Ask An Astrobiologist

Episode 30: March 30th, 2020

Dr. Colin Goldblatt

NASA Astrobiology Program

1
00:00:37,280 --> 00:00:34,360
[Music]

2
00:00:38,720 --> 00:00:37,290
greetings friends of us Riley welcome to

3
00:00:40,790 --> 00:00:38,730
our brand new episode of as an

4
00:00:44,000 --> 00:00:40,800
astrobiologist a show where we celebrate

5
00:00:46,310 --> 00:00:44,010
science and celebrate science from home

6
00:00:47,960 --> 00:00:46,320
I mean a centrosome and its program is

7
00:00:50,030 --> 00:00:47,970
made possible by contributions from the

8
00:00:52,850 --> 00:00:50,040
NASA Astrobiology program and a

9
00:00:55,040 --> 00:00:52,860
non-profit bloom ramble space we live in

10
00:00:57,140 --> 00:00:55,050
unsettling times I think all of you like

11
00:00:59,509 --> 00:00:57,150
me are sheltering at home concerned

12
00:01:02,119 --> 00:00:59,519
about ourselves our families our loved

13
00:01:03,319 --> 00:01:02,129

ones and our broader community but

14
00:01:03,889 --> 00:01:03,329
perhaps for the first time in a long

15
00:01:06,279 --> 00:01:03,899
time

16
00:01:09,230 --> 00:01:06,289
his brother committee has included our

17
00:01:10,400 --> 00:01:09,240
planet as no matter who you believe in

18
00:01:11,900 --> 00:01:10,410
doesn't matter what the color of your

19
00:01:13,999 --> 00:01:11,910
skin is doesn't matter what language you

20
00:01:17,210 --> 00:01:14,009
speak we're all in this together

21
00:01:19,580 --> 00:01:17,220
floating in this blue marble in the

22
00:01:21,350 --> 00:01:19,590
vastness of space but there are two

23
00:01:23,480 --> 00:01:21,360
elements of humanity that bring me hope

24
00:01:26,240 --> 00:01:23,490
today one of which has been the

25
00:01:27,830 --> 00:01:26,250
incredible strength of compassion I've

26
00:01:30,230 --> 00:01:27,840
seen coming out from everybody around

27
00:01:32,840 --> 00:01:30,240
the world that has been really uplifting

28
00:01:34,940 --> 00:01:32,850
the second has been the strength of the

29
00:01:37,010 --> 00:01:34,950
scientific voice in implementing change

30
00:01:39,770 --> 00:01:37,020
that would help us all overcome this

31
00:01:42,169 --> 00:01:39,780
pandemic and so it's in the spirit of

32
00:01:44,389 --> 00:01:42,179
science that we have this show and we

33
00:01:45,949 --> 00:01:44,399
are very excited today to host dr.

34
00:01:48,229 --> 00:01:45,959
calling all black from the University of

35
00:01:51,710 --> 00:01:48,239
Victoria to chat with us about the magic

36
00:01:54,260 --> 00:01:51,720
of his science but first it's time for

37
00:01:57,740 --> 00:01:54,270
the competition that was formerly known

38
00:02:00,440 --> 00:01:57,750

as the background who is last Friday my

39
00:02:03,080 --> 00:02:00,450
wonderful colleague Mike Toyon sent up a

40
00:02:05,839 --> 00:02:03,090
picture on the Twitterverse about a

41
00:02:07,669 --> 00:02:05,849
astrobiology field location of interests

42
00:02:11,540 --> 00:02:07,679
Mike if you could put that up

43
00:02:15,050 --> 00:02:11,550
a lot of you got it all right it is

44
00:02:18,020 --> 00:02:15,060
indeed the clouds of the planet Venus

45
00:02:20,059 --> 00:02:18,030
Venus is the second closest planet to

46
00:02:22,880 --> 00:02:20,069
our star a little bit further inland we

47
00:02:24,740 --> 00:02:22,890
are about the same size but all of its

48
00:02:27,020 --> 00:02:24,750
carbon dioxide is in the atmosphere

49
00:02:29,930 --> 00:02:27,030
as opposed to earth where a lot of ours

50
00:02:31,490 --> 00:02:29,940
is actually locked up into rocks this

51
00:02:33,830 --> 00:02:31,500
large amount of co2 in the atmosphere

52
00:02:35,839 --> 00:02:33,840
causes a massive greenhouse effect and

53
00:02:38,720 --> 00:02:35,849
we'll talk about greenhouse effect on

54
00:02:40,610 --> 00:02:38,730
this show as well so huge shout out to

55
00:02:41,480 --> 00:02:40,620
all of you who got it right but the

56
00:02:44,300 --> 00:02:41,490
winner is

57
00:02:45,110 --> 00:02:44,310
laz who is the husband of rachel destroy

58
00:02:48,230 --> 00:02:45,120
your worlds

59
00:02:49,100 --> 00:02:48,240
that's tweeting at as at lhasa room

60
00:02:51,830 --> 00:02:49,110
terror

61
00:02:54,890 --> 00:02:51,840
so everybody is a winner this month the

62
00:02:57,110 --> 00:02:54,900
the winning material has always been our

63
00:02:59,210 --> 00:02:57,120

wonderful astrobiology graphics novel

64
00:03:02,000 --> 00:02:59,220
but i don't have a bunch of it at home

65
00:03:03,950 --> 00:03:02,010
here and so i will send it to you as

66
00:03:05,270 --> 00:03:03,960
soon as we can but but we have a

67
00:03:07,730 --> 00:03:05,280
surprise for you because they are all

68
00:03:10,460 --> 00:03:07,740
available for free online

69
00:03:13,580 --> 00:03:10,470
so Mike could you put up the URL of all

70
00:03:17,090 --> 00:03:13,590
the the location of these astrobiology

71
00:03:19,070 --> 00:03:17,100
graphics novel they're written by dr.

72
00:03:21,980 --> 00:03:19,080
Aaron grunts tall and they are fun to

73
00:03:24,920 --> 00:03:21,990
read for people of all ages so I highly

74
00:03:26,420 --> 00:03:24,930
recommend them we also give a huge shout

75
00:03:28,250 --> 00:03:26,430
out to all of you who's been tweeting

76
00:03:30,620 --> 00:03:28,260
our show this show could not be possible

77
00:03:33,050 --> 00:03:30,630
without your support and many of you are

78
00:03:35,570 --> 00:03:33,060
helping us advertise our programs to the

79
00:03:37,250 --> 00:03:35,580
broader online world and this one's

80
00:03:39,650 --> 00:03:37,260
ambassador of the month I'm very pleased

81
00:03:43,070 --> 00:03:39,660
to announce is birthing formaldehyde

82
00:03:45,710 --> 00:03:43,080
that is tweeting as at birth index face

83
00:03:47,210 --> 00:03:45,720
thank you so much birthing for your

84
00:03:48,500 --> 00:03:47,220
support and thank you for all of you out

85
00:03:50,390 --> 00:03:48,510
there in the Twitter world and the

86
00:03:52,340 --> 00:03:50,400
online world or helping advertise our

87
00:03:54,710 --> 00:03:52,350
show if you have any questions during

88
00:03:56,720 --> 00:03:54,720

this program for mice for our guest dr.

89
00:03:59,120 --> 00:03:56,730
Colin goal but please add them in the

90
00:04:01,880 --> 00:03:59,130
comments we're currently live on Signet

91
00:04:03,980 --> 00:04:01,890
org as well as facebook life and i wish

92
00:04:06,260 --> 00:04:03,990
you all a wonderful show so without

93
00:04:08,510 --> 00:04:06,270
further ado it's my great pleasure to

94
00:04:10,010 --> 00:04:08,520
introduce dr. Colin gold that was a

95
00:04:11,810 --> 00:04:10,020
professor of all things

96
00:04:14,900 --> 00:04:11,820
atmospheres at the University of

97
00:04:16,729 --> 00:04:14,910
Victoria in Canada and a good friend of

98
00:04:21,710 --> 00:04:16,739
mine and Colin is wonderful to have you

99
00:04:24,080 --> 00:04:21,720
on the program thank you for coming so

100
00:04:25,790 --> 00:04:24,090
I'd like to do in this program is turn

101
00:04:28,730 --> 00:04:25,800
back the wheels of time to begin with

102
00:04:31,100 --> 00:04:28,740
and try to figure out how what happened

103
00:04:32,600 --> 00:04:31,110
to turn you into the wonderful scientist

104
00:04:37,490 --> 00:04:32,610
that you are today this is something in

105
00:04:40,090 --> 00:04:37,500
your childhood that occurred or high

106
00:04:42,060 --> 00:04:40,100
school on my favorite subject there were

107
00:04:46,440 --> 00:04:42,070
would you uncuff a

108
00:04:48,330 --> 00:04:46,450
and physics oh yeah to video about

109
00:04:50,370 --> 00:04:48,340
looking at the world around us and try

110
00:04:52,920 --> 00:04:50,380
to understand what was happening and why

111
00:04:56,220 --> 00:04:52,930
then of course physics with with using

112
00:04:59,340 --> 00:04:56,230
those though to pivot to do that and

113
00:05:01,620 --> 00:04:59,350

then I you know I also started I guess

114
00:05:03,930 --> 00:05:01,630
when I was a kid in the teenager to

115
00:05:06,090 --> 00:05:03,940
start liking going into the outdoor

116
00:05:09,050 --> 00:05:06,100
starting into the mountain for another

117
00:05:18,720 --> 00:05:09,060
teenager I merely observing the world

118
00:05:22,410 --> 00:05:18,730
outside and then I think my world worked

119
00:05:24,150 --> 00:05:22,420
and then started feel I think that

120
00:05:26,760 --> 00:05:24,160
chemistry and biology were quite

121
00:05:30,360 --> 00:05:26,770
important to somewhere somewhere through

122
00:05:33,810 --> 00:05:30,370
my training and that got me to where I

123
00:05:36,330 --> 00:05:33,820
am now I think so so you you grew up in

124
00:05:37,160 --> 00:05:36,340
the UK so you went to school in in in

125
00:05:39,270 --> 00:05:37,170
England

126
00:05:41,520 --> 00:05:39,280
tell us a little bit about your your

127
00:05:43,110 --> 00:05:41,530
academic path like it's what I discover

128
00:05:45,150 --> 00:05:43,120
when I talk to pass for biologists it's

129
00:05:47,250 --> 00:05:45,160
not a single one of us has the same

130
00:05:48,750 --> 00:05:47,260
academic path that leads us to be an

131
00:05:55,170 --> 00:05:48,760
astrobiologist so I'm very curious about

132
00:06:00,090 --> 00:05:58,170
and then I metamorphose into a new

133
00:06:02,940 --> 00:06:00,100
degree they had they're called metrology

134
00:06:10,380 --> 00:06:02,950
and oceanography so I'm studying the

135
00:06:14,280 --> 00:06:10,390
physics of the atmosphere oceanography

136
00:06:16,890 --> 00:06:14,290
and the last minute you know change your

137
00:06:20,250 --> 00:06:16,900
mind and I thought well all of it that I

138
00:06:23,070 --> 00:06:20,260

came into this at the beginning to try

139
00:06:27,750 --> 00:06:23,080
to understand and that was how did how

140
00:06:30,660 --> 00:06:27,760
how that world all work together and I

141
00:06:32,460 --> 00:06:30,670
don't you know when I have a teenage

142
00:06:40,140 --> 00:06:32,470
like that a little bit about something

143
00:06:43,350 --> 00:06:40,150
called Gaia hypothesis going into a PhD

144
00:06:48,030 --> 00:06:43,360
that turned out to be about being about

145
00:06:51,720 --> 00:06:48,040
that that's there so it would shoot the

146
00:06:53,520 --> 00:06:51,730
big to finally understand how everything

147
00:06:56,589 --> 00:06:53,530
work together on out

148
00:06:58,629 --> 00:06:56,599
that's the evolution of the atmosphere

149
00:07:00,309 --> 00:06:58,639
is an incredible topic because it's not

150
00:07:01,990 --> 00:07:00,319
you cannot understand the emotion in the

151
00:07:03,820 --> 00:07:02,000
physics of the atmosphere with physics

152
00:07:06,249 --> 00:07:03,830
alone right because biology has played

153
00:07:08,800 --> 00:07:06,259
such an important role in shaping the

154
00:07:10,869 --> 00:07:08,810
planet we are today and so in your day

155
00:07:13,089 --> 00:07:10,879
to day life now you're a professor at

156
00:07:16,469 --> 00:07:13,099
the University of Victoria tell us about

157
00:07:21,580 --> 00:07:18,459
professor you know thought would be

158
00:07:25,240 --> 00:07:21,590
about 15 but part of it is teaching and

159
00:07:29,800 --> 00:07:25,250
that's a great opportunity to share the

160
00:07:32,559 --> 00:07:29,810
science and share the research lead view

161
00:07:34,119 --> 00:07:32,569
of how to view the world 12

162
00:07:37,749 --> 00:07:34,129
undergraduates and of course to my

163
00:07:40,600 --> 00:07:37,759

spectacular students and and then doing

164
00:07:42,550 --> 00:07:40,610
research about atmospheric evolution and

165
00:07:49,300 --> 00:07:42,560
you know of course doing our part to

166
00:07:51,399 --> 00:07:49,310
keep the University bombing to keep

167
00:07:54,040 --> 00:07:51,409
doing science and you realize it's not

168
00:07:56,499 --> 00:07:54,050
all doing research at a small part of my

169
00:07:59,499 --> 00:07:56,509
job right now you know everything else

170
00:08:02,260 --> 00:07:59,509
takes up the rest of the time but you

171
00:08:05,409 --> 00:08:02,270
really facilitating other people to have

172
00:08:07,659 --> 00:08:05,419
that understanding of how our world

173
00:08:10,059 --> 00:08:07,669
works from the point of view that I

174
00:08:12,399 --> 00:08:10,069
learned so what you're doing these days

175
00:08:14,230 --> 00:08:12,409
is you're using your background in

176
00:08:16,899 --> 00:08:14,240
physics and mathematics to write

177
00:08:19,149 --> 00:08:16,909
computer software that simulates the

178
00:08:26,950 --> 00:08:19,159
physics of the atmosphere on our planet

179
00:08:28,869 --> 00:08:26,960
right my words got the elements which is

180
00:08:31,689 --> 00:08:28,879
about the climate evolution of us and

181
00:08:33,969 --> 00:08:31,699
also about the chemical evolution of the

182
00:08:37,000 --> 00:08:33,979
atmosphere so you know one of the things

183
00:08:39,579 --> 00:08:37,010
that we can do is if you take a column

184
00:08:41,170 --> 00:08:39,589
of the atmosphere we can calculate the

185
00:08:44,019 --> 00:08:41,180
relative fan first through that

186
00:08:46,240 --> 00:08:44,029
arbitrarily well and you know if you

187
00:08:49,540 --> 00:08:46,250
know the atmosphere composition you can

188
00:08:51,280 --> 00:08:49,550

you know physics is one of my expertise

189
00:08:53,680 --> 00:08:51,290
and we can we can do that job really

190
00:08:56,710 --> 00:08:53,690
nicely but they do need to know you have

191
00:08:58,840 --> 00:08:56,720
a composition and we don't have good

192
00:09:00,759 --> 00:08:58,850
model but how that's changed through

193
00:09:01,460 --> 00:09:00,769
time that's one of the things that I

194
00:09:09,770 --> 00:09:01,470
know

195
00:09:13,430 --> 00:09:09,780
well I hope you understand how it the

196
00:09:14,990 --> 00:09:13,440
bold ah that's a fascinating topic and I

197
00:09:17,360 --> 00:09:15,000
know we're gonna completely get there

198
00:09:18,670 --> 00:09:17,370
guaranteed so relative transfer of

199
00:09:20,750 --> 00:09:18,680
course is that is the mathematical

200
00:09:23,060 --> 00:09:20,760
formulation of energy from the Sun

201
00:09:24,380 --> 00:09:23,070
coming it and how the planet keeps it or

202
00:09:27,050 --> 00:09:24,390
reflects it out and that's all very

203
00:09:29,000 --> 00:09:27,060
tractable with the tools of physics now

204
00:09:30,530 --> 00:09:29,010
if we go back in the early earth which

205
00:09:32,750 --> 00:09:30,540
is a time period that you and I both

206
00:09:35,420 --> 00:09:32,760
enjoy thinking about and by earlier that

207
00:09:36,920 --> 00:09:35,430
no no not mean you know hundreds of

208
00:09:38,660 --> 00:09:36,930
thousands of years ago even million

209
00:09:42,560 --> 00:09:38,670
years ago when the dinosaurs were around

210
00:09:44,780 --> 00:09:42,570
but billions was a B years ago when the

211
00:09:47,060 --> 00:09:44,790
planet looked nothing like it does today

212
00:09:49,940 --> 00:09:47,070
so Colin I wish you take us in the time

213
00:09:52,010 --> 00:09:49,950

machine dump us in this period of Earth

214
00:09:54,620 --> 00:09:52,020
called the Archaean before two and a

215
00:09:57,170 --> 00:09:54,630
half billion years ago if we had a

216
00:10:08,930 --> 00:09:57,180
breathing mask what would we see what

217
00:10:11,180 --> 00:10:08,940
would the world look like then and 20

218
00:10:13,910 --> 00:10:11,190
percent oxygen and some important place

219
00:10:19,460 --> 00:10:13,920
species and you know - species like

220
00:10:22,550 --> 00:10:19,470
carbon dioxide its water vapor today

221
00:10:26,150 --> 00:10:22,560
really biological products or at least

222
00:10:28,280 --> 00:10:26,160
they're strongly modulated or controlled

223
00:10:31,250 --> 00:10:28,290
by the biology that we have to think of

224
00:10:34,010 --> 00:10:31,260
how that has changed to Earth history so

225
00:10:36,020 --> 00:10:34,020
then get back to the archaea well the

226
00:10:38,570 --> 00:10:36,030
thing that we know we didn't have in the

227
00:10:43,160 --> 00:10:38,580
atmosphere with any oxygen you know the

228
00:10:45,490 --> 00:10:43,170
air we please today which is 20% America

229
00:10:49,250 --> 00:10:45,500
spends days in New York in was probably

230
00:10:53,510 --> 00:10:49,260
about one part per million in the

231
00:10:57,290 --> 00:10:53,520
atmosphere that's about the same methane

232
00:11:01,790 --> 00:10:57,300
is in the atmosphere today so why is

233
00:11:05,120 --> 00:11:01,800
that well oxygen and biological product

234
00:11:08,180 --> 00:11:05,130
it made by oxygen producing

235
00:11:09,850 --> 00:11:08,190
photosynthesis which is the most amazing

236
00:11:13,750 --> 00:11:09,860
advanced metabolize

237
00:11:15,700 --> 00:11:13,760
this is where we sit send plants but

238
00:11:18,610 --> 00:11:15,710

we'd also see it in the Archaean inside

239
00:11:20,620 --> 00:11:18,620
in the bacteria eat photons from the Sun

240
00:11:25,030 --> 00:11:20,630
they get their energy down bets on the

241
00:11:27,370 --> 00:11:25,040
Sun split water use carbon dioxide make

242
00:11:30,610 --> 00:11:27,380
organic matter make energy and then

243
00:11:34,990 --> 00:11:30,620
oxygen is the toxic by-product because

244
00:11:38,200 --> 00:11:35,000
that I came at the fair that wasn't much

245
00:11:40,960 --> 00:11:38,210
of any end of the Archaean with where

246
00:11:44,830 --> 00:11:40,970
oxygen built up in the atmosphere has a

247
00:11:47,080 --> 00:11:44,840
very fast transition to you probably

248
00:11:49,870 --> 00:11:47,090
percent levels of oxygen that we call

249
00:11:51,730 --> 00:11:49,880
the the great oxidation and after that

250
00:11:53,890 --> 00:11:51,740
the oxygen started rising there was the

251
00:12:00,940 --> 00:11:53,900
biggest climate up here all that we've

252
00:12:07,630 --> 00:12:00,950
ever seen right lows we moved into

253
00:12:09,430 --> 00:12:07,640
something called a snowball alphabet the

254
00:12:12,130 --> 00:12:09,440
poles of the earth and it gets bit

255
00:12:15,010 --> 00:12:12,140
colder and the ice lines start to move

256
00:12:17,050 --> 00:12:15,020
never near an equator and that's a bit

257
00:12:21,970 --> 00:12:17,060
like leaning back in a chair you lean

258
00:12:25,330 --> 00:12:21,980
back too far over and in the same way

259
00:12:26,890 --> 00:12:25,340
the ice line creased was the equator and

260
00:12:29,710 --> 00:12:26,900
then when you get into the mid latitudes

261
00:12:33,930 --> 00:12:29,720
we were affecting so much energy away

262
00:12:36,730 --> 00:12:33,940
that the whole planet get glaciated

263
00:12:40,150 --> 00:12:36,740

absolutely biggest climate catastrophe

264
00:12:45,790 --> 00:12:40,160
that we've experienced on earth that

265
00:12:48,070 --> 00:12:45,800
could happen so the the Archean was a

266
00:12:49,510 --> 00:12:48,080
time period where the Sun was fainter

267
00:12:52,090 --> 00:12:49,520
because we understand the physics of the

268
00:12:53,890 --> 00:12:52,100
Sun as well and so we can predict using

269
00:12:56,050 --> 00:12:53,900
the computer simulations that the Sun

270
00:12:57,640 --> 00:12:56,060
was fainter back then and so to keep the

271
00:12:59,530 --> 00:12:57,650
planet warm they needed to be some

272
00:13:01,840 --> 00:12:59,540
greenhouse gases like methane you're

273
00:13:04,120 --> 00:13:01,850
talking about in carbon dioxide so this

274
00:13:06,220 --> 00:13:04,130
rise of oxygen this oxygen can started

275
00:13:10,420 --> 00:13:06,230
eating up to this this methane which

276
00:13:13,900 --> 00:13:10,430
caused the car the greenhouse cover to

277
00:13:16,360 --> 00:13:13,910
collapse and so hence the snowball earth

278
00:13:17,560 --> 00:13:16,370
it's just and yet cities for about

279
00:13:19,870 --> 00:13:17,570
microbes didn't know what they were

280
00:13:21,100 --> 00:13:19,880
doing what they were doing right

281
00:13:22,509 --> 00:13:21,110
we know what we're doing with our

282
00:13:24,040 --> 00:13:22,519
atmosphere and yet we're not doing

283
00:13:27,129 --> 00:13:24,050
anything which is driving me crazy

284
00:13:29,110 --> 00:13:27,139
so can we learn from our ancestors right

285
00:13:31,420 --> 00:13:29,120
you know I think one of the thing that

286
00:13:33,730 --> 00:13:31,430
we can you know we're in a time of

287
00:13:37,680 --> 00:13:33,740
unprecedented environmental change at

288
00:13:41,379 --> 00:13:37,690

the moment the the late of change now

289
00:13:44,829 --> 00:13:41,389
because of human-caused carbon dioxide

290
00:13:47,079 --> 00:13:44,839
emissions is faster than almost anything

291
00:13:50,319 --> 00:13:47,089
I can think of in the geologic record

292
00:13:53,110 --> 00:13:50,329
the last good contender is 60 million

293
00:13:58,290 --> 00:13:53,120
years ago but anything of asked that

294
00:14:02,199 --> 00:13:58,300
we're seeing out paleo climate is really

295
00:14:05,019 --> 00:14:02,209
important in terms of understanding what

296
00:14:07,660 --> 00:14:05,029
can happen and what we've seen through

297
00:14:10,689 --> 00:14:07,670
the past it is long periods of climate

298
00:14:15,960 --> 00:14:10,699
stability and then a period of rapid

299
00:14:18,040 --> 00:14:15,970
change to different climates days yeah I

300
00:14:20,019 --> 00:14:18,050
was gonna say maybe Earth has seen

301
00:14:21,400 --> 00:14:20,029
climates much different than today there

302
00:14:22,930 --> 00:14:21,410
was a point in the earth like you

303
00:14:24,490 --> 00:14:22,940
mentioned it was completely covered in

304
00:14:27,579 --> 00:14:24,500
ice there's been a time period where

305
00:14:30,040 --> 00:14:27,589
there is no ice on the surface right we

306
00:14:31,870 --> 00:14:30,050
do have climate change we see that right

307
00:14:34,780 --> 00:14:31,880
through the geologic record if we look

308
00:14:37,300 --> 00:14:34,790
at our planets we see them wear them and

309
00:14:40,960 --> 00:14:37,310
whackier climate so we know that change

310
00:14:44,970 --> 00:14:40,970
happens so one thing that we do have now

311
00:14:47,199 --> 00:14:44,980
which is a very interesting even though

312
00:14:49,269 --> 00:14:47,209
evolutionary innovation of Farr's we

313
00:14:53,170 --> 00:14:49,279

know is that we actually know what we're

314
00:14:55,389 --> 00:14:53,180
doing so my colleague David Grinspoon

315
00:14:58,960 --> 00:14:55,399
called the planetary change of the

316
00:15:00,939 --> 00:14:58,970
Fourth Kind if we actually know what

317
00:15:03,100 --> 00:15:00,949
we're doing and we can make choices to

318
00:15:07,389 --> 00:15:03,110
change it and what that is going to

319
00:15:09,040 --> 00:15:07,399
require is a collective action and you

320
00:15:10,840 --> 00:15:09,050
know these are very difficult times at

321
00:15:13,600 --> 00:15:10,850
the moment but something that gives me

322
00:15:16,240 --> 00:15:13,610
great hope is seeing us taking

323
00:15:18,819 --> 00:15:16,250
collective action we can see those

324
00:15:21,040 --> 00:15:18,829
effect we can see something that could

325
00:15:23,499 --> 00:15:21,050
hurt ourselves hurt our family

326
00:15:26,230 --> 00:15:23,509
hurt members back many and we're taking

327
00:15:28,510 --> 00:15:26,240
action and climate change is just the

328
00:15:31,480 --> 00:15:28,520
same we need to take the kind

329
00:15:35,170 --> 00:15:31,490
collective action that we're taking now

330
00:15:36,670 --> 00:15:35,180
to slow down this epidemic and we need

331
00:15:39,730 --> 00:15:36,680
to take that kind of collective action

332
00:15:42,820 --> 00:15:39,740
to slow down climate change and we can

333
00:15:45,370 --> 00:15:42,830
do that what happening now has shown

334
00:15:47,860 --> 00:15:45,380
that we can do that kind of collective

335
00:15:49,660 --> 00:15:47,870
action I couldn't agree more

336
00:15:52,780 --> 00:15:49,670
and in fact if you if you kept the

337
00:15:54,400 --> 00:15:52,790
climate change action going in you know

338
00:15:57,100 --> 00:15:54,410

I'm exaggerating obviously here in

339
00:15:58,510 --> 00:15:57,110
billions of years in the future as I

340
00:15:59,890 --> 00:15:58,520
mentioned the Sun in the past was

341
00:16:08,440 --> 00:15:59,900
fainter is actually getting brighter

342
00:16:10,720 --> 00:16:08,450
earth might turn into a Venus right I'll

343
00:16:15,640 --> 00:16:10,730
go back to the story of my academic path

344
00:16:17,560 --> 00:16:15,650
here if I worked on earth evolution to

345
00:16:20,590 --> 00:16:17,570
in my PhD I worked on the problem of the

346
00:16:23,560 --> 00:16:20,600
great oxidation and then we we got to

347
00:16:26,350 --> 00:16:23,570
the you get the problem Bob you've only

348
00:16:27,970 --> 00:16:26,360
got a sample size of one and this was

349
00:16:36,310 --> 00:16:27,980
really pointed out to me by one of my

350
00:16:38,530 --> 00:16:36,320
PhD advisor Andy Watson what he had

351
00:16:40,330 --> 00:16:38,540
training in planetary science and the

352
00:16:43,180 --> 00:16:40,340
question of astrobiology what to

353
00:16:45,130 --> 00:16:43,190
understand earth better we need to look

354
00:16:46,930 --> 00:16:45,140
at the other planets and of course the

355
00:16:49,570 --> 00:16:46,940
way we can understand the other planets

356
00:16:54,610 --> 00:16:49,580
I understand the earth bit sir it's a

357
00:16:59,020 --> 00:16:54,620
beautiful cycle there so bigger is earth

358
00:17:01,840 --> 00:16:59,030
in the distant future say you know this

359
00:17:03,700 --> 00:17:01,850
wonderful habitable planet we've taken

360
00:17:06,100 --> 00:17:03,710
most of the carbon dioxide and not

361
00:17:08,140 --> 00:17:06,110
better pin marks biology has been really

362
00:17:11,440 --> 00:17:08,150
important in doing that in building

363
00:17:14,949 --> 00:17:11,450

carbonate rocks but you get to a point

364
00:17:17,199 --> 00:17:14,959
where they think all of that only

365
00:17:19,930 --> 00:17:17,209
greenhouse happens if you're getting

366
00:17:22,840 --> 00:17:19,940
more energy from the Sun then you can

367
00:17:25,960 --> 00:17:22,850
possibly get out some atmosphere like a

368
00:17:31,590 --> 00:17:25,970
strapless it's like turning the

369
00:17:36,520 --> 00:17:34,360
eventually that bathtub can overflow and

370
00:17:38,410 --> 00:17:36,530
that's gonna happen on earth

371
00:17:40,510 --> 00:17:38,420
you know maybe 500 billion a year the

372
00:17:42,790 --> 00:17:40,520
billion years and that is really going

373
00:17:45,610 --> 00:17:42,800
to be the end of the year is the world

374
00:17:46,960 --> 00:17:45,620
the month the apocalypse is going to be

375
00:17:49,960 --> 00:17:46,970
a ban on my greenhouse

376
00:17:55,420 --> 00:17:49,970
lime kilm infernos and what that means

377
00:17:58,630 --> 00:17:55,430
if all we're gonna start warming and

378
00:18:01,210 --> 00:17:58,640
then all of the oceans will eventually

379
00:18:03,070 --> 00:18:01,220
evaporate into the atmosphere and then

380
00:18:06,100 --> 00:18:03,080
the greenhouse effect is going to be so

381
00:18:08,680 --> 00:18:06,110
strong then it's going to bake off all

382
00:18:11,140 --> 00:18:08,690
the carbon that stored in limestone at

383
00:18:13,990 --> 00:18:11,150
the moment then all the carbon dioxide

384
00:18:16,210 --> 00:18:14,000
in the atmosphere - and then other than

385
00:18:19,900 --> 00:18:16,220
a couple of hundred billion a year will

386
00:18:22,480 --> 00:18:19,910
lose the water vapor by hydrogen escape

387
00:18:26,860 --> 00:18:22,490
to space and then we'll end up like

388
00:18:29,530 --> 00:18:26,870

peanuts wow that's that's quite the the

389
00:18:30,910 --> 00:18:29,540
future I'm so those of you who are

390
00:18:32,560 --> 00:18:30,920
watching it please don't forget you can

391
00:18:35,320 --> 00:18:32,570
ask questions so if you want to Facebook

392
00:18:36,700 --> 00:18:35,330
live just use the comments down below to

393
00:18:39,550 --> 00:18:36,710
ask your questions if you're on Twitter

394
00:18:41,710 --> 00:18:39,560
please use hash tag ask Astro bio and if

395
00:18:43,870 --> 00:18:41,720
you're watching on say canet please use

396
00:18:45,790 --> 00:18:43,880
the chat there to ask questions and it's

397
00:18:47,530 --> 00:18:45,800
a wonderful conversation so this is a

398
00:18:49,750 --> 00:18:47,540
Shabbat astrobiology college I was

399
00:18:51,520 --> 00:18:49,760
wondering when did you discover the the

400
00:18:52,990 --> 00:18:51,530
discipline of astrobiology and how did

401
00:18:56,530 --> 00:18:53,000
you tailor your science to that

402
00:18:59,730 --> 00:18:56,540
discipline like if someone during my PhD

403
00:19:01,750 --> 00:18:59,740
I found it by accident because I was

404
00:19:04,050 --> 00:19:01,760
working on the early Earth and there

405
00:19:06,820 --> 00:19:04,060
wasn't that much community in the UK

406
00:19:09,520 --> 00:19:06,830
doing that at that time it wasn't very

407
00:19:12,850 --> 00:19:09,530
well funded but it was getting funded

408
00:19:16,450 --> 00:19:12,860
through the nasa expulsion astrobiology

409
00:19:19,030 --> 00:19:16,460
programs constant session the people I

410
00:19:21,400 --> 00:19:19,040
was talking to work with people in the

411
00:19:24,010 --> 00:19:21,410
US fund it out of the house of the

412
00:19:27,970 --> 00:19:24,020
astrobiology program there that's one

413
00:19:31,360 --> 00:19:27,980

way to talk about my my science and you

414
00:19:33,370 --> 00:19:31,370
know after value meetings including the

415
00:19:37,390 --> 00:19:33,380
anthropology graduate conference which

416
00:19:40,300 --> 00:19:37,400
is I think why yes enjoy and there's

417
00:19:43,990 --> 00:19:40,310
just a great community an amazingly

418
00:19:46,990 --> 00:19:44,000
community of people working on these

419
00:19:49,630 --> 00:19:47,000
questions we understand early Earth and

420
00:19:51,340 --> 00:19:49,640
all of people

421
00:19:54,100 --> 00:19:51,350
it's like watching a feature-length

422
00:19:58,230 --> 00:19:54,110
movie loveland just taking a snapshot of

423
00:20:00,940 --> 00:19:58,240
now saying that the habitable planet

424
00:20:02,770 --> 00:20:00,950
sorry I like you I say I study the early

425
00:20:04,480 --> 00:20:02,780
Earth and I want to discuss them like my

426
00:20:06,550 --> 00:20:04,490
science the public didn't tell me like

427
00:20:08,470 --> 00:20:06,560
who cares about your list why is that

428
00:20:10,150 --> 00:20:08,480
even important and so the answer is

429
00:20:12,910 --> 00:20:10,160
always in the astrobiology field because

430
00:20:15,850 --> 00:20:12,920
the early Earth is the most study wheel

431
00:20:17,500 --> 00:20:15,860
planet that we know is alive that's not

432
00:20:24,880 --> 00:20:17,510
our modern world still share these

433
00:20:26,380 --> 00:20:24,890
thoughts so many different samples of

434
00:20:28,420 --> 00:20:26,390
water planet could be like and I

435
00:20:30,270 --> 00:20:28,430
actually think in the astrobiology

436
00:20:32,980 --> 00:20:30,280
community there's a little bit of a

437
00:20:36,190 --> 00:20:32,990
tendency to simplify this is what the

438
00:20:40,000 --> 00:20:36,200

Archaean was like this is what modernist

439
00:20:44,020 --> 00:20:40,010
it's like actually there is smorgasbord

440
00:20:48,430 --> 00:20:44,030
of climate and Composition that we don't

441
00:20:56,320 --> 00:20:48,440
really understand very well when were

442
00:20:58,330 --> 00:20:56,330
able to observe other planets but we've

443
00:21:01,180 --> 00:20:58,340
got really good instruments to look at

444
00:21:03,360 --> 00:21:01,190
the atmospheres of a many distant

445
00:21:06,670 --> 00:21:03,370
exoplanets we'll find that our

446
00:21:08,590 --> 00:21:06,680
imagination was not sufficient for what

447
00:21:12,370 --> 00:21:08,600
a planet could be like and what a

448
00:21:14,410 --> 00:21:12,380
habitable planet could be like so if you

449
00:21:16,930 --> 00:21:14,420
had extraterrestrial astronomers they

450
00:21:19,810 --> 00:21:16,940
were looking at Earth today they were

451
00:21:21,760 --> 00:21:19,820
also looking at Earth a very very long

452
00:21:23,260 --> 00:21:21,770
time ago in the Archaean period what

453
00:21:25,030 --> 00:21:23,270
would be the differences that they would

454
00:21:34,360 --> 00:21:25,040
see and how could they tell that the

455
00:21:36,670 --> 00:21:34,370
planet was alive the plane only to tell

456
00:21:40,060 --> 00:21:36,680
that the earth was alive today would be

457
00:21:41,530 --> 00:21:40,070
to look at the radio wave leakage that

458
00:21:44,620 --> 00:21:41,540
we've got we've been broadcasting

459
00:21:46,870 --> 00:21:44,630
television and baby home for the last 50

460
00:21:49,210 --> 00:21:46,880
years and who knows what other things

461
00:21:50,830 --> 00:21:49,220
we're with broadcasting accidentally you

462
00:21:51,790 --> 00:21:50,840
could listening to that you could just

463
00:21:55,990 --> 00:21:51,800

either

464
00:21:57,940 --> 00:21:56,000
Ponyo antenna a planet and watch the six

465
00:22:02,060 --> 00:21:57,950
o'clock news so that would be a good way

466
00:22:07,710 --> 00:22:04,649
not an option you've got to look at the

467
00:22:11,549 --> 00:22:07,720
atmospheric composition you know the

468
00:22:13,680 --> 00:22:11,559
atmosphere is really part of the earth

469
00:22:16,020 --> 00:22:13,690
that's a bit of theory that dates to the

470
00:22:19,529 --> 00:22:16,030
Russian Jew chemist urbanovsky might

471
00:22:21,960 --> 00:22:19,539
think about a hundred years ago and if

472
00:22:24,330 --> 00:22:21,970
the by Affairs having living part and

473
00:22:25,560 --> 00:22:24,340
that you and I and the plant sitting

474
00:22:27,960 --> 00:22:25,570
behind me

475
00:22:31,820 --> 00:22:27,970
blue the nonliving part in the

476
00:22:34,409 --> 00:22:31,830
atmosphere is part of our biosphere and

477
00:22:37,950 --> 00:22:34,419
change the atmospheric composition we

478
00:22:40,590 --> 00:22:37,960
put it into disequilibrium and that was

479
00:22:42,960 --> 00:22:40,600
a very important observation by James

480
00:22:45,930 --> 00:22:42,970
Lovelock when he was working on the Mars

481
00:22:50,430 --> 00:22:45,940
program that you can look at planetary

482
00:22:51,870 --> 00:22:50,440
atmosphere and say like that okay that

483
00:22:54,779 --> 00:22:51,880
was just body chemistry

484
00:22:56,789 --> 00:22:54,789
you look at Martha it's like pretty here

485
00:22:59,549 --> 00:22:56,799
thermo chemical equilibrium it's just

486
00:23:02,940 --> 00:22:59,559
like if you left it's a very long time

487
00:23:03,539 --> 00:23:02,950
how it would be but you look it's so

488
00:23:06,390 --> 00:23:03,549

weird

489
00:23:10,169 --> 00:23:06,400
either we have methane that about a part

490
00:23:12,659 --> 00:23:10,179
per million when we got 20% oxygen and

491
00:23:14,399 --> 00:23:12,669
that's the only last 10 years if you

492
00:23:17,549 --> 00:23:14,409
just left everything alone there's gonna

493
00:23:20,279 --> 00:23:17,559
be a constant saw of both those gases

494
00:23:23,970 --> 00:23:20,289
and that source is like do you look at

495
00:23:28,080 --> 00:23:23,980
the atmospheric composition and then you

496
00:23:31,470 --> 00:23:28,090
think can we explain it any why other

497
00:23:33,990 --> 00:23:31,480
than oh yeah by the action of Mike and

498
00:23:37,649 --> 00:23:34,000
if you can oh well and good and it not

499
00:23:40,529 --> 00:23:37,659
well that is your tentative detection of

500
00:23:43,350 --> 00:23:40,539
life on your planet but all about

501
00:23:45,870 --> 00:23:43,360
looking at the atmosphere so we can't

502
00:23:47,850 --> 00:23:45,880
think of modern earth independently of

503
00:23:55,980 --> 00:23:47,860
life like earth would look nothing like

504
00:23:58,080 --> 00:23:55,990
it does today with that life look out

505
00:23:59,110 --> 00:23:58,090
the window you're seeing the evidence of

506
00:24:01,210 --> 00:23:59,120
knife right now

507
00:24:02,950 --> 00:24:01,220
you know I'm looking at that you're the

508
00:24:06,250 --> 00:24:02,960
plant in my garden

509
00:24:09,310 --> 00:24:06,260
you know I be atmosphere with it

510
00:24:12,610 --> 00:24:09,320
competition today is all about life you

511
00:24:14,830 --> 00:24:12,620
know absolutely no idea what earth would

512
00:24:18,400 --> 00:24:14,840
be like today whatever but there would

513
00:24:19,720 --> 00:24:18,410

be like without life so all the gases

514
00:24:22,540 --> 00:24:19,730
that we breathe that our inner

515
00:24:25,840 --> 00:24:22,550
atmosphere completely cycles well not

516
00:24:34,030 --> 00:24:25,850
all but most are completely cycled by

517
00:24:37,120 --> 00:24:34,040
biology we don't think I had anything to

518
00:24:40,330 --> 00:24:37,130
do with them oxygen we talked about

519
00:24:42,430 --> 00:24:40,340
either the carbon cycle where all life

520
00:24:44,560 --> 00:24:42,440
is you know its carbon has got a

521
00:24:47,350 --> 00:24:44,570
carbon-based metabolism so we're using

522
00:24:49,420 --> 00:24:47,360
co2 we're putting it out again the

523
00:24:52,480 --> 00:24:49,430
oxygen of course is linked in with that

524
00:24:54,040 --> 00:24:52,490
carbon cycle and even the nitrogen you

525
00:24:57,250 --> 00:24:54,050
know something that both you and I have

526
00:24:59,950 --> 00:24:57,260
worked on we we know they're the cycle

527
00:25:02,770 --> 00:24:59,960
of long term fixing of that nitrogen by

528
00:25:05,440 --> 00:25:02,780
biology of the nutrient and then some of

529
00:25:08,310 --> 00:25:05,450
that fix nitrogen get can get cycled

530
00:25:10,600 --> 00:25:08,320
through the box and powd again

531
00:25:12,730 --> 00:25:10,610
absolutely had the thing have got that

532
00:25:15,550 --> 00:25:12,740
I've got a fingerprint of biology

533
00:25:17,200 --> 00:25:15,560
involved and that's why I find it so

534
00:25:18,100 --> 00:25:17,210
interesting because it's it's so

535
00:25:20,110 --> 00:25:18,110
complicated

536
00:25:22,180 --> 00:25:20,120
and yet so revealing because I think

537
00:25:24,370 --> 00:25:22,190
that like you mentioned so the earth has

538
00:25:26,980 --> 00:25:24,380

changed over time and studying it over

539
00:25:29,290 --> 00:25:26,990
time gives us a snapshot of a different

540
00:25:31,720 --> 00:25:29,300
planet that could host life but that's

541
00:25:35,650 --> 00:25:31,730
nothing compared to the diversity of

542
00:25:37,570 --> 00:25:35,660
planets are out there so as as you know

543
00:25:39,310 --> 00:25:37,580
they've been thousands of planets that

544
00:25:42,030 --> 00:25:39,320
have been discovered outside our solar

545
00:25:44,500 --> 00:25:42,040
system what do you think the future of

546
00:25:49,660 --> 00:25:44,510
exoplanet science and early Earth

547
00:25:51,850 --> 00:25:49,670
science have in store you know looking a

548
00:25:53,920 --> 00:25:51,860
long way forward when we got instruments

549
00:25:57,400 --> 00:25:53,930
where we can really start to probe the

550
00:25:59,620 --> 00:25:57,410
atmospheres of exoplanets that is going

551
00:26:04,600 --> 00:25:59,630
to be a revolution in our understanding

552
00:26:06,520 --> 00:26:04,610
we're going to find I mean that's the

553
00:26:09,040 --> 00:26:06,530
emphasis in the astral body community

554
00:26:10,259 --> 00:26:09,050
are we going to find light are we going

555
00:26:14,519 --> 00:26:10,269
to find a

556
00:26:16,919 --> 00:26:14,529
another earth-like planet and the fields

557
00:26:18,570 --> 00:26:16,929
gonna go up at some point and people are

558
00:26:20,459 --> 00:26:18,580
gonna start to big how can we

559
00:26:24,359 --> 00:26:20,469
characterize the whole range of

560
00:26:25,739 --> 00:26:24,369
atmospheres about the planet I've got no

561
00:26:30,539 --> 00:26:25,749
idea what we're gonna find but it's

562
00:26:32,219 --> 00:26:30,549
gonna be fascinating strength in within

563
00:26:34,680 --> 00:26:32,229

my career I know some of my colleagues

564
00:26:38,669 --> 00:26:34,690
are working really hard to make sure

565
00:26:42,149 --> 00:26:38,679
that we do and then we're gonna see a

566
00:26:44,430 --> 00:26:42,159
diversity of planets and we can start to

567
00:26:46,919 --> 00:26:44,440
see one of the property the planetary

568
00:26:50,869 --> 00:26:46,929
atmospheres and then one of the things

569
00:26:53,789 --> 00:26:50,879
we'll see is what is the frequency of

570
00:26:56,579 --> 00:26:53,799
planets that we think have life on we'll

571
00:26:58,769 --> 00:26:56,589
find out whether life is a rare

572
00:27:02,159 --> 00:26:58,779
phenomenon or whether it's a common

573
00:27:04,979 --> 00:27:02,169
phenomenon and that new bit of

574
00:27:07,109 --> 00:27:04,989
understanding I think it's gonna really

575
00:27:08,069 --> 00:27:07,119
change the way we think about absolutely

576
00:27:10,339 --> 00:27:08,079
has nothing

577
00:27:12,329 --> 00:27:10,349
I completely agree I completely agree

578
00:27:15,180 --> 00:27:12,339
yeah the question of whether our Laura

579
00:27:16,499 --> 00:27:15,190
where we are in the universe is the

580
00:27:19,049 --> 00:27:16,509
biggest questions we could ask ourselves

581
00:27:21,719 --> 00:27:19,059
as a species but beyond science so

582
00:27:23,399 --> 00:27:21,729
you're an avid outdoorsman I think

583
00:27:25,529 --> 00:27:23,409
that's a way you can clear your head

584
00:27:28,109 --> 00:27:25,539
from from from academics and also get

585
00:27:29,669 --> 00:27:28,119
inspired to do science based on what you

586
00:27:35,379 --> 00:27:29,679
see what are some of the outdoors

587
00:27:45,520 --> 00:27:37,779
get out into the outside I think it's uh

588
00:27:55,580 --> 00:27:52,240

quiet to time enjoy beautiful places it

589
00:27:59,630 --> 00:27:55,590
even my my long-term hobby have been

590
00:28:05,810 --> 00:28:03,020
each other around the world you know my

591
00:28:07,910 --> 00:28:05,820
live in the Pacific Northwest at the

592
00:28:09,770 --> 00:28:07,920
moment so the Olympic mountain the thumb

593
00:28:13,400 --> 00:28:09,780
that I love you know I go to the Cascade

594
00:28:16,610 --> 00:28:13,410
sometimes and either mountains here I'd

595
00:28:19,490 --> 00:28:16,620
like to you know like a good backpacking

596
00:28:23,060 --> 00:28:19,500
I can be self-sufficient four or five

597
00:28:25,760 --> 00:28:23,070
days and get me out there and listen to

598
00:28:27,770 --> 00:28:25,770
the mama call to each other from

599
00:28:31,190 --> 00:28:27,780
different mountain peaks watch the Bears

600
00:28:35,300 --> 00:28:31,200
wonder path and just enjoy that that

601
00:28:37,450 --> 00:28:35,310
quiet time outside and then living in

602
00:28:40,280 --> 00:28:37,460
Victoria where I do

603
00:28:42,320 --> 00:28:40,290
beautify to get outside is it a sea

604
00:28:45,470 --> 00:28:42,330
kayak where we've got a beautiful

605
00:28:47,810 --> 00:28:45,480
coastline it's I live 15 minutes from

606
00:28:51,830 --> 00:28:47,820
the beach in four different directions I

607
00:28:54,650 --> 00:28:51,840
think so we can get out kayaking on the

608
00:28:57,890 --> 00:28:54,660
coast of British Columbia here so

609
00:29:00,910 --> 00:28:57,900
there's very good opportunities to be an

610
00:29:02,780 --> 00:29:00,920
explorer is incredibly productive

611
00:29:06,770 --> 00:29:02,790
ecosystem here in the Pacific Northwest

612
00:29:10,400 --> 00:29:06,780
one where we can still see what it was

613
00:29:13,160 --> 00:29:10,410

like before them you know the European

614
00:29:17,620 --> 00:29:13,170
you get into what it was like before the

615
00:29:22,130 --> 00:29:17,630
European invasion here and see what an

616
00:29:23,480 --> 00:29:22,140
almost 15 environment was like and a

617
00:29:26,120 --> 00:29:23,490
beauty of the the scientific background

618
00:29:28,460 --> 00:29:26,130
is Eakins read the landscape right and

619
00:29:30,050 --> 00:29:28,470
you can understand mountain here why not

620
00:29:32,960 --> 00:29:30,060
what does the lake here why not what is

621
00:29:34,790 --> 00:29:32,970
this it's not this rock is all polished

622
00:29:42,200 --> 00:29:34,800
and so on so that's Ghostly really

623
00:29:44,570 --> 00:29:42,210
rewarding yeah with anyone you know from

624
00:29:47,150 --> 00:29:44,580
another bunch of environmental sciences

625
00:29:50,000 --> 00:29:47,160
and if I get to hear how they understand

626
00:29:52,910 --> 00:29:50,010
the world to that the way that a really

627
00:29:54,380 --> 00:29:52,920
great pleasure wonderful I have this

628
00:29:55,970 --> 00:29:54,390
conversation forever Colin this is

629
00:29:57,470 --> 00:29:55,980
really wonderful but we're gonna we're

630
00:29:59,360 --> 00:29:57,480
gonna have to end here and start one of

631
00:30:02,240 --> 00:29:59,370
my favorite parts of this show which is

632
00:30:03,500 --> 00:30:02,250
the Q&A so thank you all for those of

633
00:30:05,340 --> 00:30:03,510
you have sending questions there's a

634
00:30:08,730 --> 00:30:05,350
bunch I hope we can address all of the

635
00:30:11,129 --> 00:30:08,740
but we'll do our best so the so here we

636
00:30:14,850 --> 00:30:11,139
go so sending in your questions and the

637
00:30:16,590 --> 00:30:14,860
first question is by Graham LA my

638
00:30:19,289 --> 00:30:16,600

co-host here at Aspen astrobiologists

639
00:30:22,289 --> 00:30:19,299
who asks on Twitter if life is common in

640
00:30:24,509 --> 00:30:22,299
the universe how likely do you think we

641
00:30:26,100 --> 00:30:24,519
are to find signs of alien life bio

642
00:30:38,519 --> 00:30:26,110
signatures or technical signatures in

643
00:30:40,529 --> 00:30:38,529
the near future works on geologic time

644
00:30:44,159 --> 00:30:40,539
I'm going to call the near future within

645
00:30:45,690 --> 00:30:44,169
my lifetime and I think that's all going

646
00:30:49,560 --> 00:30:45,700
to depend on what we invest in the

647
00:30:51,419 --> 00:30:49,570
instrument to to detect these things so

648
00:30:54,600 --> 00:30:51,429
if we're if we're willing to detect

649
00:30:57,360 --> 00:30:54,610
invest in East once then we've got a

650
00:30:59,369 --> 00:30:57,370
fairly good chance of finding finding

651
00:31:02,460 --> 00:30:59,379
something I think life thought would be

652
00:31:05,279 --> 00:31:02,470
fairly common I'm going to guess what in

653
00:31:07,560 --> 00:31:05,289
a one in a hundred planets might have

654
00:31:11,009 --> 00:31:07,570
life I'm going to call that comment so

655
00:31:12,990 --> 00:31:11,019
if we can sum up you hundred planets I

656
00:31:16,080 --> 00:31:13,000
think we've got a very good chance I

657
00:31:18,960 --> 00:31:16,090
love that optimism it's awesome

658
00:31:21,480 --> 00:31:18,970
next question is from Brant detering who

659
00:31:24,029 --> 00:31:21,490
asks on Facebook what would the

660
00:31:27,480 --> 00:31:24,039
indicators of life on Earth be from the

661
00:31:29,730 --> 00:31:27,490
perspective of an exoplanet absolutely

662
00:31:32,730 --> 00:31:29,740
so if we look at us right now we will

663
00:31:36,899 --> 00:31:32,740

see that at equilibrium so we talked

664
00:31:39,509 --> 00:31:36,909
about the idea of the oxygen and methane

665
00:31:51,060 --> 00:31:39,519
together we could also as I said look at

666
00:31:53,070 --> 00:31:51,070
the radio the outer solar system

667
00:31:56,700 --> 00:31:53,080
it did a couple of gravity assists

668
00:32:00,180 --> 00:31:56,710
around the earth and so the Cassini not

669
00:32:02,430 --> 00:32:00,190
Galileo and those experiments opposed by

670
00:32:06,600 --> 00:32:02,440
Carl Sagan which was to turn the

671
00:32:10,259 --> 00:32:06,610
instruments on and and pointman on earth

672
00:32:12,600 --> 00:32:10,269
and say can we detect life on Earth

673
00:32:15,600 --> 00:32:12,610
cymaspace parked and there's a beautiful

674
00:32:15,910 --> 00:32:15,610
paper in the building I think that you

675
00:32:18,040 --> 00:32:15,920
know

676
00:32:20,190 --> 00:32:18,050
to where where Carl Sagan's they will be

677
00:32:23,560 --> 00:32:20,200
a week and it may be a feeble

678
00:32:27,150 --> 00:32:23,570
disequilibrium very cool yeah that's a

679
00:32:29,680 --> 00:32:27,160
phenomenal paper the next question is by

680
00:32:32,710 --> 00:32:29,690
astrobiology Club on Twitter who tweet

681
00:32:34,540 --> 00:32:32,720
us at Astro bio Club and ask the

682
00:32:36,490 --> 00:32:34,550
following even that our industrial

683
00:32:37,300 --> 00:32:36,500
activities are altering the makeup of

684
00:32:39,730 --> 00:32:37,310
the planet

685
00:32:41,740 --> 00:32:39,740
you think the effects of a global

686
00:32:43,690 --> 00:32:41,750
pandemic like the one we're having now

687
00:32:46,030 --> 00:32:43,700
will be something that future will

688
00:32:50,650 --> 00:32:46,040

feature people will see in the rock

689
00:32:54,100 --> 00:32:50,660
record you know I don't think what we

690
00:32:56,230 --> 00:32:54,110
say now it's big not to be preserved in

691
00:32:59,170 --> 00:32:56,240
the geologic record it's a it's gonna be

692
00:33:02,670 --> 00:32:59,180
a very important event from our society

693
00:33:05,710 --> 00:33:02,680
and I think there going to be a lot of

694
00:33:07,390 --> 00:33:05,720
societal change after this right other

695
00:33:11,320 --> 00:33:07,400
things you not to see in the geologic

696
00:33:13,690 --> 00:33:11,330
record I think humans overall we're now

697
00:33:17,890 --> 00:33:13,700
imprinting something that that will be

698
00:33:20,860 --> 00:33:17,900
in the geologic record but a little bit

699
00:33:23,380 --> 00:33:20,870
of a trying to now project to me I don't

700
00:33:28,720 --> 00:33:23,390
think it's gonna be able to be preserved

701
00:33:30,760 --> 00:33:28,730
in the logs yeah I agree with that

702
00:33:34,200 --> 00:33:30,770
thank you um the next question is by

703
00:33:36,970 --> 00:33:34,210
andrew planet on Signet who writes i

704
00:33:39,370 --> 00:33:36,980
wonder if the carbon dioxide clouds of

705
00:33:41,830 --> 00:33:39,380
Venus as an example would tend to rule

706
00:33:44,500 --> 00:33:41,840
out life initially evolving on earth in

707
00:33:46,300 --> 00:33:44,510
the same atmospheric circumstances in

708
00:33:48,250 --> 00:33:46,310
favor of atmospheric water vapor on

709
00:33:50,190 --> 00:33:48,260
earth as the main greenhouse gas as a

710
00:34:00,250 --> 00:33:50,200
precursor to life evolving here

711
00:34:04,300 --> 00:34:00,260
initially we have the standoff in the

712
00:34:08,950 --> 00:34:04,310
Hadean Eon which is the beautiful nation

713
00:34:11,710 --> 00:34:08,960

where now you know the planet it would

714
00:34:14,140 --> 00:34:11,720
not be hard in a transient battle a

715
00:34:16,890 --> 00:34:14,150
greenhouse and then cooled from there

716
00:34:20,680 --> 00:34:16,900
we'd have had a a water vapor atmosphere

717
00:34:23,650 --> 00:34:20,690
which would have then condensed out to

718
00:34:26,589 --> 00:34:23,660
form an atmosphere which i think is

719
00:34:29,529 --> 00:34:26,599
gonna be not different amount you know

720
00:34:32,079 --> 00:34:29,539
gonna be a hydrological cycle I probably

721
00:34:36,460 --> 00:34:32,089
won't be carbon dioxide cloud that just

722
00:34:39,969 --> 00:34:36,470
probably wasn't cold enough for that so

723
00:34:42,309 --> 00:34:39,979
we started our math better not to

724
00:34:45,339 --> 00:34:42,319
distance about maybe warmer maybe a

725
00:34:48,960 --> 00:34:45,349
stone between health effect but you know

726
00:34:51,219 --> 00:34:48,970
we've been there different planets have

727
00:34:53,289 --> 00:34:51,229
cycles of different gases we have a

728
00:34:56,589 --> 00:34:53,299
hydrological cycle on earth because of

729
00:35:00,390 --> 00:34:56,599
the temperature where that on Mars which

730
00:35:03,519 --> 00:35:00,400
is much colder there carbon dioxide

731
00:35:04,769 --> 00:35:03,529
condensation and and then if you have to

732
00:35:07,690 --> 00:35:04,779
tighten you can get anything

733
00:35:10,210 --> 00:35:07,700
condensation but we're here on earth

734
00:35:12,279 --> 00:35:10,220
into them where water is the main

735
00:35:16,150 --> 00:35:12,289
species which we can evaporate and

736
00:35:18,640 --> 00:35:16,160
condensed Thank You Colin an expression

737
00:35:21,339 --> 00:35:18,650
is by sir hatt's F Jen who asks on

738
00:35:23,200 --> 00:35:21,349

Signet is there any possibility or idea

739
00:35:25,809 --> 00:35:23,210
occurring life that could have started

740
00:35:28,210 --> 00:35:25,819
in Earth's atmosphere like we think

741
00:35:34,779 --> 00:35:28,220
today or Venus atmosphere that could

742
00:35:36,759 --> 00:35:34,789
potentially sustain life you know the

743
00:35:40,120 --> 00:35:36,769
answer I think some of the things we do

744
00:35:42,400 --> 00:35:40,130
know is that surfaces are very good but

745
00:35:45,009 --> 00:35:42,410
healthy in chemical reactions to occur

746
00:35:49,509 --> 00:35:45,019
lot so if I was to think of where I

747
00:35:55,239 --> 00:35:49,519
would start light it would be you know

748
00:35:57,039 --> 00:35:55,249
on minimal surfaces either influence the

749
00:36:00,120 --> 00:35:57,049
thing it wouldn't be the first place I

750
00:36:02,709 --> 00:36:00,130
would think of looking at now

751
00:36:05,739 --> 00:36:02,719
you know life today

752
00:36:08,920 --> 00:36:05,749
spores being moved around so a part of

753
00:36:11,109 --> 00:36:08,930
the biosphere but it's not my income to

754
00:36:13,959 --> 00:36:11,119
start looking for for the genesis of

755
00:36:17,499 --> 00:36:13,969
life Thank You Colin good question so

756
00:36:19,469 --> 00:36:17,509
hot next question is by Jacob hot misra

757
00:36:22,359 --> 00:36:19,479
who was asking you on Twitter as at

758
00:36:24,519 --> 00:36:22,369
atmósfera what do you think of the Gaia

759
00:36:29,180 --> 00:36:24,529
hypothesis is it scientifically useful

760
00:36:31,730 --> 00:36:29,190
or merely a poetic device so

761
00:36:35,260 --> 00:36:31,740
which makes them some James Lovelock who

762
00:36:39,290 --> 00:36:35,270
was actually my PhD advisor PhD advisor

763
00:36:42,109 --> 00:36:39,300

and that is to propose that life on

764
00:36:44,120 --> 00:36:42,119
earth regulated the climate and

765
00:36:47,660 --> 00:36:44,130
chemistry of birth for Earth history

766
00:36:49,910 --> 00:36:47,670
that this isn't the four billion year of

767
00:36:51,349 --> 00:36:49,920
habitability hasn't happened by

768
00:36:54,579 --> 00:36:51,359
coincidence

769
00:36:57,740 --> 00:36:54,589
it happened because life has been

770
00:37:01,670 --> 00:36:57,750
dominating our our chemical and climate

771
00:37:05,150 --> 00:37:01,680
evolution and the way I think about now

772
00:37:07,809 --> 00:37:05,160
in Copiah as a name for Mars it's one of

773
00:37:10,910 --> 00:37:07,819
the names out by filling earth

774
00:37:16,730 --> 00:37:10,920
recognizing our inhabited planet as a

775
00:37:20,440 --> 00:37:16,740
coherent entity so I would define me you

776
00:37:23,839 --> 00:37:20,450
Jacob the plants outside even the

777
00:37:29,839 --> 00:37:23,849
coronaviruses part of Gaia we're all

778
00:37:34,160 --> 00:37:29,849
part of one global ecosystem where

779
00:37:36,890 --> 00:37:34,170
everything affects everything else so in

780
00:37:39,140 --> 00:37:36,900
that sense you know Gaia hypothesis has

781
00:37:40,940 --> 00:37:39,150
been fundamental to my thinking of

782
00:37:45,710 --> 00:37:40,950
thinking about the single planetary

783
00:37:50,030 --> 00:37:45,720
entity but there's a question of house

784
00:37:54,589 --> 00:37:50,040
has it has life controlled well yes it's

785
00:37:56,930 --> 00:37:54,599
controlled it regulated the evolution of

786
00:37:59,300 --> 00:37:56,940
our climate I don't know the answer now

787
00:38:02,510 --> 00:37:59,310
I think that for me one of the most

788
00:38:05,599 --> 00:38:02,520

fascinating open questions in Palestine

789
00:38:07,370 --> 00:38:05,609
volution yeah well regardless of whether

790
00:38:09,260 --> 00:38:07,380
the Gaia hypothesis is correct or not I

791
00:38:11,359 --> 00:38:09,270
think it has really pushed the

792
00:38:13,339 --> 00:38:11,369
scientific community forward in thinking

793
00:38:16,220 --> 00:38:13,349
at all your interconnections between

794
00:38:17,660 --> 00:38:16,230
life and the planet that lives on so and

795
00:38:21,109 --> 00:38:17,670
that did that sense I guess it's it's

796
00:38:23,540 --> 00:38:21,119
been a very useful the next question

797
00:38:26,450 --> 00:38:23,550
comes from Marian Denton who is asking

798
00:38:27,740 --> 00:38:26,460
on Twitter as at a stroll in no she's

799
00:38:31,690 --> 00:38:27,750
actually quoting one of your papers

800
00:38:38,020 --> 00:38:34,480
and she asks Colin can you please

801
00:38:40,089 --> 00:38:38,030
elaborate on quote existence of oxygenic

802
00:38:45,310 --> 00:38:40,099
photosynthesis is not sufficient

803
00:38:55,020 --> 00:38:45,320
condition for either atmosphere or based

804
00:38:55,030 --> 00:39:13,170
[Music]

805
00:39:20,560 --> 00:39:17,470
atmosphere by the by spirits those it

806
00:39:23,349 --> 00:39:20,570
waste gases and oxygen being one of them

807
00:39:27,160 --> 00:39:23,359
and then we looked at well how long will

808
00:39:29,890 --> 00:39:27,170
that oxygen survive and you know what in

809
00:39:33,490 --> 00:39:29,900
the archetype has been not they long but

810
00:39:34,930 --> 00:39:33,500
what did you level sleep are you getting

811
00:39:39,790 --> 00:39:34,940
enough oxygen

812
00:39:42,490 --> 00:39:39,800
the chemistry starts changing and if

813
00:39:45,670 --> 00:39:42,500

there's enough oxygen to start forming

814
00:39:49,660 --> 00:39:45,680
ozone so oxygen is the o2 molecule

815
00:39:51,220 --> 00:39:49,670
ozone o3 molecule and we understand

816
00:39:53,319 --> 00:39:51,230
those three formation by something

817
00:39:59,069 --> 00:39:53,329
called the Chapman cycle that chemistry

818
00:40:06,780 --> 00:40:02,290
again you need a big enough column of

819
00:40:10,359 --> 00:40:06,790
oxygen to start forming ozone and ozone

820
00:40:12,460 --> 00:40:10,369
layer it's a brilliant sunscreen and as

821
00:40:14,140 --> 00:40:12,470
well as healthy stopping of get

822
00:40:17,440 --> 00:40:14,150
sunburned when we're allowed to go

823
00:40:20,020 --> 00:40:17,450
outside it also changes all the

824
00:40:22,720 --> 00:40:20,030
atmospheric chemistry slows down all the

825
00:40:25,510 --> 00:40:22,730
chemistry because UV is really important

826
00:40:27,180 --> 00:40:25,520
in doing that chemistry so once you know

827
00:40:31,329 --> 00:40:27,190
the ozone layer

828
00:40:36,040 --> 00:40:31,339
it means the oxygen can build up and

829
00:40:38,170 --> 00:40:36,050
that's the great oxidation so we call it

830
00:40:40,750 --> 00:40:38,180
a bi stability because you can have two

831
00:40:42,970 --> 00:40:40,760
different stable States at low oxygen

832
00:40:45,940 --> 00:40:42,980
state without a bozo

833
00:40:50,530 --> 00:40:45,950
a higher oxygen state with an ozone

834
00:40:52,540 --> 00:40:50,540
layer tweak the parameters of that model

835
00:40:54,609 --> 00:40:52,550
if we believe the model back to them in

836
00:40:58,090 --> 00:40:54,619
their world we could keep going but

837
00:41:01,540 --> 00:40:58,100
quite a long time without an ozone layer

838
00:41:03,910 --> 00:41:01,550

and then without oxygen much more than a

839
00:41:06,640 --> 00:41:03,920
part per million level and that would

840
00:41:10,200 --> 00:41:06,650
make it really difficult to detect so

841
00:41:13,660 --> 00:41:10,210
that's the really big challenge in in

842
00:41:15,520 --> 00:41:13,670
exoplanet astronomy is the idea that you

843
00:41:17,950 --> 00:41:15,530
could have a biosphere humming away

844
00:41:19,750 --> 00:41:17,960
producing oxygen but you wouldn't be

845
00:41:24,160 --> 00:41:19,760
able to see the science make that would

846
00:41:26,920 --> 00:41:24,170
be to dilute in the atmosphere Thank You

847
00:41:30,070 --> 00:41:26,930
Carly the next question is an excellent

848
00:41:31,870 --> 00:41:30,080
one by a burl wing on Facebook she asks

849
00:41:33,430 --> 00:41:31,880
a question that I would've asked you

850
00:41:34,630 --> 00:41:33,440
Colleen how did not come up so Thank You

851
00:41:37,420 --> 00:41:34,640
Admiral for asking it

852
00:41:39,190 --> 00:41:37,430
and she asks what are some tips you have

853
00:41:41,050 --> 00:41:39,200
for undergraduate students who are

854
00:41:43,270 --> 00:41:41,060
interested in going into astrobiology

855
00:41:45,420 --> 00:41:43,280
what should we do if there is no

856
00:41:49,570 --> 00:41:45,430
undergraduate program for astrobiology

857
00:41:51,820 --> 00:41:49,580
well there are antibodies every

858
00:41:52,690 --> 00:41:51,830
University back home chemistry they

859
00:41:55,859 --> 00:41:52,700
called physics

860
00:41:58,420 --> 00:41:55,869
they're called science they're called

861
00:42:00,090 --> 00:41:58,430
biology they're called microbiology

862
00:42:03,790 --> 00:42:00,100
they're called oceanography

863
00:42:07,150 --> 00:42:03,800

do some science because if I'm looking

864
00:42:09,820 --> 00:42:07,160
further advanced student I want to join

865
00:42:12,370 --> 00:42:09,830
my group better either I'm looking for

866
00:42:14,440 --> 00:42:12,380
them having done a science degree where

867
00:42:16,660 --> 00:42:14,450
they got some of the Vela bird

868
00:42:19,750 --> 00:42:16,670
scientists have made that that's you

869
00:42:23,430 --> 00:42:19,760
know usually for people working migrants

870
00:42:26,050 --> 00:42:23,440
in our math you know some programming

871
00:42:27,849 --> 00:42:26,060
ideally some atmospheric science or some

872
00:42:31,210 --> 00:42:27,859
geology so do something you're

873
00:42:33,609 --> 00:42:31,220
passionate about light now and then get

874
00:42:35,140 --> 00:42:33,619
research experience you know it really

875
00:42:37,630 --> 00:42:35,150
doesn't matter what that research

876
00:42:39,790 --> 00:42:37,640
experience is in but I'd like to know

877
00:42:43,180 --> 00:42:39,800
that you can do something you can

878
00:42:45,970 --> 00:42:43,190
actually go and do research so see if

879
00:42:48,220 --> 00:42:45,980
you can do an honors project or get a

880
00:42:49,870 --> 00:42:48,230
summer research experience as an

881
00:42:51,760 --> 00:42:49,880
undergraduate program I need one of

882
00:42:57,480 --> 00:42:51,770
those with Hole Oceanographic

883
00:43:03,130 --> 00:42:59,440
do be searched

884
00:43:04,510 --> 00:43:03,140
I will float for them yeah I agree what

885
00:43:07,200 --> 00:43:04,520
makes you an astrobiologist is the

886
00:43:10,930 --> 00:43:07,210
questions you ask not the science you do

887
00:43:12,460 --> 00:43:10,940
so keep your mind open and pursue what

888
00:43:15,480 --> 00:43:12,470

you love every illness it's the most

889
00:43:18,040 --> 00:43:15,490
important part the next question is by

890
00:43:20,200 --> 00:43:18,050
pretty.i Powell who asks on say Gannett

891
00:43:22,330 --> 00:43:20,210
what are the chances that a planet

892
00:43:23,440 --> 00:43:22,340
hosting multicellular life could be

893
00:43:25,900 --> 00:43:23,450
lacking in oxygen

894
00:43:27,610 --> 00:43:25,910
what gases could be a replacement could

895
00:43:38,160 --> 00:43:27,620
there be another mechanism similar to

896
00:43:47,620 --> 00:43:44,020
when you on the on the show one of the

897
00:43:52,060 --> 00:43:47,630
things I like working a plenary failed

898
00:43:55,440 --> 00:43:52,070
since I got no idea and that's that's

899
00:43:58,390 --> 00:43:55,450
perfectly okay to say such things

900
00:44:01,060 --> 00:43:58,400
Christophe fun Cowan barek on say

901
00:44:02,650 --> 00:44:01,070
Gannett asks what would be your biggest

902
00:44:04,630 --> 00:44:02,660
dream come true in the field of

903
00:44:06,310 --> 00:44:04,640
astrobiology that is what do you hope

904
00:44:12,300 --> 00:44:06,320
will be discovered Lord and anything

905
00:44:15,520 --> 00:44:12,310
else so I think the may I

906
00:44:18,940 --> 00:44:15,530
understanding what the population of

907
00:44:21,220 --> 00:44:18,950
Paris the atmospheres is so I think that

908
00:44:26,560 --> 00:44:21,230
would be we need a big telescope where

909
00:44:27,970 --> 00:44:26,570
we can look at the atmosphere around a

910
00:44:30,040 --> 00:44:27,980
lot of distant stars

911
00:44:35,590 --> 00:44:30,050
I'd like a population of at least a

912
00:44:37,330 --> 00:44:35,600
hundred different sized planets and be

913
00:44:40,060 --> 00:44:37,340

able to see that population because I

914
00:44:43,330 --> 00:44:40,070
think statistics of a population is

915
00:44:46,420 --> 00:44:43,340
gonna be the thing we will learn most

916
00:44:49,390 --> 00:44:46,430
long you know I heard stories from you

917
00:44:50,590 --> 00:44:49,400
know some of my some of my senior

918
00:44:52,780 --> 00:44:50,600
colleagues from when I was at NASA

919
00:44:54,930 --> 00:44:52,790
talking about what it was like when we

920
00:44:58,180 --> 00:44:54,940
were exploring the outer solar system

921
00:45:01,510 --> 00:44:58,190
and we found things that we never

922
00:45:03,430 --> 00:45:01,520
expected to find and you just and that

923
00:45:05,710 --> 00:45:03,440
exact same thing happened with the basic

924
00:45:08,349 --> 00:45:05,720
mission to complete her

925
00:45:12,010 --> 00:45:08,359
all thought Pluto would be really boring

926
00:45:16,839 --> 00:45:12,020
and no idea why their permission being

927
00:45:21,910 --> 00:45:16,849
fed to Pluto and then we get about

928
00:45:25,510 --> 00:45:21,920
geology gang going on on the on the on

929
00:45:31,210 --> 00:45:25,520
the surface they're shown the the images

930
00:45:33,250 --> 00:45:31,220
is absolutely amazing or boring then

931
00:45:34,750 --> 00:45:33,260
that same thing is gonna happen when we

932
00:45:38,740 --> 00:45:34,760
look at new things we're gonna find

933
00:45:41,500 --> 00:45:38,750
things we never imagined very well said

934
00:45:43,270 --> 00:45:41,510
color in a category worth the next

935
00:45:45,070 --> 00:45:43,280
question is by Tom Caruso and it's

936
00:45:46,930 --> 00:45:45,080
fairly long and there's not much

937
00:45:49,930 --> 00:45:46,940
punctuation so I'm gonna do my best

938
00:45:51,820 --> 00:45:49,940

Tom and hopefully we can capture it it

939
00:45:54,400 --> 00:45:51,830
seems earth became more likely to

940
00:45:56,740 --> 00:45:54,410
support that bit of the developments of

941
00:45:58,960 --> 00:45:56,750
advanced life as geological activity

942
00:46:02,410 --> 00:45:58,970
mellowed down and earth climate changed

943
00:46:04,390 --> 00:46:02,420
at one time icy moons and planets would

944
00:46:06,250 --> 00:46:04,400
have resembled water worlds at further

945
00:46:08,670 --> 00:46:06,260
distances from the Sun so if we try to

946
00:46:12,010 --> 00:46:08,680
model the early atmospheres of young

947
00:46:14,050 --> 00:46:12,020
warmer warmer water world's they are

948
00:46:16,329 --> 00:46:14,060
currently ice that are currently as

949
00:46:18,250 --> 00:46:16,339
ice-covered are there similar

950
00:46:21,010 --> 00:46:18,260
similarities or life-bearing

951
00:46:28,030 --> 00:46:21,020
possibilities between outer water worlds

952
00:46:31,079 --> 00:46:28,040
and younger earths in Arizona the idea

953
00:46:33,880 --> 00:46:31,089
is that if we've got this idea that we

954
00:46:35,950 --> 00:46:33,890
that we need things to be just like just

955
00:46:39,609 --> 00:46:35,960
like earth it to have night life on

956
00:46:43,660 --> 00:46:39,619
earth you know that so I think that's a

957
00:46:46,060 --> 00:46:43,670
little bit it's a little bit focused on

958
00:46:48,310 --> 00:46:46,070
we know you know we know how thing does

959
00:46:51,460 --> 00:46:48,320
I think must be just like me and I

960
00:46:54,640 --> 00:46:51,470
disagree I think a lot of bulk anism

961
00:46:58,540 --> 00:46:54,650
actually puts a lot of in a special

962
00:47:01,960 --> 00:46:58,550
material into one each of the biosphere

963
00:47:04,120 --> 00:47:01,970

you know it's a long chemical gradient

964
00:47:06,070 --> 00:47:04,130
in which life can exploit and you know

965
00:47:08,890 --> 00:47:06,080
actually one of the most volcanically

966
00:47:11,530 --> 00:47:08,900
active planets in the solar system not

967
00:47:13,190 --> 00:47:11,540
the most that I am onizuka nuts but

968
00:47:16,099 --> 00:47:13,200
we've got a lot of volcanism

969
00:47:19,250 --> 00:47:16,109
got help that's probably good for life I

970
00:47:22,309 --> 00:47:19,260
don't know whether it's essential but

971
00:47:26,950 --> 00:47:22,319
think about parallel between Earth's and

972
00:47:30,079 --> 00:47:26,960
down and some of those icy moons so

973
00:47:32,630 --> 00:47:30,089
we've just around a triple point of

974
00:47:34,880 --> 00:47:32,640
water and that the triple point is that

975
00:47:39,410 --> 00:47:34,890
the template compression condition where

976
00:47:42,650 --> 00:47:39,420
you can have liquid solid and gas of

977
00:47:47,500 --> 00:47:42,660
water vapor and then let go way out to

978
00:47:51,079 --> 00:47:47,510
Titan of moon of Saturn and it turns out

979
00:47:54,289 --> 00:47:51,089
the surface condition there and pretty

980
00:47:56,210 --> 00:47:54,299
near to the triple point of me saying

981
00:48:10,760 --> 00:47:56,220
the temperature pressure conditions

982
00:48:14,150 --> 00:48:10,770
where there can be liquid B be just the

983
00:48:16,400 --> 00:48:14,160
same but with with me same instead say

984
00:48:18,530 --> 00:48:16,410
either you get clouds of methane baton

985
00:48:22,190 --> 00:48:18,540
at me saying that you look at different

986
00:48:24,829 --> 00:48:22,200
planets and you see just the same

987
00:48:26,510 --> 00:48:24,839
physics going on so I think that's one

988
00:48:28,640 --> 00:48:26,520

of those really useful comparative

989
00:48:31,520 --> 00:48:28,650
planetology things that we can we can

990
00:48:35,120 --> 00:48:31,530
pick up what do you think in the solar

991
00:48:40,670 --> 00:48:35,130
system are most likely habitats for a

992
00:48:42,950 --> 00:48:40,680
biology oh that's a great question so I

993
00:48:47,109 --> 00:48:42,960
mean all of us of course but that answer

994
00:48:50,390 --> 00:48:47,119
is cheating we know everywhere on earth

995
00:48:53,480 --> 00:48:50,400
Titan I'm fascinated by where if there's

996
00:48:55,819 --> 00:48:53,490
anything completely different weird that

997
00:48:58,359 --> 00:48:55,829
that you know Title II that would be a

998
00:49:01,099 --> 00:48:58,369
great place to look it's something that

999
00:49:03,230 --> 00:49:01,109
any of the icy moons actually where

1000
00:49:05,240 --> 00:49:03,240
you've got some geology going on under

1001
00:49:08,030 --> 00:49:05,250
the ice one of the things that makes me

1002
00:49:10,849 --> 00:49:08,040
a little worried about some of the

1003
00:49:12,319 --> 00:49:10,859
explanation that it's gonna go a lot of

1004
00:49:14,870 --> 00:49:12,329
those icy moons putting instruments

1005
00:49:17,660 --> 00:49:14,880
light on them the risk of contamination

1006
00:49:19,280 --> 00:49:17,670
I would probably love the way we look we

1007
00:49:21,980 --> 00:49:19,290
rather we waited another

1008
00:49:24,260 --> 00:49:21,990
hundred years or so into our five got

1009
00:49:28,960 --> 00:49:24,270
better and we could actually understand

1010
00:49:31,700 --> 00:49:28,970
what there's life there so then I go to

1011
00:49:34,210 --> 00:49:31,710
icy moons and something totally

1012
00:49:37,640 --> 00:49:34,220
different right cool

1013
00:49:41,210 --> 00:49:37,650

the next question is by gaurav elo who

1014
00:49:43,520 --> 00:49:41,220
on Facebook asks does the atmosphere of

1015
00:49:45,200 --> 00:49:43,530
a planet to determine or rather candid

1016
00:49:49,840 --> 00:49:45,210
atmosphere of a planet determine the

1017
00:50:00,680 --> 00:49:49,850
presence of life yes absolutely so

1018
00:50:03,170 --> 00:50:00,690
there's a lot of it it's just too hot on

1019
00:50:05,810 --> 00:50:03,180
Venus for there to be life on the

1020
00:50:08,360 --> 00:50:05,820
surface you know it's not excluded that

1021
00:50:10,760 --> 00:50:08,370
you could have like high up in the

1022
00:50:13,040 --> 00:50:10,770
clouds but we've got enough we've got no

1023
00:50:15,860 --> 00:50:13,050
idea so there's something like that you

1024
00:50:18,500 --> 00:50:15,870
can get too hot you know that's a

1025
00:50:20,420 --> 00:50:18,510
problem if you get too cold it's gonna

1026
00:50:24,320 --> 00:50:20,430
mean that life is going to just be

1027
00:50:24,770 --> 00:50:24,330
really really slow will it be over keep

1028
00:50:26,840 --> 00:50:24,780
going

1029
00:50:29,660 --> 00:50:26,850
could there be life on Mars we've got

1030
00:50:32,480 --> 00:50:29,670
weather with the thin atmosphere it's

1031
00:50:35,360 --> 00:50:32,490
really cold we don't know so you need an

1032
00:50:37,520 --> 00:50:35,370
atmosphere where the atmosphere is

1033
00:50:42,950 --> 00:50:37,530
important is it determines the climate

1034
00:50:45,950 --> 00:50:42,960
and you know we think that we want a

1035
00:50:48,530 --> 00:50:45,960
medium age temperature a life as we know

1036
00:50:51,740 --> 00:50:48,540
it but then of course what about life if

1037
00:50:53,720 --> 00:50:51,750
we don't know it I was gonna ask you do

1038
00:50:57,290 --> 00:50:53,730

you think we could detect life as we

1039
00:51:01,730 --> 00:50:57,300
don't know it I think that would be a

1040
00:51:03,520 --> 00:51:01,740
test about imagination I think that the

1041
00:51:07,100 --> 00:51:03,530
idea of life detection by atmospheric

1042
00:51:09,680 --> 00:51:07,110
analysis is very general it's looking

1043
00:51:14,300 --> 00:51:09,690
for signs of disequilibrium in the

1044
00:51:17,600 --> 00:51:14,310
atmosphere and that shouldn't work so

1045
00:51:22,490 --> 00:51:17,610
long as life is working quicker than the

1046
00:51:24,950 --> 00:51:22,500
photochemistry and that lovably is

1047
00:51:27,740 --> 00:51:24,960
required for life so I think using that

1048
00:51:29,750 --> 00:51:27,750
my general toll of analyzing the whole

1049
00:51:32,359 --> 00:51:29,760
atmosphere and then trying to understand

1050
00:51:34,430 --> 00:51:32,369
it without best

1051
00:51:37,010 --> 00:51:34,440
yeah I think I agree that chemical

1052
00:51:40,460 --> 00:51:37,020
disequilibrium is probably a universal

1053
00:51:42,200 --> 00:51:40,470
sign of something weird happening on

1054
00:51:49,250 --> 00:51:42,210
that planet where that's something weird

1055
00:51:51,910 --> 00:51:49,260
could possibly be life chemical

1056
00:51:55,310 --> 00:51:51,920
disequilibrium really is a mark of

1057
00:51:58,250 --> 00:51:55,320
photosynthesis it's a marker of life

1058
00:52:01,220 --> 00:51:58,260
using energy from the Sun or from the

1059
00:52:04,130 --> 00:52:01,230
planet star and then it creates that

1060
00:52:06,800 --> 00:52:04,140
disequilibrium with that free energy

1061
00:52:09,770 --> 00:52:06,810
that it getting Thunder the Sun so we

1062
00:52:11,390 --> 00:52:09,780
think about very early Earth before we

1063
00:52:13,099 --> 00:52:11,400

had photosynthesis

1064
00:52:15,349 --> 00:52:13,109
well now the biosphere that was

1065
00:52:18,290 --> 00:52:15,359
diffusing the chemical gradient in the

1066
00:52:22,130 --> 00:52:18,300
environment their life would reduce the

1067
00:52:25,880 --> 00:52:22,140
amount of disequilibrium so there's

1068
00:52:29,900 --> 00:52:25,890
probably no way of finding a planet

1069
00:52:35,540 --> 00:52:29,910
where there isn't photosynthesis ah

1070
00:52:39,470 --> 00:52:35,550
that's provocative our next question is

1071
00:52:42,859 --> 00:52:39,480
by Patti Hernandez on Facebook who asks

1072
00:52:45,349 --> 00:52:42,869
white Mike planets circling and dwarfs

1073
00:52:50,480 --> 00:52:45,359
be good locations to search for the

1074
00:52:54,349 --> 00:52:50,490
evidence of life mmm it's um that's

1075
00:52:58,970 --> 00:52:54,359
called a red dwarf star it's smaller and

1076
00:53:00,650 --> 00:52:58,980
less light of the Sun which was to be

1077
00:53:05,030 --> 00:53:00,660
kind of the same temperature of Earth

1078
00:53:09,079 --> 00:53:05,040
would have to be orbiting much closer to

1079
00:53:11,720 --> 00:53:09,089
that star and probably so close that it

1080
00:53:14,089 --> 00:53:11,730
would always the same side of the planet

1081
00:53:16,670 --> 00:53:14,099
would always be facing the star like the

1082
00:53:20,690 --> 00:53:16,680
same side of the Moon always faces the

1083
00:53:24,050 --> 00:53:20,700
earth now what the advantage of that is

1084
00:53:26,780 --> 00:53:24,060
or as rebellious because the planet is

1085
00:53:30,770 --> 00:53:26,790
near to the star is very easy to observe

1086
00:53:32,930 --> 00:53:30,780
we can observe it as it goes in front of

1087
00:53:37,040 --> 00:53:32,940
the star what we call it found it and

1088
00:53:39,140 --> 00:53:37,050

then we can see we can measure that the

1089
00:53:41,390 --> 00:53:39,150
sun's bathe the starways

1090
00:53:43,730 --> 00:53:41,400
that have gone through the atmosphere

1091
00:53:44,810 --> 00:53:43,740
and how they changed as they've gone

1092
00:53:49,280 --> 00:53:44,820
through the ass

1093
00:53:52,330 --> 00:53:49,290
that's all transit spectroscopy so I'd

1094
00:53:54,680 --> 00:53:52,340
say the good reason to look at um

1095
00:53:56,600 --> 00:53:54,690
planets around end dwarfs is because

1096
00:53:59,390 --> 00:53:56,610
they're really easy to look at and then

1097
00:54:01,850 --> 00:53:59,400
whether we're not is the James Webb

1098
00:54:06,560 --> 00:54:01,860
Space Telescope ever launched earth is

1099
00:54:08,240 --> 00:54:06,570
going to be the best instrument the only

1100
00:54:11,780 --> 00:54:08,250
thing we should be using joke the James

1101
00:54:14,270 --> 00:54:11,790
Webb for is looking at the mound n star

1102
00:54:16,310 --> 00:54:14,280
and then we can start to build up a bit

1103
00:54:20,480 --> 00:54:16,320
of a sense of what the population of

1104
00:54:22,400 --> 00:54:20,490
their atmosphere is like this this T's

1105
00:54:26,090 --> 00:54:22,410
are free well the next question by

1106
00:54:28,220 --> 00:54:26,100
pretty ipod on sega net who asks how do

1107
00:54:31,280 --> 00:54:28,230
we detect the composition of atmospheres

1108
00:54:36,880 --> 00:54:31,290
on planets far away is spectroscopy the

1109
00:54:41,470 --> 00:54:36,890
only way with present technology

1110
00:54:46,010 --> 00:54:41,480
absolutely the only way so that is

1111
00:54:48,830 --> 00:54:46,020
looking at what wavelengths of light get

1112
00:54:52,490 --> 00:54:48,840
absorbed in the atmosphere so we know

1113
00:54:55,970 --> 00:54:52,500

what that we know how much beat

1114
00:54:59,120 --> 00:54:55,980
wavelength of light the a star is going

1115
00:55:01,490 --> 00:54:59,130
to admit and then if we let that light

1116
00:55:03,920 --> 00:55:01,500
come through a planetary atmosphere so

1117
00:55:07,160 --> 00:55:03,930
when they're in dwarf planet for example

1118
00:55:08,570 --> 00:55:07,170
it going in front a bit star we look at

1119
00:55:10,640 --> 00:55:08,580
the light that comes through the

1120
00:55:12,530 --> 00:55:10,650
atmosphere there and we look at that

1121
00:55:15,290 --> 00:55:12,540
with our telescope we can see what's

1122
00:55:17,600 --> 00:55:15,300
missing and it's a little bit like you

1123
00:55:20,690 --> 00:55:17,610
know reading a barcode there's different

1124
00:55:22,280 --> 00:55:20,700
lines that day for gases will absorb and

1125
00:55:25,790 --> 00:55:22,290
they'll be able to tell us which gas are

1126
00:55:29,210 --> 00:55:25,800
the back so that is absolutely out top

1127
00:55:30,560 --> 00:55:29,220
tool cool cool I'm so we're really

1128
00:55:32,480 --> 00:55:30,570
running out of time Colin which is

1129
00:55:35,390 --> 00:55:32,490
really a disappointing so I'm gonna give

1130
00:55:38,480 --> 00:55:35,400
Graham the last question here and he

1131
00:55:40,700 --> 00:55:38,490
asks a very good question Thank You

1132
00:55:43,010 --> 00:55:40,710
Graham for asking it given the current

1133
00:55:44,990 --> 00:55:43,020
state of world affairs are there any

1134
00:55:47,630 --> 00:55:45,000
positive messages you perceive from the

1135
00:55:49,310 --> 00:55:47,640
realm of astrobiology that may help our

1136
00:55:51,280 --> 00:55:49,320
communities across the globe weather the

1137
00:55:53,170 --> 00:55:51,290
storm

1138
00:55:55,570 --> 00:55:53,180

I think one of the important things that

1139
00:55:58,510 --> 00:55:55,580
we get sense master marginal or

1140
00:56:01,180 --> 00:55:58,520
callously sign that even deep Tiber five

1141
00:56:04,930 --> 00:56:01,190
in a sense of time and a sense of

1142
00:56:07,480 --> 00:56:04,940
perspective you know where humans are

1143
00:56:11,020 --> 00:56:07,490
part of the biosphere we're not

1144
00:56:14,710 --> 00:56:11,030
something sexist of nature we're part of

1145
00:56:17,740 --> 00:56:14,720
it and we're actually very smart you

1146
00:56:20,020 --> 00:56:17,750
know we can think about what we need to

1147
00:56:22,900 --> 00:56:20,030
do you know and leave a challenging

1148
00:56:25,660 --> 00:56:22,910
times to make ourselves and our families

1149
00:56:27,910 --> 00:56:25,670
and our communities safer but also as we

1150
00:56:29,140 --> 00:56:27,920
move forward and we we take this entity

1151
00:56:32,410 --> 00:56:29,150
we take what we've learned about

1152
00:56:35,320 --> 00:56:32,420
communal action and apply that to the

1153
00:56:37,510 --> 00:56:35,330
climate change biodiversity loss we can

1154
00:56:39,460 --> 00:56:37,520
do those things we can do that communal

1155
00:56:42,580 --> 00:56:39,470
action and I think the sense of

1156
00:56:47,670 --> 00:56:42,590
perspective that we care for looking at

1157
00:56:51,310 --> 00:56:47,680
the other planets is something that that

1158
00:56:53,080 --> 00:56:51,320
we can all take board and one great

1159
00:56:54,970 --> 00:56:53,090
thing we can do it anybody's got a pair

1160
00:56:56,740 --> 00:56:54,980
of binoculars at home if you look at

1161
00:56:58,630 --> 00:56:56,750
look at the moon tonight and the

1162
00:57:00,190 --> 00:56:58,640
beautiful pleasant moon look at that

1163
00:57:03,040 --> 00:57:00,200

with your binoculars and you can see the

1164
00:57:06,070 --> 00:57:03,050
beautiful relief on the exciters of the

1165
00:57:11,410 --> 00:57:06,080
moon near the Terminator so you can look

1166
00:57:12,610 --> 00:57:11,420
at another planet tonight so do that get

1167
00:57:15,520 --> 00:57:12,620
that little bit of a sense of

1168
00:57:18,160 --> 00:57:15,530
perspective and then channel that energy

1169
00:57:21,040 --> 00:57:18,170
into communal action to make us all

1170
00:57:23,200 --> 00:57:21,050
safer I couldn't think of a better way

1171
00:57:25,660 --> 00:57:23,210
to end this episode Colin it's been an

1172
00:57:27,220 --> 00:57:25,670
absolute wonderful conversation thank

1173
00:57:31,090 --> 00:57:27,230
you so much for taking the time to chat

1174
00:57:33,190 --> 00:57:31,100
with us today for those of you are

1175
00:57:35,440 --> 00:57:33,200
watching thank you for sticking around

1176
00:57:37,330 --> 00:57:35,450
and we really look forward to a use

1177
00:57:39,430 --> 00:57:37,340
being with us next month

1178
00:57:43,150 --> 00:57:39,440
keep in mind that NASA has a bunch of

1179
00:57:46,000 --> 00:57:43,160
tools provided for educational materials

1180
00:57:48,880 --> 00:57:46,010
and activities and other fun videos for

1181
00:57:50,560 --> 00:57:48,890
folks of all ages while you are stuck at

1182
00:57:51,310 --> 00:57:50,570
home and the website for that is

1183
00:57:55,210 --> 00:57:51,320
science.nasa.gov

1184
00:57:58,570 --> 00:57:55,220
slash get that involved slash NASA at

1185
00:57:59,860 --> 00:57:58,580
home in one word so folks wonderful to

1186
00:58:01,510 --> 00:57:59,870
have you on the show thank you so much

1187
00:58:03,460 --> 00:58:01,520
for tuning in please continue to be

1188
00:58:04,370 --> 00:58:03,470

active on social media helping us spread

1189
00:58:07,279 --> 00:58:04,380
the word about our

1190
00:58:08,740 --> 00:58:07,289
and until then stay curious we'll see

1191
00:58:49,349 --> 00:58:08,750
you soon