

Ask An Astrobiologist



EPISODE 11: FEBRUARY 28TH, 2018

DR. SARA IMARI WALKER



ASTROBIOLOGY PROGRAM

1
00:00:00,500 --> 00:00:29,320

[Music]

2
00:00:33,740 --> 00:00:31,429

greetings friends of astrobiology

3
00:00:35,780 --> 00:00:33,750

welcome to a brand-new episode of ask an

4
00:00:38,420 --> 00:00:35,790

astrobiologist Asher we celebrate

5
00:00:39,889 --> 00:00:38,430

science and celebrate scientists my name

6
00:00:41,630 --> 00:00:39,899

is Sanjay zoom and this program is made

7
00:00:44,630 --> 00:00:41,640

possible by contributions from the NASA

8
00:00:46,850 --> 00:00:44,640

Astrobiology program LC the earth Life

9
00:00:49,040 --> 00:00:46,860

Science Institute at Tokyo Tech and a

10
00:00:50,690 --> 00:00:49,050

non profit blue marble space today we

11
00:00:51,950 --> 00:00:50,700

are extremely lucky to welcome back to

12
00:00:54,920 --> 00:00:51,960

stay canet although she's never really

13
00:00:57,650 --> 00:00:54,930

left dr. Sarah Mary Walker she's a

14

00:00:59,840 --> 00:00:57,660

co-founder of our network back in 2011

15

00:01:01,790 --> 00:00:59,850

she's also an assistant professor at the

16

00:01:03,380 --> 00:01:01,800

school of Earth and space exploration at

17

00:01:06,080 --> 00:01:03,390

the Arizona State University in the

18

00:01:08,690 --> 00:01:06,090

United States and this goes on the

19

00:01:11,240 --> 00:01:08,700

deputy director of the Beyond Center for

20

00:01:15,499 --> 00:01:11,250

fundamental concepts in science Sarah

21

00:01:17,140 --> 00:01:15,509

welcome Sanjay I'm super excited to be

22

00:01:19,520 --> 00:01:17,150

here and talk with everyone today

23

00:01:21,200 --> 00:01:19,530

before we start though it's time for a

24

00:01:23,480 --> 00:01:21,210

monthly background quiz which I know

25

00:01:25,700 --> 00:01:23,490

you're all excited about last month we

26

00:01:28,070 --> 00:01:25,710

had a wonderful landscape of a

27

00:01:29,420 --> 00:01:28,080

terrifying planets terrifying and

28

00:01:33,289 --> 00:01:29,430

beautiful Mike if you could put it up

29

00:01:36,740 --> 00:01:33,299

and I'm sure many of you recognized the

30

00:01:39,770 --> 00:01:36,750

surface of the planet Venus so this is

31

00:01:41,899 --> 00:01:39,780

actually only able to be measured using

32

00:01:44,929 --> 00:01:41,909

radar which was obtained by the Magellan

33

00:01:47,749 --> 00:01:44,939

spacecraft it is spacious craft in 1990

34

00:01:49,370 --> 00:01:47,759

and because the atmosphere is so thick

35

00:01:51,859 --> 00:01:49,380

only radar can reach the surface and the

36

00:01:53,780 --> 00:01:51,869

color is actually deduced from the

37

00:01:55,550 --> 00:01:53,790

Venera landers which are Russian Landers

38

00:01:58,120 --> 00:01:55,560

who made it to the surface I think a

39

00:02:01,100 --> 00:01:58,130

decade a few years before but 1986 and

40

00:02:02,840 --> 00:02:01,110

the Landers lasted an hour or two max

41

00:02:04,459 --> 00:02:02,850

because the atmosphere is so thick

42

00:02:06,560 --> 00:02:04,469

there's so much co2 the greenhouse is

43

00:02:09,460 --> 00:02:06,570

terrible and so the Machine essentially

44

00:02:12,350 --> 00:02:09,470

died very quickly and so shout out to

45

00:02:13,460 --> 00:02:12,360

Jaime Cordova congratulations for you

46

00:02:17,030 --> 00:02:13,470

guests er you

47

00:02:20,240 --> 00:02:17,040

right and you are going to get all six

48

00:02:22,340 --> 00:02:20,250

of the astrobiology graphic novel which

49

00:02:24,170 --> 00:02:22,350

are really fun way to discover the

50

00:02:26,510 --> 00:02:24,180

discipline and so please reach out to us

51
00:02:28,120 --> 00:02:26,520
via Twitter or other means and we'll get

52
00:02:31,430 --> 00:02:28,130
your address and send those to you so

53
00:02:32,720 --> 00:02:31,440
congratulations and so next month though

54
00:02:35,300 --> 00:02:32,730
we'll have to you'll have to be guessing

55
00:02:38,810 --> 00:02:35,310
what is my background today so make sure

56
00:02:41,510 --> 00:02:38,820
you use hashtag ask Esther bio and use

57
00:02:44,690 --> 00:02:41,520
it also today to ask your questions for

58
00:02:47,690 --> 00:02:44,700
dr. Walker and if you're on cigarettes

59
00:02:49,670 --> 00:02:47,700
just use the chat directly so with that

60
00:02:51,199 --> 00:02:49,680
Sarah yay I'm so excited that you're

61
00:02:52,580 --> 00:02:51,209
here I know you're very busy so I'm very

62
00:02:54,530 --> 00:02:52,590
grateful that you took the time to chat

63
00:02:55,910 --> 00:02:54,540

with us today what we like to do first

64

00:02:57,680 --> 00:02:55,920

is get to know you a little bit before

65

00:02:59,600 --> 00:02:57,690

talking about the incredible science

66

00:03:00,920 --> 00:02:59,610

that you do and so like we like to do in

67

00:03:02,540 --> 00:03:00,930

the show is turn back the wheels of time

68

00:03:04,310 --> 00:03:02,550

a little bit and wonder if you could

69

00:03:06,110 --> 00:03:04,320

share perhaps a story when you were

70

00:03:15,920 --> 00:03:06,120

young that kind of led you to become a

71

00:03:20,210 --> 00:03:15,930

scientist today I was in college the

72

00:03:22,820 --> 00:03:20,220

back story but both my parents so my dad

73

00:03:23,420 --> 00:03:22,830

the hairstylist and my mom deals in

74

00:03:24,530 --> 00:03:23,430

antiques

75

00:03:28,340 --> 00:03:24,540

so I actually grew up on a really

76

00:03:30,320 --> 00:03:28,350

artistic household and they were both

77

00:03:32,390 --> 00:03:30,330

enthusiastic about science but not

78

00:03:34,910 --> 00:03:32,400

really like thinking scientifically and

79

00:03:36,650 --> 00:03:34,920

so I I went to Community College for my

80

00:03:38,030 --> 00:03:36,660

first two years of college and I took

81

00:03:40,520 --> 00:03:38,040

all the science classes I could my first

82

00:03:42,920 --> 00:03:40,530

year and just like fell in love with

83

00:03:45,470 --> 00:03:42,930

physics and so I remember coming home

84

00:03:47,000 --> 00:03:45,480

from school and telling everyone I was

85

00:03:48,710 --> 00:03:47,010

going to be a theoretical physicist when

86

00:03:50,570 --> 00:03:48,720

I grew up and then looking at me like I

87

00:03:53,000 --> 00:03:50,580

was had two heads and nobody really

88

00:03:55,670 --> 00:03:53,010

believed me at the time but I just made

89

00:03:58,430 --> 00:03:55,680

the decision and I I was so excited

90

00:04:00,199 --> 00:03:58,440

about it and so I remember you know

91

00:04:02,900 --> 00:04:00,209

being 18 and starting to read things

92

00:04:04,130 --> 00:04:02,910

like I've heard me and Dirac from like

93

00:04:08,710 --> 00:04:04,140

you know and getting rid of my Seventeen

94

00:04:12,380 --> 00:04:10,789

transition but the thing that's been

95

00:04:14,000 --> 00:04:12,390

interesting for me about being a

96

00:04:15,710 --> 00:04:14,010

scientist is I feel like that's my

97

00:04:17,390 --> 00:04:15,720

creative outlet so I didn't really lose

98

00:04:19,789 --> 00:04:17,400

sort of like the creativity and the

99

00:04:21,830 --> 00:04:19,799

artistic things that that my family

100

00:04:23,870 --> 00:04:21,840

really tried to cultivate as a child I

101
00:04:26,140 --> 00:04:23,880
just used them to try to create new ways

102
00:04:28,960 --> 00:04:26,150
of understanding the world and so

103
00:04:31,120 --> 00:04:28,970
really become my creative outlets so use

104
00:04:33,820 --> 00:04:31,130
your artistic background to help you

105
00:04:35,800 --> 00:04:33,830
kind of generate new ideas for studying

106
00:04:37,689 --> 00:04:35,810
the concepts of the origin of life which

107
00:04:38,950 --> 00:04:37,699
we'll talk in a bit but you know what

108
00:04:41,379 --> 00:04:38,960
theoretical physics is quite different

109
00:04:43,659 --> 00:04:41,389
from studying yards you know life from a

110
00:04:44,740 --> 00:04:43,669
broad perspective but we know it's quite

111
00:04:46,060 --> 00:04:44,750
different but perhaps you can tell us

112
00:04:49,150 --> 00:04:46,070
how you're interested in the origin of

113
00:04:54,370 --> 00:04:49,160

life and astrobiology in particular got

114

00:04:57,610 --> 00:04:54,380

got on words for two years at a

115

00:05:02,020 --> 00:04:57,620

community college and I really just sit

116

00:05:05,620 --> 00:05:02,030

there and then I ended up going which we

117

00:05:08,680 --> 00:05:05,630

didn't cross paths there but but and I

118

00:05:10,420 --> 00:05:08,690

majored in physics and I was doing

119

00:05:12,610 --> 00:05:10,430

research in that group that did

120

00:05:13,990 --> 00:05:12,620

experimental particle physics but I

121

00:05:15,219 --> 00:05:14,000

really wanted to do Siri because the

122

00:05:16,719 --> 00:05:15,229

thing that really got me excited about

123

00:05:18,159 --> 00:05:16,729

physics in the first place was that we

124

00:05:19,870 --> 00:05:18,169

could describe the world using

125

00:05:21,129 --> 00:05:19,880

mathematics and in fact that we could

126

00:05:23,730 --> 00:05:21,139

predict things that we don't even

127

00:05:26,529 --> 00:05:23,740

understand if they exist yet and so that

128

00:05:28,300 --> 00:05:26,539

that to me was really the most beautiful

129

00:05:29,860 --> 00:05:28,310

and fascinating thing about doing

130

00:05:31,629 --> 00:05:29,870

physics and I'm so I really wanted to be

131

00:05:33,219 --> 00:05:31,639

a theorist and so when I was looking for

132

00:05:34,810 --> 00:05:33,229

grad schools I was looking for places I

133

00:05:36,820 --> 00:05:34,820

could do like fundamental physics like

134

00:05:39,279 --> 00:05:36,830

early universe cosmology theory or

135

00:05:41,379 --> 00:05:39,289

particle physics and I ended up going to

136

00:05:42,909 --> 00:05:41,389

grad school at Dartmouth College and

137

00:05:47,170 --> 00:05:42,919

when I started working there my PhD

138

00:05:49,450 --> 00:05:47,180

advisor it was kind of sort of a broad

139

00:05:50,890 --> 00:05:49,460

thinker and has focused most of his

140

00:05:51,760 --> 00:05:50,900

career on an early universe that started

141

00:05:54,219 --> 00:05:51,770

getting interested in astrobiology

142

00:05:55,570 --> 00:05:54,229

around the time I started working with

143

00:05:58,810 --> 00:05:55,580

him and I didn't even know what

144

00:06:00,129 --> 00:05:58,820

astrobiology was so he's like trying to

145

00:06:01,150 --> 00:06:00,139

convince me work on this subject and I'm

146

00:06:01,540 --> 00:06:01,160

like I've never even heard of this

147

00:06:03,670 --> 00:06:01,550

before

148

00:06:05,200 --> 00:06:03,680

okay and so I actually what I ended up

149

00:06:07,420 --> 00:06:05,210

doing was I started working on projects

150

00:06:10,060 --> 00:06:07,430

in astrobiology but in parallel doing

151
00:06:11,860 --> 00:06:10,070
some cosmology and I kept thinking that

152
00:06:14,170 --> 00:06:11,870
I was gonna really develop the cosmology

153
00:06:15,610 --> 00:06:14,180
into my thesis and the astrobiology was

154
00:06:17,140 --> 00:06:15,620
just something I was doing in the short

155
00:06:19,870 --> 00:06:17,150
term but it ended up being a total

156
00:06:22,000 --> 00:06:19,880
reversal and and part of that happened

157
00:06:23,860 --> 00:06:22,010
because I was working on origins of life

158
00:06:26,020 --> 00:06:23,870
and I really realized that this was like

159
00:06:28,990 --> 00:06:26,030
a place where we really didn't have any

160
00:06:30,219 --> 00:06:29,000
fundamental conceptual understanding of

161
00:06:31,810 --> 00:06:30,229
the problem or how to ask the right

162
00:06:35,230 --> 00:06:31,820
questions about the problem and it was a

163
00:06:39,119 --> 00:06:35,240

place I saw physics really being able to

164

00:06:40,769 --> 00:06:39,129

contribute to some understanding

165

00:06:42,949 --> 00:06:40,779

fundamental principles or universal

166

00:06:45,179 --> 00:06:42,959

principles for life in the universe and

167

00:06:46,709 --> 00:06:45,189

that got me really excited because the

168

00:06:48,299 --> 00:06:46,719

whole reason I wanted to be a physicist

169

00:06:49,439 --> 00:06:48,309

in the first place was I was like in

170

00:06:51,570 --> 00:06:49,449

love with these major scientific

171

00:06:52,979 --> 00:06:51,580

revolutions and advances in our

172

00:06:54,419 --> 00:06:52,989

understanding like quantum mechanics or

173

00:06:56,969 --> 00:06:54,429

generality that really changed

174

00:06:58,379 --> 00:06:56,979

everything about how we think and so the

175

00:07:00,719 --> 00:06:58,389

idea that we could have a theory of life

176
00:07:02,609 --> 00:07:00,729
and it might equally change everything

177
00:07:05,279 --> 00:07:02,619
about how we think is to me just so

178
00:07:07,799 --> 00:07:05,289
fascinating so I don't think that I

179
00:07:09,059 --> 00:07:07,809
really like ideologically my interests

180
00:07:12,179 --> 00:07:09,069
didn't change watch us is that the

181
00:07:14,399 --> 00:07:12,189
questions evolved and and I just found

182
00:07:16,230 --> 00:07:14,409
this area of astrobiology to be so rich

183
00:07:18,689 --> 00:07:16,240
for exploration and creativity and

184
00:07:20,249 --> 00:07:18,699
contributing new ideas so you found a

185
00:07:21,689 --> 00:07:20,259
community of people of like-minded

186
00:07:23,339 --> 00:07:21,699
dividuals who are interested in the

187
00:07:27,119 --> 00:07:23,349
origin of life but coming at it from a

188
00:07:29,009 --> 00:07:27,129

friend that's right that's kind of what

189

00:07:31,230 --> 00:07:29,019

God's saying that going I'm so do you

190

00:07:32,549 --> 00:07:31,240

interact with scientists from a bunch of

191

00:07:36,179 --> 00:07:32,559

different disciplines to help you

192

00:07:38,399 --> 00:07:36,189

advance your science today yeah I do

193

00:07:39,899 --> 00:07:38,409

so so actually one of the reasons I

194

00:07:41,699 --> 00:07:39,909

really fell in love with astrobiology in

195

00:07:43,139 --> 00:07:41,709

particular when I was a grad student was

196

00:07:44,939 --> 00:07:43,149

because of the sense of community and

197

00:07:47,730 --> 00:07:44,949

the exposure to people from all kinds of

198

00:07:49,559 --> 00:07:47,740

different disciplines and and I also

199

00:07:50,969 --> 00:07:49,569

really liked that about being at ASU cuz

200

00:07:52,829 --> 00:07:50,979

it's a really unique place like the

201
00:07:54,600 --> 00:07:52,839
school earth and space exploration and

202
00:07:56,579 --> 00:07:54,610
I'm in a department with geologists and

203
00:07:58,619 --> 00:07:56,589
astrophysicists and I'm really neither

204
00:08:03,899 --> 00:07:58,629
of those things but somehow still fit in

205
00:08:06,600 --> 00:08:03,909
a mix of people so I I do a lot of work

206
00:08:08,100 --> 00:08:06,610
in complex systems science which is very

207
00:08:09,749 --> 00:08:08,110
broad and interdisciplinary and that's

208
00:08:11,609 --> 00:08:09,759
more like a mathematical set of tools so

209
00:08:14,850 --> 00:08:11,619
I interact a lot with complexity

210
00:08:16,139 --> 00:08:14,860
scientists who are thinking about life I

211
00:08:18,350 --> 00:08:16,149
interact a lot with people that think

212
00:08:21,959 --> 00:08:18,360
about exoplanets ob1 actually

213
00:08:24,779 --> 00:08:21,969

astrophysics a lot of theoretical

214

00:08:26,489 --> 00:08:24,789

physicists a lot of biologists a lot of

215

00:08:30,089 --> 00:08:26,499

chemists for original life stuff

216

00:08:31,679 --> 00:08:30,099

sometimes computer scientists so it's

217

00:08:33,839 --> 00:08:31,689

pretty much if there is a discipline

218

00:08:36,719 --> 00:08:33,849

that exists I think I have worked with

219

00:08:39,600 --> 00:08:36,729

somebody you'll push is I think the best

220

00:08:40,980 --> 00:08:39,610

thing about philosophers it's it's so

221

00:08:44,370 --> 00:08:40,990

incredibly broad this question of

222

00:08:47,160 --> 00:08:44,380

understanding life I think it really it

223

00:08:51,870 --> 00:08:47,170

requires involving as breadth of

224

00:08:52,560 --> 00:08:51,880

expertise as you possibly can so during

225

00:08:54,870 --> 00:08:52,570

your universe

226

00:08:56,640 --> 00:08:54,880

career is wondering if you've benefitted

227

00:08:58,080 --> 00:08:56,650

from from person you could look up to

228

00:09:01,170 --> 00:08:58,090

like mentors who helped you guide

229

00:09:03,750 --> 00:09:01,180

through the the most what must have been

230

00:09:07,490 --> 00:09:03,760

quite a non-linear thought process of

231

00:09:11,460 --> 00:09:07,500

going through school that you had yeah

232

00:09:13,590 --> 00:09:11,470

it was not linear at the time but i'm

233

00:09:14,640 --> 00:09:13,600

like looking at it backwards i feel like

234

00:09:18,630 --> 00:09:14,650

there was actually like a clear

235

00:09:20,460 --> 00:09:18,640

trajectory but yeah so so mentors are

236

00:09:22,230 --> 00:09:20,470

incredibly important and particular have

237

00:09:25,050 --> 00:09:22,240

adventures that are really supportive

238

00:09:26,670 --> 00:09:25,060

and are willing to you know let you

239

00:09:28,050 --> 00:09:26,680

explore the questions that you're most

240

00:09:30,570 --> 00:09:28,060

passionate about and really go after

241

00:09:33,360 --> 00:09:30,580

them and so for me i was incredibly

242

00:09:34,710 --> 00:09:33,370

lucky through my graduate education my

243

00:09:36,630 --> 00:09:34,720

undergrad also i had a really good

244

00:09:38,510 --> 00:09:36,640

mentor in undergrad and my graduate

245

00:09:40,950 --> 00:09:38,520

education and my postdocs will have

246

00:09:43,260 --> 00:09:40,960

really good mentors that were really

247

00:09:45,260 --> 00:09:43,270

encouraging of me asking really deep

248

00:09:47,400 --> 00:09:45,270

fundamental questions and in particular

249

00:09:49,770 --> 00:09:47,410

one person who's inspired me a lot was

250

00:09:52,530 --> 00:09:49,780

my postdoc advisor here is used paul

251
00:09:54,420 --> 00:09:52,540
davies because he encouraged me like no

252
00:09:56,730 --> 00:09:54,430
one else to really go after the really

253
00:09:59,460 --> 00:09:56,740
hard questions and i think that's a

254
00:10:02,360 --> 00:09:59,470
really important thing to instill on

255
00:10:04,530 --> 00:10:02,370
early career researchers because

256
00:10:05,790 --> 00:10:04,540
oftentimes when you're at the earliest

257
00:10:07,800 --> 00:10:05,800
stages in your career have the most

258
00:10:09,840 --> 00:10:07,810
creativity and the innovative ideas but

259
00:10:12,090 --> 00:10:09,850
you're often encouraged not to go after

260
00:10:13,770 --> 00:10:12,100
those things and to be safe and to save

261
00:10:15,510 --> 00:10:13,780
your career whereas you might have the

262
00:10:16,890 --> 00:10:15,520
most potential for impact if you you

263
00:10:19,380 --> 00:10:16,900

actually go after those things so i

264

00:10:23,430 --> 00:10:19,390

think the experience of having a mentor

265

00:10:25,230 --> 00:10:23,440

who was enthusiastic for me really going

266

00:10:27,720 --> 00:10:25,240

after the really tough question it's

267

00:10:29,790 --> 00:10:27,730

really changed everything about what I

268

00:10:32,010 --> 00:10:29,800

could accomplish in my career and how I

269

00:10:33,510 --> 00:10:32,020

was going after things it's also

270

00:10:35,960 --> 00:10:33,520

probably quite a bit more rewarding to

271

00:10:41,850 --> 00:10:35,970

take a bit more risks in your research

272

00:10:44,100 --> 00:10:41,860

right I think so for me it's more

273

00:10:46,320 --> 00:10:44,110

personally rewarding but it is scary I

274

00:10:48,240 --> 00:10:46,330

mean so so there's always this challenge

275

00:10:50,280 --> 00:10:48,250

that you have to make it in science and

276
00:10:51,960 --> 00:10:50,290
obviously you're in science because you

277
00:10:53,250 --> 00:10:51,970
love it so you want to stay in it so

278
00:10:57,300 --> 00:10:53,260
it's sort of like it feels like a

279
00:10:59,100 --> 00:10:57,310
catch-22 but I think at least in my

280
00:11:00,240 --> 00:10:59,110
experience when people are like original

281
00:11:01,740 --> 00:11:00,250
and true to themselves and really go

282
00:11:03,850 --> 00:11:01,750
after the things that they they care

283
00:11:06,850 --> 00:11:03,860
about that's when their talent

284
00:11:09,550 --> 00:11:06,860
you know like added as fast where they

285
00:11:12,370 --> 00:11:09,560
like really shine so I think it's if

286
00:11:13,960 --> 00:11:12,380
who's us to try to train our like crew

287
00:11:17,980 --> 00:11:13,970
people to find what their passion is and

288
00:11:19,690 --> 00:11:17,990

Paulo it really nice words for those of

289

00:11:21,699 --> 00:11:19,700

you watching don't take life too much

290

00:11:23,920 --> 00:11:21,709

coasting right take the chance to take a

291

00:11:25,509 --> 00:11:23,930

few risks you'll be rewarding so in the

292

00:11:27,130 --> 00:11:25,519

decades of origin of of life research

293

00:11:28,690 --> 00:11:27,140

has been kind of two camps that have

294

00:11:30,340 --> 00:11:28,700

developed right they have been kind of

295

00:11:32,500 --> 00:11:30,350

metabolism first people which you

296

00:11:34,990 --> 00:11:32,510

describe is kind of the analog origin of

297

00:11:37,660 --> 00:11:35,000

life and genetics first origin of life

298

00:11:40,030 --> 00:11:37,670

camp which is kind of a digital origin

299

00:11:41,110 --> 00:11:40,040

of life approach but you have some new

300

00:11:43,600 --> 00:11:41,120

thoughts and how to think about these

301
00:11:45,460 --> 00:11:43,610
two camps merging them into a way that

302
00:11:47,590 --> 00:11:45,470
that if you've published about kind of

303
00:11:49,150 --> 00:11:47,600
an algorithmic origin of life could you

304
00:11:54,639 --> 00:11:49,160
describe a little bit more more about

305
00:11:56,860 --> 00:11:54,649
what that so the so the main question

306
00:11:58,480 --> 00:11:56,870
that really drives me is with the origin

307
00:12:00,190 --> 00:11:58,490
of life question in particular is we're

308
00:12:01,300 --> 00:12:00,200
talking about life originating but we

309
00:12:02,590 --> 00:12:01,310
don't really have a clear idea of what

310
00:12:03,850 --> 00:12:02,600
we mean by life and that's very

311
00:12:06,850 --> 00:12:03,860
problematic if you want to build a

312
00:12:08,019 --> 00:12:06,860
theory for origins of life and so from

313
00:12:10,449 --> 00:12:08,029

their perspective of physics which

314

00:12:11,680 --> 00:12:10,459

obviously is my training and biases the

315

00:12:13,600 --> 00:12:11,690

way I'm thinking and it's always really

316

00:12:15,460 --> 00:12:13,610

good to be aware of those biases but

317

00:12:17,350 --> 00:12:15,470

from that perspective the things that

318

00:12:19,660 --> 00:12:17,360

seem most unique about living systems

319

00:12:21,160 --> 00:12:19,670

are their ability to manage and process

320

00:12:25,900 --> 00:12:21,170

information or in particular to use

321

00:12:29,199 --> 00:12:25,910

information and so what I've been trying

322

00:12:31,090 --> 00:12:29,209

to think about a lot over my career is

323

00:12:32,470 --> 00:12:31,100

how we might use the concept of

324

00:12:34,329 --> 00:12:32,480

information as a way to actually

325

00:12:37,780 --> 00:12:34,339

quantify the original life transition

326

00:12:39,340 --> 00:12:37,790

and how that might provide us a more

327

00:12:41,019 --> 00:12:39,350

rigorous set of mathematical tools for

328

00:12:43,180 --> 00:12:41,029

talking about life the conditions under

329

00:12:46,030 --> 00:12:43,190

which it might arise and and how likely

330

00:12:47,259 --> 00:12:46,040

life is and from that perspective it's

331

00:12:49,590 --> 00:12:47,269

really nice because if you start

332

00:12:51,639 --> 00:12:49,600

thinking about like our traditional

333

00:12:53,889 --> 00:12:51,649

divisions that we have about thinking

334

00:12:56,800 --> 00:12:53,899

about biology genetics or metabolism

335

00:12:58,300 --> 00:12:56,810

which are really just sort of I mean

336

00:13:00,100 --> 00:12:58,310

they are very different fundamentally

337

00:13:03,189 --> 00:13:00,110

different processes in biology but there

338

00:13:04,600 --> 00:13:03,199

are also partitions that we are ways of

339

00:13:06,160 --> 00:13:04,610

partitioning the world that we ascribe

340

00:13:07,960 --> 00:13:06,170

to the world it's not that nature is

341

00:13:13,780 --> 00:13:07,970

necessarily has the same categories that

342

00:13:15,610 --> 00:13:13,790

we make so so I so the idea being that

343

00:13:17,500 --> 00:13:15,620

some of these things that are very

344

00:13:20,590 --> 00:13:17,510

biologically relevant like genetics and

345

00:13:22,330 --> 00:13:20,600

Tabo ISM might not be very different at

346

00:13:24,400 --> 00:13:22,340

the origins because those concepts are

347

00:13:27,040 --> 00:13:24,410

very biological and in particular that

348

00:13:28,780 --> 00:13:27,050

they have if you if use this language of

349

00:13:30,220 --> 00:13:28,790

thinking about information there's a

350

00:13:31,360 --> 00:13:30,230

common way of describing both of them

351

00:13:32,980 --> 00:13:31,370

that becomes a very natural way of

352

00:13:34,180 --> 00:13:32,990

describing them when they're when

353

00:13:35,820 --> 00:13:34,190

they're not so different and that they

354

00:13:38,170 --> 00:13:35,830

might be two aspects for example of

355

00:13:40,720 --> 00:13:38,180

information processing on being digital

356

00:13:42,610 --> 00:13:40,730

one being analog and so that's really

357

00:13:44,020 --> 00:13:42,620

kind of the idea is is to try to look

358

00:13:47,320 --> 00:13:44,030

for the unifications rather than the

359

00:13:50,020 --> 00:13:47,330

divisions I guess so it's thinking about

360

00:13:52,350 --> 00:13:50,030

life as a transmitter of information

361

00:13:54,790 --> 00:13:52,360

it's how information is transferred in

362

00:13:57,160 --> 00:13:54,800

what we call a living system that

363

00:14:00,280 --> 00:13:57,170

characterizes life from non-life is that

364

00:14:01,690 --> 00:14:00,290

right right right that's very

365

00:14:03,910 --> 00:14:01,700

fascinating and so that's that's a very

366

00:14:06,760 --> 00:14:03,920

Universal way of thinking about like you

367

00:14:08,560 --> 00:14:06,770

know when we talk about the current or

368

00:14:11,860 --> 00:14:08,570

2018 way of searching for life on other

369

00:14:13,930 --> 00:14:11,870

worlds it's a it's a very I guess it's a

370

00:14:16,060 --> 00:14:13,940

very traditional way of looking for life

371

00:14:18,100 --> 00:14:16,070

looking for life as we know it on earth

372

00:14:20,350 --> 00:14:18,110

right but it's not necessarily that life

373

00:14:21,730 --> 00:14:20,360

is earth based and so there are a couple

374

00:14:23,320 --> 00:14:21,740

years ago I'm sure you know there was

375

00:14:25,030 --> 00:14:23,330

the the weird life report from the

376

00:14:27,910 --> 00:14:25,040

National Academies that identify kind of

377

00:14:29,430 --> 00:14:27,920

four Universal universities of life

378

00:14:32,230 --> 00:14:29,440

what were they thermodynamic equilibrium

379

00:14:34,240 --> 00:14:32,240

liquid environment molecular system of

380

00:14:36,130 --> 00:14:34,250

capable of Darwinian evolution and then

381

00:14:38,200 --> 00:14:36,140

an environment that can sustain covalent

382

00:14:40,920 --> 00:14:38,210

bonds but you're you're doing research

383

00:14:43,660 --> 00:14:40,930

to look for other universes that any

384

00:14:44,430 --> 00:14:43,670

universality ease of life right tell us

385

00:14:49,450 --> 00:14:44,440

more about that

386

00:14:51,370 --> 00:14:49,460

okay so there's a make about in my views

387

00:14:54,370 --> 00:14:51,380

so so one of the things people people

388

00:14:56,620 --> 00:14:54,380

often before I get so kind of addressing

389

00:14:58,660 --> 00:14:56,630

your question but it's relevant and so

390

00:14:59,830 --> 00:14:58,670

there's when I talk about like the

391

00:15:01,540 --> 00:14:59,840

distinction between life and non-life

392

00:15:03,760 --> 00:15:01,550

people think I'm trying to talk about

393

00:15:06,400 --> 00:15:03,770

like a hard boundary between life life

394

00:15:08,110 --> 00:15:06,410

is this and not life is this but the

395

00:15:10,060 --> 00:15:08,120

actual thing that I think is happening

396

00:15:13,240 --> 00:15:10,070

is that we don't understand the physics

397

00:15:14,260 --> 00:15:13,250

of information period and that if we

398

00:15:15,880 --> 00:15:14,270

really want to understand how

399

00:15:18,310 --> 00:15:15,890

information operates in the physical

400

00:15:20,620 --> 00:15:18,320

world and how it how it manifests that

401
00:15:22,450 --> 00:15:20,630
the best place to study that is biology

402
00:15:25,030 --> 00:15:22,460
and it's sort of analogy I like to make

403
00:15:28,510 --> 00:15:25,040
is if you think about gravitation as a

404
00:15:30,130 --> 00:15:28,520
physical law you might if you want to

405
00:15:31,060 --> 00:15:30,140
study gravitation a really good place to

406
00:15:32,230 --> 00:15:31,070
study gravitation

407
00:15:34,630 --> 00:15:32,240
limits of gravitation or what

408
00:15:36,460 --> 00:15:34,640
gravitation is capable of is to study

409
00:15:38,110 --> 00:15:36,470
black holes if you wanna study

410
00:15:40,120 --> 00:15:38,120
information in the physical world and

411
00:15:42,940 --> 00:15:40,130
how information operates in physical

412
00:15:45,130 --> 00:15:42,950
reality you study life and and the laws

413
00:15:48,670 --> 00:15:45,140

of information are probably the laws of

414

00:15:50,140 --> 00:15:48,680

life and so so that's sort of my

415

00:15:51,760 --> 00:15:50,150

perspective on that and then if you're

416

00:15:53,910 --> 00:15:51,770

thinking about it from that very sort of

417

00:15:57,010 --> 00:15:53,920

broad Universal perspective it opens up

418

00:15:59,230 --> 00:15:57,020

entirely new ways of thinking about life

419

00:16:00,400 --> 00:15:59,240

that aren't necessarily our traditional

420

00:16:02,290 --> 00:16:00,410

ones that we think about in astrobiology

421

00:16:04,300 --> 00:16:02,300

so for example most of the things that

422

00:16:06,820 --> 00:16:04,310

you mentioned those four criteria are

423

00:16:10,000 --> 00:16:06,830

based on thinking about life as a

424

00:16:11,950 --> 00:16:10,010

property of chemical organization and we

425

00:16:13,540 --> 00:16:11,960

tend to think about life as a chemical

426
00:16:15,160 --> 00:16:13,550
phenomena because life emerges from

427
00:16:18,700 --> 00:16:15,170
chemistry but it might not be that life

428
00:16:20,320 --> 00:16:18,710
is actually chemical in any sense and so

429
00:16:22,930 --> 00:16:20,330
what I mean by that is one of the places

430
00:16:25,090 --> 00:16:22,940
I look for inspiration most in thinking

431
00:16:26,410 --> 00:16:25,100
about organization of living systems and

432
00:16:29,140 --> 00:16:26,420
behavior of living systems is not

433
00:16:30,670 --> 00:16:29,150
necessarily chemistry but social systems

434
00:16:32,770 --> 00:16:30,680
because social systems are highly

435
00:16:34,780 --> 00:16:32,780
organized there's a lot of information

436
00:16:36,760 --> 00:16:34,790
and social systems that helps organize

437
00:16:41,740 --> 00:16:36,770
them and there's a lot of ways of

438
00:16:43,810 --> 00:16:41,750

understanding ourselves at that kind of

439

00:16:46,300 --> 00:16:43,820

level of organization and to me that

440

00:16:48,370 --> 00:16:46,310

that system is just as much alive as a

441

00:16:50,970 --> 00:16:48,380

chemical organization inside myself it's

442

00:16:54,660 --> 00:16:50,980

just a different scale and so

443

00:16:56,440 --> 00:16:54,670

understanding what properties of

444

00:16:59,470 --> 00:16:56,450

information if you want to call it that

445

00:17:01,660 --> 00:16:59,480

or organizing principles operate across

446

00:17:03,490 --> 00:17:01,670

these scales that we see in living

447

00:17:05,140 --> 00:17:03,500

systems that are common across those

448

00:17:08,290 --> 00:17:05,150

scales is probably going to be our best

449

00:17:09,660 --> 00:17:08,300

bet for identifying Universal properties

450

00:17:12,310 --> 00:17:09,670

of life that are likely to apply

451

00:17:13,980 --> 00:17:12,320

elsewhere in the universe even if it's

452

00:17:16,179 --> 00:17:13,990

radically different chemistry

453

00:17:18,130 --> 00:17:16,189

fascinating so do you think there is a

454

00:17:19,390 --> 00:17:18,140

universal theory of life like there is a

455

00:17:26,980 --> 00:17:19,400

theory of gravitation

456

00:17:28,690 --> 00:17:26,990

I hope my suspicion is that there

457

00:17:30,790 --> 00:17:28,700

probably is I mean there's something

458

00:17:33,880 --> 00:17:30,800

fundamentally weird about life and it's

459

00:17:35,740 --> 00:17:33,890

not it doesn't in my mind it does not

460

00:17:38,860 --> 00:17:35,750

demand a trivial explanation it demands

461

00:17:40,300 --> 00:17:38,870

a profound one and I think that and and

462

00:17:42,160 --> 00:17:40,310

that's just my own personal bias so

463

00:17:43,600 --> 00:17:42,170

again I think that when we're thinking

464

00:17:44,120 --> 00:17:43,610

about these questions especially when

465

00:17:50,390 --> 00:17:44,130

there

466

00:17:51,920 --> 00:17:50,400

things that you know are so intrinsic to

467

00:17:54,770 --> 00:17:51,930

understanding ourselves that we have to

468

00:17:56,240 --> 00:17:54,780

be careful about our biases but but

469

00:17:58,970 --> 00:17:56,250

living systems are very weird they're

470

00:18:01,540 --> 00:17:58,980

very interesting and special it's it's

471

00:18:03,680 --> 00:18:01,550

very unique that for example we have

472

00:18:05,750 --> 00:18:03,690

scientists on earth that can understand

473

00:18:07,850 --> 00:18:05,760

how the world works there's the example

474

00:18:09,740 --> 00:18:07,860

that I really like is thinking about

475

00:18:12,050 --> 00:18:09,750

quantum mechanics there's no

476
00:18:14,810 --> 00:18:12,060
evolutionary advantage to our ability to

477
00:18:17,030 --> 00:18:14,820
think to have knowledge of the laws of

478
00:18:19,820 --> 00:18:17,040
quantum mechanics none whatsoever

479
00:18:21,860 --> 00:18:19,830
yet somehow we have this deep knowledge

480
00:18:24,620 --> 00:18:21,870
we have information about the inner

481
00:18:27,230 --> 00:18:24,630
workings of reality in the scale that is

482
00:18:30,380 --> 00:18:27,240
almost completely irrelevant to our

483
00:18:31,910 --> 00:18:30,390
daily operation and those kind of things

484
00:18:33,110 --> 00:18:31,920
you know like it's easy to sweep those

485
00:18:36,020 --> 00:18:33,120
things under the rug and say oh those

486
00:18:37,850 --> 00:18:36,030
are not important things but but they

487
00:18:44,590 --> 00:18:37,860
seem very critical to addressing these

488
00:18:46,730 --> 00:18:44,600

kind of questions so yeah I think I hope

489

00:18:48,470 --> 00:18:46,740

so that would mean that there's new

490

00:18:49,940 --> 00:18:48,480

physics yet to be discovered to

491

00:18:51,770 --> 00:18:49,950

understand the theory of life right

492

00:18:53,810 --> 00:18:51,780

something that was as mysterious as

493

00:18:59,300 --> 00:18:53,820

comforta mechanics thinking about it in

494

00:19:01,820 --> 00:18:59,310

the you know 18th century yes yeah

495

00:19:03,890 --> 00:19:01,830

fantastic so your research as taking

496

00:19:06,320 --> 00:19:03,900

also it was the same philosophy taking

497

00:19:08,330 --> 00:19:06,330

another spin and more applied to the

498

00:19:10,370 --> 00:19:08,340

search for life on exoplanets for

499

00:19:13,190 --> 00:19:10,380

example so currently we search for life

500

00:19:14,930 --> 00:19:13,200

on exoplanets we will at least by

501
00:19:16,520 --> 00:19:14,940
looking at the products of biology right

502
00:19:18,260 --> 00:19:16,530
so if you look at Earth atmosphere from

503
00:19:20,870 --> 00:19:18,270
far away for example you recognize an

504
00:19:22,280 --> 00:19:20,880
oxidant oxygen and a reductant methane

505
00:19:23,510 --> 00:19:22,290
and the fact that yeah both of them in

506
00:19:26,630 --> 00:19:23,520
our atmosphere suggest that there's a

507
00:19:28,840 --> 00:19:26,640
process on the surface that is actively

508
00:19:31,070 --> 00:19:28,850
you know producing those those two

509
00:19:33,680 --> 00:19:31,080
chemicals that would react otherwise and

510
00:19:35,300 --> 00:19:33,690
so when thinking about life on those

511
00:19:37,160 --> 00:19:35,310
other planets that's kind of a strategy

512
00:19:40,580 --> 00:19:37,170
that is going to be put forward in the

513
00:19:41,630 --> 00:19:40,590

next decade or two and but you're

514

00:19:42,940 --> 00:19:41,640

thinking about it differently right

515

00:19:45,410 --> 00:19:42,950

you're thinking about it using

516

00:19:47,990 --> 00:19:45,420

statistics as a means to infer the

517

00:19:51,740 --> 00:19:48,000

possibility of life just from observing

518

00:19:54,020 --> 00:19:51,750

what you can observe on the planet yeah

519

00:19:57,789 --> 00:19:54,030

so I've gotten really intrigued by the

520

00:19:59,590 --> 00:19:57,799

exoplanet discoveries recently and look

521

00:20:01,629 --> 00:19:59,600

for life on exoplanets because of the

522

00:20:03,039 --> 00:20:01,639

issue of statistics so so one of my

523

00:20:04,479 --> 00:20:03,049

reasons is really selfish and it has

524

00:20:06,820 --> 00:20:04,489

nothing to do with wanting to discover

525

00:20:08,499 --> 00:20:06,830

life but I want like I want bounds for

526
00:20:10,840 --> 00:20:08,509
theory development we don't understand

527
00:20:12,249 --> 00:20:10,850
how frequent life is so if we had some

528
00:20:13,720 --> 00:20:12,259
understanding of at least the

529
00:20:15,159 --> 00:20:13,730
distribution of planets that can't

530
00:20:16,629 --> 00:20:15,169
harbor life that would be more

531
00:20:21,220 --> 00:20:16,639
information than we have our don't

532
00:20:22,509 --> 00:20:21,230
harbor life so that's sort of that that

533
00:20:24,669 --> 00:20:22,519
we need more information for

534
00:20:25,960 --> 00:20:24,679
understanding life more broadly and how

535
00:20:28,269 --> 00:20:25,970
its distributed so that was my original

536
00:20:31,690 --> 00:20:28,279
kind of thinking for getting into

537
00:20:33,879 --> 00:20:31,700
exoplanet bio signature research but the

538
00:20:39,930 --> 00:20:33,889

thing that I've been working on more

539

00:20:43,419 --> 00:20:39,940

actively is actually thinking about on

540

00:20:46,889 --> 00:20:43,429

like planetary systems and how they

541

00:20:49,210 --> 00:20:46,899

organize and so when we're talking about

542

00:20:51,820 --> 00:20:49,220

biology from this kind of abstract

543

00:20:54,159 --> 00:20:51,830

perspective one of the ways that we try

544

00:20:57,460 --> 00:20:54,169

to build mathematical structures to

545

00:20:59,049 --> 00:20:57,470

describe that is by using networks so

546

00:21:02,019 --> 00:20:59,059

the familiar example actually probably

547

00:21:03,279 --> 00:21:02,029

to everyone I'm faking it is a social

548

00:21:05,349 --> 00:21:03,289

network because we're part of a social

549

00:21:07,210 --> 00:21:05,359

network being here on say Gannett and um

550

00:21:08,229 --> 00:21:07,220

and some of you that are logged in are

551
00:21:10,060 --> 00:21:08,239
probably friends with each other I'm

552
00:21:13,060 --> 00:21:10,070
sake Annette and so so you can actually

553
00:21:14,739 --> 00:21:13,070
represents a Gannett as a network where

554
00:21:16,899 --> 00:21:14,749
all the people logged in would be nodes

555
00:21:18,279 --> 00:21:16,909
and you know if they're friends with

556
00:21:19,989 --> 00:21:18,289
each other they would be connected and

557
00:21:23,229 --> 00:21:19,999
you can represent chemistry this way too

558
00:21:24,999 --> 00:21:23,239
and so what has been shown in the past

559
00:21:29,950 --> 00:21:25,009
with some preliminary analysis is that

560
00:21:31,180 --> 00:21:29,960
you actually can potentially look at the

561
00:21:34,599 --> 00:21:31,190
network structure of Earth's atmosphere

562
00:21:37,989 --> 00:21:34,609
and see that has distinct structure from

563
00:21:39,909 --> 00:21:37,999

atmospheres of other planets and forces

564

00:21:41,289 --> 00:21:39,919

them so if you if you run an atmospheric

565

00:21:43,330 --> 00:21:41,299

model and then you look at the structure

566

00:21:45,399 --> 00:21:43,340

of the chemical Network in the

567

00:21:47,320 --> 00:21:45,409

atmosphere they look different for Earth

568

00:21:49,479 --> 00:21:47,330

and they do from other planets and it's

569

00:21:52,539 --> 00:21:49,489

intriguing because first differences

570

00:21:54,789 --> 00:21:52,549

make it look more like the structure of

571

00:21:56,830 --> 00:21:54,799

networks and metabolism inside cells and

572

00:21:58,810 --> 00:21:56,840

then it does like other atmospheric

573

00:22:01,840 --> 00:21:58,820

networks so it looks like life has sort

574

00:22:04,180 --> 00:22:01,850

of globally organized the statistical

575

00:22:06,220 --> 00:22:04,190

properties of chemical reaction networks

576

00:22:06,600 --> 00:22:06,230

and Earth's atmosphere in a way that is

577

00:22:35,610 --> 00:22:06,610

a

578

00:22:38,399 --> 00:22:35,620

being you know the ordered or this you

579

00:22:40,620 --> 00:22:38,409

know patterns organization and so it's

580

00:22:43,799 --> 00:22:40,630

kind of trying to step toward that in a

581

00:22:46,680 --> 00:22:43,809

more quantitative way from from what we

582

00:22:48,269 --> 00:22:46,690

have right now so that framework you're

583

00:22:50,279 --> 00:22:48,279

building really requires a strong

584

00:22:52,200 --> 00:22:50,289

cooperation between physicists like you

585

00:22:54,000 --> 00:22:52,210

who bill ken is at the statistics model

586

00:22:55,320 --> 00:22:54,010

most of the astronomers will be looking

587

00:22:57,480 --> 00:22:55,330

for those signatures the atmospheric

588

00:22:59,279 --> 00:22:57,490

modelers be modeling to be able to say

589

00:23:00,629 --> 00:22:59,289

something about probably the likelihood

590

00:23:02,899 --> 00:23:00,639

of such atmospheres which are

591

00:23:05,940 --> 00:23:02,909

constrained by geological measurements

592

00:23:08,399 --> 00:23:05,950

and so this is awesome like it's really

593

00:23:10,860 --> 00:23:08,409

like the quest to understand life on

594

00:23:12,570 --> 00:23:10,870

Earth is a quest that requires all of us

595

00:23:16,919 --> 00:23:12,580

on earth to be involved in in answering

596

00:23:19,200 --> 00:23:16,929

this magnificent yes one of the

597

00:23:21,029 --> 00:23:19,210

implications of that beyond from a

598

00:23:24,570 --> 00:23:21,039

scientific perspective but on what it

599

00:23:33,960 --> 00:23:24,580

means to be humans are also also you

600

00:23:35,519 --> 00:23:33,970

know kind of mind-boggling I like most

601
00:23:36,990 --> 00:23:35,529
about my job is working with different

602
00:23:38,909 --> 00:23:37,000
people and in particular like this

603
00:23:40,320 --> 00:23:38,919
students and postdocs in my group are so

604
00:23:41,639 --> 00:23:40,330
diverse and they all have like such

605
00:23:44,100 --> 00:23:41,649
brilliant ideas to interview all the

606
00:23:45,840 --> 00:23:44,110
time that it's just like it's so cool to

607
00:23:52,980 --> 00:23:45,850
follow the path so things that are

608
00:23:55,649 --> 00:23:52,990
they're proposing so yeah it just shows

609
00:23:57,360 --> 00:23:55,659
that you can seek those the answers to

610
00:23:58,409 --> 00:23:57,370
such fundamental questions from as the

611
00:24:00,000 --> 00:23:58,419
origin of life you don't necessarily

612
00:24:02,340 --> 00:24:00,010
need to be in a lab and try to replicate

613
00:24:05,159 --> 00:24:02,350

you can have these broader thoughts on

614

00:24:08,039 --> 00:24:05,169

how we actually do try to define what

615

00:24:12,090 --> 00:24:08,049

life is you is there a definition do you

616

00:24:14,070 --> 00:24:12,100

think well so my feeling is the

617

00:24:17,279 --> 00:24:14,080

definitions for should derive from a

618

00:24:18,250 --> 00:24:17,289

theory and so oftentimes in particular

619

00:24:20,020 --> 00:24:18,260

in astrobiology

620

00:24:22,210 --> 00:24:20,030

and we've tried to start from definition

621

00:24:24,520 --> 00:24:22,220

and then try to infer properties of life

622

00:24:25,840 --> 00:24:24,530

and and and there have been arguments

623

00:24:28,600 --> 00:24:25,850

against that approach that really we

624

00:24:30,610 --> 00:24:28,610

need to start with theories and then and

625

00:24:32,590 --> 00:24:30,620

then derive definitions from those

626

00:24:35,230 --> 00:24:32,600

theories and that's really an approach

627

00:24:36,610 --> 00:24:35,240

that I can get behind so I think then

628

00:24:38,710 --> 00:24:36,620

they think about is like what are the

629

00:24:40,030 --> 00:24:38,720

first one of the axioms of life or the

630

00:24:42,400 --> 00:24:40,040

first starting principles that you would

631

00:24:43,720 --> 00:24:42,410

reason to build a theory and then try to

632

00:24:45,820 --> 00:24:43,730

build that theory and see what it tells

633

00:24:50,860 --> 00:24:45,830

you about life and presumably those

634

00:24:52,120 --> 00:24:50,870

should be testable hypotheses yeah so

635

00:24:54,340 --> 00:24:52,130

don't forget for those of you who are

636

00:24:56,110 --> 00:24:54,350

watching use hashtag ask Esther bio to

637

00:24:58,120 --> 00:24:56,120

ask some questions or use a signet chat

638

00:25:00,310 --> 00:24:58,130

directly you'll be opening up the floor

639

00:25:02,560 --> 00:25:00,320

for questions for y'all in a few minutes

640

00:25:04,289 --> 00:25:02,570

but I wanted to chat about something

641

00:25:06,669 --> 00:25:04,299

else if you if you don't mind because

642

00:25:08,500 --> 00:25:06,679

you're kind of almost a superhero right

643

00:25:10,720 --> 00:25:08,510

you're you do incredible science you

644

00:25:12,340 --> 00:25:10,730

publish really thought-provoking papers

645

00:25:13,630 --> 00:25:12,350

that are changing the way we think about

646

00:25:16,510 --> 00:25:13,640

problems that we've been working on for

647

00:25:18,159 --> 00:25:16,520

decades your research group is has over

648

00:25:20,350 --> 00:25:18,169

ten people I think now you're teaching

649

00:25:23,080 --> 00:25:20,360

classes and you're the mom of two

650

00:25:38,919 --> 00:25:23,090

wonderful kids tell me your secret of

651
00:25:42,909 --> 00:25:38,929
how you manage your time but I think the

652
00:25:45,159 --> 00:25:42,919
thing that really motivates me is I

653
00:25:48,400 --> 00:25:45,169
really love what I do and I also really

654
00:25:50,169 --> 00:25:48,410
love my kids and my family so I I have

655
00:25:53,530 --> 00:25:50,179
to try to make sure that I like balance

656
00:25:54,940 --> 00:25:53,540
my time accordingly and sometimes that

657
00:25:56,650 --> 00:25:54,950
can be easier than others because

658
00:25:58,299 --> 00:25:56,660
sometimes everything wants to demand

659
00:26:05,080 --> 00:25:58,309
your attention at once and sometimes

660
00:26:07,900 --> 00:26:05,090
well I'm going to but yeah so so I think

661
00:26:09,340 --> 00:26:07,910
that's also like goes back to my advice

662
00:26:10,870 --> 00:26:09,350
at the beginning about following things

663
00:26:12,580 --> 00:26:10,880

that you're really passionate about if

664

00:26:16,000 --> 00:26:12,590

you if you really care about the things

665

00:26:17,470 --> 00:26:16,010

you work on even if there there might be

666

00:26:19,090 --> 00:26:17,480

things that are really challenging about

667

00:26:24,130 --> 00:26:19,100

your job or you have to juggle a lot of

668

00:26:25,840 --> 00:26:24,140

things it makes it worthwhile so I would

669

00:26:29,799 --> 00:26:25,850

I would obviously not have as much high

670

00:26:30,899 --> 00:26:29,809

energy or or be as I guess productive if

671

00:26:36,180 --> 00:26:30,909

I didn't care about

672

00:26:38,669 --> 00:26:36,190

things that I work on so much yeah yeah

673

00:26:40,499 --> 00:26:38,679

but with two little kids it's difficult

674

00:26:41,909 --> 00:26:40,509

like I got a bit like why something

675

00:26:43,289 --> 00:26:41,919

therefore for this morning to get up so

676

00:26:44,489 --> 00:26:43,299

I could do stuff before they got up but

677

00:26:46,619 --> 00:26:44,499

then I couldn't get up second up at 5:00

678

00:26:58,080 --> 00:26:46,629

I got 45 minutes though really so that's

679

00:27:02,009 --> 00:26:58,090

like a you know it's like you know I

680

00:27:06,419 --> 00:27:02,019

just I really like it your enthusiasm is

681

00:27:08,279 --> 00:27:06,429

contagious Sarah it's fantastic so I

682

00:27:10,320 --> 00:27:08,289

would have to plug in your your book

683

00:27:11,940 --> 00:27:10,330

that you just released fairly recently

684

00:27:13,859 --> 00:27:11,950

and Cambridge University Press called

685

00:27:18,570 --> 00:27:13,869

from matter to life can you tell us a

686

00:27:19,979 --> 00:27:18,580

bit about it yeah talk to people about

687

00:27:22,229 --> 00:27:19,989

like this kind of perspective on life

688

00:27:23,789 --> 00:27:22,239

and stuff they think that's like um you

689

00:27:24,960 --> 00:27:23,799

know it's a it is a really new

690

00:27:26,940 --> 00:27:24,970

perspective but there are a lot of

691

00:27:31,229 --> 00:27:26,950

really good people working on thinking

692

00:27:33,450 --> 00:27:31,239

about what life is in in a fundamental

693

00:27:35,969 --> 00:27:33,460

way and trying to build new ways of

694

00:27:37,589 --> 00:27:35,979

thinking about it in particular from the

695

00:27:40,440 --> 00:27:37,599

information perspective but just more

696

00:27:41,969 --> 00:27:40,450

broadly and so the idea with that book

697

00:27:44,330 --> 00:27:41,979

was really to try to get some of these

698

00:27:47,759 --> 00:27:44,340

people that are really contributing

699

00:27:50,279 --> 00:27:47,769

great thoughts to this literature to to

700

00:27:52,409 --> 00:27:50,289

write pieces on what they were thinking

701
00:27:55,979 --> 00:27:52,419
for this collection so that we could

702
00:27:57,690 --> 00:27:55,989
have a group of essays that were really

703
00:27:59,729 --> 00:27:57,700
representing the state of the field as

704
00:28:02,339 --> 00:27:59,739
far as how we're thinking about life and

705
00:28:04,409 --> 00:28:02,349
how to approach it from more

706
00:28:06,570 --> 00:28:04,419
quantitative directions and more ways of

707
00:28:08,369 --> 00:28:06,580
thinking more rigorously about some of

708
00:28:12,299 --> 00:28:08,379
these philosophical concepts that have

709
00:28:14,070 --> 00:28:12,309
been maybe a little bit hairy and so we

710
00:28:18,200 --> 00:28:14,080
have contributions from people across

711
00:28:21,690 --> 00:28:18,210
the spectrum of sciences and philosophy

712
00:28:23,820 --> 00:28:21,700
contributing to it so it was really

713
00:28:25,739 --> 00:28:23,830

exciting to work on it was a lot of work

714

00:28:28,379 --> 00:28:25,749

but I'm really glad that I did it

715

00:28:30,089 --> 00:28:28,389

because it was a really fun project to

716

00:28:31,379 --> 00:28:30,099

do and it's really cool to see all of

717

00:28:32,580 --> 00:28:31,389

those things together and it was super

718

00:28:35,009 --> 00:28:32,590

fun for me to read everybody else's

719

00:28:38,190 --> 00:28:35,019

contributions yeah it's a great

720

00:28:39,509 --> 00:28:38,200

contribution as a whole so let's let's

721

00:28:42,329 --> 00:28:39,519

open it up the questions for now I'm

722

00:28:43,960 --> 00:28:42,339

sure all of you online have dying to ask

723

00:28:46,660 --> 00:28:43,970

dr. Walker some

724

00:28:48,310 --> 00:28:46,670

for questions again use hashtag ask a

725

00:28:49,900 --> 00:28:48,320

survey on Twitter to let us know about

726

00:28:52,480 --> 00:28:49,910

your questions or use a cigarette chat

727

00:28:55,390 --> 00:28:52,490

directly so the first question comes

728

00:28:57,100 --> 00:28:55,400

from motor protein and so we talked a

729

00:28:59,080 --> 00:28:57,110

little bit about that question and

730

00:29:01,420 --> 00:28:59,090

during our conversation Sarah but they

731

00:29:02,890 --> 00:29:01,430

want to know how does one get into the

732

00:29:05,290 --> 00:29:02,900

origin of live research and does one

733

00:29:08,020 --> 00:29:05,300

need to be you know in biology to do

734

00:29:10,660 --> 00:29:08,030

that yeah so no you don't necessarily

735

00:29:12,850 --> 00:29:10,670

need to be in biology and I think the

736

00:29:16,060 --> 00:29:12,860

thing to do is to show up and start

737

00:29:18,640 --> 00:29:16,070

doing it so so my path was kind of a

738

00:29:21,730 --> 00:29:18,650

little unusual because I was in a ph.d

739

00:29:23,350 --> 00:29:21,740

program in physics and my advisor just

740

00:29:26,050 --> 00:29:23,360

started working on origins of life when

741

00:29:27,580 --> 00:29:26,060

I started working on it so most of the

742

00:29:30,010 --> 00:29:27,590

way like when I was applying for jobs

743

00:29:31,990 --> 00:29:30,020

and things I actually really had to go

744

00:29:34,060 --> 00:29:32,000

out on my own and go to conferences and

745

00:29:36,220 --> 00:29:34,070

like meet people and talk to them and

746

00:29:38,560 --> 00:29:36,230

try to get them excited about the ways I

747

00:29:40,480 --> 00:29:38,570

was thinking about the problem and I

748

00:29:42,220 --> 00:29:40,490

remember like a few of conferences I

749

00:29:44,110 --> 00:29:42,230

would - I was I was like one of two

750

00:29:46,120 --> 00:29:44,120

physicists or theorists in the room

751
00:29:47,430 --> 00:29:46,130
because mostly the origins of life has

752
00:29:49,540 --> 00:29:47,440
been Oh

753
00:29:51,360 --> 00:29:49,550
predominantly organic chemists and

754
00:29:56,080 --> 00:29:51,370
people thinking about provided chemistry

755
00:29:58,390 --> 00:29:56,090
and so so I really just had to be very

756
00:29:59,770 --> 00:29:58,400
persistent and in fact I will tell you

757
00:30:01,330 --> 00:29:59,780
don't let anybody tell you you can't do

758
00:30:02,680 --> 00:30:01,340
or Jin - like her career if you really

759
00:30:04,240 --> 00:30:02,690
care about it cuz somebody told me in

760
00:30:05,560 --> 00:30:04,250
grad school is a very prominent origin

761
00:30:06,910 --> 00:30:05,570
of life researcher that I should get out

762
00:30:08,110 --> 00:30:06,920
of the field now because I there's no

763
00:30:15,280 --> 00:30:08,120

hope of a career in it because there are

764

00:30:17,530 --> 00:30:15,290

no jobs in origins of life sorry to wake

765

00:30:19,690 --> 00:30:17,540

everybody but I think it's really like

766

00:30:21,610 --> 00:30:19,700

like at the time I was mortified I

767

00:30:23,620 --> 00:30:21,620

remember like I was a grad student and

768

00:30:24,970 --> 00:30:23,630

you know in a cosmology group I want to

769

00:30:26,350 --> 00:30:24,980

do origins of life and I met this

770

00:30:28,030 --> 00:30:26,360

conference like try to talk to be able

771

00:30:34,600 --> 00:30:28,040

so I like go back my room like crying

772

00:30:35,980 --> 00:30:34,610

about it I'm like oh but um but I I you

773

00:30:37,630 --> 00:30:35,990

know the next day went and talked to

774

00:30:39,750 --> 00:30:37,640

more people and and I actually ended up

775

00:30:43,390 --> 00:30:39,760

getting a job out of that conference so

776

00:30:45,910 --> 00:30:43,400

so I think it takes a lot of persistence

777

00:30:47,700 --> 00:30:45,920

a origin or life obviously is not you

778

00:30:50,950 --> 00:30:47,710

know a field that's in every department

779

00:30:53,170 --> 00:30:50,960

but even if like you get into an

780

00:30:55,060 --> 00:30:53,180

undergrad program or grad program and

781

00:30:56,710 --> 00:30:55,070

there's not anybody explicitly working

782

00:30:58,630 --> 00:30:56,720

on words of life you can

783

00:30:59,980 --> 00:30:58,640

try to direct your program into things

784

00:31:02,169 --> 00:30:59,990

that are using or going to be relevant

785

00:31:04,600 --> 00:31:02,179

and try to read the relevant literature

786

00:31:05,980 --> 00:31:04,610

and steer yourself in that direction and

787

00:31:07,720 --> 00:31:05,990

start trying to connect with people who

788

00:31:09,430 --> 00:31:07,730

are in origins of communities so I think

789

00:31:11,620 --> 00:31:09,440

with all these things that's really

790

00:31:14,230 --> 00:31:11,630

about your passion and your drive and

791

00:31:18,820 --> 00:31:14,240

and all the other things follow after

792

00:31:20,230 --> 00:31:18,830

that all right thanks Rashi asks about

793

00:31:23,890 --> 00:31:20,240

something we've talked about also about

794

00:31:31,570 --> 00:31:23,900

your search for this theory of life are

795

00:31:34,750 --> 00:31:33,250

I guess maybe I've been thinking about

796

00:31:35,680 --> 00:31:34,760

it long enough that I'm not so worried

797

00:31:38,350 --> 00:31:35,690

about it I guess the one thing I'm

798

00:31:42,730 --> 00:31:38,360

worried about is like that I might never

799

00:31:44,169 --> 00:31:42,740

see it so like yeah and actually some of

800

00:31:45,370 --> 00:31:44,179

my students joke that like if they ever

801
00:31:52,330 --> 00:31:45,380
figure out what like this they're not

802
00:31:54,640 --> 00:31:52,340
gonna tell me I mean I think about it a

803
00:31:56,649 --> 00:31:54,650
lot I think about it at odd times so it

804
00:31:58,120 --> 00:31:56,659
might be like you know I'm I'm in the

805
00:31:59,560 --> 00:31:58,130
car with my family they pick me up from

806
00:32:00,760 --> 00:31:59,570
work and I still have like my head in

807
00:32:02,110 --> 00:32:00,770
the clouds about like thinking about

808
00:32:04,570 --> 00:32:02,120
things or like pop in when I'm like

809
00:32:05,649 --> 00:32:04,580
redoing my kids at night but but I think

810
00:32:08,320 --> 00:32:05,659
that's because like when you're working

811
00:32:09,700 --> 00:32:08,330
in creative spaces and it requires a lot

812
00:32:13,480 --> 00:32:09,710
of mental power you can't really get

813
00:32:15,210 --> 00:32:13,490

your head out of it so but I don't I

814

00:32:18,310 --> 00:32:15,220

don't like sit away at night wondering

815

00:32:20,529 --> 00:32:18,320

things usually unless well occasionally

816

00:32:24,130 --> 00:32:20,539

I do but it's usually very more specific

817

00:32:26,110 --> 00:32:24,140

not kind of general things I hear yeah I

818

00:32:27,669 --> 00:32:26,120

think I have my my personal assign to

819

00:32:32,880 --> 00:32:27,679

make insights come from when I'm not at

820

00:32:36,909 --> 00:32:32,890

work strangely enough I'm like so rohan

821

00:32:39,430 --> 00:32:36,919

asks in which areas of astrobiology you

822

00:32:45,299 --> 00:32:39,440

think artificial intelligence will be

823

00:32:48,220 --> 00:32:45,309

most useful so this is a great question

824

00:32:50,020 --> 00:32:48,230

I mean the one that I thought about the

825

00:32:52,210 --> 00:32:50,030

most are origins of life research

826

00:32:55,690 --> 00:32:52,220

because there there's the ability with

827

00:32:57,159 --> 00:32:55,700

AI to to enhance like exploration of

828

00:32:58,419 --> 00:32:57,169

chemical space with like chemical

829

00:33:02,799 --> 00:32:58,429

robotics like things and people are

830

00:33:04,570 --> 00:33:02,809

publishing on that now and exoplanet

831

00:33:08,789 --> 00:33:04,580

research with trying to like mine large

832

00:33:11,560 --> 00:33:08,799

datasets very rapidly and

833

00:33:13,240 --> 00:33:11,570

but I think also even just understanding

834

00:33:15,630 --> 00:33:13,250

evolution better like looking for

835

00:33:18,400 --> 00:33:15,640

patterns in the history of the coupled

836

00:33:21,400 --> 00:33:18,410

biological and geological record I mean

837

00:33:24,820 --> 00:33:21,410

we have massive data and trying to make

838

00:33:26,950 --> 00:33:24,830

sense of that is difficult so I think I

839

00:33:28,510 --> 00:33:26,960

think AI and machine learning are gonna

840

00:33:32,289 --> 00:33:28,520

be really important for those kind of

841

00:33:34,060 --> 00:33:32,299

questions as well so I think like most

842

00:33:35,890 --> 00:33:34,070

fields of science it's going to be a

843

00:33:39,669 --> 00:33:35,900

major revolution for us in astrobiology

844

00:33:43,090 --> 00:33:39,679

in the coming decade as far as our

845

00:33:46,750 --> 00:33:43,100

methods cool

846

00:33:49,000 --> 00:33:46,760

Siraj asks what language you code in and

847

00:34:01,570 --> 00:33:49,010

what computer science subject do you use

848

00:34:03,370 --> 00:34:01,580

in your day-to-day work yeah so most of

849

00:34:04,390 --> 00:34:03,380

the people in my research group also use

850

00:34:06,070 --> 00:34:04,400

python but we have a couple of people

851

00:34:06,970 --> 00:34:06,080

that use julia and i've been trying to

852

00:34:07,990 --> 00:34:06,980

wait to see like when the phase

853

00:34:09,310 --> 00:34:08,000

transition is going to happen from

854

00:34:11,109 --> 00:34:09,320

Python to Julia because they're very

855

00:34:12,760 --> 00:34:11,119

convincing that julia is better which I

856

00:34:17,230 --> 00:34:12,770

don't even really understand the details

857

00:34:19,780 --> 00:34:17,240

but so I use Python personally but we we

858

00:34:22,480 --> 00:34:19,790

use a lot of different kinds of things

859

00:34:24,159 --> 00:34:22,490

in our work because I like we work a lot

860

00:34:25,629 --> 00:34:24,169

in origins of life but we work across

861

00:34:28,540 --> 00:34:25,639

all scales of biological organization

862

00:34:31,690 --> 00:34:28,550

and depending on the system different

863

00:34:32,649 --> 00:34:31,700

methods are needed so so there was just

864

00:34:34,599 --> 00:34:32,659

a question about like machine learning

865

00:34:37,060 --> 00:34:34,609

and doing those kind of techniques and I

866

00:34:38,530 --> 00:34:37,070

have a student that's very into AI and

867

00:34:41,770 --> 00:34:38,540

he's basically taught himself like the

868

00:34:43,930 --> 00:34:41,780

entire field and he's amazing and then I

869

00:34:45,760 --> 00:34:43,940

we work on ants and we needed something

870

00:34:47,470 --> 00:34:45,770

to be able to track the ants so that we

871

00:34:49,000 --> 00:34:47,480

could actually do information measures

872

00:34:50,830 --> 00:34:49,010

on ant behavior because we want to

873

00:34:53,500 --> 00:34:50,840

understand how information might

874

00:34:57,150 --> 00:34:53,510

structure collective behavior in ant

875

00:34:59,440 --> 00:34:57,160

colonies and so so he ended up building

876
00:35:01,900 --> 00:34:59,450
some deep learning algorithms for us to

877
00:35:03,660 --> 00:35:01,910
track the ants and so that's just like

878
00:35:05,680 --> 00:35:03,670
one example of sort of

879
00:35:07,540 --> 00:35:05,690
cross-disciplinary work just in our own

880
00:35:08,800 --> 00:35:07,550
research group as far as you know like

881
00:35:09,970 --> 00:35:08,810
somebody working on something totally

882
00:35:13,510 --> 00:35:09,980
distinct helping with another project

883
00:35:16,450 --> 00:35:13,520
and I think that's really cool and so I

884
00:35:18,160 --> 00:35:16,460
don't I think one of the things that is

885
00:35:19,660 --> 00:35:18,170
the best skill set as a

886
00:35:21,370 --> 00:35:19,670
programmer or somebody interested in

887
00:35:22,900 --> 00:35:21,380
computational methods it's just to be

888
00:35:25,510 --> 00:35:22,910

adaptable and be able to learn new

889

00:35:27,010 --> 00:35:25,520

techniques and also to be able to code

890

00:35:29,650 --> 00:35:27,020

with other people so one of the things

891

00:35:31,480 --> 00:35:29,660

that I think is the most exciting about

892

00:35:32,380 --> 00:35:31,490

the students and postdocs I work with is

893

00:35:35,020 --> 00:35:32,390

how much they like to work together

894

00:35:36,700 --> 00:35:35,030

which is super cool because they're

895

00:35:37,809 --> 00:35:36,710

they're like so creative when they get

896

00:35:38,920 --> 00:35:37,819

together in groups and like try to

897

00:35:40,569 --> 00:35:38,930

figure stuff out and they do a lot of

898

00:35:42,039 --> 00:35:40,579

coding together and developing the

899

00:35:43,780 --> 00:35:42,049

software packages and stuff and those

900

00:35:45,849 --> 00:35:43,790

end up being very useful like to the

901
00:35:48,579 --> 00:35:45,859
whole group and so I think that's been

902
00:35:50,849 --> 00:35:48,589
really powerful and important for our

903
00:35:53,410 --> 00:35:50,859
research as far as being able to do more

904
00:35:56,140 --> 00:35:53,420
collectively than we would ever do

905
00:35:57,390 --> 00:35:56,150
individually which is always the great

906
00:36:02,250 --> 00:35:57,400
thing about working with other people

907
00:36:07,329 --> 00:36:05,859
Julia the Marine asks tell us more about

908
00:36:13,589 --> 00:36:07,339
the difference between living systems

909
00:36:19,559 --> 00:36:15,730
you may have asking me what I think the

910
00:36:26,289 --> 00:36:23,650
yeah so it's a great question so I think

911
00:36:28,420 --> 00:36:26,299
the key differences go to to information

912
00:36:30,700 --> 00:36:28,430
but that's actually a really loaded word

913
00:36:32,230 --> 00:36:30,710

and so there are like a million

914

00:36:34,270 --> 00:36:32,240

definitions for how people think about

915

00:36:36,849 --> 00:36:34,280

information that range from things that

916

00:36:38,740 --> 00:36:36,859

are trying to capture its meaningful

917

00:36:41,890 --> 00:36:38,750

aspects or semantic aspects or to like

918

00:36:43,870 --> 00:36:41,900

the way Shannon qualified information

919

00:36:45,460 --> 00:36:43,880

theory is like communication on a noisy

920

00:36:47,920 --> 00:36:45,470

Channel and all those things are sort of

921

00:36:52,150 --> 00:36:47,930

relevant but the thing that I think is

922

00:36:53,740 --> 00:36:52,160

really important and and might be useful

923

00:36:55,120 --> 00:36:53,750

for purposes of discussion although I

924

00:36:56,589 --> 00:36:55,130

have never figured out really how to

925

00:36:58,359 --> 00:36:56,599

formulate this in the right way in my

926

00:36:59,799 --> 00:36:58,369

own mind is that the concept that's

927

00:37:02,470 --> 00:36:59,809

really relevant to biology it's not

928

00:37:04,599 --> 00:37:02,480

necessarily information but knowledge

929

00:37:06,190 --> 00:37:04,609

and that seems like a subtle distinction

930

00:37:08,170 --> 00:37:06,200

but the thing that's intriguing about

931

00:37:09,579 --> 00:37:08,180

biological systems is they have models

932

00:37:11,260 --> 00:37:09,589

of their world or knowledge of the

933

00:37:14,260 --> 00:37:11,270

external world and they can actually use

934

00:37:16,240 --> 00:37:14,270

that knowledge so the example I give

935

00:37:19,809 --> 00:37:16,250

which seems very far from origins of

936

00:37:21,130 --> 00:37:19,819

life but as my favorite example is to

937

00:37:24,609 --> 00:37:21,140

think about like launching satellites

938

00:37:29,170 --> 00:37:24,619

into space and so we do that as a

939

00:37:30,700 --> 00:37:29,180

technological civilization now and and

940

00:37:31,970 --> 00:37:30,710

the reason I think is a relevant example

941

00:37:34,310 --> 00:37:31,980

because Earth

942

00:37:35,780 --> 00:37:34,320

as thousands of satellites orbiting it

943

00:37:38,420 --> 00:37:35,790

right now but if you think about Earth

944

00:37:40,550 --> 00:37:38,430

without life earth without technology we

945

00:37:42,500 --> 00:37:40,560

have the moon as the only satellite the

946

00:37:45,859 --> 00:37:42,510

only natural satellite orbiting Earth

947

00:37:48,230 --> 00:37:45,869

and so basically what our civilization

948

00:37:49,970 --> 00:37:48,240

has accomplished is making more

949

00:37:52,190 --> 00:37:49,980

artificial satellites than natural

950

00:37:53,930 --> 00:37:52,200

satellites for Earth now that's

951
00:37:55,820 --> 00:37:53,940
interesting because those natural

952
00:37:57,530 --> 00:37:55,830
satellites would never exist unless

953
00:37:58,700 --> 00:37:57,540
there was a technological I mean those

954
00:38:00,440 --> 00:37:58,710
artificial satellites would never exist

955
00:38:02,690 --> 00:38:00,450
unless there was a civilization with

956
00:38:04,849 --> 00:38:02,700
knowledge of the laws of gravitation so

957
00:38:07,400 --> 00:38:04,859
we figured out something about the world

958
00:38:09,710 --> 00:38:07,410
about how the world works and we used it

959
00:38:11,480 --> 00:38:09,720
to create this new thing this this

960
00:38:12,830 --> 00:38:11,490
possibility of Earth having thousands of

961
00:38:15,890 --> 00:38:12,840
satellites whereas natural processes

962
00:38:18,050 --> 00:38:15,900
might give it one or a few and I think

963
00:38:20,090 --> 00:38:18,060

that's that is very telling of the most

964

00:38:22,790 --> 00:38:20,100

intrinsic property of life it's not just

965

00:38:24,500 --> 00:38:22,800

that it takes information or that it

966

00:38:27,590 --> 00:38:24,510

uses information but it actually uses

967

00:38:28,640 --> 00:38:27,600

that information to generate novelty to

968

00:38:30,080 --> 00:38:28,650

generate things that wouldn't exist

969

00:38:31,730 --> 00:38:30,090

without that information and that sort

970

00:38:33,260 --> 00:38:31,740

of the cascading process that the

971

00:38:36,050 --> 00:38:33,270

biosphere has been doing over four

972

00:38:37,490 --> 00:38:36,060

billion years and so that's the process

973

00:38:40,640 --> 00:38:37,500

that we need to understand is that

974

00:38:42,530 --> 00:38:40,650

extended structure of acquiring

975

00:38:50,390 --> 00:38:42,540

knowledge and using it to generate new

976

00:38:52,370 --> 00:38:50,400

possibilities over time this I wish to

977

00:38:53,599 --> 00:38:52,380

show was like three hours long for every

978

00:38:56,150 --> 00:38:53,609

one of our guests it's always such a

979

00:38:58,580 --> 00:38:56,160

fascinating conversation so the

980

00:39:00,500 --> 00:38:58,590

discussion about information translates

981

00:39:03,260 --> 00:39:00,510

a little bit to the next question by Ben

982

00:39:05,390 --> 00:39:03,270

Pierce who asks you mentioned describing

983

00:39:07,280 --> 00:39:05,400

life as information transfer when

984

00:39:08,510 --> 00:39:07,290

imagining the units of information being

985

00:39:10,370 --> 00:39:08,520

transferred are you thinking about

986

00:39:14,030 --> 00:39:10,380

information polymers or other

987

00:39:16,040 --> 00:39:14,040

non-genetic types of information it

988

00:39:18,290 --> 00:39:16,050

could be non-genetic I mean certainly I

989

00:39:20,060 --> 00:39:18,300

am transferring information to everyone

990

00:39:21,740 --> 00:39:20,070

right now and I would by no means say

991

00:39:23,480 --> 00:39:21,750

that's genetic information but I think

992

00:39:25,340 --> 00:39:23,490

it's important information and it's

993

00:39:28,120 --> 00:39:25,350

relevant and it and so the interesting

994

00:39:32,540 --> 00:39:28,130

thing about information that I think is

995

00:39:35,270 --> 00:39:32,550

not as appreciated unless you think

996

00:39:38,960 --> 00:39:35,280

about it a lot is that information has

997

00:39:40,400 --> 00:39:38,970

this property that it can be it can mean

998

00:39:42,080 --> 00:39:40,410

the same thing even though it might be

999

00:39:44,359 --> 00:39:42,090

in difficult different physical hardware

1000

00:39:45,980 --> 00:39:44,369

so so I'm talking now and

1001
00:39:48,019 --> 00:39:45,990
you know my information is entering my

1002
00:39:49,160 --> 00:39:48,029
speakers and it's transferring like all

1003
00:39:51,499 --> 00:39:49,170
the way to you guys and then being

1004
00:39:52,640 --> 00:39:51,509
output and and just read through the air

1005
00:39:53,870 --> 00:39:52,650
to your ears and then you're getting the

1006
00:39:55,400 --> 00:39:53,880
information and you're understanding uh

1007
00:39:56,870 --> 00:39:55,410
somehow in your brain so there's a lot

1008
00:40:01,130 --> 00:39:56,880
of different kinds of physical media

1009
00:40:02,749 --> 00:40:01,140
that information moved through and the

1010
00:40:04,960 --> 00:40:02,759
information is not necessarily an

1011
00:40:08,359 --> 00:40:04,970
intrinsic property of any one of them

1012
00:40:10,220 --> 00:40:08,369
it's more about how that signal is

1013
00:40:13,819 --> 00:40:10,230

propagated through those systems and how

1014

00:40:15,349 --> 00:40:13,829

you as a receiver or somebody that can

1015

00:40:17,509 --> 00:40:15,359

understand what I'm saying actually

1016

00:40:19,039 --> 00:40:17,519

interpret that information and so that's

1017

00:40:20,960 --> 00:40:19,049

the more critical aspect so we tend to

1018

00:40:23,210 --> 00:40:20,970

think about like DNA as having

1019

00:40:27,950 --> 00:40:23,220

information DNA doesn't have information

1020

00:40:29,569 --> 00:40:27,960

it has a FS you think about storing

1021

00:40:31,489 --> 00:40:29,579

information but it doesn't really do

1022

00:40:33,289 --> 00:40:31,499

anything until it's read out and that's

1023

00:40:34,940 --> 00:40:33,299

actually when it is information is when

1024

00:40:38,029 --> 00:40:34,950

it's controlling something about the

1025

00:40:40,819 --> 00:40:38,039

cellular state and so that kind of

1026

00:40:44,480 --> 00:40:40,829

process actually can happen in chemistry

1027

00:40:50,210 --> 00:40:44,490

it can happen in computers it can happen

1028

00:40:52,339 --> 00:40:50,220

in ant colonies so so there it's a more

1029

00:40:56,589 --> 00:40:52,349

ubiquitous process than just being types

1030

00:41:00,859 --> 00:40:56,599

of thinking about genetics fascinating

1031

00:41:02,569 --> 00:41:00,869

Eduardo Rodriguez Roman asks about your

1032

00:41:03,859 --> 00:41:02,579

personal definition of life or you have

1033

00:41:08,029 --> 00:41:03,869

one or maybe you don't because that

1034

00:41:10,160 --> 00:41:08,039

would bias your research no I do I do

1035

00:41:12,200 --> 00:41:10,170

have a personal definition but it falls

1036

00:41:13,670 --> 00:41:12,210

as a function of time and actually one

1037

00:41:15,049 --> 00:41:13,680

of my favorite things to do and we

1038

00:41:16,370 --> 00:41:15,059

haven't done this in a while but in my

1039

00:41:17,870 --> 00:41:16,380

research group is to have a what is life

1040

00:41:19,549 --> 00:41:17,880

discussion and everybody's right their

1041

00:41:20,930 --> 00:41:19,559

definition on the board so like I get

1042

00:41:22,370 --> 00:41:20,940

held to having to write a definition to

1043

00:41:23,539 --> 00:41:22,380

so it's kind of funny because nobody

1044

00:41:26,690 --> 00:41:23,549

wants to like say what their definition

1045

00:41:28,729 --> 00:41:26,700

is and underpinned to it and they change

1046

00:41:31,940 --> 00:41:28,739

all the time so my definition today

1047

00:41:36,819 --> 00:41:31,950

might be different than tomorrow but I

1048

00:41:39,140 --> 00:41:36,829

think so so one thing I think is a

1049

00:41:41,779 --> 00:41:39,150

common misconception as we think with

1050

00:41:46,930 --> 00:41:41,789

like more like a thing than a process

1051
00:41:49,370 --> 00:41:46,940
and so what I think life is is when

1052
00:41:56,870 --> 00:41:49,380
information matters to systems and

1053
00:42:05,280 --> 00:42:00,270
for let me try to think about how to say

1054
00:42:06,900 --> 00:42:05,290
this yeah with it's it's sort of like

1055
00:42:08,460 --> 00:42:06,910
like life is a property that's

1056
00:42:10,200 --> 00:42:08,470
distributed in space and time and the

1057
00:42:12,780 --> 00:42:10,210
the structure of that system is actually

1058
00:42:14,160 --> 00:42:12,790
that by how information is flowing and

1059
00:42:16,260 --> 00:42:14,170
that system so that that seems very

1060
00:42:17,609 --> 00:42:16,270
abstract but but basically it means when

1061
00:42:20,299 --> 00:42:17,619
information actually matters to the

1062
00:42:25,680 --> 00:42:20,309
world its life in a way that is

1063
00:42:29,520 --> 00:42:25,690

reproducible yeah so so obviously very

1064

00:42:31,170 --> 00:42:29,530

abstract and needs articulation it's a

1065

00:42:33,059 --> 00:42:31,180

great way to think differently about

1066

00:42:34,680 --> 00:42:33,069

something we've been thinking similarly

1067

00:42:35,700 --> 00:42:34,690

for half a decade so it's just setting

1068

00:42:38,339 --> 00:42:35,710

us in a new course I think it's

1069

00:42:40,680 --> 00:42:38,349

fantastic right yeah and I think is like

1070

00:42:42,210 --> 00:42:40,690

it's that and that's why it's hard it's

1071

00:42:44,010 --> 00:42:42,220

like there's not really a clear boundary

1072

00:42:46,049 --> 00:42:44,020

to that prop because it's a dynamical

1073

00:42:48,720 --> 00:42:46,059

process that has to involve it and it's

1074

00:42:50,430 --> 00:42:48,730

about the structure of that process yeah

1075

00:42:51,809 --> 00:42:50,440

that's what makes it so hard and why

1076

00:42:53,430 --> 00:42:51,819

origins of life research are really

1077

00:42:58,859 --> 00:42:53,440

important it's essentially job to you

1078

00:43:03,150 --> 00:42:58,869

because the problem is so hard so Nitin

1079

00:43:06,990 --> 00:43:03,160

asks how can we use microbes to attack

1080

00:43:10,170 --> 00:43:07,000

your origin of life research fantastic

1081

00:43:11,970 --> 00:43:10,180

so so I think one of the things that's

1082

00:43:15,990 --> 00:43:11,980

really been interesting for me be

1083

00:43:17,760 --> 00:43:16,000

thinking about using current biology to

1084

00:43:20,670 --> 00:43:17,770

understand origins of life is to think

1085

00:43:23,190 --> 00:43:20,680

about in this kind of abstract sense

1086

00:43:25,109 --> 00:43:23,200

like how our living systems processing

1087

00:43:29,609 --> 00:43:25,119

information what are they doing and also

1088

00:43:31,940 --> 00:43:29,619

how the structure of systems like what

1089

00:43:35,789 --> 00:43:31,950

might be that the things that are

1090

00:43:37,349 --> 00:43:35,799

universal across all life and also how

1091

00:43:38,370 --> 00:43:37,359

that is tied to the environment so that

1092

00:43:40,099 --> 00:43:38,380

seems like a whole bunch of things

1093

00:43:45,000 --> 00:43:40,109

somehow my brain those are all related

1094

00:43:47,480 --> 00:43:45,010

but but the idea is if you if you say

1095

00:43:51,839 --> 00:43:47,490

take a microbe and you want to look at

1096

00:43:53,520 --> 00:43:51,849

how it's working and usually what we do

1097

00:43:54,720 --> 00:43:53,530

right currently is like try to look at

1098

00:43:56,370 --> 00:43:54,730

all the individual parts and then we

1099

00:43:58,049 --> 00:43:56,380

build up the system from there but you

1100

00:43:59,700 --> 00:43:58,059

can actually also look at it as systems

1101

00:44:01,079 --> 00:43:59,710

level and look at the organization of

1102

00:44:03,210 --> 00:44:01,089

that system and how information is

1103

00:44:06,480 --> 00:44:03,220

flowing that's and so that's one way of

1104

00:44:09,150 --> 00:44:06,490

trying to understand what that system is

1105

00:44:10,220 --> 00:44:09,160

from a more fundamental perspective but

1106

00:44:13,130 --> 00:44:10,230

just to give you a more kind

1107

00:44:14,480 --> 00:44:13,140

example because I've been talking Everio

1108

00:44:16,220 --> 00:44:14,490

abstractly but we do do a lot of

1109

00:44:18,320 --> 00:44:16,230

concrete work in my group it's just

1110

00:44:20,090 --> 00:44:18,330

trying to give this sort of high-level

1111

00:44:21,800 --> 00:44:20,100

picture while us are resolving details

1112

00:44:26,990 --> 00:44:21,810

is very challenging in the short time we

1113

00:44:28,550 --> 00:44:27,000

have but by a lot of people work in you

1114

00:44:29,690 --> 00:44:28,560

know like hot spring ecosystems and

1115

00:44:31,160 --> 00:44:29,700

things in their study and like whole

1116

00:44:33,140 --> 00:44:31,170

communities and I think that kind of

1117

00:44:34,580 --> 00:44:33,150

work as far as like how microbes are

1118

00:44:36,470 --> 00:44:34,590

interacting with their environment and

1119

00:44:38,180 --> 00:44:36,480

things is very important for

1120

00:44:39,470 --> 00:44:38,190

understanding what the early drivers of

1121

00:44:42,220 --> 00:44:39,480

the emergence of those kind of systems

1122

00:44:44,870 --> 00:44:42,230

might events and so when I think that

1123

00:44:47,780 --> 00:44:44,880

we're really interested in doing is

1124

00:44:48,890 --> 00:44:47,790

looking at the structure of networks in

1125

00:44:50,480 --> 00:44:48,900

those systems and how those networks

1126

00:44:52,070 --> 00:44:50,490

actually coupled to the geochemical

1127

00:44:53,390 --> 00:44:52,080

context and so that's one way of trying

1128

00:44:55,160 --> 00:44:53,400

to actually really look at like the

1129

00:44:57,800 --> 00:44:55,170

planetary drivers of processes which

1130

00:44:59,930 --> 00:44:57,810

would actually hopefully help illuminate

1131

00:45:03,109 --> 00:44:59,940

how those kind of systems emerged in my

1132

00:45:03,859 --> 00:45:03,119

first place so why studying microbes and

1133

00:45:11,620 --> 00:45:03,869

hot springs

1134

00:45:14,900 --> 00:45:11,630

hint hint - sure has the next question

1135

00:45:17,090 --> 00:45:14,910

and he asks how do you connect the third

1136

00:45:19,030 --> 00:45:17,100

bounnam if the thermodynamic drivers for

1137

00:45:21,230 --> 00:45:19,040

the origin of life in parentheses

1138

00:45:23,660 --> 00:45:21,240

relaxation pathways for planetary

1139

00:45:26,090 --> 00:45:23,670

chemical disequilibrium with your

1140

00:45:30,530 --> 00:45:26,100

perspective on information essential to

1141

00:45:31,790 --> 00:45:30,540

the nature of life yeah it's quite a lot

1142

00:45:33,290 --> 00:45:31,800

lately and there's a couple of things

1143

00:45:34,820 --> 00:45:33,300

that I think are really promising in

1144

00:45:36,200 --> 00:45:34,830

that direction one is a field that I'm

1145

00:45:39,020 --> 00:45:36,210

not so familiar with but I've been

1146

00:45:40,040 --> 00:45:39,030

trying to like learn more about which is

1147

00:45:42,800 --> 00:45:40,050

that there's been some really

1148

00:45:46,910 --> 00:45:42,810

fascinating and work in non equilibrium

1149

00:45:50,420 --> 00:45:46,920

thermodynamics about what information is

1150

00:45:51,770 --> 00:45:50,430

in the thermodynamic sense and so so

1151

00:45:53,920 --> 00:45:51,780

there have been some some new

1152

00:45:57,620 --> 00:45:53,930

innovations about information actually

1153

00:45:59,570 --> 00:45:57,630

being a way of extracting work and so

1154

00:46:00,800 --> 00:45:59,580

that seems have relevance for origins of

1155

00:46:02,510 --> 00:46:00,810

life where we want to talk about these

1156

00:46:04,760 --> 00:46:02,520

thermodynamic processes driving the

1157

00:46:06,500 --> 00:46:04,770

system but ultimately somehow we have to

1158

00:46:08,810 --> 00:46:06,510

transition to an informational narrative

1159

00:46:10,010 --> 00:46:08,820

to be consistent with biology and so

1160

00:46:11,690 --> 00:46:10,020

I've been trying to do some work on

1161

00:46:13,220 --> 00:46:11,700

importing some of those ideas into how

1162

00:46:14,390 --> 00:46:13,230

we think about working like models and

1163

00:46:15,410 --> 00:46:14,400

other people have been doing those kind

1164

00:46:18,800 --> 00:46:15,420

of things which i think is really

1165

00:46:19,810 --> 00:46:18,810

exciting work the other one is that

1166

00:46:21,800 --> 00:46:19,820

we've been doing some work with

1167

00:46:23,599 --> 00:46:21,810

biochemical networks and their

1168

00:46:23,930 --> 00:46:23,609

organization and I think there is a way

1169

00:46:29,120 --> 00:46:23,940

of

1170

00:46:31,190 --> 00:46:29,130

electrons like redox is what usually

1171

00:46:33,110 --> 00:46:31,200

people think about and there's natural

1172

00:46:34,970 --> 00:46:33,120

analogies there between the structure

1173

00:46:36,590 --> 00:46:34,980

biochemistry and the structure of

1174

00:46:38,390 --> 00:46:36,600

computer architecture and how electrons

1175

00:46:40,010 --> 00:46:38,400

are flowing through computers and what

1176

00:46:41,030 --> 00:46:40,020

those networks look like and so I've

1177

00:46:42,980 --> 00:46:41,040

been trying to actually explore those

1178

00:46:45,800 --> 00:46:42,990

kind of analogies as far as if they

1179

00:46:47,210 --> 00:46:45,810

think about redox and how redox greens

1180

00:46:49,160 --> 00:46:47,220

might have structured life on a planet

1181

00:46:50,030 --> 00:46:49,170

that maybe that's really kind of you

1182

00:46:51,410 --> 00:46:50,040

could think of that as a kind of

1183

00:46:54,200 --> 00:46:51,420

computation and emergence of a

1184

00:46:56,090 --> 00:46:54,210

computational system so I think that

1185

00:46:58,100 --> 00:46:56,100

that's also this part where we think

1186

00:46:59,420 --> 00:46:58,110

about information is being genetics but

1187

00:47:00,830 --> 00:46:59,430

it could be much earlier than that and

1188

00:47:02,570 --> 00:47:00,840

it might just be embedded in the

1189

00:47:04,280 --> 00:47:02,580

structure of the way these reaction

1190

00:47:05,690 --> 00:47:04,290

networks organize that they really are

1191

00:47:09,350 --> 00:47:05,700

doing these kind of informational

1192

00:47:15,410 --> 00:47:09,360

processes from a start it's good

1193

00:47:17,270 --> 00:47:15,420

question Karl Siraj asks does your

1194

00:47:19,910 --> 00:47:17,280

research help understand the hierarchy

1195

00:47:23,810 --> 00:47:19,920

of biology that develops following the

1196

00:47:25,430 --> 00:47:23,820

start yeah so I'm fascinated by that

1197

00:47:27,110 --> 00:47:25,440

question like most physicists I could

1198

00:47:28,700 --> 00:47:27,120

have specified hierarchies I don't I

1199

00:47:30,440 --> 00:47:28,710

don't know what it is but the way our

1200

00:47:32,570 --> 00:47:30,450

brains are trained but hierarchies are

1201

00:47:33,830 --> 00:47:32,580

fascinating and a lot of people from

1202

00:47:35,480 --> 00:47:33,840

like the physics side think that the

1203

00:47:36,890 --> 00:47:35,490

hierarchy of biology is actually the

1204

00:47:38,150 --> 00:47:36,900

hardest problem of understanding life

1205

00:47:41,180 --> 00:47:38,160

and that's where most of the fundamental

1206

00:47:43,370 --> 00:47:41,190

physics is explainable because that's

1207

00:47:45,200 --> 00:47:43,380

where you start to get information flows

1208

00:47:47,620 --> 00:47:45,210

that are not necessarily just bottom up

1209

00:47:50,120 --> 00:47:47,630

but top down information flows like the

1210

00:47:51,710 --> 00:47:50,130

example is the most abstract and

1211

00:47:53,660 --> 00:47:51,720

philosophical is that your brain has

1212

00:47:54,920 --> 00:47:53,670

thoughts and those actually control your

1213

00:47:56,810 --> 00:47:54,930

actions so it's a very high level

1214

00:47:59,150 --> 00:47:56,820

process controlling a low level process

1215

00:48:01,490 --> 00:47:59,160

but we see that across the hierarchy so

1216

00:48:03,560 --> 00:48:01,500

I'm really interested in why new levels

1217

00:48:04,670 --> 00:48:03,570

emerge what they're doing and also how

1218

00:48:07,280 --> 00:48:04,680

they change the structure of lower

1219

00:48:08,780 --> 00:48:07,290

levels by the kind of constraints they

1220

00:48:10,460 --> 00:48:08,790

impose in one place that we've been

1221

00:48:13,190 --> 00:48:10,470

looking at that is with biochemical

1222

00:48:15,410 --> 00:48:13,200

networks more generally and showing that

1223

00:48:17,440 --> 00:48:15,420

if you look at the structure from like

1224

00:48:19,460 --> 00:48:17,450

an abstract network perspective

1225

00:48:21,590 --> 00:48:19,470

individuals don't look very like they

1226
00:48:23,240 --> 00:48:21,600
scale the same way as ecosystems and

1227
00:48:24,530 --> 00:48:23,250
that structure actually seems to extend

1228
00:48:26,150 --> 00:48:24,540
all the way to the biosphere as a whole

1229
00:48:27,770 --> 00:48:26,160
so there there's a very regular

1230
00:48:30,320 --> 00:48:27,780
structure across the hierarchy of

1231
00:48:31,730 --> 00:48:30,330
individuals ecosystems biosphere as far

1232
00:48:33,860 --> 00:48:31,740
as how biochemistry is organized

1233
00:48:37,339 --> 00:48:33,870
globally and I think that's a really

1234
00:48:39,620 --> 00:48:37,349
fascinating window into this problem of

1235
00:48:43,640 --> 00:48:39,630
European how living systems organize

1236
00:48:45,200 --> 00:48:43,650
across scales well it's a really good

1237
00:48:46,370 --> 00:48:45,210
question if any of you are interested in

1238
00:48:52,759 --> 00:48:46,380

working on hierarchies you should

1239

00:48:55,249 --> 00:48:52,769

they're very tough Yanis tom vacas asks

1240

00:48:57,349 --> 00:48:55,259

hi Sarah I have a possible generic life

1241

00:49:00,289 --> 00:48:57,359

quantification metric that I'm working

1242

00:49:01,700 --> 00:49:00,299

on and I have was wondering if you have

1243

00:49:07,400 --> 00:49:01,710

anything along these lines that you're

1244

00:49:09,079 --> 00:49:07,410

thinking of as well so I am interested

1245

00:49:11,479 --> 00:49:09,089

in quantifying life but as I said I

1246

00:49:13,849 --> 00:49:11,489

don't I don't think of life as a static

1247

00:49:14,900 --> 00:49:13,859

property so I think I don't know

1248

00:49:15,979 --> 00:49:14,910

anything about your measure I think it's

1249

00:49:16,579 --> 00:49:15,989

fascinating that you have one so that's

1250

00:49:19,160 --> 00:49:16,589

awesome

1251
00:49:23,319 --> 00:49:19,170
and you should keep developing it but I

1252
00:49:26,539 --> 00:49:23,329
I guess I think that you can measure

1253
00:49:28,819 --> 00:49:26,549
like how alive a system is but but it

1254
00:49:31,160 --> 00:49:28,829
would be something about the dynamical

1255
00:49:31,549 --> 00:49:31,170
structure of that system and that's all

1256
00:49:35,089 --> 00:49:31,559
I can say

1257
00:49:39,680 --> 00:49:35,099
at this exact juncture at night as far

1258
00:49:42,200 --> 00:49:39,690
as my thinking Richard Gordon asks what

1259
00:49:42,829 --> 00:49:42,210
are your thoughts on oil droplets origin

1260
00:49:45,680 --> 00:49:42,839
of life

1261
00:49:51,499 --> 00:49:45,690
I like oil droplet they're fun to watch

1262
00:49:53,719 --> 00:49:51,509
scurry around I so so something that

1263
00:49:55,219 --> 00:49:53,729

that probably annoyed some people is

1264

00:49:57,709 --> 00:49:55,229

that I'm sure I'm not stink about the

1265

00:49:59,930 --> 00:49:57,719

chemistry that started like I don't I

1266

00:50:02,959 --> 00:49:59,940

don't necessarily have a preference of

1267

00:50:04,999 --> 00:50:02,969

like oil droplets first or metabolism

1268

00:50:06,589 --> 00:50:05,009

first or genetics first I really just

1269

00:50:08,299 --> 00:50:06,599

want I want to understand the processes

1270

00:50:10,190 --> 00:50:08,309

that give rise to living systems and

1271

00:50:11,630 --> 00:50:10,200

they might in my mind they could

1272

00:50:13,069 --> 00:50:11,640

manifest in a lot of different chemical

1273

00:50:14,809 --> 00:50:13,079

systems and this might be why we have

1274

00:50:16,749 --> 00:50:14,819

promising leads a lots of different

1275

00:50:21,940 --> 00:50:16,759

kinds of chemistry being the first step

1276
00:50:25,009 --> 00:50:21,950
and so so from the sense that they have

1277
00:50:26,269 --> 00:50:25,019
they can exhibit lifelike behavior and

1278
00:50:28,479 --> 00:50:26,279
those kind of things I'm interested in

1279
00:50:30,799 --> 00:50:28,489
how chemistry can organize to do that

1280
00:50:32,539 --> 00:50:30,809
but the oil droplets themselves I don't

1281
00:50:34,959 --> 00:50:32,549
have a preference on whether that's the

1282
00:50:40,519 --> 00:50:34,969
exact model for origins of life on Earth

1283
00:50:43,309 --> 00:50:40,529
Lee Cronin might disagree Maya or

1284
00:50:47,029 --> 00:50:43,319
escovitch English asks I've been writing

1285
00:50:49,999 --> 00:50:47,039
a sci-fi story where a planetary is sigh

1286
00:50:51,020 --> 00:50:50,009
artists assesses planets based on

1287
00:50:52,580 --> 00:50:51,030
initial conditions

1288
00:50:54,400 --> 00:50:52,590

and one estimates the possibility the

1289

00:50:56,990 --> 00:50:54,410

possible evolutionary scenarios and

1290

00:50:57,560 --> 00:50:57,000

life-forms that can or will live on that

1291

00:50:59,960 --> 00:50:57,570

planet

1292

00:51:04,760 --> 00:50:59,970

well that ever be possible to do or is

1293

00:51:06,650 --> 00:51:04,770

it just sci-fi at this stage it depends

1294

00:51:08,360 --> 00:51:06,660

on what you mean by possible so there's

1295

00:51:09,530 --> 00:51:08,370

there's possible and that we don't have

1296

00:51:11,120 --> 00:51:09,540

the knowledge to do it or there's

1297

00:51:13,670 --> 00:51:11,130

possible that it's actually physically

1298

00:51:15,290 --> 00:51:13,680

possible to predict and I'm on the line

1299

00:51:19,160 --> 00:51:15,300

that it's not physically possible to

1300

00:51:21,500 --> 00:51:19,170

predict because if you if you look at I

1301

00:51:23,750 --> 00:51:21,510

guess the reason I ate I take that

1302

00:51:26,690 --> 00:51:23,760

perspective is that I really do think

1303

00:51:32,360 --> 00:51:26,700

that biology genuinely generates novelty

1304

00:51:33,920 --> 00:51:32,370

and it's not necessarily my favorite try

1305

00:51:37,280 --> 00:51:33,930

to avoid it was hard in these concepts

1306

00:51:39,050 --> 00:51:37,290

but but if you think about like what is

1307

00:51:43,510 --> 00:51:39,060

possible physicists usually like to

1308

00:51:45,590 --> 00:51:43,520

iterate a finite set of things but in

1309

00:51:46,910 --> 00:51:45,600

biology seems to generally create things

1310

00:51:48,740 --> 00:51:46,920

that are new and and maybe aren't

1311

00:51:50,180 --> 00:51:48,750

anticipated so I think we can understand

1312

00:51:51,770 --> 00:51:50,190

the process of generating those new

1313

00:51:53,870 --> 00:51:51,780

things but not the specific new things

1314

00:51:55,400 --> 00:51:53,880

that are generated I can't predict the

1315

00:51:58,070 --> 00:51:55,410

future essentially of what life is going

1316

00:52:00,530 --> 00:51:58,080

to do because it's so scary I think

1317

00:52:01,820 --> 00:52:00,540

whatever the evolutionary process is if

1318

00:52:04,790 --> 00:52:01,830

we can understand that at a more

1319

00:52:06,560 --> 00:52:04,800

fundamental level is universal and so

1320

00:52:08,150 --> 00:52:06,570

you might understand the conditions I'm

1321

00:52:10,460 --> 00:52:08,160

under which you start that process

1322

00:52:13,240 --> 00:52:10,470

origins of life but predicting where

1323

00:52:16,190 --> 00:52:13,250

that process is going is very difficult

1324

00:52:18,710 --> 00:52:16,200

and so just to give you an example like

1325

00:52:22,850 --> 00:52:18,720

if we invent AI

1326

00:52:24,320 --> 00:52:22,860

I mean we're heading there it's really

1327

00:52:26,570 --> 00:52:24,330

difficult for us to anticipate what's

1328

00:52:28,160 --> 00:52:26,580

that what's that going to do because

1329

00:52:29,870 --> 00:52:28,170

there are so many possibilities that it

1330

00:52:31,250 --> 00:52:29,880

actually can do predicting which one I

1331

00:52:33,410 --> 00:52:31,260

don't I don't actually think it's a

1332

00:52:35,120 --> 00:52:33,420

statement that we we could predict ahead

1333

00:52:38,840 --> 00:52:35,130

I think we can predict general trends

1334

00:52:44,450 --> 00:52:38,850

but not specifics that makes sense Jake

1335

00:52:47,660 --> 00:52:44,460

and Haque misra asks our stars alive all

1336

00:52:51,110 --> 00:52:47,670

right eyes a great question um not in my

1337

00:52:52,700 --> 00:52:51,120

mind although so so this is where it

1338

00:52:53,930 --> 00:52:52,710

gets really murky so so people talk

1339

00:52:55,730 --> 00:52:53,940

about stars being alive because they

1340

00:52:58,940 --> 00:52:55,740

undergo an evolutionary process so you

1341

00:53:01,460 --> 00:52:58,950

have a star and it burns all its fuel

1342

00:53:02,990 --> 00:53:01,470

and it dies and it spreads new elements

1343

00:53:04,280 --> 00:53:03,000

out into the universe and then if that

1344

00:53:05,960 --> 00:53:04,290

enriches the next generation

1345

00:53:07,190 --> 00:53:05,970

stars and might change their properties

1346

00:53:08,690 --> 00:53:07,200

and then that can happen again so it

1347

00:53:10,850 --> 00:53:08,700

looks like there's even an evolutionary

1348

00:53:12,560 --> 00:53:10,860

inheritance there but I don't take an

1349

00:53:14,390 --> 00:53:12,570

evolutionary definition of life I take

1350

00:53:19,580 --> 00:53:14,400

this kind of informational one and there

1351

00:53:21,560 --> 00:53:19,590

seems to be no real information

1352

00:53:24,710 --> 00:53:21,570

necessary for that process but that

1353

00:53:26,030 --> 00:53:24,720

being said I think this is one of the

1354

00:53:27,500 --> 00:53:26,040

things that's sort of a gray area

1355

00:53:28,850 --> 00:53:27,510

because I think there are plenty of

1356

00:53:31,370 --> 00:53:28,860

things that are very close to being

1357

00:53:32,660 --> 00:53:31,380

alive or almost alive and that then

1358

00:53:34,220 --> 00:53:32,670

there are things that we qualify as

1359

00:53:36,260 --> 00:53:34,230

alive but I don't think that that

1360

00:53:37,880 --> 00:53:36,270

boundary between those is is well

1361

00:53:40,190 --> 00:53:37,890

defined and I don't think that that's

1362

00:53:41,540 --> 00:53:40,200

because we don't have a good definition

1363

00:53:43,130 --> 00:53:41,550

for it I just think it's not a

1364

00:53:44,600 --> 00:53:43,140

well-defined boundary because that's not

1365

00:53:45,770 --> 00:53:44,610

really the right question to ask the

1366

00:53:48,970 --> 00:53:45,780

question is to ask what are the

1367

00:53:51,290 --> 00:53:48,980

processes that drive increasing

1368

00:53:53,240 --> 00:53:51,300

increasingly complex and rich

1369

00:53:58,130 --> 00:53:53,250

information processing structures in

1370

00:53:59,330 --> 00:53:58,140

nature and how do those arise and and if

1371

00:54:00,440 --> 00:53:59,340

you want to trace that process all the

1372

00:54:01,460 --> 00:54:00,450

way back to it through I guess you

1373

00:54:03,410 --> 00:54:01,470

better go all the way back to the Big

1374

00:54:05,510 --> 00:54:03,420

Bang because it's it's a process that

1375

00:54:08,630 --> 00:54:05,520

emerges from nature it's not a it's not

1376
00:54:10,010 --> 00:54:08,640
a hard boundary so I'm not saying the

1377
00:54:12,260 --> 00:54:10,020
original life was in the Big Bang I'm

1378
00:54:14,330 --> 00:54:12,270
just saying that like it's kind of a

1379
00:54:19,060 --> 00:54:14,340
it's it's a different way of thinking

1380
00:54:21,920 --> 00:54:19,070
about the question all right nitin asks

1381
00:54:27,290 --> 00:54:21,930
what are your thoughts of DNA having a

1382
00:54:28,580 --> 00:54:27,300
more prevalent role in in computing yeah

1383
00:54:31,430 --> 00:54:28,590
I think it's super cool that people are

1384
00:54:32,690 --> 00:54:31,440
doing stuff with DNA computing I think I

1385
00:54:36,050 --> 00:54:32,700
mean it's just another piece of hardware

1386
00:54:37,610 --> 00:54:36,060
it's just a different one than what

1387
00:54:40,730 --> 00:54:37,620
we're used to thinking about so I don't

1388
00:54:43,580 --> 00:54:40,740

I don't think I don't think it's

1389

00:54:45,410 --> 00:54:43,590

necessarily like a major revolution and

1390

00:54:47,360 --> 00:54:45,420

how we're thinking about computing or

1391

00:54:50,540 --> 00:54:47,370

anything like that but it is fun that we

1392

00:54:52,370 --> 00:54:50,550

can do computation and DNA and it might

1393

00:54:55,580 --> 00:54:52,380

be useful to like programming biological

1394

00:54:57,110 --> 00:54:55,590

systems technology no it's exciting to

1395

00:54:59,390 --> 00:54:57,120

pad the computation is taking for sure

1396

00:55:02,570 --> 00:54:59,400

so here's a question that all of us who

1397

00:55:11,420 --> 00:55:02,580

are fans of Firefly want to know is how

1398

00:55:12,860 --> 00:55:11,430

did you meet Nathan Fillion so we have

1399

00:55:14,330 --> 00:55:12,870

this awesome thing at ASU which is

1400

00:55:16,280 --> 00:55:14,340

called the Center for science and the

1401
00:55:17,180 --> 00:55:16,290
imagination and they do all these kind

1402
00:55:21,440 --> 00:55:17,190
of things with

1403
00:55:23,299 --> 00:55:21,450
and scientists and like trying to you

1404
00:55:26,150 --> 00:55:23,309
know get science fiction to talk to

1405
00:55:29,059 --> 00:55:26,160
science fact and so they were having a

1406
00:55:31,579 --> 00:55:29,069
panel with Nathan Fillion because he is

1407
00:55:33,920 --> 00:55:31,589
a friend of affiliate of the center and

1408
00:55:36,319 --> 00:55:33,930
and they were looking for scientists to

1409
00:55:38,450 --> 00:55:36,329
be on it and so they asked me and that

1410
00:55:40,730 --> 00:55:38,460
was really fun it was a very lively

1411
00:55:44,720 --> 00:55:40,740
conversation with a few scientists and

1412
00:55:49,130 --> 00:55:44,730
even and it was it was fun I had a good

1413
00:56:01,279 --> 00:55:49,140

name yes tumblr does use into show I'm

1414

00:56:02,900 --> 00:56:01,289

just kidding yeah is a very dynamic and

1415

00:56:04,520 --> 00:56:02,910

charismatic personality so he's very

1416

00:56:08,299 --> 00:56:04,530

good at like engaging the audience which

1417

00:56:10,069 --> 00:56:08,309

I thought was cool yeah wonderful well

1418

00:56:11,809 --> 00:56:10,079

sorry we at the top of the hour just

1419

00:56:13,400 --> 00:56:11,819

want to say thank you so much for taking

1420

00:56:15,500 --> 00:56:13,410

the time to chat with us today I know

1421

00:56:18,470 --> 00:56:15,510

you're super busy it was absolutely

1422

00:56:20,029 --> 00:56:18,480

wonderful to have you thanks so much I

1423

00:56:21,109 --> 00:56:20,039

was really happy to be here and so

1424

00:56:23,480 --> 00:56:21,119

excited to get a little wonderful

1425

00:56:25,430 --> 00:56:23,490

question for those of you are watching

1426

00:56:27,289 --> 00:56:25,440

catch us next month for askin

1427

00:56:28,430 --> 00:56:27,299

astrobiologists again look at that

1428

00:56:30,559 --> 00:56:28,440

background because that's gonna be a

1429

00:56:33,230 --> 00:56:30,569

question for next month's episode and

1430

00:56:35,130 --> 00:56:33,240

until then stay curious do take care bye