
AbSciCon
2019

1
00:00:00,790 --> 00:00:07,320
[Music]

2
00:00:11,520 --> 00:00:08,759
[Applause]

3
00:00:13,379 --> 00:00:11,530
I just wanted to point out like if

4
00:00:14,580 --> 00:00:13,389
astrobiology successful what we're

5
00:00:17,370 --> 00:00:14,590
actually going to accomplish which is

6
00:00:18,480 --> 00:00:17,380
adding a new cosmological parameter to

7
00:00:20,010 --> 00:00:18,490
our understanding of the universe which

8
00:00:21,450 --> 00:00:20,020
I think effectively Eddie was trying to

9
00:00:23,819 --> 00:00:21,460
get at by expanding our horizons and

10
00:00:26,460 --> 00:00:23,829
thinking beyond the solar system but I

11
00:00:28,140 --> 00:00:26,470
think it's really important to kind of

12
00:00:30,210 --> 00:00:28,150
understand the context of our science in

13
00:00:31,679 --> 00:00:30,220

sort in terms of the scope of what has

14
00:00:33,390 --> 00:00:31,689
been accomplished in the past as far as

15
00:00:36,060 --> 00:00:33,400
our understanding of the natural world

16
00:00:37,710 --> 00:00:36,070
and where we're going and so the way I

17
00:00:39,450 --> 00:00:37,720
think about astrobiology really is in

18
00:00:41,610 --> 00:00:39,460
terms of a probabilistic framework about

19
00:00:43,200 --> 00:00:41,620
what is the percentage of living matter

20
00:00:44,369 --> 00:00:43,210
that the universe actually can support

21
00:00:45,899 --> 00:00:44,379
and can we constrain that as

22
00:00:48,359 --> 00:00:45,909
astrobiologists and how will we do that

23
00:00:50,189 --> 00:00:48,369
quantitatively and so this is trying to

24
00:00:52,770 --> 00:00:50,199
move into quantitative frameworks for

25
00:00:54,810 --> 00:00:52,780
astrobiology and thinking more about our

26
00:00:57,240 --> 00:00:54,820
biology as a quantitative science and a

27
00:00:59,969 --> 00:00:57,250
theoretically driven science than one

28
00:01:01,469 --> 00:00:59,979
just based on sort of anthropic

29
00:01:04,500 --> 00:01:01,479
perspectives that we have about life on

30
00:01:06,359 --> 00:01:04,510
Earth and so there's a long tradition

31
00:01:07,710 --> 00:01:06,369
obviously of people asking the question

32
00:01:09,060 --> 00:01:07,720
what is life and trying to think about

33
00:01:10,980 --> 00:01:09,070
it from a definitional perspective

34
00:01:13,740 --> 00:01:10,990
particularly in our field and that's

35
00:01:14,969 --> 00:01:13,750
gotten us really far but I think that we

36
00:01:16,919 --> 00:01:14,979
really need to challenge ourselves at

37
00:01:19,200 --> 00:01:16,929
this stage in our biology to really

38
00:01:20,880 --> 00:01:19,210

think about what life is but not from a

39
00:01:22,800 --> 00:01:20,890
definitional framework but from a

40
00:01:23,940 --> 00:01:22,810
quantitative one and so there's a lot of

41
00:01:25,709 --> 00:01:23,950
people that have quoted or in sronger

42
00:01:27,029 --> 00:01:25,719
over the years as far as his framework

43
00:01:29,550 --> 00:01:27,039
for what his life and thinking about

44
00:01:31,349 --> 00:01:29,560
that but my favorite part of that book

45
00:01:33,120 --> 00:01:31,359
is absolutely the one of the last things

46
00:01:34,709 --> 00:01:33,130
he says in the book about a plea for

47
00:01:36,060 --> 00:01:34,719
other laws of physics that there's

48
00:01:38,160 --> 00:01:36,070
really something missing from our

49
00:01:40,469 --> 00:01:38,170
understanding of the way the world works

50
00:01:43,260 --> 00:01:40,479
and how we can actually understand

51
00:01:44,520 --> 00:01:43,270
ourselves in terms of new principles or

52
00:01:45,270 --> 00:01:44,530
laws that are actually necessary to

53
00:01:47,520 --> 00:01:45,280
explain life

54
00:01:49,289 --> 00:01:47,530
so what astrobiology really needs to get

55
00:01:50,580 --> 00:01:49,299
at the question what is life is to

56
00:01:53,190 --> 00:01:50,590
really start thinking about quantitative

57
00:01:54,510 --> 00:01:53,200
approaches and not just definitions but

58
00:01:55,499 --> 00:01:54,520
ways that we can actually quantify bio

59
00:01:57,870 --> 00:01:55,509
signatures in the way that have been

60
00:01:59,039 --> 00:01:57,880
presented so far but also combining that

61
00:02:00,719 --> 00:01:59,049
with new ways of trying to understand

62
00:02:02,969 --> 00:02:00,729
what life is fundamentally and then

63
00:02:03,959 --> 00:02:02,979

unifying how we think about that not

64
00:02:05,340 --> 00:02:03,969
just from the perspective of bio

65
00:02:06,870 --> 00:02:05,350
signatures but how we think about it for

66
00:02:10,590 --> 00:02:06,880
origins science or across all of the

67
00:02:12,059 --> 00:02:10,600
astrobiology disciplines so the question

68
00:02:14,190 --> 00:02:12,069
what is life is all that was really hard

69
00:02:15,540 --> 00:02:14,200
but there are some things life does that

70
00:02:17,850 --> 00:02:15,550
no other physical processes in the

71
00:02:19,410 --> 00:02:17,860
universe do right so we don't know of

72
00:02:20,270 --> 00:02:19,420
any other kind of physical process that

73
00:02:22,340 --> 00:02:20,280
can launch that

74
00:02:23,630 --> 00:02:22,350
into space I say this process of anti

75
00:02:25,610 --> 00:02:23,640
chrétien that David Grinspoon has been

76
00:02:27,740 --> 00:02:25,620
talking about is a biological process

77
00:02:29,240 --> 00:02:27,750
it's an interesting process and that

78
00:02:31,220 --> 00:02:29,250
actually requires information it

79
00:02:33,140 --> 00:02:31,230
requires technological civilization like

80
00:02:35,090 --> 00:02:33,150
our own that has some sort of knowledge

81
00:02:36,740 --> 00:02:35,100
in it and so to me that suggestive of

82
00:02:38,090 --> 00:02:36,750
what life is and actually informs kind

83
00:02:40,250 --> 00:02:38,100
of new principle is the same thing with

84
00:02:43,040 --> 00:02:40,260
thinking about certain elements in the

85
00:02:44,870 --> 00:02:43,050
periodic table that couldn't be produced

86
00:02:46,250 --> 00:02:44,880
without technology all right but

87
00:02:47,750 --> 00:02:46,260
technology is not usually thought of as

88
00:02:49,400 --> 00:02:47,760

a physical process we don't think about

89
00:02:51,020 --> 00:02:49,410
intelligence as a physical thing we

90
00:02:52,220 --> 00:02:51,030
don't think about it as something to be

91
00:02:53,870 --> 00:02:52,230
discovered in the universe but that's

92
00:02:57,020 --> 00:02:53,880
really what the mission of astrobiology

93
00:02:58,160 --> 00:02:57,030
is so obviously in bio signature science

94
00:02:59,240 --> 00:02:58,170
we've been doing this for quite a while

95
00:03:00,590 --> 00:02:59,250
we've been thinking what are the

96
00:03:02,479 --> 00:03:00,600
signatures what are the things that we

97
00:03:04,759 --> 00:03:02,489
think biology can uniquely produce and

98
00:03:06,590 --> 00:03:04,769
so really what we've been doing

99
00:03:08,300 --> 00:03:06,600
astrobiology right along is reframing

100
00:03:09,890 --> 00:03:08,310
the question from what is life to what

101
00:03:12,440 --> 00:03:09,900
does life do and what does life produce

102
00:03:13,699 --> 00:03:12,450
and I think we're at a stage with asking

103
00:03:15,800 --> 00:03:13,709
that question that we can really not

104
00:03:17,870 --> 00:03:15,810
just think about what does life do as a

105
00:03:20,120 --> 00:03:17,880
bio signature as the signatures of known

106
00:03:21,380 --> 00:03:20,130
life but also use the new frameworks

107
00:03:22,670 --> 00:03:21,390
that people have been talking about in

108
00:03:24,560 --> 00:03:22,680
the session so far and that we're going

109
00:03:26,090 --> 00:03:24,570
to hear about all week to think about

110
00:03:27,080 --> 00:03:26,100
reframing the question of what life is

111
00:03:30,770 --> 00:03:27,090
itself I'm going to give a couple

112
00:03:32,420 --> 00:03:30,780
examples of that later in my talk so

113
00:03:33,590 --> 00:03:32,430

we've obviously been think about this

114
00:03:36,590 --> 00:03:33,600
question how do we search for life in

115
00:03:38,180 --> 00:03:36,600
terms of what does life produce and Eddy

116
00:03:39,920 --> 00:03:38,190
already introduced this series of papers

117
00:03:41,180 --> 00:03:39,930
that came out last year on exoplanet bio

118
00:03:42,650 --> 00:03:41,190
signatures I'm going to talk about that

119
00:03:44,690 --> 00:03:42,660
a little bit more from this quantitative

120
00:03:46,370 --> 00:03:44,700
framework perspective so when we're

121
00:03:49,160 --> 00:03:46,380
think about what life produces there's

122
00:03:50,900 --> 00:03:49,170
always the problem of the fact that some

123
00:03:54,520 --> 00:03:50,910
things like producers can be produced by

124
00:03:59,300 --> 00:03:54,530
nonliving processes so we can be fooled

125
00:04:00,949 --> 00:03:59,310
and so it could absolutely fool us and

126
00:04:02,390 --> 00:04:00,959
we know this really clearly now from all

127
00:04:04,400 --> 00:04:02,400
the examples of false positive bio

128
00:04:05,750 --> 00:04:04,410
signatures that we have and so Eddie

129
00:04:07,789 --> 00:04:05,760
walked through on some really nice

130
00:04:09,770 --> 00:04:07,799
examples of that but one of the things a

131
00:04:11,539 --> 00:04:09,780
quantitative framework allows us to do

132
00:04:14,060 --> 00:04:11,549
is not say that this thing is absolutely

133
00:04:16,069 --> 00:04:14,070
indicative of life and this one is not

134
00:04:17,779 --> 00:04:16,079
indicative of life we need to think

135
00:04:20,060 --> 00:04:17,789
about this thing is having a statistical

136
00:04:22,069 --> 00:04:20,070
likelihood of being produced by life

137
00:04:24,650 --> 00:04:22,079
that's higher than the likelihood of it

138
00:04:25,760 --> 00:04:24,660

not being produced by life and so this

139
00:04:28,610 --> 00:04:25,770
is the motivation for thinking

140
00:04:30,290 --> 00:04:28,620
statistically that in order to tweeze

141
00:04:32,590 --> 00:04:30,300
out the certainty that something is

142
00:04:34,870 --> 00:04:32,600
actually a biological process we have

143
00:04:35,980 --> 00:04:34,880
knowledge the fact that biology can't do

144
00:04:37,990 --> 00:04:35,990
anything that physics and chemistry

145
00:04:39,520 --> 00:04:38,000
can't do unless you get to a

146
00:04:41,470 --> 00:04:39,530
technological civilization you require

147
00:04:42,820 --> 00:04:41,480
extra information and intelligence we're

148
00:04:45,190 --> 00:04:42,830
talking about small molecule bio

149
00:04:46,660 --> 00:04:45,200
signatures physics and chemistry alone

150
00:04:48,340 --> 00:04:46,670
can produce most of those so we have to

151
00:04:50,080 --> 00:04:48,350
understand what is it that biology does

152
00:04:52,960 --> 00:04:50,090
above and beyond that and how do we

153
00:04:54,370 --> 00:04:52,970
actually quantify that so if we're

154
00:04:55,870 --> 00:04:54,380
thinking about these things it's not

155
00:04:57,970 --> 00:04:55,880
just the constraints from the fact that

156
00:04:59,560 --> 00:04:57,980
we have false positives that a dead

157
00:05:00,850 --> 00:04:59,570
planet can fool us but we also have

158
00:05:02,950 --> 00:05:00,860
another set of constraints that's really

159
00:05:05,290 --> 00:05:02,960
hard is that our observational

160
00:05:07,300 --> 00:05:05,300
constraints especially with exoplanets

161
00:05:09,340 --> 00:05:07,310
this issue is critical because we get

162
00:05:11,740 --> 00:05:09,350
very limited data and we don't even have

163
00:05:13,900 --> 00:05:11,750

certainty of what we're measuring right

164
00:05:16,600 --> 00:05:13,910
we have statistical models that might

165
00:05:17,470 --> 00:05:16,610
produce a given observable and we may

166
00:05:18,700 --> 00:05:17,480
have some likelihood that that

167
00:05:21,010 --> 00:05:18,710
observable is consistent with our

168
00:05:22,990 --> 00:05:21,020
framework and so we need to really move

169
00:05:24,790 --> 00:05:23,000
to not just thinking statistically about

170
00:05:27,160 --> 00:05:24,800
bio signatures for bio signatures sake

171
00:05:31,030 --> 00:05:27,170
but also in terms of observational

172
00:05:32,470 --> 00:05:31,040
constraints and so a number of us got

173
00:05:33,790 --> 00:05:32,480
together as part of this nexus and of

174
00:05:35,800 --> 00:05:33,800
initiative to try to think

175
00:05:37,660 --> 00:05:35,810
quantitatively about bio signatures and

176
00:05:39,310 --> 00:05:37,670
came up with a Bayesian framework for

177
00:05:40,540 --> 00:05:39,320
life detection there's a lot of

178
00:05:42,160 --> 00:05:40,550
different statistical methods you could

179
00:05:44,710 --> 00:05:42,170
use to think about detecting life but

180
00:05:46,360 --> 00:05:44,720
this is just one of them and so the

181
00:05:47,980 --> 00:05:46,370
basic idea is that we really need to

182
00:05:50,050 --> 00:05:47,990
think about astrobiology from a more

183
00:05:52,900 --> 00:05:50,060
unified approach and try to think about

184
00:05:55,150 --> 00:05:52,910
how do we actually say with a high

185
00:05:57,310 --> 00:05:55,160
confidence level as Sarah was indicating

186
00:05:58,990 --> 00:05:57,320
that we have detected life rather than

187
00:06:00,670 --> 00:05:59,000
not life which means we need a

188
00:06:02,620 --> 00:06:00,680

conditional probability of life being

189
00:06:05,230 --> 00:06:02,630
produced from that particular set of

190
00:06:06,970 --> 00:06:05,240
observational data now the compounding

191
00:06:09,670 --> 00:06:06,980
factor is that a certain set of data

192
00:06:12,160 --> 00:06:09,680
might also be produced abiotic ly so we

193
00:06:14,320 --> 00:06:12,170
have a probability that the same

194
00:06:16,480 --> 00:06:14,330
observational data might be produced by

195
00:06:17,530 --> 00:06:16,490
a nonliving process and so if you really

196
00:06:20,020 --> 00:06:17,540
want to have something that's a very

197
00:06:22,030 --> 00:06:20,030
detectable bio signature or a techno

198
00:06:24,100 --> 00:06:22,040
signature it needs to be something where

199
00:06:26,680 --> 00:06:24,110
the probability that it was created by

200
00:06:28,840 --> 00:06:26,690
life is higher than the probability it

201
00:06:30,100 --> 00:06:28,850
was created by not life and so what we

202
00:06:32,200 --> 00:06:30,110
need to do as a community is try to

203
00:06:34,180 --> 00:06:32,210
figure out what are those things what

204
00:06:35,950 --> 00:06:34,190
are those observables that give us high

205
00:06:38,440 --> 00:06:35,960
confidence that we're actually looking

206
00:06:39,640 --> 00:06:38,450
at a sample of life and the interesting

207
00:06:42,310 --> 00:06:39,650
thing about this framework is that

208
00:06:44,530 --> 00:06:42,320
doesn't matter for looking at a bio

209
00:06:46,600 --> 00:06:44,540
signature about morphology or by

210
00:06:48,310 --> 00:06:46,610
signature about chemistry they can all

211
00:06:50,170 --> 00:06:48,320
go into the same quantitative framework

212
00:06:52,630 --> 00:06:50,180
and so we really need to think about all

213
00:06:54,460 --> 00:06:52,640

the observables as Dave was saying that

214
00:06:55,360 --> 00:06:54,470
we possibly can gather to increase the

215
00:06:58,090 --> 00:06:55,370
likelihood that the particular

216
00:07:03,850 --> 00:06:58,100
observation was produced by life and not

217
00:07:05,590 --> 00:07:03,860
a nonliving process so I want to go back

218
00:07:07,210 --> 00:07:05,600
to this idea of thinking about how we're

219
00:07:10,150 --> 00:07:07,220
actually constraining the probability of

220
00:07:12,700 --> 00:07:10,160
life so one of the problems is that we

221
00:07:13,930 --> 00:07:12,710
don't have an a priori probability we

222
00:07:15,880 --> 00:07:13,940
don't actually know what the likelihood

223
00:07:17,320 --> 00:07:15,890
of life in the universe is all right so

224
00:07:18,850 --> 00:07:17,330
I think I think this is something that

225
00:07:20,290 --> 00:07:18,860
in the astrobiology community we don't

226
00:07:21,880 --> 00:07:20,300
think about enough because we like to

227
00:07:24,760 --> 00:07:21,890
make wild speculation that life is

228
00:07:26,470 --> 00:07:24,770
common or that life is you know gonna

229
00:07:28,990 --> 00:07:26,480
look like us but the truth of the matter

230
00:07:30,790 --> 00:07:29,000
is we don't know we don't know if we're

231
00:07:32,080 --> 00:07:30,800
the only life in the universe and that's

232
00:07:34,180 --> 00:07:32,090
actually empowering just as an

233
00:07:36,220 --> 00:07:34,190
astrobiology community if we think about

234
00:07:37,480 --> 00:07:36,230
that from the proper perspective of the

235
00:07:39,460 --> 00:07:37,490
fact that we really need to think very

236
00:07:41,170 --> 00:07:39,470
rigorously about this problem because we

237
00:07:42,370 --> 00:07:41,180
don't know what we're looking for we

238
00:07:43,600 --> 00:07:42,380

don't know what life is going to be like

239
00:07:45,850 --> 00:07:43,610
on other worlds we don't even know if it

240
00:07:47,230 --> 00:07:45,860
exists and so we need to start bounding

241
00:07:49,440 --> 00:07:47,240
what we think the likelihood of the

242
00:07:51,610 --> 00:07:49,450
process is what we think that thing is

243
00:07:54,100 --> 00:07:51,620
I'm trying to think about it from both

244
00:07:56,470 --> 00:07:54,110
sides so one way I like to think about

245
00:07:58,180 --> 00:07:56,480
astrobiology is that it's not like we

246
00:08:00,010 --> 00:07:58,190
really have sub disciplines that are

247
00:08:01,690 --> 00:08:00,020
tackling separate problems so we have

248
00:08:03,130 --> 00:08:01,700
people that do study that are looking

249
00:08:05,350 --> 00:08:03,140
for intelligent life and people that do

250
00:08:06,760 --> 00:08:05,360
origins of life research but really all

251
00:08:08,500 --> 00:08:06,770
of us are kind of interested in this

252
00:08:10,120 --> 00:08:08,510
common understanding of what life is in

253
00:08:13,300 --> 00:08:10,130
the universe and how we can actually

254
00:08:15,190 --> 00:08:13,310
understand if we're alone and I think

255
00:08:16,660 --> 00:08:15,200
that if we actually try to unify our

256
00:08:17,770 --> 00:08:16,670
perspectives a little bit more that we

257
00:08:19,660 --> 00:08:17,780
actually can make more meaningful

258
00:08:21,400 --> 00:08:19,670
progress and so you can think about it

259
00:08:23,950 --> 00:08:21,410
from their perspective of looking for

260
00:08:25,240 --> 00:08:23,960
another example of life that's one way

261
00:08:26,800 --> 00:08:25,250
of constraining the likelihood or the

262
00:08:29,410 --> 00:08:26,810
understanding the probabilities for life

263
00:08:31,480 --> 00:08:29,420

so for example if we do have a

264
00:08:33,850 --> 00:08:31,490
statistical ensemble of exoplanets and

265
00:08:35,530 --> 00:08:33,860
we don't know if there's actually life

266
00:08:37,330 --> 00:08:35,540
on any of those worlds but we have some

267
00:08:39,130 --> 00:08:37,340
confidence that life might be on those

268
00:08:40,690 --> 00:08:39,140
worlds we don't know which world that

269
00:08:42,010 --> 00:08:40,700
actually constrains the probability for

270
00:08:43,839 --> 00:08:42,020
life existing in the universe in a way

271
00:08:46,060 --> 00:08:43,849
that we don't know now and gives us

272
00:08:48,010 --> 00:08:46,070
someone in knowledge and information on

273
00:08:50,560 --> 00:08:48,020
the planetary context in which life is

274
00:08:52,780 --> 00:08:50,570
actually likely to emerge from the other

275
00:08:54,730 --> 00:08:52,790
side if we start trying to make life in

276
00:08:56,040 --> 00:08:54,740
the lab under conditions of early Earth

277
00:08:57,329 --> 00:08:56,050
but just expanding

278
00:08:58,680 --> 00:08:57,339
something you have alternative

279
00:09:01,079 --> 00:08:58,690
chemistry's for life in the lab or

280
00:09:03,060 --> 00:09:01,089
eternity of chemical contacts for life

281
00:09:05,130 --> 00:09:03,070
we start to actually think about the

282
00:09:06,660 --> 00:09:05,140
principles that underlie life that can

283
00:09:09,630 --> 00:09:06,670
actually inform the probability of life

284
00:09:10,320 --> 00:09:09,640
from the other perspective and so one

285
00:09:12,389 --> 00:09:10,330
thing I think is really interesting

286
00:09:14,430 --> 00:09:12,399
thinking about bio signature science and

287
00:09:16,560 --> 00:09:14,440
this kind of quantitative perspective is

288
00:09:18,030 --> 00:09:16,570

that it starts to get bio signatures

289
00:09:19,680 --> 00:09:18,040
more intimately related to other areas

290
00:09:21,120 --> 00:09:19,690
of astrobiology and one of the ones I

291
00:09:24,360 --> 00:09:21,130
like to think about a lot is origins of

292
00:09:26,370 --> 00:09:24,370
life and the fact that if we had a real

293
00:09:27,720 --> 00:09:26,380
theory or a real quantitative framework

294
00:09:29,699 --> 00:09:27,730
for the origins of life we would

295
00:09:30,750 --> 00:09:29,709
actually have a predictive framework for

296
00:09:32,639 --> 00:09:30,760
thinking about life on other worlds

297
00:09:34,769 --> 00:09:32,649
which is not something that we have

298
00:09:36,060 --> 00:09:34,779
right now but this is really going to

299
00:09:37,560 --> 00:09:36,070
require a merger of theory and

300
00:09:38,699 --> 00:09:37,570
experiment in a way astrobiologists

301
00:09:40,829 --> 00:09:38,709
haven't been able to accomplish before

302
00:09:42,889 --> 00:09:40,839
and I think we're on that horizon so

303
00:09:45,000 --> 00:09:42,899
this actually image came out of a

304
00:09:46,470 --> 00:09:45,010
workshop at Carnegie a couple years ago

305
00:09:48,660 --> 00:09:46,480
and reekin sexualizing the origins of

306
00:09:49,889 --> 00:09:48,670
life which was to the point of trying to

307
00:09:51,420 --> 00:09:49,899
think about merging theory and

308
00:09:53,490 --> 00:09:51,430
experiment in a more meaningful way and

309
00:09:54,930 --> 00:09:53,500
I just give you an example of what that

310
00:09:56,490 --> 00:09:54,940
might look like you can think about the

311
00:09:57,930 --> 00:09:56,500
fact that a lot of the kinds of

312
00:09:59,550 --> 00:09:57,940
chemistry that people are doing now in

313
00:10:01,019 --> 00:09:59,560

origins of life is moving towards sort

314
00:10:03,240 --> 00:10:01,029
of quote/unquote messy chemistry

315
00:10:04,500 --> 00:10:03,250
approaches thinking statistically about

316
00:10:06,449 --> 00:10:04,510
the chemistry that might have given rise

317
00:10:07,889 --> 00:10:06,459
to life and so if you think about the

318
00:10:09,420 --> 00:10:07,899
fact that you have some kind of messy

319
00:10:12,930 --> 00:10:09,430
chemical soup and this experiment came

320
00:10:14,400 --> 00:10:12,940
from leek Cronin's lab you can actually

321
00:10:17,670 --> 00:10:14,410
think about whether you could actually

322
00:10:19,019 --> 00:10:17,680
distinguish a chemical system from

323
00:10:20,579 --> 00:10:19,029
another chemical system based on its

324
00:10:22,050 --> 00:10:20,589
history this is not even talking about

325
00:10:23,519 --> 00:10:22,060
life but you can actually talk about the

326
00:10:24,630 --> 00:10:23,529
historical context of like the different

327
00:10:26,610 --> 00:10:24,640
minerals and things that we're out of

328
00:10:27,900 --> 00:10:26,620
the chemistry and start to say that you

329
00:10:29,610 --> 00:10:27,910
actually can distinguish chemistry's

330
00:10:31,260 --> 00:10:29,620
based on their history now think about

331
00:10:32,340 --> 00:10:31,270
that in a planetary context imagine

332
00:10:33,480 --> 00:10:32,350
you're doing these kind of origins of

333
00:10:34,800 --> 00:10:33,490
life experiments but you're actually

334
00:10:36,840 --> 00:10:34,810
looking at the diversity of planets that

335
00:10:38,250 --> 00:10:36,850
we have from other areas of astrobiology

336
00:10:40,019 --> 00:10:38,260
environments that we know about origins

337
00:10:40,920 --> 00:10:40,029
of life it gives us some constraints on

338
00:10:42,210 --> 00:10:40,930

what kind of chemistry's and

339
00:10:46,560 --> 00:10:42,220
complexities of chemistry we should

340
00:10:48,710 --> 00:10:46,570
expect on those worlds we don't have any

341
00:10:50,939 --> 00:10:48,720
large-scale experiments in astrobiology

342
00:10:52,710 --> 00:10:50,949
this experiment I'm showing on this

343
00:10:54,000 --> 00:10:52,720
slide is something from the particle

344
00:10:55,560 --> 00:10:54,010
physics community it's super coming a

345
00:10:58,079 --> 00:10:55,570
conde which is neutrino physics

346
00:11:01,350 --> 00:10:58,089
experiment this experiment is designed

347
00:11:03,240 --> 00:11:01,360
to bound the proton to Craver II so if

348
00:11:06,090 --> 00:11:03,250
you think about proton decay it's never

349
00:11:07,560 --> 00:11:06,100
been observed so we have an experiment

350
00:11:08,560 --> 00:11:07,570
that's basically trying to look for

351
00:11:10,720 --> 00:11:08,570
something that we don't

352
00:11:11,980 --> 00:11:10,730
no physical exists it's motivated by

353
00:11:13,600 --> 00:11:11,990
theory we have some theories that

354
00:11:15,280 --> 00:11:13,610
predict that process might exist in the

355
00:11:17,410 --> 00:11:15,290
universe and what we're doing with this

356
00:11:19,990 --> 00:11:17,420
experiment it was rebuilt a large volume

357
00:11:21,820 --> 00:11:20,000
of water to look for proton decay and

358
00:11:23,320 --> 00:11:21,830
every time we don't observe the event we

359
00:11:25,810 --> 00:11:23,330
have a bound on the probability of that

360
00:11:27,040 --> 00:11:25,820
event happening in the universe imagine

361
00:11:29,620 --> 00:11:27,050
if we did this with an Origin 'life

362
00:11:30,940 --> 00:11:29,630
experiments right and we actually took

363
00:11:33,130 --> 00:11:30,950

those kind of ensemble statistic

364
00:11:34,510 --> 00:11:33,140
approaches to thinking about messy

365
00:11:35,920 --> 00:11:34,520
chemistry's and their likelihood for

366
00:11:37,810 --> 00:11:35,930
life didn't constrain them by our

367
00:11:39,910 --> 00:11:37,820
anthropocentric biases about what we

368
00:11:43,630 --> 00:11:39,920
think life is and like chemistry do what

369
00:11:46,090 --> 00:11:43,640
it does on planets in the lab and we

370
00:11:47,470 --> 00:11:46,100
bound the process we at least can look

371
00:11:49,090 --> 00:11:47,480
at the probability we can connect

372
00:11:50,590 --> 00:11:49,100
origins of life science to exoplanet

373
00:11:52,390 --> 00:11:50,600
science and we can find ways of thinking

374
00:11:57,010 --> 00:11:52,400
quantitatively about bio signatures in

375
00:11:59,140 --> 00:11:57,020
those experiments the main point of this

376
00:12:01,060 --> 00:11:59,150
is that our experiments both in absolute

377
00:12:03,220 --> 00:12:01,070
observations in terms of how we're doing

378
00:12:05,140 --> 00:12:03,230
observations now with exoplanets they're

379
00:12:06,310 --> 00:12:05,150
they're based on likelihoods that we

380
00:12:08,740 --> 00:12:06,320
think that you know this is the most

381
00:12:10,960 --> 00:12:08,750
likely observation they have statistical

382
00:12:12,460 --> 00:12:10,970
errors associated both experimental and

383
00:12:14,380 --> 00:12:12,470
the fact that we're just constrained in

384
00:12:16,000 --> 00:12:14,390
the limited data that we can take and

385
00:12:17,950 --> 00:12:16,010
the experiments that we're doing in the

386
00:12:19,120 --> 00:12:17,960
lab now for origins of life hit least

387
00:12:21,820 --> 00:12:19,130
the most cutting-edge ones for my

388
00:12:23,740 --> 00:12:21,830

perspective they're all statistical so

389
00:12:25,000 --> 00:12:23,750
what we need to do is build statistical

390
00:12:26,770 --> 00:12:25,010
frameworks for biosignatures

391
00:12:28,690 --> 00:12:26,780
we have a statistical framework for

392
00:12:30,310 --> 00:12:28,700
assessing the likelihood of life and now

393
00:12:31,600 --> 00:12:30,320
building into that framework we need to

394
00:12:32,980 --> 00:12:31,610
think more statistically about the bio

395
00:12:34,600 --> 00:12:32,990
signatures that were actually developing

396
00:12:36,100 --> 00:12:34,610
and use them to motivate more

397
00:12:38,890 --> 00:12:36,110
understanding of what we're thinking

398
00:12:40,030 --> 00:12:38,900
about as far as life what life is and so

399
00:12:41,290 --> 00:12:40,040
one way to think about this that might

400
00:12:42,610 --> 00:12:41,300
be more familiar to most people in this

401
00:12:44,680 --> 00:12:42,620
room is just to acknowledge the fact

402
00:12:46,480 --> 00:12:44,690
that life is an emergent property right

403
00:12:47,830 --> 00:12:46,490
nobody in this room has individual atoms

404
00:12:49,150 --> 00:12:47,840
that are alive but we're all alive as

405
00:12:52,150 --> 00:12:49,160
sort of collections of atoms that are

406
00:12:53,770 --> 00:12:52,160
interacting molecules interacting so the

407
00:12:55,540 --> 00:12:53,780
quantitative observables of you is a

408
00:12:58,150 --> 00:12:55,550
living entity to talk about how alive

409
00:12:59,830 --> 00:12:58,160
you are must be things that are emergent

410
00:13:01,960 --> 00:12:59,840
properties they have to be statistical

411
00:13:05,100 --> 00:13:01,970
in nature life is a statistical

412
00:13:07,060 --> 00:13:05,110
phenomenon it's a macro scale phenomena

413
00:13:08,320 --> 00:13:07,070

so we need to think about it from that

414
00:13:09,550 --> 00:13:08,330
perspective and we need to start

415
00:13:11,560 --> 00:13:09,560
developing bio Spooner's does that

416
00:13:13,150 --> 00:13:11,570
really quantify that I think one of the

417
00:13:14,740 --> 00:13:13,160
things anything sara touched on this a

418
00:13:16,540 --> 00:13:14,750
little bit is not to think about

419
00:13:18,550 --> 00:13:16,550
something as measuring you know this

420
00:13:20,230 --> 00:13:18,560
thing's life or this thing's no life but

421
00:13:21,020 --> 00:13:20,240
you can assign a likelihood to it being

422
00:13:24,260 --> 00:13:21,030
life and actually

423
00:13:26,180 --> 00:13:24,270
it's not even quite that that's the most

424
00:13:27,500 --> 00:13:26,190
interesting thing about it it's actually

425
00:13:29,510 --> 00:13:27,510
that you could talk about how alive a

426
00:13:30,740 --> 00:13:29,520
system is some systems are just more

427
00:13:32,060 --> 00:13:30,750
alive than others this is like the

428
00:13:33,860 --> 00:13:32,070
nature of the origin of life transition

429
00:13:35,750 --> 00:13:33,870
it didn't go from non-life to life there

430
00:13:37,310 --> 00:13:35,760
a gradation of stages in between and so

431
00:13:39,050 --> 00:13:37,320
we need to figure out how to quantify

432
00:13:43,190 --> 00:13:39,060
those stages we need to understand how

433
00:13:45,110 --> 00:13:43,200
we can actually measure it so one of the

434
00:13:45,980 --> 00:13:45,120
things that my group's been doing is

435
00:13:47,840 --> 00:13:45,990
actually thinking about something called

436
00:13:49,610 --> 00:13:47,850
plant we calling nominally planetary

437
00:13:51,950 --> 00:13:49,620
systems biochemistry but really think

438
00:13:53,210 --> 00:13:51,960

about life at a planetary scale and

439
00:13:54,740 --> 00:13:53,220
using all of the data that we have

440
00:13:56,150 --> 00:13:54,750
across biochemistry on earth to really

441
00:13:59,120 --> 00:13:56,160
understand what the statistical

442
00:14:00,770 --> 00:13:59,130
properties of biochemistry are and so

443
00:14:02,270 --> 00:14:00,780
this necessitates kind of going to an

444
00:14:03,800 --> 00:14:02,280
abstract approach so we can look at

445
00:14:05,000 --> 00:14:03,810
planet Earth and we can necessarily see

446
00:14:06,470 --> 00:14:05,010
it's alive because we have some

447
00:14:08,840 --> 00:14:06,480
subjective notion of what we think life

448
00:14:10,310 --> 00:14:08,850
is but the whole point of astrobiology

449
00:14:12,440 --> 00:14:10,320
is if we look at another world it might

450
00:14:14,240 --> 00:14:12,450
be alive and we might look at it and we

451
00:14:16,040 --> 00:14:14,250
might not recognize it so we actually

452
00:14:18,560 --> 00:14:16,050
have to look at the patterns and the

453
00:14:21,080 --> 00:14:18,570
data and understand what it is about

454
00:14:22,310 --> 00:14:21,090
that system that's alive and I think

455
00:14:23,990 --> 00:14:22,320
that those things are necessarily going

456
00:14:25,280 --> 00:14:24,000
to be some kind of abstract mathematical

457
00:14:26,600 --> 00:14:25,290
principle and the only example I can

458
00:14:28,190 --> 00:14:26,610
give you that really like resonates for

459
00:14:29,480 --> 00:14:28,200
me it's just to think about the fact

460
00:14:31,820 --> 00:14:29,490
that we're all bound to the planet right

461
00:14:34,670 --> 00:14:31,830
now by gravity right does anybody not

462
00:14:36,830 --> 00:14:34,680
bound by gravity okay good all right so

463
00:14:39,080 --> 00:14:36,840

we all day the laws of physics right but

464
00:14:40,250 --> 00:14:39,090
you don't intuitively obviously think

465
00:14:41,660 --> 00:14:40,260
about the fact that you're sitting in

466
00:14:43,130 --> 00:14:41,670
your chair right now and not floating

467
00:14:45,860 --> 00:14:43,140
off into space because the space around

468
00:14:46,910 --> 00:14:45,870
you is curved right it's because of the

469
00:14:48,860 --> 00:14:46,920
curvature in space and time that's a

470
00:14:50,090 --> 00:14:48,870
pretty abstract concept and I think

471
00:14:51,920 --> 00:14:50,100
we're looking at life we have to think

472
00:14:53,060 --> 00:14:51,930
in similar levels of abstraction and so

473
00:14:54,440 --> 00:14:53,070
one of the ways that we've been doing it

474
00:14:56,630 --> 00:14:54,450
to quantify it it's actually think in

475
00:14:58,220 --> 00:14:56,640
terms of network properties a network is

476
00:14:59,780 --> 00:14:58,230
a really nice representation because it

477
00:15:01,610 --> 00:14:59,790
allows you to talk about the statistical

478
00:15:04,220 --> 00:15:01,620
properties of a system as it's organized

479
00:15:05,540 --> 00:15:04,230
and so in this particular network that

480
00:15:07,670 --> 00:15:05,550
I'm showing here this is a network

481
00:15:09,020 --> 00:15:07,680
representation of the biosphere well you

482
00:15:10,250 --> 00:15:09,030
mean by that is this is all of the

483
00:15:11,720 --> 00:15:10,260
biochemistry that's known

484
00:15:14,060 --> 00:15:11,730
that's cataloged in the Kyoto

485
00:15:15,860 --> 00:15:14,070
encyclopedia of genes and genomes in

486
00:15:17,630 --> 00:15:15,870
each mall each node in the network is a

487
00:15:19,850 --> 00:15:17,640
molecule and it's connected to by other

488
00:15:22,220 --> 00:15:19,860

molecules if it participates in a common

489
00:15:24,080 --> 00:15:22,230
reaction you can be part of a social

490
00:15:25,370 --> 00:15:24,090
network in the sense that all of you

491
00:15:27,080 --> 00:15:25,380
could be nodes in a social network like

492
00:15:28,670 --> 00:15:27,090
on Twitter if anybody's tweeting right

493
00:15:30,350 --> 00:15:28,680
now and you could be connected by other

494
00:15:31,400 --> 00:15:30,360
people by liking them that allows you

495
00:15:32,910 --> 00:15:31,410
just to study the statistical

496
00:15:33,900 --> 00:15:32,920
regularities in that system

497
00:15:35,069 --> 00:15:33,910
it allows you to say some of the

498
00:15:37,169 --> 00:15:35,079
emergent properties in terms of the

499
00:15:38,789 --> 00:15:37,179
organization and so one of the things

500
00:15:41,460 --> 00:15:38,799
that we've been able to show is that if

501
00:15:44,699 --> 00:15:41,470
you look at biochemistry on planet Earth

502
00:15:47,309 --> 00:15:44,709
it is statistically very regular it has

503
00:15:49,499 --> 00:15:47,319
very regular Network properties in terms

504
00:15:51,299 --> 00:15:49,509
of fact if you look at networks of what

505
00:15:54,299 --> 00:15:51,309
reactions and individual organism

506
00:15:56,780 --> 00:15:54,309
catalyzes an ecosystem catalyzes or the

507
00:16:00,419 --> 00:15:56,790
planet as a living entity as a biosphere

508
00:16:02,099 --> 00:16:00,429
catalyzes they have the same structural

509
00:16:03,599 --> 00:16:02,109
properties in terms of their network

510
00:16:05,579 --> 00:16:03,609
representation that scale is a function

511
00:16:08,069 --> 00:16:05,589
of the number of compounds and it's

512
00:16:09,599 --> 00:16:08,079
different than random chemistry now the

513
00:16:10,949 --> 00:16:09,609

point of this in terms of a statistical

514
00:16:12,359 --> 00:16:10,959
framework is that once you know what

515
00:16:14,069 --> 00:16:12,369
those kind of scaling relations are you

516
00:16:14,909 --> 00:16:14,079
have a quantitative rule you can

517
00:16:17,340 --> 00:16:14,919
actually start talking about

518
00:16:18,689 --> 00:16:17,350
statistically distinguishing systems so

519
00:16:20,340 --> 00:16:18,699
if I'm one thing we've been able to show

520
00:16:21,720 --> 00:16:20,350
is if you just look at the patterns and

521
00:16:23,220 --> 00:16:21,730
the reactions in a network you can

522
00:16:24,929 --> 00:16:23,230
statistically distinguish anarchie

523
00:16:25,889 --> 00:16:24,939
a--from a bacteria you don't need to

524
00:16:26,789 --> 00:16:25,899
know anything about the chemistry

525
00:16:28,079 --> 00:16:26,799
they're doing you just need to know

526
00:16:29,819 --> 00:16:28,089
about the patterns the statistical

527
00:16:32,729 --> 00:16:29,829
patterns and the correlation of how the

528
00:16:34,409 --> 00:16:32,739
molecules are interacting if you're

529
00:16:35,669 --> 00:16:34,419
talking about agnostic bio signatures

530
00:16:37,409 --> 00:16:35,679
and you want to build quantitative

531
00:16:39,179 --> 00:16:37,419
frameworks for not only looking for life

532
00:16:40,619 --> 00:16:39,189
on other worlds but quantifiably

533
00:16:42,720 --> 00:16:40,629
predicting what that life might look

534
00:16:44,999 --> 00:16:42,730
like if you have a set of statistical

535
00:16:46,799 --> 00:16:45,009
constraints you can start to think about

536
00:16:47,970 --> 00:16:46,809
building machine learning algorithms for

537
00:16:50,249 --> 00:16:47,980
constructing chemistry's with

538
00:16:52,109 --> 00:16:50,259

alternative chemistry's but the same

539
00:16:53,129 --> 00:16:52,119
sets of constraints and so what we're

540
00:16:54,780 --> 00:16:53,139
really looking for are what are the

541
00:16:56,069 --> 00:16:54,790
statistical regularities across life on

542
00:16:57,720 --> 00:16:56,079
earth and how do we actually quantify

543
00:17:01,650 --> 00:16:57,730
them and then build predictive models

544
00:17:04,019 --> 00:17:01,660
for astrobiology another kind of measure

545
00:17:06,149 --> 00:17:04,029
you might use is to think about

546
00:17:08,220 --> 00:17:06,159
biomolecular chirality now usually we

547
00:17:09,449 --> 00:17:08,230
think about this also as we do with life

548
00:17:11,610 --> 00:17:09,459
as a black or white issue it's either

549
00:17:12,659 --> 00:17:11,620
homo chiral or it's not but if you

550
00:17:14,309 --> 00:17:12,669
actually look at the statistical

551
00:17:16,189 --> 00:17:14,319
patterns in chirality across the

552
00:17:17,939 --> 00:17:16,199
biosphere it's a much more complex story

553
00:17:19,829 --> 00:17:17,949
so it's shown in this network

554
00:17:23,159 --> 00:17:19,839
representation and how do Kim is giving

555
00:17:25,529 --> 00:17:23,169
a talk on this work later today is the

556
00:17:27,179 --> 00:17:25,539
biosphere level Network now looking for

557
00:17:29,519 --> 00:17:27,189
statistical patterns and whether a

558
00:17:30,930 --> 00:17:29,529
molecule is chiral or achiral now if you

559
00:17:31,830 --> 00:17:30,940
have a chiral molecule it's not just

560
00:17:33,690 --> 00:17:31,840
whether it's left-handed or right-handed

561
00:17:35,639 --> 00:17:33,700
but how many chiral centers it has it's

562
00:17:36,930 --> 00:17:35,649
a very complex problem but you can

563
00:17:38,129 --> 00:17:36,940

actually start to look at statistical

564
00:17:40,440 --> 00:17:38,139
regularities and build particular

565
00:17:42,690 --> 00:17:40,450
frameworks for how lot how biology is

566
00:17:44,610 --> 00:17:42,700
actually using chirality to architect

567
00:17:46,549 --> 00:17:44,620
biochemical networks and maybe there

568
00:17:49,080 --> 00:17:46,559
might be some universal rules underlying

569
00:17:50,130 --> 00:17:49,090
and you just speed up so pathway

570
00:17:51,690 --> 00:17:50,140
assembly and thinking about

571
00:17:53,580 --> 00:17:51,700
probabilistic bio signatures has also

572
00:17:55,140 --> 00:17:53,590
been discussed already the only plan I'm

573
00:17:56,790 --> 00:17:55,150
gonna make about this with what Luke

574
00:17:58,410 --> 00:17:56,800
Ronan is doing is that it actually

575
00:18:00,120 --> 00:17:58,420
connects to theoretical frameworks

576
00:18:01,919 --> 00:18:00,130
because not only do you have a way of

577
00:18:03,180 --> 00:18:01,929
fresh holding for biology but you have a

578
00:18:05,730 --> 00:18:03,190
way of thinking about what biology is

579
00:18:07,049 --> 00:18:05,740
doing in chemical space which allows us

580
00:18:08,640 --> 00:18:07,059
to think about building quantitative

581
00:18:11,250 --> 00:18:08,650
theory and predictive frameworks for

582
00:18:12,419 --> 00:18:11,260
other chemistry's you can do the same

583
00:18:14,340 --> 00:18:12,429
thing with thinking about life on other

584
00:18:15,570 --> 00:18:14,350
planets and so this is on Harrison Smith

585
00:18:17,549 --> 00:18:15,580
poster that's gonna be presented later

586
00:18:18,960 --> 00:18:17,559
thinking about how could you actually

587
00:18:22,230 --> 00:18:18,970
predict what biochemistry might look

588
00:18:23,760 --> 00:18:22,240

like on other worlds and it also leads

589
00:18:25,830 --> 00:18:23,770
to statistical characterization of

590
00:18:26,760 --> 00:18:25,840
exoplanet atmospheres and so one of the

591
00:18:28,770 --> 00:18:26,770
things that we've been doing is taking

592
00:18:30,720 --> 00:18:28,780
this idea of taking observational

593
00:18:32,700 --> 00:18:30,730
uncertainties and building statistical

594
00:18:34,620 --> 00:18:32,710
models for how you might think about

595
00:18:36,210 --> 00:18:34,630
what's detectable and what's actually

596
00:18:39,060 --> 00:18:36,220
going to quantify the differences in

597
00:18:40,650 --> 00:18:39,070
plants that are alive or not again using

598
00:18:42,090 --> 00:18:40,660
this kind of network based approach and

599
00:18:43,770 --> 00:18:42,100
I'm just going to make a nod to Tulsa

600
00:18:45,690 --> 00:18:43,780
Fisher's talk later this week about

601
00:18:46,919 --> 00:18:45,700
statistical characterization of jovi and

602
00:18:48,720 --> 00:18:46,929
atmospheres based on the network

603
00:18:50,430 --> 00:18:48,730
structure of the planetary atmosphere

604
00:18:52,740 --> 00:18:50,440
and how you can actually start to think

605
00:18:53,880 --> 00:18:52,750
about system level organizational

606
00:18:55,440 --> 00:18:53,890
planets from a quantitative framework

607
00:18:57,780 --> 00:18:55,450
and talk about quantitatively the

608
00:18:59,220 --> 00:18:57,790
differences so just go back to the

609
00:19:00,810 --> 00:18:59,230
Bayesian framework I think the thing

610
00:19:03,000 --> 00:19:00,820
that's really important for us to start

611
00:19:04,500 --> 00:19:03,010
thinking about is how we're actually

612
00:19:06,480 --> 00:19:04,510
building our approaches together for a

613
00:19:07,830 --> 00:19:06,490

common goal and how we can put this into

614
00:19:09,750 --> 00:19:07,840
quantitative frameworks that are really

615
00:19:11,820 --> 00:19:09,760
going to bring out your biology into the

616
00:19:14,690 --> 00:19:11,830
next decades where we actually can talk

617
00:19:16,890 --> 00:19:14,700
about statistical confidence levels in

618
00:19:18,780 --> 00:19:16,900
what the likelihood of life is in the

619
00:19:19,710 --> 00:19:18,790
universe and with that I'm just going to

620
00:19:26,300 --> 00:19:19,720
thank my group because they're pretty