> 00:58:41,270
watching the show if you had questions

1443
00:58:44,799 --> 00:58:42,559
we didn't get to I'm really sorry we

1444
00:58:46,089 --> 00:58:44,809
actually had the most questions ever for

1445
00:58:47,500 --> 00:58:46,099
one of our shows for this episode we

1446
00:58:49,480 --> 00:58:47,510
didn't even get to nearly all of them

1447
00:58:50,680 --> 00:58:49,490
here there were just so many so thank

1448
00:58:51,819 --> 00:58:50,690
you to all of you at home who are

1449
00:58:54,370 --> 00:58:51,829
watching who asked all these wonderful

1450
00:58:56,920 --> 00:58:54,380
questions dr. Dana it's been great

1451
00:58:59,440 --> 00:58:56,930
having you on the show I do want to plug

1452
00:59:00,970 --> 00:58:59,450
you a little bit here you have de morgue

1453
00:59:02,950 --> 00:59:00,980
is your website where people can go and

1454
00:59:06,849 --> 00:59:02,960
read some more about you though

1455
00:59:09,130 --> 00:59:06,859
yeah yeah yeah and I mentioned earlier

1456
00:59:10,960 --> 00:59:09,140
too that I I've listened the lebanese

1457
00:59:12,370 --> 00:59:10,970
urn podcast i've really enjoyed all the

1458
00:59:14,500 --> 00:59:12,380
episodes i've listed i've listened to so

1459
00:59:17,559 --> 00:59:14,510
far they're really great the first one

1460
00:59:18,609 --> 00:59:17,569
in genesis engines is incredible and

1461
00:59:22,829 --> 00:59:18,619
definitely worth a listen for our

1462
00:59:24,910 --> 00:59:22,839
audience and then is there any last

1463
00:59:27,490 --> 00:59:24,920

parting words you'd like to give our

1464
00:59:30,279 --> 00:59:27,500
audience our intrigue astrobiologists

1465
00:59:32,799 --> 00:59:30,289
and astrobiology enthusiasts yeah I

1466
00:59:35,589 --> 00:59:32,809
think that we are in an exciting

1467
00:59:38,650 --> 00:59:35,599
revolutionary time in the origin of life

1468
00:59:40,510 --> 00:59:38,660
field that because of the power of the

1469
00:59:41,680 --> 00:59:40,520
field of astrobiology and all the minds

1470
00:59:44,529 --> 00:59:41,690
that have come together and all the

1471
00:59:46,660 --> 00:59:44,539
collaborations now and that when we

1472
00:59:49,269 --> 00:59:46,670
address the question of the origin of

1473
00:59:52,329 --> 00:59:49,279
life it's also our own origins and that

1474
00:59:54,519 --> 00:59:52,339
we hope that perhaps the discovery that

1475
00:59:56,440 --> 00:59:54,529
we needed to have a communal unit at the

1476
00:59:59,260 --> 00:59:56,450
beginning of life not individuals in

1477
01:00:01,359 --> 00:59:59,270
competition but a community of simpler

1478
01:00:03,880 --> 01:00:01,369
units that were in collaboration to

1479
01:00:06,400 --> 01:00:03,890
start life that you can actually see all

1480
01:00:07,539 --> 01:00:06,410
of life through that lens and that as we

1481
01:00:10,029 --> 01:00:07,549
go into the future

1482
01:00:12,490 --> 01:00:10,039
it isn't competition between us as

1483
01:00:13,030 --> 01:00:12,500
humans and us and the biosphere that is

1484
01:00:15,550 --> 01:00:13,040
going to let

1485
01:00:19,690 --> 01:00:15,560
survive that's a metaphor that's perhaps

1486
01:00:21,370 --> 01:00:19,700
not cannot constructive constructive for

1487
01:00:24,010 --> 01:00:21,380
a future it is the collaborative

1488
01:00:26,020 --> 01:00:24,020

communal unit that will give us our

1489
01:00:28,090 --> 01:00:26,030
biggest chance of survival and if we

1490
01:00:30,580 --> 01:00:28,100
show that that life itself came from

1491
01:00:32,800 --> 01:00:30,590
that that forests are made that way that

1492
01:00:34,240 --> 01:00:32,810
all ikan systems are made that way and

1493
01:00:37,150 --> 01:00:34,250
thrive that way we'll learn how to

1494
01:00:39,310 --> 01:00:37,160
thrive through collaboration it's

1495
01:00:40,690 --> 01:00:39,320
awesome thank you so much for that and

1496
01:00:42,700 --> 01:00:40,700
thank you so much for joining us on the

1497
01:00:44,410 --> 01:00:42,710
show dr. Damon it's been a pleasure

1498
01:00:46,180 --> 01:00:44,420
having you here I'm sure our audience

1499
01:00:48,250 --> 01:00:46,190
really loved it as shown by all the

1500
01:00:49,360 --> 01:00:48,260
questions they had for you I can try to

1501
01:00:51,430 --> 01:00:49,370
share some more of those questions with

1502
01:00:54,370 --> 01:00:51,440
you if you're interested after the show

1503
01:00:56,800 --> 01:00:54,380
to all of our audience members we tried

1504
01:00:58,480 --> 01:00:56,810
something new this month with our new

1505
01:01:00,490 --> 01:00:58,490
graphics for this show you'll see some

1506
01:01:02,470 --> 01:01:00,500
more of the artwork from Aaron Gronstal

1507
01:01:04,450 --> 01:01:02,480
from the astrobiology graphic histories

1508
01:01:05,710 --> 01:01:04,460
are in the show now we have some of new

1509
01:01:08,260 --> 01:01:05,720
things and so we'd love to know what you

1510
01:01:10,300 --> 01:01:08,270
guys think about what we're doing here

1511
01:01:12,640 --> 01:01:10,310
through Twitter through our YouTube let

1512
01:01:14,110 --> 01:01:12,650
us know what you think our next episode

1513
01:01:15,970 --> 01:01:14,120

we'll have the final versions of this

1514
01:01:17,980 --> 01:01:15,980
new format for the show moving forward

1515
01:01:19,570 --> 01:01:17,990
I'm glad we also mentioned Laurie barge

1516
01:01:21,730 --> 01:01:19,580
because she actually is our next guest

1517
01:01:22,780 --> 01:01:21,740
on the show as well so expect that

1518
01:01:24,910 --> 01:01:22,790
coming soon

1519
01:01:26,410 --> 01:01:24,920
dr. Damer to all of our guests thank you

1520
01:01:27,810 --> 01:01:26,420
very much for joining us and remember

1521
01:02:08,450 --> 01:01:27,820
stay curious