
AbSciCon
2019

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

2
00:00:12,780 --> 00:00:09,410
[Applause]

3
00:00:17,310 --> 00:00:12,790
welcome to the third day of apps icon

4
00:00:20,490 --> 00:00:17,320
and our third plenary I Jim and I are

5
00:00:22,200 --> 00:00:20,500
the conveners for this but my job is

6
00:00:25,109 --> 00:00:22,210
just to go through a couple of

7
00:00:27,120 --> 00:00:25,119
housekeeping announcements so I want to

8
00:00:29,700 --> 00:00:27,130
remind you that tonight is open mic

9
00:00:33,030 --> 00:00:29,710
night for those of you that went to them

10
00:00:35,040 --> 00:00:33,040
I went to this event last year or two

11
00:00:37,440 --> 00:00:35,050
years ago it's very successful and you

12
00:00:38,790 --> 00:00:37,450
can see all the talent within amongst

13
00:00:41,189 --> 00:00:38,800

the astrobiologist we're not just great

14
00:00:42,840 --> 00:00:41,199
scientists we also have the performance

15
00:00:46,740 --> 00:00:42,850
bug to some extent so please come

16
00:00:49,380 --> 00:00:46,750
tonight it's in Regency ABC in addition

17
00:00:53,250 --> 00:00:49,390
how many of you out there have picked up

18
00:00:57,689 --> 00:00:53,260
your passport not to get out of the

19
00:00:59,520 --> 00:00:57,699
country but your passport to understand

20
00:01:01,709 --> 00:00:59,530
understand about the science that is

21
00:01:03,180 --> 00:01:01,719
done by the RCN show hands there better

22
00:01:05,310 --> 00:01:03,190
be some people that picked it up

23
00:01:08,730 --> 00:01:05,320
remember this is your opportunity to win

24
00:01:10,320 --> 00:01:08,740
great prizes there are 22 posters you

25
00:01:12,300 --> 00:01:10,330
need to go take a look at you'll get a

26
00:01:14,280 --> 00:01:12,310
stamp for each one of them and then

27
00:01:16,740 --> 00:01:14,290
people who fill out the card or eligible

28
00:01:22,230 --> 00:01:16,750
for three big prizes either a gift

29
00:01:25,440 --> 00:01:22,240
certificate to a GU swag a hospitality

30
00:01:27,870 --> 00:01:25,450
basket with goodies from Seattle and the

31
00:01:31,679 --> 00:01:27,880
top prize is free registration to apps

32
00:01:37,080 --> 00:01:31,689
icon 2021 so this is your last day to

33
00:01:39,270 --> 00:01:37,090
get stamps tonight's the second poster

34
00:01:41,609 --> 00:01:39,280
session so please please look for those

35
00:01:46,200 --> 00:01:41,619
passports and get them filled out so

36
00:01:49,590 --> 00:01:46,210
without further ado take it away okay

37
00:01:53,999 --> 00:01:49,600
good morning now I'm told this is a

38
00:01:57,240 --> 00:01:54,009

quick welcome to the morning plenary

39
00:01:58,679 --> 00:01:57,250
session on the origins of life we're

40
00:02:00,450 --> 00:01:58,689
gonna I'm going to tell you quickly what

41
00:02:02,190 --> 00:02:00,460
the format of this is I'm gonna give you

42
00:02:03,870 --> 00:02:02,200
some very brief kind of introductory

43
00:02:05,459 --> 00:02:03,880
orientation slides and then we're going

44
00:02:06,480 --> 00:02:05,469
to go through a series of presenters

45
00:02:08,670 --> 00:02:06,490
we're going to talk for about five

46
00:02:10,790 --> 00:02:08,680
minutes each we're gonna give them a

47
00:02:13,050 --> 00:02:10,800
moment to comment on each other's

48
00:02:14,220 --> 00:02:13,060
presentations discuss and then we're

49
00:02:19,240 --> 00:02:14,230
going to open this to a community

50
00:02:22,840 --> 00:02:19,250
discussion okay it is working

51
00:02:25,120 --> 00:02:22,850
the origin of life is a the best

52
00:02:27,910 --> 00:02:25,130
scientific question I can think of in

53
00:02:31,810 --> 00:02:27,920
that it has resisted explanation for a

54
00:02:33,430 --> 00:02:31,820
very long time people from all sorts of

55
00:02:36,210 --> 00:02:33,440
fields have something very important to

56
00:02:38,920 --> 00:02:36,220
say about it we have a couple of

57
00:02:41,050 --> 00:02:38,930
bookmarks we can add to the to

58
00:02:44,500 --> 00:02:41,060
understanding what even the question is

59
00:02:46,780 --> 00:02:44,510
which is we exist we are alive by our

60
00:02:50,020 --> 00:02:46,790
own definition we have some concept of

61
00:02:52,270 --> 00:02:50,030
how old the earth is we have some

62
00:02:54,130 --> 00:02:52,280
concept that there was a moon-forming

63
00:02:56,530 --> 00:02:54,140

impact in between when the earth formed

64
00:02:58,030 --> 00:02:56,540
and when that impact happened it would

65
00:03:02,980 --> 00:02:58,040
have been very difficult for life to

66
00:03:05,950 --> 00:03:02,990
exist we have some hints of when there

67
00:03:07,960 --> 00:03:05,960
was liquid water on earth which we think

68
00:03:10,480 --> 00:03:07,970
is essential for life so that gives us

69
00:03:14,080 --> 00:03:10,490
some indication of where the planet was

70
00:03:16,210 --> 00:03:14,090
becoming habitable we have some evidence

71
00:03:23,530 --> 00:03:16,220
of when there actually was life on Earth

72
00:03:25,660 --> 00:03:23,540
which gives us now oldest point for life

73
00:03:28,420 --> 00:03:25,670
on Earth so that still leaves us an

74
00:03:29,440 --> 00:03:28,430
extremely long window to understand what

75
00:03:32,110 --> 00:03:29,450
kinds of chemical and physical

76
00:03:37,120 --> 00:03:32,120
geochemical processes were happening on

77
00:03:39,940 --> 00:03:37,130
the planet and that gives us a really

78
00:03:41,380 --> 00:03:39,950
large window to allow for the evolution

79
00:03:43,540 --> 00:03:41,390
of the living things that exist today

80
00:03:46,570 --> 00:03:43,550
whose phylogenetic history we can trace

81
00:03:48,130 --> 00:03:46,580
right there could be a very large gap in

82
00:03:49,750 --> 00:03:48,140
complexity between the first living

83
00:03:52,449 --> 00:03:49,760
things and the things that are still

84
00:03:56,740 --> 00:03:52,459
existing that bears some conceptual

85
00:03:58,900 --> 00:03:56,750
explanation I just like to leave you

86
00:04:01,900 --> 00:03:58,910
with this very nice factoid I found a

87
00:04:04,300 --> 00:04:01,910
couple of weeks ago now that we are able

88
00:04:06,580 --> 00:04:04,310

to do massive bibliometric searches of

89
00:04:09,100 --> 00:04:06,590
chemical databases it turns out that

90
00:04:10,949 --> 00:04:09,110
only 3% of all reactions that have been

91
00:04:13,449 --> 00:04:10,959
done by professional chemists

92
00:04:15,370 --> 00:04:13,459
essentially since chemistry has been a

93
00:04:17,229 --> 00:04:15,380
professional science have been done for

94
00:04:19,509 --> 00:04:17,239
longer than two days all right

95
00:04:21,490 --> 00:04:19,519
that's a weekend right that's you you

96
00:04:24,820 --> 00:04:21,500
set the reaction up on Friday and you

97
00:04:27,070 --> 00:04:24,830
measure it on Monday all right that's

98
00:04:28,590 --> 00:04:27,080
that's potentially a very important clue

99
00:04:29,800 --> 00:04:28,600
to something we might be missing

100
00:04:34,990 --> 00:04:29,810
conceptually

101
00:04:37,660 --> 00:04:35,000
all right so why should this community

102
00:04:40,360 --> 00:04:37,670
care we do have this concept of the

103
00:04:42,370 --> 00:04:40,370
Fermi paradox there are books written

104
00:04:44,560 --> 00:04:42,380
there's 75 explanations for the Fermi

105
00:04:47,140 --> 00:04:44,570
paradox there are many many more than 75

106
00:04:49,720 --> 00:04:47,150
possible ones right so we know where we

107
00:04:55,600 --> 00:04:49,730
are thanks to the Astronomy community in

108
00:04:57,370 --> 00:04:55,610
relation to large cosmic structures so

109
00:04:59,379 --> 00:04:57,380
far we've been looking at our solar

110
00:05:01,470 --> 00:04:59,389
system without much luck we've been

111
00:05:04,630 --> 00:05:01,480
looking in our galaxy without much luck

112
00:05:09,720 --> 00:05:04,640
our galaxy is just a single point in a

113
00:05:15,909 --> 00:05:12,310

where are they right something is wrong

114
00:05:18,010 --> 00:05:15,919
the origin of life might be an important

115
00:05:22,870 --> 00:05:18,020
bottleneck and why we're having so much

116
00:05:26,800 --> 00:05:22,880
trouble finding some things so some open

117
00:05:28,750 --> 00:05:26,810
questions in this this field are what is

118
00:05:31,180 --> 00:05:28,760
life what is the origin of life what

119
00:05:33,490 --> 00:05:31,190
does that even mean we need to have some

120
00:05:36,580 --> 00:05:33,500
consensus about that is it easy or hard

121
00:05:38,770 --> 00:05:36,590
is it rare or frequent is it a unique

122
00:05:40,659 --> 00:05:38,780
process are there multiple ways right

123
00:05:42,070 --> 00:05:40,669
the chemical space is very large there

124
00:05:45,070 --> 00:05:42,080
could be multiple ways for things to

125
00:05:47,080 --> 00:05:45,080
self-organize are there different kinds

126
00:05:49,080 --> 00:05:47,090
of life are we a specific kind that

127
00:05:53,710 --> 00:05:49,090
happens to have a very open-ended

128
00:05:55,300 --> 00:05:53,720
evolutionary dynamic do all things kind

129
00:05:57,190 --> 00:05:55,310
of end up being the same at some point

130
00:06:00,100 --> 00:05:57,200
is there a converging nature to living

131
00:06:03,490 --> 00:06:00,110
things is it fast or slow it comes back

132
00:06:05,740 --> 00:06:03,500
to that weekend question is it do you

133
00:06:08,040 --> 00:06:05,750
need very very specific types of

134
00:06:10,810 --> 00:06:08,050
planetary environments for life to start

135
00:06:13,150 --> 00:06:10,820
and then the you know the question I'm

136
00:06:15,909 --> 00:06:13,160
interested in as a lab chemist is how

137
00:06:17,920 --> 00:06:15,919
does that happen I want to see it so

138
00:06:22,469 --> 00:06:17,930

without any further ado I'm gonna turn

139
00:06:24,430 --> 00:06:22,479
this over to word barge from Caltech and

140
00:06:26,230 --> 00:06:24,440
ocean laboratory you're welcome to come

141
00:06:31,300 --> 00:06:26,240
to the lectern or sit there as you as

142
00:06:33,550 --> 00:06:31,310
you feel free oh wait sorry one quick

143
00:06:35,710 --> 00:06:33,560
plug we actually do have a we do have a

144
00:06:36,700 --> 00:06:35,720
professional society dedicated to this

145
00:06:37,990 --> 00:06:36,710
question which is called the

146
00:06:41,620 --> 00:06:38,000
International Society for the study the

147
00:06:43,330 --> 00:06:41,630
origins of life our next meeting is in

148
00:06:45,460 --> 00:06:43,340
Ecuador next year

149
00:06:47,140 --> 00:06:45,470
in Quito and there's an excursion of the

150
00:06:48,430 --> 00:06:47,150
globe because Highlands if you're

151
00:06:51,370 --> 00:06:48,440
interested in these questions please

152
00:06:54,640 --> 00:06:51,380
consider joining the society you can

153
00:06:55,900 --> 00:06:54,650
find us at a soul org there's a you'll

154
00:06:57,550 --> 00:06:55,910
find a community of people who are

155
00:06:59,650 --> 00:06:57,560
dedicated to trying to understand these

156
00:07:05,860 --> 00:06:59,660
questions and with that I will turn it

157
00:07:07,420 --> 00:07:05,870
over to Lori alright so my name is Lori

158
00:07:10,450 --> 00:07:07,430
barge and I'm at the NASA Jet Propulsion

159
00:07:12,190 --> 00:07:10,460
Laboratory and my perspective on origin

160
00:07:13,750 --> 00:07:12,200
of life is coming from kind of a

161
00:07:16,180 --> 00:07:13,760
combined geology and chemistry

162
00:07:18,700 --> 00:07:16,190
perspective but also not just geology of

163
00:07:20,770 --> 00:07:18,710

Earth but geology of other worlds and so

164
00:07:23,320 --> 00:07:20,780
Jim asked us to talk about stuff that

165
00:07:24,640 --> 00:07:23,330
that we are you know that we like seeing

166
00:07:26,050 --> 00:07:24,650
in the field and things that we want to

167
00:07:28,030 --> 00:07:26,060
see more of and just kind of thoughts

168
00:07:30,400 --> 00:07:28,040
about things and so I just want to talk

169
00:07:32,860 --> 00:07:30,410
first about how it has been really nice

170
00:07:34,660 --> 00:07:32,870
in general to see more incorporation of

171
00:07:36,610 --> 00:07:34,670
geological conditions into chemical

172
00:07:38,590 --> 00:07:36,620
experiments for the origin of life and

173
00:07:40,690 --> 00:07:38,600
that's important because early Earth has

174
00:07:42,220 --> 00:07:40,700
so many possible varieties of conditions

175
00:07:43,900 --> 00:07:42,230
that you could have we don't actually

176
00:07:45,580 --> 00:07:43,910
know that much about early Earth we know

177
00:07:47,320 --> 00:07:45,590
some major things like there was no

178
00:07:49,780 --> 00:07:47,330
oxygen in the atmosphere there was an

179
00:07:51,100 --> 00:07:49,790
ocean but you know debates are still had

180
00:07:52,660 --> 00:07:51,110
about things like how much land was

181
00:07:53,020 --> 00:07:52,670
there and how deep was the ocean and so

182
00:08:00,520 --> 00:07:53,030
on

183
00:08:02,230 --> 00:08:00,530
are of interest to different people in

184
00:08:04,300 --> 00:08:02,240
this field things like hydrothermal

185
00:08:06,340 --> 00:08:04,310
vents and hot springs on land volcanoes

186
00:08:08,740 --> 00:08:06,350
and lightning and beaches and so on and

187
00:08:10,570 --> 00:08:08,750
I think one of the most important things

188
00:08:13,180 --> 00:08:10,580

is for those of us who are doing

189
00:08:15,040 --> 00:08:13,190
reactions in the lab to try and you know

190
00:08:16,840 --> 00:08:15,050
make these realistic of course and try

191
00:08:18,340 --> 00:08:16,850
to incorporate different important

192
00:08:20,080 --> 00:08:18,350
geological conditions into your

193
00:08:22,450 --> 00:08:20,090
experiments and one of those is

194
00:08:24,220 --> 00:08:22,460
gradients because a lot of environments

195
00:08:26,170 --> 00:08:24,230
that you see on planets are actually not

196
00:08:28,210 --> 00:08:26,180
closed systems they're open systems and

197
00:08:30,160 --> 00:08:28,220
so you have far from equilibrium

198
00:08:33,010 --> 00:08:30,170
conditions you have gradients of things

199
00:08:35,320 --> 00:08:33,020
like temperature pH redox conditions

200
00:08:37,300 --> 00:08:35,330
chemical concentrations and so on and

201
00:08:39,070 --> 00:08:37,310
it's possible to do experiments in

202
00:08:41,170 --> 00:08:39,080
setups like that and you sometimes get

203
00:08:43,330 --> 00:08:41,180
very different results when you do so I

204
00:08:45,460 --> 00:08:43,340
think that is one thing to you know

205
00:08:46,630 --> 00:08:45,470
consider and and maybe it's a good way

206
00:08:49,090 --> 00:08:46,640
to collaborate as well between

207
00:08:51,120 --> 00:08:49,100
geologists and chemists so that's one

208
00:08:53,980 --> 00:08:51,130
thing that's been really nice to see and

209
00:08:55,510 --> 00:08:53,990
in a lot of the experiments that are

210
00:08:56,860 --> 00:08:55,520
going on in this field it's it's

211
00:08:58,630 --> 00:08:56,870
exciting to see how we can

212
00:09:00,850 --> 00:08:58,640
start to narrow down which which

213
00:09:03,040 --> 00:09:00,860

conditions are conducive to certain

214
00:09:04,960 --> 00:09:03,050
reactions and so when you do experiments

215
00:09:06,550 --> 00:09:04,970
in the lab for origin of life we're

216
00:09:07,990 --> 00:09:06,560
usually doing things like hey you know

217
00:09:10,570 --> 00:09:08,000
what at what pH does this reaction

218
00:09:12,490 --> 00:09:10,580
really go forward or does it work best

219
00:09:15,010 --> 00:09:12,500
in the presence or absence of oxygen or

220
00:09:17,530 --> 00:09:15,020
is there some you know other ion that

221
00:09:19,269 --> 00:09:17,540
really helps it or hurts it and it's

222
00:09:20,829 --> 00:09:19,279
important to consider you know like

223
00:09:23,140 --> 00:09:20,839
let's say they have a reaction where a

224
00:09:25,090 --> 00:09:23,150
presence of magnesium really helps it is

225
00:09:26,590 --> 00:09:25,100
it the fact that it's magnesium is it

226
00:09:28,750 --> 00:09:26,600
the fact that it's a diabetic cation

227
00:09:30,519 --> 00:09:28,760
well other things work too if you have

228
00:09:32,769 --> 00:09:30,529
oxygen there and that works can another

229
00:09:34,300 --> 00:09:32,779
oxidant do that also and just kind of

230
00:09:36,610 --> 00:09:34,310
trying out things to figure out what

231
00:09:38,920 --> 00:09:36,620
actually is affecting the reaction as

232
00:09:41,140 --> 00:09:38,930
far as a conditioned space and I guess

233
00:09:43,360 --> 00:09:41,150
one thing that I I think would be

234
00:09:45,160 --> 00:09:43,370
helpful as far as trying to apply a lot

235
00:09:47,440 --> 00:09:45,170
of this origin of life work to planetary

236
00:09:48,970 --> 00:09:47,450
science because in planetary science we

237
00:09:51,519 --> 00:09:48,980
see a lot of environments that are not

238
00:09:52,870 --> 00:09:51,529

so earth-like but they're also they do

239
00:09:55,750 --> 00:09:52,880
you contain conditions that can be

240
00:09:57,610 --> 00:09:55,760
important for origin of life and one of

241
00:09:59,950 --> 00:09:57,620
the important things about combining

242
00:10:01,660 --> 00:09:59,960
origin of life and space exploration is

243
00:10:03,130 --> 00:10:01,670
that we always look for organics for

244
00:10:05,560 --> 00:10:03,140
looking for life in the universe and

245
00:10:08,470 --> 00:10:05,570
there's this idea of going from abiotic

246
00:10:10,420 --> 00:10:08,480
to prebiotic to biotic but if you never

247
00:10:12,190 --> 00:10:10,430
had a full origin of life on a world

248
00:10:14,890 --> 00:10:12,200
it's possible that you might have a

249
00:10:16,180 --> 00:10:14,900
really complex organic abiotic system

250
00:10:18,010 --> 00:10:16,190
that something like you wouldn't

251
00:10:19,630 --> 00:10:18,020
necessarily see on the earth because if

252
00:10:21,670 --> 00:10:19,640
you have that happening here life

253
00:10:23,350 --> 00:10:21,680
consumes those molecules so maybe

254
00:10:25,390 --> 00:10:23,360
there's possibilities on other planets

255
00:10:26,769 --> 00:10:25,400
of having complex abiotic organic

256
00:10:28,840 --> 00:10:26,779
chemistry that might look a little

257
00:10:30,340 --> 00:10:28,850
unrecognizable to us but it's things

258
00:10:32,949 --> 00:10:30,350
that we might see with future missions

259
00:10:34,570 --> 00:10:32,959
and when we're trying to do experiments

260
00:10:36,100 --> 00:10:34,580
and figure out you know what

261
00:10:38,380 --> 00:10:36,110
environments should these types of

262
00:10:40,329 --> 00:10:38,390
experiments belong in if we find that a

263
00:10:42,460 --> 00:10:40,339

condition drives a reaction let's say

264
00:10:44,620 --> 00:10:42,470
that I don't know amino acid synthesis

265
00:10:46,540 --> 00:10:44,630
happens best at alkaline pH and with a

266
00:10:49,180 --> 00:10:46,550
partially reduced mineral or something

267
00:10:51,040 --> 00:10:49,190
that is a great thing to know and I

268
00:10:52,750 --> 00:10:51,050
think that one thing to avoid is to jump

269
00:10:54,730 --> 00:10:52,760
from that into saying there's a super

270
00:10:56,110 --> 00:10:54,740
specific environment on earth that this

271
00:10:57,670 --> 00:10:56,120
reaction must have occurred and

272
00:10:59,620 --> 00:10:57,680
therefore the origin of life occurred in

273
00:11:01,150 --> 00:10:59,630
this particular environment because we

274
00:11:03,010 --> 00:11:01,160
should be open to any environment that

275
00:11:05,380 --> 00:11:03,020
has the condition that facilitates that

276
00:11:07,360 --> 00:11:05,390
reaction and that's it's good to think

277
00:11:09,160 --> 00:11:07,370
about because when we go and we explore

278
00:11:10,780 --> 00:11:09,170
the solar system we find a lot of

279
00:11:13,090 --> 00:11:10,790
environments that we did not expect

280
00:11:14,770 --> 00:11:13,100
so I put I put pictures of things here

281
00:11:16,750 --> 00:11:14,780
that we found with missions that we did

282
00:11:18,760 --> 00:11:16,760
not expect to find and there's a lot of

283
00:11:20,020 --> 00:11:18,770
stuff like that things like you know we

284
00:11:21,700 --> 00:11:20,030
went to Enceladus and found these

285
00:11:23,620 --> 00:11:21,710
amazing plumes full of organics

286
00:11:25,570 --> 00:11:23,630
there's organics on Ceres we have the

287
00:11:28,300 --> 00:11:25,580
oceans on Europa and other ocean worlds

288
00:11:30,010 --> 00:11:28,310

possible brines flowing on Mars and so

289
00:11:31,930 --> 00:11:30,020
if a reaction goes forward with a

290
00:11:34,120 --> 00:11:31,940
certain set of conditions rather than

291
00:11:35,920 --> 00:11:34,130
restricting it to one specific early

292
00:11:37,810 --> 00:11:35,930
Earth environment now if we just say

293
00:11:39,430 --> 00:11:37,820
what those conditions are it really

294
00:11:40,990 --> 00:11:39,440
helps planetary scientists to kind of go

295
00:11:42,280 --> 00:11:41,000
out and look for that elsewhere in

296
00:11:44,290 --> 00:11:42,290
places where maybe you wouldn't have

297
00:11:46,150 --> 00:11:44,300
thought it could exist and so when we

298
00:11:48,700 --> 00:11:46,160
look for another origin of life in the

299
00:11:50,170 --> 00:11:48,710
universe or maybe another prebiotic

300
00:11:52,690 --> 00:11:50,180
situation that never quite made it to

301
00:11:54,400 --> 00:11:52,700
life this is also very helpful so I'm

302
00:11:56,740 --> 00:11:54,410
excited as we go forward to kind of see

303
00:11:58,600 --> 00:11:56,750
how the organic chemistry we observe on

304
00:12:00,220 --> 00:11:58,610
other planets can relate to the types of

305
00:12:02,230 --> 00:12:00,230
chemistry we do in the lab with our

306
00:12:04,290 --> 00:12:02,240
abiotic prebiotic system and how that

307
00:12:08,440 --> 00:12:04,300
can relate to how life started here I

308
00:12:12,650 --> 00:12:08,450
think that's about five minutes so yeah

309
00:12:22,250 --> 00:12:18,160
[Applause]

310
00:12:24,200 --> 00:12:22,260
hi so I'm Jamie Ella from NASA Goddard

311
00:12:25,910 --> 00:12:24,210
and when I think about these questions

312
00:12:27,800 --> 00:12:25,920
about the origin of life I come at it

313
00:12:30,230 --> 00:12:27,810

from the perspective of China understand

314
00:12:32,690 --> 00:12:30,240
that inventory of prebiotic organic

315
00:12:35,000 --> 00:12:32,700
molecules the ingredients that were

316
00:12:36,740 --> 00:12:35,010
present for when life arose on earth and

317
00:12:38,510 --> 00:12:36,750
whether those ingredients can be present

318
00:12:41,300 --> 00:12:38,520
in other places and what we can learn

319
00:12:42,290 --> 00:12:41,310
about them and one way to do that is to

320
00:12:43,610 --> 00:12:42,300
look at all of the different

321
00:12:45,440 --> 00:12:43,620
environments where we know organic

322
00:12:47,390 --> 00:12:45,450
chemistry can take place and can produce

323
00:12:48,680 --> 00:12:47,400
and cause the evolution of these

324
00:12:51,320 --> 00:12:48,690
ingredients of life and so that's

325
00:12:52,940 --> 00:12:51,330
everything from the defuse interstellar

326
00:12:55,370 --> 00:12:52,950
medium through dense molecular clouds

327
00:12:56,720 --> 00:12:55,380
the formation of planetary systems where

328
00:13:00,170 --> 00:12:56,730
we know there's organic chemistry going

329
00:13:01,880 --> 00:13:00,180
taking place and then into small

330
00:13:03,830 --> 00:13:01,890
primitive bodies within a solar system

331
00:13:05,300 --> 00:13:03,840
or again some of those earlier materials

332
00:13:08,120 --> 00:13:05,310
might be incorporated and undergo

333
00:13:09,830 --> 00:13:08,130
further chemical evolution those bodies

334
00:13:11,600 --> 00:13:09,840
can then deliver organic materials to

335
00:13:13,700 --> 00:13:11,610
the early Earth or the other planetary

336
00:13:16,070 --> 00:13:13,710
surfaces and then we also know that on

337
00:13:17,780 --> 00:13:16,080
planetary surfaces there's a variety of

338
00:13:19,550 --> 00:13:17,790

environments where this chemistry can

339
00:13:20,990 --> 00:13:19,560
also take place so there's a lot of

340
00:13:22,880 --> 00:13:21,000
place there's a lot of ways in which

341
00:13:25,640 --> 00:13:22,890
those building blocks those ingredients

342
00:13:27,710 --> 00:13:25,650
of life can be formed but when I look at

343
00:13:29,180 --> 00:13:27,720
the cartoon like this one of the

344
00:13:31,730 --> 00:13:29,190
questions that immediately springs to

345
00:13:33,470 --> 00:13:31,740
mind is are any of these environments

346
00:13:35,960 --> 00:13:33,480
unique in what they produce and was

347
00:13:37,790 --> 00:13:35,970
anything unique and essential for the

348
00:13:38,900 --> 00:13:37,800
origin of life from the work that's

349
00:13:40,490 --> 00:13:38,910
going on looking at all of these

350
00:13:42,260 --> 00:13:40,500
environments we know that some of the

351
00:13:43,430 --> 00:13:42,270
ingredients the building blocks that we

352
00:13:45,710 --> 00:13:43,440
think are essential to life on Earth

353
00:13:47,210 --> 00:13:45,720
like amino acids can be produced in

354
00:13:49,070 --> 00:13:47,220
multiple environments they're found in

355
00:13:51,110 --> 00:13:49,080
multiple environments and when you see

356
00:13:52,790 --> 00:13:51,120
that it leads you towards thinking life

357
00:13:54,680 --> 00:13:52,800
could be common because these

358
00:13:56,540 --> 00:13:54,690
ingredients for life appear to be common

359
00:13:58,070 --> 00:13:56,550
the reactions that form them appear to

360
00:13:59,860 --> 00:13:58,080
be robust and be able to occur in

361
00:14:02,420 --> 00:13:59,870
different ways and so that's encouraging

362
00:14:03,950 --> 00:14:02,430
but what we don't know yet because I

363
00:14:06,230 --> 00:14:03,960

think it's a really hard question is how

364
00:14:08,540 --> 00:14:06,240
you go from these ingredients from these

365
00:14:09,950 --> 00:14:08,550
prebiotic molecules to the first life

366
00:14:12,320 --> 00:14:09,960
and so we don't know if there's anything

367
00:14:14,750 --> 00:14:12,330
essential and unique that was required

368
00:14:16,160 --> 00:14:14,760
when life got started on earth and then

369
00:14:18,230 --> 00:14:16,170
from that we also don't know if there's

370
00:14:20,420 --> 00:14:18,240
if that unique essential material can

371
00:14:22,280 --> 00:14:20,430
only be produced in one or a few of

372
00:14:25,360 --> 00:14:22,290
these environments so I have big

373
00:14:27,560 --> 00:14:25,370
questions about the universality of the

374
00:14:30,319 --> 00:14:27,570
formation of these ingredients of these

375
00:14:32,449 --> 00:14:30,329
essential organics for life and the

376
00:14:33,889 --> 00:14:32,459
differences the diversity that can

377
00:14:35,780 --> 00:14:33,899
happen in these stuff in these different

378
00:14:38,449 --> 00:14:35,790
environments so that's one way of

379
00:14:39,650 --> 00:14:38,459
looking at this another way of thinking

380
00:14:41,660 --> 00:14:39,660
about the questions that we have

381
00:14:43,729 --> 00:14:41,670
relating to these ingredients of life

382
00:14:45,530 --> 00:14:43,739
are looking at the tools that we have

383
00:14:47,600 --> 00:14:45,540
for studying and understanding them and

384
00:14:49,400 --> 00:14:47,610
the limitations of these tools and

385
00:14:50,539 --> 00:14:49,410
speaking of limitations since I only

386
00:14:52,100 --> 00:14:50,549
have five minutes I'm not really going

387
00:14:53,840 --> 00:14:52,110
to talk about the top or the bottom of

388
00:14:55,549 --> 00:14:53,850

the cartoon right now I'm just going to

389
00:14:57,769 --> 00:14:55,559
focus in on the middle part that what

390
00:14:59,600 --> 00:14:57,779
the ways that were able to study the

391
00:15:01,369 --> 00:14:59,610
organic inventory present in small

392
00:15:02,929 --> 00:15:01,379
primitive bodies within our solar system

393
00:15:04,069 --> 00:15:02,939
and what that tells us about the

394
00:15:06,229 --> 00:15:04,079
ingredients that might have been

395
00:15:07,970 --> 00:15:06,239
available for the origin of life and we

396
00:15:09,889 --> 00:15:07,980
have a lot of tools that are available

397
00:15:13,579 --> 00:15:09,899
for studying these we have things like

398
00:15:16,069 --> 00:15:13,589
in situations so for example the Rosetta

399
00:15:17,780 --> 00:15:16,079
mission to comet 67p that was able to

400
00:15:20,179 --> 00:15:17,790
visit a comet and expand our knowledge

401
00:15:21,919 --> 00:15:20,189
of the organic inventory present in a

402
00:15:23,389 --> 00:15:21,929
cometary environment where we have

403
00:15:25,429 --> 00:15:23,399
sample return missions and we're very

404
00:15:27,499 --> 00:15:25,439
much looking forward to the asteroid or

405
00:15:29,989 --> 00:15:27,509
material that will be returned by

406
00:15:31,249 --> 00:15:29,999
Hayabusa 2 and by osiris-rex that's

407
00:15:33,470 --> 00:15:31,259
going to give us a lot of insight into

408
00:15:34,789 --> 00:15:33,480
this organic inventory these ingredients

409
00:15:36,979 --> 00:15:34,799
that were available in the early solar

410
00:15:39,259 --> 00:15:36,989
system but it's important to note the

411
00:15:41,479 --> 00:15:39,269
limitations of this as well we're still

412
00:15:43,939 --> 00:15:41,489
only able to sample a very small number

413
00:15:45,859 --> 00:15:43,949

of environments a small number of bodies

414
00:15:47,629 --> 00:15:45,869
within our solar system and then we have

415
00:15:50,150 --> 00:15:47,639
to extrapolate from that knowledge and

416
00:15:52,479 --> 00:15:50,160
basically try and assume that that's

417
00:15:54,499 --> 00:15:52,489
telling us about the diversity the full

418
00:15:56,299 --> 00:15:54,509
ingredients that were available and

419
00:15:57,379 --> 00:15:56,309
that's an important thing to realize

420
00:15:59,749 --> 00:15:57,389
that we still have a lot of limitations

421
00:16:01,309 --> 00:15:59,759
even though these these tools tell us a

422
00:16:03,139 --> 00:16:01,319
lot there's still a lot of limitations

423
00:16:04,759 --> 00:16:03,149
and one way to look at that a little

424
00:16:06,889 --> 00:16:04,769
further is by looking at our study of

425
00:16:08,780 --> 00:16:06,899
meteorites meteorites have been a really

426
00:16:10,489 --> 00:16:08,790
great resource for understanding this

427
00:16:12,439 --> 00:16:10,499
organic inventory throughout the solar

428
00:16:13,729 --> 00:16:12,449
system they sample a variety of

429
00:16:17,090 --> 00:16:13,739
different parent bodies and different

430
00:16:19,159 --> 00:16:17,100
environments but for many we still have

431
00:16:21,350 --> 00:16:19,169
to be careful of which meteorites and

432
00:16:23,539 --> 00:16:21,360
how much we're extrapolating from and so

433
00:16:25,669 --> 00:16:23,549
this is just a chart showing published

434
00:16:27,109 --> 00:16:25,679
amino acid analyses over the years and

435
00:16:29,539 --> 00:16:27,119
you can see that for about the first

436
00:16:31,220 --> 00:16:29,549
three decades on this chart almost all

437
00:16:33,109 --> 00:16:31,230
of the published analyses were of one

438
00:16:35,239 --> 00:16:33,119

type of meteor one group of meteorite

439
00:16:36,919 --> 00:16:35,249
the CM carbonaceous chondrites and of

440
00:16:38,749 --> 00:16:36,929
that almost all of those studies were of

441
00:16:39,949 --> 00:16:38,759
the Murchison meteorite where Justin's a

442
00:16:41,269 --> 00:16:39,959
great meteorite it contains a lot of

443
00:16:44,060 --> 00:16:41,279
organics we learned a lot about

444
00:16:46,070 --> 00:16:44,070
potential inventory there but it's not

445
00:16:47,570 --> 00:16:46,080
till the last decade or two where we've

446
00:16:50,000 --> 00:16:47,580
started to really expand our knowledge

447
00:16:52,010 --> 00:16:50,010
of the diversity of chemistry throughout

448
00:16:54,500 --> 00:16:52,020
other parent bodies other meteorite

449
00:16:56,330 --> 00:16:54,510
groups and when we do that we see that

450
00:16:58,760 --> 00:16:56,340
Murchison is not unique but it's also

451
00:17:00,290 --> 00:16:58,770
not necessarily representative and so

452
00:17:02,030 --> 00:17:00,300
this is just an example looking at amino

453
00:17:04,340 --> 00:17:02,040
acid abundances on a log scale and the

454
00:17:06,620 --> 00:17:04,350
y-axis every bar there is a different

455
00:17:08,949 --> 00:17:06,630
meteorite and it's just to show that if

456
00:17:11,540 --> 00:17:08,959
we study only one or two or a few

457
00:17:13,040 --> 00:17:11,550
samples from throughout these different

458
00:17:15,110 --> 00:17:13,050
environments these different solar

459
00:17:16,460 --> 00:17:15,120
system bodies it's not necessarily

460
00:17:18,770 --> 00:17:16,470
giving us the full picture so I think

461
00:17:20,780 --> 00:17:18,780
it's important to recognize the

462
00:17:23,960 --> 00:17:20,790
limitations of what our tools are and

463
00:17:25,760 --> 00:17:23,970

what we're able to do and the final

464
00:17:28,460 --> 00:17:25,770
thing I would say in my few minutes is

465
00:17:30,110 --> 00:17:28,470
that it's important to understand these

466
00:17:32,270 --> 00:17:30,120
this prebiotic inventory these

467
00:17:34,010 --> 00:17:32,280
ingredients for life not only to

468
00:17:36,050 --> 00:17:34,020
understand the origin of life on Earth

469
00:17:37,760 --> 00:17:36,060
but the potential to recognize life

470
00:17:39,980 --> 00:17:37,770
elsewhere and so many of you familiar

471
00:17:41,630 --> 00:17:39,990
with the ladder of life and I've put up

472
00:17:44,210 --> 00:17:41,640
just a little part of the ladder of life

473
00:17:45,380 --> 00:17:44,220
table here and I've circled some of the

474
00:17:48,940 --> 00:17:45,390
questions some of the potential

475
00:17:51,650 --> 00:17:48,950
biomarkers that rely on molecular

476
00:17:53,780 --> 00:17:51,660
molecules on potential biomolecules as

477
00:17:55,130 --> 00:17:53,790
bio signatures and I've circled some of

478
00:17:57,410 --> 00:17:55,140
the things that we need to know in order

479
00:17:59,150 --> 00:17:57,420
to put this these questions into the

480
00:18:01,820 --> 00:17:59,160
proper context to be able to interpret

481
00:18:04,430 --> 00:18:01,830
them we need to really understand that

482
00:18:06,050 --> 00:18:04,440
full range of abiotic chemistry so what

483
00:18:07,790 --> 00:18:06,060
Lori just said about you know we might

484
00:18:09,710 --> 00:18:07,800
see totally different about it chemistry

485
00:18:11,480 --> 00:18:09,720
in a different environment elsewhere we

486
00:18:13,400 --> 00:18:11,490
need to really understand what abiotic

487
00:18:15,680 --> 00:18:13,410
chemistry can produce and things like

488
00:18:18,380 --> 00:18:15,690

how much of an enantiomeric excess can

489
00:18:20,480 --> 00:18:18,390
you produce so that we can later we can

490
00:18:22,970 --> 00:18:20,490
understand what we see elsewhere as

491
00:18:25,250 --> 00:18:22,980
potential bio signatures versus what

492
00:18:27,110 --> 00:18:25,260
ibadat chemistry can produce and so

493
00:18:28,910 --> 00:18:27,120
that's sort of my quick overview and

494
00:18:31,190 --> 00:18:28,920
I'll pass it off to Chris Keating now

495
00:18:36,729 --> 00:18:31,200
from Penn State

496
00:18:40,459 --> 00:18:36,739
[Applause]

497
00:18:42,080 --> 00:18:40,469
thank you so how do you find my mind

498
00:18:44,149 --> 00:18:42,090
blown by pictures like the ones we just

499
00:18:46,159 --> 00:18:44,159
saw I'm a chemist and I think about

500
00:18:47,899 --> 00:18:46,169
compartmentalization and I like to think

501
00:18:49,729 --> 00:18:47,909
about things that are sort of tangible

502
00:18:51,709 --> 00:18:49,739
and so it's really hard for me to think

503
00:18:53,930 --> 00:18:51,719
about a planetary system is in the

504
00:18:56,330 --> 00:18:53,940
original life but I try and I find it

505
00:18:58,940 --> 00:18:56,340
really fun even though it's hard but

506
00:19:00,680 --> 00:18:58,950
what I want to talk to you about is

507
00:19:03,229 --> 00:19:00,690
compartmentalization so that's where my

508
00:19:05,149 --> 00:19:03,239
mind focuses and I think a permutation

509
00:19:06,769 --> 00:19:05,159
is something that would fall between

510
00:19:08,479 --> 00:19:06,779
sort of having these beginnings of

511
00:19:10,159 --> 00:19:08,489
molecules and then how do we get to

512
00:19:11,719 --> 00:19:10,169
something that starts towards life I'm

513
00:19:13,430 --> 00:19:11,729

not gonna answer that for you don't get

514
00:19:15,829 --> 00:19:13,440
excited but but if we'll talk about

515
00:19:17,209 --> 00:19:15,839
compartments and you know what's a

516
00:19:19,430 --> 00:19:17,219
compartment good for well if it's

517
00:19:20,989 --> 00:19:19,440
fundamental right you put things in it

518
00:19:23,389 --> 00:19:20,999
that's what a compartment is good for

519
00:19:30,589 --> 00:19:23,399
and what does that mean and I think in

520
00:19:31,849 --> 00:19:30,599
this community is actually what people

521
00:19:33,229 --> 00:19:31,859
think about in the origins of life

522
00:19:34,899 --> 00:19:33,239
community they think about you need a

523
00:19:36,889 --> 00:19:34,909
compartment to make an individual and

524
00:19:38,180 --> 00:19:36,899
and then they argue about whether need

525
00:19:39,909 --> 00:19:38,190
is the right word in that sentence and

526
00:19:42,229 --> 00:19:39,919
those are good things to argue about

527
00:19:43,190 --> 00:19:42,239
that's not really what I want to be the

528
00:19:46,129 --> 00:19:43,200
main focus today

529
00:19:47,149 --> 00:19:46,139
um yes making in visual is really

530
00:19:48,589 --> 00:19:47,159
important it's something you can do with

531
00:19:50,989 --> 00:19:48,599
the compartment there are other things

532
00:19:52,129 --> 00:19:50,999
that happen potentially before that and

533
00:19:53,659 --> 00:19:52,139
this might get to some of the things

534
00:19:56,180 --> 00:19:53,669
that Laurie was saying about even in a

535
00:19:58,039 --> 00:19:56,190
prebiotic situation there are roles for

536
00:19:59,810 --> 00:19:58,049
complex chemistry's to be going on even

537
00:20:00,919 --> 00:19:59,820
before life and I think compartments

538
00:20:03,200 --> 00:20:00,929

would have played important roles in

539
00:20:04,879 --> 00:20:03,210
this and so I want to think about sort

540
00:20:06,079 --> 00:20:04,889
of more fundamental things so you put

541
00:20:07,519 --> 00:20:06,089
things in a compartment does that mean

542
00:20:09,769 --> 00:20:07,529
well it changes the thermodynamics of

543
00:20:11,719 --> 00:20:09,779
association so like non covalent

544
00:20:13,940 --> 00:20:11,729
associations oligomerization is that

545
00:20:15,289 --> 00:20:13,950
sort of thing it changes kinetics so you

546
00:20:17,629 --> 00:20:15,299
can have rate increases by having

547
00:20:19,310 --> 00:20:17,639
locally high concentrations it changes

548
00:20:20,779 --> 00:20:19,320
potentially the microenvironment might

549
00:20:22,099 --> 00:20:20,789
maintain a micro environment that's more

550
00:20:23,989 --> 00:20:22,109
favorable for certain kinds of

551
00:20:25,879 --> 00:20:23,999
chemistry's than others and maybe that

552
00:20:27,440 --> 00:20:25,889
favorability is good for whatever it is

553
00:20:29,570 --> 00:20:27,450
that you need to have happen to start

554
00:20:33,019 --> 00:20:29,580
life you could imagine it might be bad

555
00:20:35,149 --> 00:20:33,029
also of selective entry and exit so

556
00:20:36,529 --> 00:20:35,159
think about gatekeepers that are formed

557
00:20:38,539 --> 00:20:36,539
by the compartments and the sort of

558
00:20:40,700 --> 00:20:38,549
example to make this tangible for you

559
00:20:42,139 --> 00:20:40,710
may be a membrane and so these are all

560
00:20:43,579 --> 00:20:42,149
things that you're getting from having a

561
00:20:45,299 --> 00:20:43,589
compartment before you have to worry

562
00:20:47,129 --> 00:20:45,309
about whether it's alive or whether it's

563
00:20:49,049 --> 00:20:47,139

or whether it's an individual and then

564
00:20:53,279 --> 00:20:49,059
ultimately it can become those things as

565
00:20:54,840 --> 00:20:53,289
well it may need more to get to those

566
00:20:57,480 --> 00:20:54,850
places right and I think that's a fair

567
00:20:58,799 --> 00:20:57,490
thing that we can think about the other

568
00:21:00,330 --> 00:20:58,809
thing I wanted to quickly mention it is

569
00:21:01,860 --> 00:21:00,340
that these compartments don't always

570
00:21:03,539 --> 00:21:01,870
need to be static they can come and go

571
00:21:05,220 --> 00:21:03,549
so if you think about coupling this with

572
00:21:06,269 --> 00:21:05,230
a gradient or a wet/dry cycle or

573
00:21:08,159 --> 00:21:06,279
something like that your compartment

574
00:21:10,860 --> 00:21:08,169
might be coming and going so capturing

575
00:21:12,600 --> 00:21:10,870
and releasing some reagents in a cyclic

576
00:21:16,049 --> 00:21:12,610
fashion which might have consequences

577
00:21:17,340 --> 00:21:16,059
that could be interesting so I just want

578
00:21:19,259 --> 00:21:17,350
to give you something to sort of sink

579
00:21:20,369 --> 00:21:19,269
your mental teeth into because I I

580
00:21:21,629 --> 00:21:20,379
always need something that sort of

581
00:21:24,029 --> 00:21:21,639
tangible it's like what are we talking

582
00:21:24,930 --> 00:21:24,039
about here what kind of thing so I be

583
00:21:26,639 --> 00:21:24,940
showing a couple pictures of

584
00:21:28,769 --> 00:21:26,649
compartments that you could have that

585
00:21:30,359 --> 00:21:28,779
you're gonna get I would say almost for

586
00:21:33,239 --> 00:21:30,369
free on a planet that has rocks and

587
00:21:34,470 --> 00:21:33,249
water like this one um so yeah there's

588
00:21:36,119 --> 00:21:34,480

gonna be rocks that means those rocks

589
00:21:37,379 --> 00:21:36,129
have surfaces they have crevices

590
00:21:39,690 --> 00:21:37,389
they have different chemistry's on the

591
00:21:41,009 --> 00:21:39,700
surface molecules will adsorb there that

592
00:21:43,950 --> 00:21:41,019
can be thought of as a compartment it

593
00:21:46,799 --> 00:21:43,960
can change reactivity in addition you

594
00:21:48,359 --> 00:21:46,809
can have liquid surfaces right molecule

595
00:21:50,129 --> 00:21:48,369
has many molecules that are organic are

596
00:21:52,680 --> 00:21:50,139
surface active even ones that you don't

597
00:21:54,539 --> 00:21:52,690
think of as surfactants those then is a

598
00:21:55,889 --> 00:21:54,549
way of concentrating if there are waves

599
00:21:57,840 --> 00:21:55,899
or wind you could make those into

600
00:21:59,909 --> 00:21:57,850
aerosols and so those then can start to

601
00:22:02,609 --> 00:21:59,919
dry and concentrate those molecules

602
00:22:04,529 --> 00:22:02,619
further if you have a cold environment

603
00:22:06,090 --> 00:22:04,539
right now you can form ice in your water

604
00:22:07,379 --> 00:22:06,100
and the bits that don't want to get into

605
00:22:08,669 --> 00:22:07,389
the ice crystal it would screw up the

606
00:22:10,859 --> 00:22:08,679
ice crystals they'll form a little inter

607
00:22:12,509 --> 00:22:10,869
systems of sort of salty organic rich

608
00:22:14,759 --> 00:22:12,519
areas if there are organics or maybe

609
00:22:16,919 --> 00:22:14,769
just salty if there are not these kinds

610
00:22:18,149 --> 00:22:16,929
of environments probably were important

611
00:22:19,259 --> 00:22:18,159
they were probably there and so you

612
00:22:21,539 --> 00:22:19,269
should probably think about them and

613
00:22:23,210 --> 00:22:21,549

role that they might have played in sort

614
00:22:25,470 --> 00:22:23,220
of forming some of these early molecules

615
00:22:26,669 --> 00:22:25,480
once you have some molecules that are

616
00:22:28,950 --> 00:22:26,679
organic then you can make all different

617
00:22:30,299 --> 00:22:28,960
kinds of compartments so a really

618
00:22:31,680 --> 00:22:30,309
important kind of compartment is a lipid

619
00:22:33,600 --> 00:22:31,690
membrane and other kinds of lipids

620
00:22:35,970 --> 00:22:33,610
self-assembly is that form these can

621
00:22:38,009 --> 00:22:35,980
form from a wide range of molecules that

622
00:22:39,210 --> 00:22:38,019
basically have certain different solvent

623
00:22:41,039 --> 00:22:39,220
properties on the different ends

624
00:22:42,149 --> 00:22:41,049
and so they'll self assemble one of the

625
00:22:44,009 --> 00:22:42,159
things that can form is a compartment

626
00:22:46,590 --> 00:22:44,019
that could contain things and can serve

627
00:22:47,879 --> 00:22:46,600
as a gatekeeper the last kind of

628
00:22:49,259 --> 00:22:47,889
compartment I'll briefly mention estar

629
00:22:50,489 --> 00:22:49,269
near and dear to my own personal heart

630
00:22:51,840 --> 00:22:50,499
because we're studying them in my lab a

631
00:22:53,519 --> 00:22:51,850
lot and these are things called

632
00:22:54,960 --> 00:22:53,529
coacervate which I understand is a

633
00:22:56,100 --> 00:22:54,970
loaded word in this community but it

634
00:22:57,049 --> 00:22:56,110
really is just a physical chemical

635
00:22:58,369 --> 00:22:57,059
phenomenon where

636
00:23:00,470 --> 00:22:58,379
have associative phase separation and

637
00:23:02,600 --> 00:23:00,480
water so multivalent molecules stick

638
00:23:03,950 --> 00:23:02,610

together they make a phase that phases

639
00:23:07,039 --> 00:23:03,960
different solver properties and you can

640
00:23:08,869 --> 00:23:07,049
put stuff in it it's not a protocell

641
00:23:12,049 --> 00:23:08,879
it's just a phase maybe it could become

642
00:23:13,759 --> 00:23:12,059
a protocell and so this these structures

643
00:23:15,889 --> 00:23:13,769
are really good not so much at gate

644
00:23:17,419 --> 00:23:15,899
keeping but accumulating and so if you

645
00:23:18,379 --> 00:23:17,429
think about the sort of different

646
00:23:20,210 --> 00:23:18,389
properties of different compartments

647
00:23:21,860 --> 00:23:20,220
they're not all going to play the same

648
00:23:23,570 --> 00:23:21,870
role and we probably shouldn't try to

649
00:23:24,889 --> 00:23:23,580
compare them as if they were playing the

650
00:23:27,440 --> 00:23:24,899
same role which I think a lot of times

651
00:23:29,749 --> 00:23:27,450
were tempted to do I would argue instead

652
00:23:32,029 --> 00:23:29,759
we should think about well over the time

653
00:23:33,049 --> 00:23:32,039
that occurred we would have started out

654
00:23:34,609 --> 00:23:33,059
with some compartment that you kind of

655
00:23:36,049 --> 00:23:34,619
get for free on your planetary surface

656
00:23:37,519 --> 00:23:36,059
whether the cons I talked about are

657
00:23:40,190 --> 00:23:37,529
different ones on some different planet

658
00:23:41,930 --> 00:23:40,200
and those can start to be functional and

659
00:23:43,460 --> 00:23:41,940
then as time progresses and you start to

660
00:23:44,749 --> 00:23:43,470
have organic molecules that those can

661
00:23:46,220 --> 00:23:44,759
start to make their own compartments and

662
00:23:47,810 --> 00:23:46,230
these would all be sort of interacting

663
00:23:50,629 --> 00:23:47,820

in the same ulugh and probably those

664
00:23:51,499 --> 00:23:50,639
interactions are quite important so I

665
00:23:52,940 --> 00:23:51,509
want to leave you with a couple of

666
00:23:55,639 --> 00:23:52,950
questions to think about since we want

667
00:23:57,680 --> 00:23:55,649
to spend a lot of time on discussion so

668
00:23:59,180 --> 00:23:57,690
Jim alluded to this you know are we

669
00:24:01,340 --> 00:23:59,190
talking about things that are easy or

670
00:24:03,200 --> 00:24:01,350
hard in terms of starting life right not

671
00:24:04,549 --> 00:24:03,210
just life itself but the parts the steps

672
00:24:06,560 --> 00:24:04,559
should we be focusing on steps that are

673
00:24:08,149 --> 00:24:06,570
easy steps that are hard as an

674
00:24:09,169 --> 00:24:08,159
experimental scientist with graduate

675
00:24:11,419 --> 00:24:09,179
students you don't want to stay forever

676
00:24:12,739 --> 00:24:11,429
I try to focus on easy ones but I don't

677
00:24:14,919 --> 00:24:12,749
know if that's the right choice right it

678
00:24:17,869 --> 00:24:14,929
only needs to happen once it's gnarly Oh

679
00:24:18,799 --> 00:24:17,879
specific molecules versus motifs right

680
00:24:20,299 --> 00:24:18,809
should we be trying to figure out

681
00:24:22,310 --> 00:24:20,309
exactly what molecules were likely to be

682
00:24:23,930 --> 00:24:22,320
there or being inspired by ones we know

683
00:24:25,850 --> 00:24:23,940
now and studying those or should be

684
00:24:27,680 --> 00:24:25,860
thinking more generally like an fo file

685
00:24:29,269 --> 00:24:27,690
and said or particularly a file or a

686
00:24:31,820 --> 00:24:29,279
poly electrolyte instead of a particular

687
00:24:33,859 --> 00:24:31,830
polyelectrolyte and the other two are

688
00:24:34,850 --> 00:24:33,869

say they may be more obvious or what

689
00:24:36,830 --> 00:24:34,860
would happen if you put these things

690
00:24:38,210 --> 00:24:36,840
together I think a lot of times in order

691
00:24:41,180 --> 00:24:38,220
to do a clean experiment we try to keep

692
00:24:42,859 --> 00:24:41,190
it simple that's a good approach but

693
00:24:44,749 --> 00:24:42,869
probably it wasn't simple and clean when

694
00:24:45,980 --> 00:24:44,759
things were actually happening and the

695
00:24:47,299 --> 00:24:45,990
synergies that might arise when you

696
00:24:48,919 --> 00:24:47,309
start to combine different compartment

697
00:24:50,629 --> 00:24:48,929
types together or compartments with

698
00:24:52,669 --> 00:24:50,639
gradients thermal vents things like that

699
00:24:54,440 --> 00:24:52,679
could be really enabling at really rich

700
00:24:57,409 --> 00:24:54,450
chemistry that we should definitely

701
00:24:58,639 --> 00:24:57,419
start exploring and then less and I

702
00:25:01,129 --> 00:24:58,649
think we've heard this from some of the

703
00:25:02,869 --> 00:25:01,139
other panelists you know what did happen

704
00:25:05,090 --> 00:25:02,879
versus what could happen they're both

705
00:25:07,460 --> 00:25:05,100
interesting questions right and I I

706
00:25:08,810 --> 00:25:07,470
think that the set of all things that

707
00:25:09,590 --> 00:25:08,820
could happen is bigger than the set of

708
00:25:12,240 --> 00:25:09,600
things that did

709
00:25:13,980 --> 00:25:12,250
we don't have a second example of that

710
00:25:15,630 --> 00:25:13,990
yet but I'd like to hope some day we'll

711
00:25:30,000 --> 00:25:15,640
find one so I'll leave you with that and

712
00:25:32,190 --> 00:25:30,010
faster over to Eric yeah thanks

713
00:25:34,500 --> 00:25:32,200

Christine so I thought I would address

714
00:25:36,840 --> 00:25:34,510
the multidisciplinary aspect of this

715
00:25:38,280 --> 00:25:36,850
session with some comments from the

716
00:25:40,620 --> 00:25:38,290
perspective of statistics and

717
00:25:43,650 --> 00:25:40,630
computation in the sense of computer

718
00:25:45,330 --> 00:25:43,660
science I want to start by acknowledging

719
00:25:50,040 --> 00:25:45,340
Jim for what has to be the most

720
00:25:52,740 --> 00:25:50,050
optimistic session title ever but behind

721
00:25:55,350 --> 00:25:52,750
that a theme in a lot of my remarks will

722
00:25:56,820 --> 00:25:55,360
be that all of our accomplished well

723
00:25:58,650 --> 00:25:56,830
understood science is built on a

724
00:26:00,810 --> 00:25:58,660
relatively small number of paradigms for

725
00:26:02,640 --> 00:26:00,820
order and I expect that the problem of

726
00:26:05,310 --> 00:26:02,650
origin of life is actually going to

727
00:26:07,380 --> 00:26:05,320
require a whole set none of which we

728
00:26:09,180 --> 00:26:07,390
have yet covered and in that sense this

729
00:26:10,710 --> 00:26:09,190
is still really early days and that's

730
00:26:14,820 --> 00:26:10,720
good and that's kind of a good frame for

731
00:26:17,040 --> 00:26:14,830
what follows so Jim proposed a set of

732
00:26:19,050 --> 00:26:17,050
sort of really open and fundamental

733
00:26:20,700 --> 00:26:19,060
questions as a way to try to cede the

734
00:26:22,410 --> 00:26:20,710
activity and the perspectives that we

735
00:26:23,580 --> 00:26:22,420
know are active in this meeting and

736
00:26:26,910 --> 00:26:23,590
bring them into discussion with each

737
00:26:28,710 --> 00:26:26,920
other and I figured yeah okay just pick

738
00:26:31,560 --> 00:26:28,720

them up and throw down some perspectives

739
00:26:34,770 --> 00:26:31,570
and give people something to you know to

740
00:26:35,280 --> 00:26:34,780
object to or fill out what is the origin

741
00:26:40,080 --> 00:26:35,290
of life

742
00:26:41,910 --> 00:26:40,090
also is I think when we understand it we

743
00:26:44,100 --> 00:26:41,920
will have to understand it as a cascade

744
00:26:46,980 --> 00:26:44,110
of non-equilibrium phase transitions in

745
00:26:49,590 --> 00:26:46,990
the energetics and chemistry at a

746
00:26:50,820 --> 00:26:49,600
planetary scale a couple years ago Sarah

747
00:26:53,190 --> 00:26:50,830
Walker put out a really great

748
00:26:54,600 --> 00:26:53,200
formulation of this in a review she said

749
00:26:56,340 --> 00:26:54,610
the origin of life is not something that

750
00:26:58,380 --> 00:26:56,350
happens on a planet it's something that

751
00:27:03,260 --> 00:26:58,390
happens to a planet I was very jealous

752
00:27:10,560 --> 00:27:05,490
very good thank you from David Grinspoon

753
00:27:13,740 --> 00:27:10,570
okay but the particular words in here

754
00:27:15,150 --> 00:27:13,750
are all links to areas where we

755
00:27:18,150 --> 00:27:15,160
understand something about either

756
00:27:20,250 --> 00:27:18,160
robustness or search in complex spaces

757
00:27:22,090 --> 00:27:20,260
or discoverability that will ultimately

758
00:27:24,010 --> 00:27:22,100
apply to some

759
00:27:26,830 --> 00:27:24,020
expect of the emergence of a form of

760
00:27:29,799 --> 00:27:26,840
order in the biosphere why is it been

761
00:27:31,450 --> 00:27:29,809
hard to explain or gain consensus I

762
00:27:33,430 --> 00:27:31,460
would say that for most of what we need

763
00:27:36,039 --> 00:27:33,440

to understand we have not had compelling

764
00:27:37,720 --> 00:27:36,049
ideas yet and if anything the fact that

765
00:27:39,430 --> 00:27:37,730
we have less consensus is kind of a

766
00:27:41,470 --> 00:27:39,440
relief it's an improvement in the state

767
00:27:44,789 --> 00:27:41,480
of our community from what it has been

768
00:27:47,500 --> 00:27:44,799
in some past times but more concretely

769
00:27:48,970 --> 00:27:47,510
chemistry is big and it's structured and

770
00:27:50,560 --> 00:27:48,980
it's big in a way that none of the

771
00:27:53,350 --> 00:27:50,570
sciences that we have yet understood

772
00:27:55,810 --> 00:27:53,360
really command probably the closest we

773
00:27:57,190 --> 00:27:55,820
come is the theory of representations

774
00:27:58,570 --> 00:27:57,200
and algorithms

775
00:28:01,659 --> 00:27:58,580
I would guess and there's an affinity

776
00:28:03,370 --> 00:28:01,669
among those at the level of mechanisms

777
00:28:04,990 --> 00:28:03,380
we may have a pretty good control of

778
00:28:07,720 --> 00:28:05,000
what's possible in chemistry sort of

779
00:28:09,580 --> 00:28:07,730
physical chemistry and up to rules but

780
00:28:11,440 --> 00:28:09,590
at the level of what the forms of order

781
00:28:13,149 --> 00:28:11,450
are and how to systematically search in

782
00:28:16,810 --> 00:28:13,159
systems I think we're still pretty early

783
00:28:18,610 --> 00:28:16,820
on in that but more abstractly you could

784
00:28:20,710 --> 00:28:18,620
say that we have only ever really been

785
00:28:22,899 --> 00:28:20,720
theoreticians of the symbol all of the

786
00:28:24,909 --> 00:28:22,909
accomplished Sciences are fundamentally

787
00:28:26,620 --> 00:28:24,919
simple in their organizing paradigms and

788
00:28:29,169 --> 00:28:26,630

I think the origin of life is going to

789
00:28:30,850 --> 00:28:29,179
demand that we become theorists of the

790
00:28:32,470 --> 00:28:30,860
complex in a way that's completely new

791
00:28:33,970 --> 00:28:32,480
and I think that point of view is

792
00:28:36,250 --> 00:28:33,980
resident in this community in a lot of

793
00:28:38,409 --> 00:28:36,260
places what do I want people to do more

794
00:28:40,450 --> 00:28:38,419
of I have some concrete ideas on that to

795
00:28:42,039 --> 00:28:40,460
follow but are there things about the

796
00:28:44,110 --> 00:28:42,049
origin of life that we will never know

797
00:28:45,909 --> 00:28:44,120
the answer to here I want to push back a

798
00:28:47,529 --> 00:28:45,919
little bit on something we sometimes see

799
00:28:49,450 --> 00:28:47,539
in the literature in this community I'm

800
00:28:51,250 --> 00:28:49,460
not a fan of the argument that because

801
00:28:53,350 --> 00:28:51,260
you can't build a time machine to stand

802
00:28:55,000 --> 00:28:53,360
on ad and earth we'll never know because

803
00:28:57,130 --> 00:28:55,010
we would never apply such a glib

804
00:28:58,510 --> 00:28:57,140
formulation to other areas in science

805
00:29:01,539 --> 00:28:58,520
and in areas a lot of areas we

806
00:29:04,299 --> 00:29:01,549
understand we know that it's not true so

807
00:29:07,299 --> 00:29:04,309
the the constructive point that I mean

808
00:29:10,210 --> 00:29:07,309
to make in this is that the whole thing

809
00:29:12,610 --> 00:29:10,220
that has made biology hard to reduce to

810
00:29:14,350 --> 00:29:12,620
a benchtop problem has been the fact

811
00:29:16,240 --> 00:29:14,360
that historical contingency brings in

812
00:29:19,240 --> 00:29:16,250
contexts that are hard to reconstruct

813
00:29:21,700 --> 00:29:19,250

when the loss of memory makes some of

814
00:29:23,950 --> 00:29:21,710
those contexts unrecoverable that's not

815
00:29:26,020 --> 00:29:23,960
the end of understanding that in some

816
00:29:27,640 --> 00:29:26,030
sense removes some of the obstacles that

817
00:29:29,620 --> 00:29:27,650
had made it hard to understand before

818
00:29:32,049 --> 00:29:29,630
and we want to keep in mind that that's

819
00:29:33,850 --> 00:29:32,059
an opportunity so there's even a

820
00:29:35,710 --> 00:29:33,860
technical sense that we have simple

821
00:29:37,450 --> 00:29:35,720
versions of in other areas in which the

822
00:29:40,810 --> 00:29:37,460
things that we do not know and cannot

823
00:29:44,049 --> 00:29:40,820
know are another name for the things

824
00:29:45,310 --> 00:29:44,059
that are not essential to causation so I

825
00:29:47,830 --> 00:29:45,320
hope there are aspects of that that

826
00:29:49,690 --> 00:29:47,840
maybe we can talk about but what can we

827
00:29:53,049 --> 00:29:49,700
do there are certain aspects of the

828
00:29:56,020 --> 00:29:53,059
living state that have wound up leading

829
00:29:57,760 --> 00:29:56,030
us and tying together a lot of the most

830
00:30:00,310 --> 00:29:57,770
fundamental organizing principles in

831
00:30:02,169 --> 00:30:00,320
life and they've done so across decades

832
00:30:03,370 --> 00:30:02,179
and even across generations and one of

833
00:30:07,390 --> 00:30:03,380
the greatest of these has been the

834
00:30:09,070 --> 00:30:07,400
genetic code so back in 1967 Carl Woese

835
00:30:12,130 --> 00:30:09,080
had recognized that the problem of

836
00:30:15,130 --> 00:30:12,140
reliable translation only made sense as

837
00:30:16,960 --> 00:30:15,140
an outcome of a dynamic of innovation

838
00:30:20,020 --> 00:30:16,970

sharing that required horizontal gene

839
00:30:21,880 --> 00:30:20,030
transfer but then also required to block

840
00:30:24,340 --> 00:30:21,890
horizontal gene transfer in order to

841
00:30:26,649 --> 00:30:24,350
preserve itself and this established an

842
00:30:29,020 --> 00:30:26,659
essential role for the code as something

843
00:30:31,480 --> 00:30:29,030
that was both needed to be and made to

844
00:30:33,610 --> 00:30:31,490
be an error buffer that's led to a whole

845
00:30:36,039 --> 00:30:33,620
generation of super high quality work on

846
00:30:38,740 --> 00:30:36,049
the analysis of the ways in which it's

847
00:30:40,630 --> 00:30:38,750
an error buffer eight years later so

848
00:30:42,940 --> 00:30:40,640
Faye Wong recognized that a lot of the

849
00:30:45,039 --> 00:30:42,950
assignment order in the code is actually

850
00:30:46,960 --> 00:30:45,049
an order of elaboration of biosynthetic

851
00:30:49,539 --> 00:30:46,970
pathways which he anchored an amino acid

852
00:30:51,520 --> 00:30:49,549
biosynthesis but in the same year Hyman

853
00:30:53,380 --> 00:30:51,530
Hartmann recognized what I think is the

854
00:30:55,120 --> 00:30:53,390
more correct argument that the anchors

855
00:30:57,279 --> 00:30:55,130
for all those actually are CH Oh

856
00:31:00,039 --> 00:30:57,289
biochemistry in the citric acid cycle

857
00:31:01,240 --> 00:31:00,049
compounds and pathways and in carbon

858
00:31:04,299 --> 00:31:01,250
fixation itself

859
00:31:07,029 --> 00:31:04,309
fast forward 25 years in this wonderful

860
00:31:08,970 --> 00:31:07,039
review of whoas olson and others where

861
00:31:10,960 --> 00:31:08,980
they tried to give an encompassing

862
00:31:13,840 --> 00:31:10,970
reconstruction of the history of the

863
00:31:15,279 --> 00:31:13,850

aminoacyl trna synthetases they were

864
00:31:17,289 --> 00:31:15,289
forced to confront the fact that

865
00:31:18,760 --> 00:31:17,299
different subsystems of biology are

866
00:31:20,980 --> 00:31:18,770
conceptually different in their

867
00:31:23,380 --> 00:31:20,990
character of modularity and that this

868
00:31:24,940 --> 00:31:23,390
abstract property governs the style of

869
00:31:28,270 --> 00:31:24,950
evolutionary dynamics that they

870
00:31:30,100 --> 00:31:28,280
experience so I think we can argue that

871
00:31:32,409 --> 00:31:30,110
the genetic code like this kind of

872
00:31:33,880 --> 00:31:32,419
seismic triple Junction is active again

873
00:31:36,549 --> 00:31:33,890
and that there's a bunch of neat stuff

874
00:31:39,490 --> 00:31:36,559
going on that it brings together so in

875
00:31:42,310 --> 00:31:39,500
the modern effort to reconstruct the

876
00:31:45,370 --> 00:31:42,320
synthesis but other proteins that have

877
00:31:47,740 --> 00:31:45,380
many forms of rearrangement going on at

878
00:31:49,150 --> 00:31:47,750
the same time we're having to go beyond

879
00:31:50,350 --> 00:31:49,160
the simple probability

880
00:31:52,360 --> 00:31:50,360
that have been the mainstay of

881
00:31:54,700 --> 00:31:52,370
phylogenetic reconstruction Gregg

882
00:31:57,130 --> 00:31:54,710
Fournier has an ongoing a wonderful

883
00:31:59,830 --> 00:31:57,140
stream of work on this that I know many

884
00:32:03,220 --> 00:31:59,840
of you know in parallel to that there's

885
00:32:04,960 --> 00:32:03,230
an idea that thye Oster energetics was

886
00:32:06,970 --> 00:32:04,970
maybe a linchpin of very early

887
00:32:09,880 --> 00:32:06,980
biochemistry this goes all the way back

888
00:32:12,220 --> 00:32:09,890

to Racker I guess in the 1930s and some

889
00:32:14,260 --> 00:32:12,230
intuitions best developed by Christian

890
00:32:17,440 --> 00:32:14,270
de Duve it's kind of laying fallow for

891
00:32:19,300 --> 00:32:17,450
periods it's now active again for

892
00:32:22,840 --> 00:32:19,310
example from a bioinformatics direction

893
00:32:25,780 --> 00:32:22,850
in this paper by Gould Ferda at all but

894
00:32:27,460 --> 00:32:25,790
at the same time in the realization that

895
00:32:29,800 --> 00:32:27,470
a lot of the earliest folds the Ross

896
00:32:32,410 --> 00:32:29,810
monoid folds are essentially sulfur

897
00:32:34,240 --> 00:32:32,420
bioenergetic proteins in any number of

898
00:32:36,490 --> 00:32:34,250
elaborations and the remarkable

899
00:32:38,470 --> 00:32:36,500
observation by jakob offski that this

900
00:32:41,770 --> 00:32:38,480
includes both classes of the aminoacyl

901
00:32:44,650 --> 00:32:41,780
trna synthetases and then from yet a

902
00:32:46,840 --> 00:32:44,660
third direction the realization from

903
00:32:48,340 --> 00:32:46,850
this paper by nicolas Kovich sorry for

904
00:32:50,560 --> 00:32:48,350
the misspelling and Lauren Williams's

905
00:32:53,320 --> 00:32:50,570
group that as we look at the elaboration

906
00:32:53,950 --> 00:32:53,330
of folds in the accretionary sequence of

907
00:32:57,670 --> 00:32:53,960
the ribosome

908
00:32:59,320 --> 00:32:57,680
you see these ross monoid folds kind of

909
00:33:02,470 --> 00:32:59,330
flowering around the same time as

910
00:33:04,360 --> 00:33:02,480
translation so i want to speculate here

911
00:33:06,340 --> 00:33:04,370
that these are all windows looking into

912
00:33:08,740 --> 00:33:06,350
the same room we're standing on the

913
00:33:12,130 --> 00:33:08,750

threshold of an era where instead of

914
00:33:14,680 --> 00:33:12,140
using diversity to reconstruct States

915
00:33:16,570 --> 00:33:14,690
the next generation will be the use of

916
00:33:18,700 --> 00:33:16,580
diversity to reconstruct models of

917
00:33:20,830 --> 00:33:18,710
dynamics and the form that that will

918
00:33:22,350 --> 00:33:20,840
have to take is a new kind of community

919
00:33:25,060 --> 00:33:22,360
structure of hypothesis driven

920
00:33:27,640 --> 00:33:25,070
experimentation complex computational

921
00:33:29,650 --> 00:33:27,650
simulation that then generates for us

922
00:33:32,920 --> 00:33:29,660
the probability models that we use in

923
00:33:35,110 --> 00:33:32,930
comparative historical analysis and you

924
00:33:37,030 --> 00:33:35,120
know me wanting things to be interesting

925
00:33:39,670 --> 00:33:37,040
almost more than I want them to be true

926
00:33:41,500 --> 00:33:39,680
the speculation would be that the three

927
00:33:43,720 --> 00:33:41,510
problems that we see in the code right

928
00:33:45,340 --> 00:33:43,730
now the elaboration of Organa synthesis

929
00:33:47,560 --> 00:33:45,350
whether there were bottlenecks and

930
00:33:50,770 --> 00:33:47,570
bioenergetics and how folding first

931
00:33:52,870 --> 00:33:50,780
learned to happen maybe none of those

932
00:33:55,510 --> 00:33:52,880
make sense as a problem considered in

933
00:33:57,670 --> 00:33:55,520
isolation but each of them winds up

934
00:33:59,350 --> 00:33:57,680
being part of the solution so that when

935
00:34:01,540 --> 00:33:59,360
we see them as three aspects of the same

936
00:34:02,200 --> 00:34:01,550
problem the whole thing kind of unravels

937
00:34:04,780 --> 00:34:02,210
and we can see

938
00:34:07,540 --> 00:34:04,790

clearly so I think there are many in

939
00:34:09,880 --> 00:34:07,550
this meeting who have highly expert

940
00:34:11,740 --> 00:34:09,890
perspectives on this maybe not all the

941
00:34:13,510 --> 00:34:11,750
same and I hope we can hear some of

942
00:34:15,280 --> 00:34:13,520
those brought together what they think

943
00:34:16,780 --> 00:34:15,290
the future is so thank you with this I

944
00:34:18,730 --> 00:34:16,790
want to turn over to Martin Van cran and

945
00:34:20,350 --> 00:34:18,740
ankh University of New South Wales and

946
00:34:30,700 --> 00:34:20,360
the director of the Australian Centre

947
00:34:32,170 --> 00:34:30,710
for astrobiology thanks very much Eric

948
00:34:33,580 --> 00:34:32,180
and in the panel and the selection

949
00:34:36,310 --> 00:34:33,590
committee for allowing me a couple of

950
00:34:38,830 --> 00:34:36,320
minutes to your time so I'm a geologist

951
00:34:41,860 --> 00:34:38,840
and I'm interested in environments where

952
00:34:43,540 --> 00:34:41,870
you can find complexity and I think we

953
00:34:45,130 --> 00:34:43,550
heard from Eric and from many others

954
00:34:46,630 --> 00:34:45,140
that you know the origin of life is such

955
00:34:49,510 --> 00:34:46,640
a complex problem it's probably the

956
00:34:51,370 --> 00:34:49,520
complex problem and so on earth and of

957
00:34:53,560 --> 00:34:51,380
course back into deep time where are the

958
00:34:55,270 --> 00:34:53,570
complex systems and so we've all grown

959
00:34:57,160 --> 00:34:55,280
up hearing about you know possible

960
00:34:59,980 --> 00:34:57,170
origin of life at deep-sea vents and the

961
00:35:02,320 --> 00:34:59,990
excitement about water rock interaction

962
00:35:03,790 --> 00:35:02,330
generating chemical complexity and here

963
00:35:06,010 --> 00:35:03,800

I want to sort of talk a little bit

964
00:35:08,950 --> 00:35:06,020
about you know this sort of evolving

965
00:35:11,590 --> 00:35:08,960
idea first started by Darwin that hot

966
00:35:13,300 --> 00:35:11,600
springs on land are of interest and so

967
00:35:15,130 --> 00:35:13,310
they share the same you know many of the

968
00:35:16,990 --> 00:35:15,140
same features as deep-sea vents they

969
00:35:19,170 --> 00:35:17,000
have hot water rock interaction but they

970
00:35:21,820 --> 00:35:19,180
have many benefits and hence the title

971
00:35:23,470 --> 00:35:21,830
I've got a bit ambitious with my slide

972
00:35:25,390 --> 00:35:23,480
so I'm going to go through a few of them

973
00:35:27,670 --> 00:35:25,400
quickly but one of the first key

974
00:35:29,710 --> 00:35:27,680
benefits of hot springs on land is they

975
00:35:31,090 --> 00:35:29,720
are able to undergo wet dry cycling

976
00:35:33,700 --> 00:35:31,100
which we know is important for making

977
00:35:35,350 --> 00:35:33,710
biopolymers and so we can see on the

978
00:35:37,510 --> 00:35:35,360
right-hand sort of set of slides from

979
00:35:39,580 --> 00:35:37,520
the top to bottom of wet pool drawing

980
00:35:41,860 --> 00:35:39,590
out to a very dry pool and the

981
00:35:45,460 --> 00:35:41,870
biopolymers synthesize on the margins of

982
00:35:46,810 --> 00:35:45,470
those hot springs have fresh water so

983
00:35:49,780 --> 00:35:46,820
they don't have the problem of oceans

984
00:35:52,300 --> 00:35:49,790
and being too salty another big

985
00:35:54,840 --> 00:35:52,310
component is that of course oceans are

986
00:35:57,730 --> 00:35:54,850
basically uniform dilute reservoirs and

987
00:36:00,790 --> 00:35:57,740
concentrating elements to prebiotic ly

988
00:36:03,730 --> 00:36:00,800

important ratios is difficult in oceans

989
00:36:05,260 --> 00:36:03,740
but much easier in hot springs and a key

990
00:36:08,170 --> 00:36:05,270
here is that different Springs can

991
00:36:09,940 --> 00:36:08,180
concentrate different elements another

992
00:36:11,350 --> 00:36:09,950
one as Dave Deemer and his group and

993
00:36:13,300 --> 00:36:11,360
many others have shown is that you can

994
00:36:15,970 --> 00:36:13,310
form lipid vesicles under low pH

995
00:36:18,940 --> 00:36:15,980
conditions that mimic the size and the

996
00:36:20,560 --> 00:36:18,950
structure of protocells and one of the

997
00:36:22,750 --> 00:36:20,570
things that I get most excited by is

998
00:36:25,060 --> 00:36:22,760
that Hot Springs occur in fields and

999
00:36:26,980 --> 00:36:25,070
each pool is different in its chemistry

1000
00:36:28,870 --> 00:36:26,990
its pH is temperature and they can mix

1001
00:36:31,090 --> 00:36:28,880
and match components so in terms of

1002
00:36:33,700 --> 00:36:31,100
complexity these are complexity factors

1003
00:36:36,730 --> 00:36:33,710
and so this is just an example from

1004
00:36:39,070 --> 00:36:36,740
Rotorua in New Zealand where we've got

1005
00:36:42,190 --> 00:36:39,080
champagne pool which is precipitating

1006
00:36:43,720 --> 00:36:42,200
arsenic and gold at pH neutral can you

1007
00:36:46,120 --> 00:36:43,730
know just a few meters away and

1008
00:36:50,109 --> 00:36:46,130
exchanging information with a sulphur

1009
00:36:51,550 --> 00:36:50,119
rich pool at pH 2 but the questions that

1010
00:36:53,440 --> 00:36:51,560
I'm interested in as a geologist who

1011
00:36:55,810 --> 00:36:53,450
works on early Earth is that could early

1012
00:36:57,310 --> 00:36:55,820
Earth have hosted hot springs and could

1013
00:36:59,770 --> 00:36:57,320

ancient hot springs provide the

1014
00:37:03,010 --> 00:36:59,780
necessary conditions for origin of life

1015
00:37:04,900 --> 00:37:03,020
as best we understand it so with regard

1016
00:37:06,849 --> 00:37:04,910
to that first question some have

1017
00:37:08,590 --> 00:37:06,859
suggested that hot springs are not a

1018
00:37:10,660 --> 00:37:08,600
good environment because on modern earth

1019
00:37:13,690 --> 00:37:10,670
they're basically ephemeral systems they

1020
00:37:15,580 --> 00:37:13,700
get formed in tectonic reactive areas

1021
00:37:17,440 --> 00:37:15,590
but they also get ripped apart so they

1022
00:37:19,660 --> 00:37:17,450
have durations of something like 10,000

1023
00:37:21,010 --> 00:37:19,670
maybe a million years which is pretty

1024
00:37:24,280 --> 00:37:21,020
short if you think about the complexity

1025
00:37:26,560 --> 00:37:24,290
required for origin of life but early

1026
00:37:28,720 --> 00:37:26,570
Earth was not modern earth and most

1027
00:37:31,420 --> 00:37:28,730
studies suggest that the very early

1028
00:37:33,880 --> 00:37:31,430
Earth was a stagnant lid a one plate

1029
00:37:37,900 --> 00:37:33,890
planet like our nearest neighbors and

1030
00:37:41,260 --> 00:37:37,910
that crust formed very thick crust with

1031
00:37:44,380 --> 00:37:41,270
volcanic welts and edifices and so if we

1032
00:37:47,440 --> 00:37:44,390
look at our one plate nearest neighbors

1033
00:37:49,420 --> 00:37:47,450
Venus for example are there parts of a

1034
00:37:52,660 --> 00:37:49,430
one plate planet that would stick above

1035
00:37:54,609 --> 00:37:52,670
the ocean and give exposed land surfaces

1036
00:37:56,530 --> 00:37:54,619
so here's an example of a very large

1037
00:37:58,090 --> 00:37:56,540
structure it's volcanic Li driven it's

1038
00:38:00,280 --> 00:37:58,100

called Artemis Coronas one of many

1039
00:38:02,560 --> 00:38:00,290
Coronas it sticks several kilometres

1040
00:38:04,720 --> 00:38:02,570
above the baseline elevation of Venus

1041
00:38:07,870 --> 00:38:04,730
and if there had been a global ocean it

1042
00:38:10,120 --> 00:38:07,880
would have been above water on Mars of

1043
00:38:12,400 --> 00:38:10,130
course everybody knows Olympus bonds 25

1044
00:38:15,460 --> 00:38:12,410
kilometers high long the volcanic

1045
00:38:18,460 --> 00:38:15,470
edifice on a much larger tarsus rise all

1046
00:38:19,810 --> 00:38:18,470
of which stuck above so yes you can do

1047
00:38:22,060 --> 00:38:19,820
that and if there was a hydrological

1048
00:38:23,680 --> 00:38:22,070
cycle those beautiful called gears on

1049
00:38:28,240 --> 00:38:23,690
the top of Olympus Mons would have had

1050
00:38:29,499 --> 00:38:28,250
hot springs so I'm working on some of

1051
00:38:31,719 --> 00:38:29,509
the oldest life on

1052
00:38:33,129 --> 00:38:31,729
in Western Australia we've been looking

1053
00:38:35,679 --> 00:38:33,139
at these stromatolites for many many

1054
00:38:37,659 --> 00:38:35,689
years in the dresser formation and we're

1055
00:38:39,879 --> 00:38:37,669
now really turning to understand that

1056
00:38:42,129 --> 00:38:39,889
system in terms of the elements and its

1057
00:38:43,749 --> 00:38:42,139
potential for acting as an analogue for

1058
00:38:46,779 --> 00:38:43,759
understanding what might have been an

1059
00:38:48,459 --> 00:38:46,789
origin of life sight on earth and where

1060
00:38:51,609 --> 00:38:48,469
we're going with this is that we have

1061
00:38:53,859 --> 00:38:51,619
found the stromatolites shown here in

1062
00:38:56,379 --> 00:38:53,869
purple this is the horizon where they

1063
00:38:58,809 --> 00:38:56,389

occur they sit within a succession

1064
00:39:01,149 --> 00:38:58,819
that's only a few meters thick but that

1065
00:39:03,069 --> 00:39:01,159
we have now discovered largely because

1066
00:39:05,319 --> 00:39:03,079
of the work of my student Tara dockage

1067
00:39:07,719 --> 00:39:05,329
but others as well has been part of a

1068
00:39:09,309 --> 00:39:07,729
terrestrial succession and what's

1069
00:39:11,409 --> 00:39:09,319
exciting is that if we look at that

1070
00:39:13,899 --> 00:39:11,419
terrestrial succession parts of those

1071
00:39:15,959 --> 00:39:13,909
units here a Haida leaf hydrothermally

1072
00:39:18,849 --> 00:39:15,969
Institute influenced marine carbonate

1073
00:39:21,549 --> 00:39:18,859
concentrated iron and manganese in these

1074
00:39:23,379 --> 00:39:21,559
bedded carbonate rocks here in the

1075
00:39:25,269 --> 00:39:23,389
stromatolites themselves they're sulphur

1076
00:39:27,099 --> 00:39:25,279
dyes but they have concentrations of

1077
00:39:29,349 --> 00:39:27,109
zinc they also have enrichments of

1078
00:39:31,089 --> 00:39:29,359
arsenic and molybdenum showing that

1079
00:39:33,819 --> 00:39:31,099
these elements were available in that

1080
00:39:36,039 --> 00:39:33,829
system as you go up the stratigraphy we

1081
00:39:38,229 --> 00:39:36,049
found a one to two centimeter thick

1082
00:39:41,379 --> 00:39:38,239
crust that's bearing tourmaline crystals

1083
00:39:43,899 --> 00:39:41,389
and this is a hot spring deposit that

1084
00:39:46,870 --> 00:39:43,909
was concentrating boron and then in the

1085
00:39:48,819 --> 00:39:46,880
guys right that that Tyrel found we have

1086
00:39:51,370 --> 00:39:48,829
concentrations of titanium as the

1087
00:39:53,439 --> 00:39:51,380
mineral anatase and also potassium in

1088
00:39:55,689 --> 00:39:53,449

kaolin it-- and illite in the light

1089
00:39:56,859 --> 00:39:55,699
layers through here so what we're

1090
00:39:58,599 --> 00:39:56,869
starting to develop and what's

1091
00:40:00,279 --> 00:39:58,609
interesting - sorry and then in the

1092
00:40:01,839 --> 00:40:00,289
footwall where the hydrothermal veins

1093
00:40:02,409 --> 00:40:01,849
are cutting through and providing the

1094
00:40:04,779 --> 00:40:02,419
fluids

1095
00:40:06,729 --> 00:40:04,789
there's concentrations of apatite so

1096
00:40:08,559 --> 00:40:06,739
we've got phosphorus in the in the

1097
00:40:10,389 --> 00:40:08,569
church veins and the hydrothermal

1098
00:40:12,759 --> 00:40:10,399
alteration of the footwall beautiful

1099
00:40:15,339 --> 00:40:12,769
Philippa salts here all altered to

1100
00:40:17,829 --> 00:40:15,349
potassium varying clays so I have clays

1101
00:40:19,959 --> 00:40:17,839
potassium and we can now start building

1102
00:40:22,269 --> 00:40:19,969
up the picture of what a hot spring of

1103
00:40:24,309 --> 00:40:22,279
3.5 billion years ago looked like and

1104
00:40:25,659 --> 00:40:24,319
what we're really excited about is the

1105
00:40:27,849 --> 00:40:25,669
possibility that it's able to

1106
00:40:30,549 --> 00:40:27,859
concentrate these prebiotic aliy

1107
00:40:33,609 --> 00:40:30,559
important elements potentially over

1108
00:40:35,289 --> 00:40:33,619
durations of significant time and so

1109
00:40:36,969 --> 00:40:35,299
that's kind of where our our group is

1110
00:40:39,099 --> 00:40:36,979
headed there are lots of questions in

1111
00:40:41,589 --> 00:40:39,109
this but if we think about it in terms

1112
00:40:43,059 --> 00:40:41,599
of complexity and early Earth we need to

1113
00:40:45,459 --> 00:40:43,069

start building up that kind

1114
00:40:47,140 --> 00:40:45,469
of repertoire and thinking about you

1115
00:40:50,979 --> 00:40:47,150
know how do all these various components

1116
00:40:53,079 --> 00:40:50,989
fit together in area and so we're trying

1117
00:40:55,599 --> 00:40:53,089
to understand the the variation the

1118
00:40:57,579 --> 00:40:55,609
variability and the gradients around us

1119
00:40:59,349 --> 00:40:57,589
as Laura talked about as being important

1120
00:41:00,549 --> 00:40:59,359
and so I think there are lots of

1121
00:41:03,009 --> 00:41:00,559
interesting questions that this is

1122
00:41:07,180 --> 00:41:03,019
opening up and allowing us to look in a

1123
00:41:08,529 --> 00:41:07,190
very relevant deep time analog I just

1124
00:41:10,059 --> 00:41:08,539
want to make a little quick shout out

1125
00:41:12,729 --> 00:41:10,069
that for those of you who might be

1126
00:41:15,249 --> 00:41:12,739
interested in hot springs there are two

1127
00:41:16,630 --> 00:41:15,259
special issues of astrobiology coming up

1128
00:41:19,209 --> 00:41:16,640
toward the end of the year with more

1129
00:41:22,120 --> 00:41:19,219
than 20 papers including a model on the

1130
00:41:22,539 --> 00:41:22,130
origin of life in hot springs by Bruce

1131
00:41:25,329 --> 00:41:22,549
Damer

1132
00:41:27,099 --> 00:41:25,339
and David Deamer there's stuff on the

1133
00:41:29,979 --> 00:41:27,109
Pilbara but a whole range of

1134
00:41:32,680 --> 00:41:29,989
investigations on hot springs so stay

1135
00:41:36,479 --> 00:41:32,690
tuned for that and with that I'll pass

1136
00:41:38,979 --> 00:41:36,489
over to baz quick acknowledgments and

1137
00:41:53,019 --> 00:41:38,989
pass on the baz being from University of

1138
00:41:55,900 --> 00:41:53,029

Colorado at Boulder cool okay well as

1139
00:42:01,029 --> 00:41:55,910
some of you may know and as I'm acutely

1140
00:42:04,299 --> 00:42:01,039
aware of I am NOT an expert in any of

1141
00:42:06,699 --> 00:42:04,309
this life stuff I've only been thinking

1142
00:42:09,609 --> 00:42:06,709
about it for the last couple of years so

1143
00:42:11,739 --> 00:42:09,619
if you um will sort of bear with me and

1144
00:42:14,380 --> 00:42:11,749
allow me to take this kind of idiomatic

1145
00:42:15,910 --> 00:42:14,390
approach on what I decided to do was

1146
00:42:18,249 --> 00:42:15,920
rather than sort of talk about the

1147
00:42:20,979 --> 00:42:18,259
research that we work on was talk more

1148
00:42:23,199 --> 00:42:20,989
about the lessons learned um from the

1149
00:42:27,370 --> 00:42:23,209
perspective of somebody new to this

1150
00:42:29,380 --> 00:42:27,380
field so I think the A's and the bees of

1151
00:42:31,269 --> 00:42:29,390
origin of life research are pretty clear

1152
00:42:33,699 --> 00:42:31,279
you can look around your neighbors at

1153
00:42:35,979 --> 00:42:33,709
the table next to you and realize that

1154
00:42:38,439 --> 00:42:35,989
we have a collaborative curious

1155
00:42:41,229 --> 00:42:38,449
community on that at least from my

1156
00:42:44,109 --> 00:42:41,239
perspective is exactly what's needed to

1157
00:42:46,449 --> 00:42:44,119
solve the problem of the origin of life

1158
00:42:49,479 --> 00:42:46,459
if you look along this table up here

1159
00:42:51,699 --> 00:42:49,489
it's not necessarily what we all do but

1160
00:42:54,609 --> 00:42:51,709
the impressive thing is what we have

1161
00:42:56,690 --> 00:42:54,619
done I mean Martin did you think when

1162
00:42:58,700 --> 00:42:56,700
you were mapping salt domes

1163
00:43:03,040 --> 00:42:58,710

axel Heiberg island back in the 80s that

1164
00:43:05,060 --> 00:43:03,050
you would be up here now yeah it is okay

1165
00:43:07,069 --> 00:43:05,070
but one of the hard things about

1166
00:43:09,890 --> 00:43:07,079
breaking into origin of life research I

1167
00:43:11,839 --> 00:43:09,900
found anyway is making sense of the

1168
00:43:13,430 --> 00:43:11,849
literature and this is probably an issue

1169
00:43:16,490 --> 00:43:13,440
with trying to break into it from

1170
00:43:17,810 --> 00:43:16,500
popular science books and articles but

1171
00:43:20,420 --> 00:43:17,820
it just seems like there's so many

1172
00:43:22,040 --> 00:43:20,430
recipes and scenarios and models out

1173
00:43:25,250 --> 00:43:22,050
there all of which have an incredible

1174
00:43:26,900 --> 00:43:25,260
logical internal consistency and it's

1175
00:43:28,700 --> 00:43:26,910
really hard to find the threads that you

1176
00:43:32,870 --> 00:43:28,710
want to pull out to try to try to test

1177
00:43:34,700 --> 00:43:32,880
them so for the C and D and E of origin

1178
00:43:36,680 --> 00:43:34,710
of life getting into origin of life

1179
00:43:39,140 --> 00:43:36,690
research what I want to do is talk about

1180
00:43:42,560 --> 00:43:39,150
some general perspective and lessons

1181
00:43:44,780 --> 00:43:42,570
learned that may allow for those of you

1182
00:43:49,040 --> 00:43:44,790
who want to break into the field to do

1183
00:43:51,440 --> 00:43:49,050
it so the C is pretty easy from my

1184
00:43:54,010 --> 00:43:51,450
perspective it's really nice to think

1185
00:43:56,450 --> 00:43:54,020
about constraints and broad constraints

1186
00:43:59,839 --> 00:43:56,460
celebrating broad constraints that may

1187
00:44:02,960 --> 00:43:59,849
actually allow us to rule out certain

1188
00:44:05,480 --> 00:44:02,970

scenarios models or recipes and Martin's

1189
00:44:09,700 --> 00:44:05,490
already alluded to one of these the idea

1190
00:44:13,880 --> 00:44:09,710
of when continents emerged and this is

1191
00:44:16,190 --> 00:44:13,890
the sub-aerial hot springs at about 3.45

1192
00:44:19,059 --> 00:44:16,200
that he discussed and what I've shown

1193
00:44:21,380 --> 00:44:19,069
here actually is a recent study that

1194
00:44:24,740 --> 00:44:21,390
hopefully will be coming soon to a

1195
00:44:26,690 --> 00:44:24,750
tabloid near you um where what we've

1196
00:44:29,900 --> 00:44:26,700
done is we've been able to constrain

1197
00:44:32,960 --> 00:44:29,910
what the Oh 18 Oh 16 ratio of the ocean

1198
00:44:35,240 --> 00:44:32,970
was slightly younger than these

1199
00:44:37,460 --> 00:44:35,250
sub-aerial hot springs and what it

1200
00:44:39,890 --> 00:44:37,470
suggests is that at least from the broad

1201
00:44:42,710 --> 00:44:39,900
perspective of oceanic water cycling

1202
00:44:45,349 --> 00:44:42,720
there weren't a huge number a great mass

1203
00:44:47,920 --> 00:44:45,359
of emergent continents and this isn't to

1204
00:44:50,420 --> 00:44:47,930
say that it's contradicting the

1205
00:44:52,520 --> 00:44:50,430
geological evidence that Martin showed

1206
00:44:54,200 --> 00:44:52,530
us but rather what it's doing is it's

1207
00:44:56,300 --> 00:44:54,210
complementing that because geology you

1208
00:44:58,130 --> 00:44:56,310
like to think of as a snapshot whereas

1209
00:45:00,530 --> 00:44:58,140
your chemistry is more like a Palin set

1210
00:45:03,940 --> 00:45:00,540
that allows you to look back in time and

1211
00:45:07,309 --> 00:45:03,950
integrates over a long history of events

1212
00:45:10,130 --> 00:45:07,319
the history the duration of that history

1213
00:45:14,509 --> 00:45:10,140

is as long as the reservoir that

1214
00:45:18,200 --> 00:45:14,519
chemical tracer is acting in and so this

1215
00:45:20,630 --> 00:45:18,210
is some work that Ben Johnson current

1216
00:45:22,579 --> 00:45:20,640
postdoc at CU future faculty member at

1217
00:45:24,259 --> 00:45:22,589
Iowa State has done I'm sure he'd be

1218
00:45:27,019 --> 00:45:24,269
glad if you reached out to him on

1219
00:45:30,650 --> 00:45:27,029
Twitter and asked him about it okay the

1220
00:45:32,120 --> 00:45:30,660
DS have to do with don't worry just do

1221
00:45:34,640 --> 00:45:32,130
it oftentimes when we think about

1222
00:45:36,200 --> 00:45:34,650
scenarios and models and recipes what we

1223
00:45:38,630 --> 00:45:36,210
try to do is we try to add make things

1224
00:45:41,660 --> 00:45:38,640
realistic or go ahead and test one

1225
00:45:43,519 --> 00:45:41,670
specific aspect of it and and actually I

1226
00:45:46,730 --> 00:45:43,529
think that's kind of limiting and an

1227
00:45:50,150 --> 00:45:46,740
example of don't worry just do it is a

1228
00:45:52,370 --> 00:45:50,160
great experiment that laura rodriguez

1229
00:45:54,769 --> 00:45:52,380
did when she was a PhD student with

1230
00:45:56,240 --> 00:45:54,779
chris house at Penn State and I'm not

1231
00:45:59,299 --> 00:45:56,250
going to go through this in any detail

1232
00:46:00,950 --> 00:45:59,309
except to say that the experiment

1233
00:46:02,660 --> 00:46:00,960
started by generating chemical

1234
00:46:04,730 --> 00:46:02,670
complexity in a spark discharge

1235
00:46:06,890 --> 00:46:04,740
apparatus and I don't know if anybody

1236
00:46:09,410 --> 00:46:06,900
thinks that spark discharge apurate

1237
00:46:11,660 --> 00:46:09,420
are good analogues for origin of life

1238
00:46:13,700 --> 00:46:11,670

anymore but they are good ways to

1239
00:46:15,890 --> 00:46:13,710
generate a large amount of chemical

1240
00:46:18,259 --> 00:46:15,900
complexity and the punchline here I'll

1241
00:46:20,180 --> 00:46:18,269
let Laura tell you about you can find

1242
00:46:21,620 --> 00:46:20,190
her here you can writer or you can wait

1243
00:46:23,599 --> 00:46:21,630
for the paper to come out which i think

1244
00:46:26,690 --> 00:46:23,609
is going to be in a couple of weeks

1245
00:46:28,220 --> 00:46:26,700
finally let's look at the ease okay one

1246
00:46:29,749 --> 00:46:28,230
of the great things about coming into a

1247
00:46:32,509 --> 00:46:29,759
new field is that you learn new

1248
00:46:34,339 --> 00:46:32,519
vocabulary things like exaptation and

1249
00:46:36,620 --> 00:46:34,349
what I don't mean here is the biological

1250
00:46:38,569 --> 00:46:36,630
definition of X application but what our

1251
00:46:41,269 --> 00:46:38,579
colleague David bound would call the

1252
00:46:43,870 --> 00:46:41,279
cultural definition of exaptation tools

1253
00:46:46,730 --> 00:46:43,880
techniques theories or models that found

1254
00:46:49,160 --> 00:46:46,740
function in one field see if we can take

1255
00:46:51,259 --> 00:46:49,170
them and use them in a new way in a

1256
00:46:53,900 --> 00:46:51,269
really fantastic example of that you're

1257
00:46:57,130 --> 00:46:53,910
going to hear about this afternoon at a

1258
00:47:00,079 --> 00:46:57,140
talk by Lena Vincent here is Lena's

1259
00:47:02,900 --> 00:47:00,089
Twitter handle if you want to tweet at

1260
00:47:06,380 --> 00:47:02,910
her after this and really the idea is

1261
00:47:08,900 --> 00:47:06,390
taking this well-honed concept from

1262
00:47:11,390 --> 00:47:08,910
microbial experimental evolution where

1263
00:47:14,120 --> 00:47:11,400

if you have cereal transfer over a

1264
00:47:16,460 --> 00:47:14,130
number of generations successful mutants

1265
00:47:19,249 --> 00:47:16,470
are inevitable and applying it not to a

1266
00:47:21,769 --> 00:47:19,259
biological system but to an a biological

1267
00:47:23,809 --> 00:47:21,779
system and I will let Lena

1268
00:47:24,380 --> 00:47:23,819
talk to you this afternoon about what

1269
00:47:26,390 --> 00:47:24,390
these pea

1270
00:47:29,090 --> 00:47:26,400
and valleys represent but suffice to say

1271
00:47:30,850 --> 00:47:29,100
it has to do with these awesome patterns

1272
00:47:33,830 --> 00:47:30,860
that you're seeing here this really is

1273
00:47:36,050 --> 00:47:33,840
chemical and mineral evolution in action

1274
00:47:40,700 --> 00:47:36,060
so there we are

1275
00:47:42,380 --> 00:47:40,710
the ABCs DS and E's of an introduction

1276
00:47:44,660 --> 00:47:42,390
to origin of life research and I'm sure

1277
00:47:46,490 --> 00:47:44,670
that you all will have your own versions

1278
00:47:59,930 --> 00:47:46,500
of these and I hope that we can discuss

1279
00:48:02,840 --> 00:47:59,940
them I'm a big fan of the George S

1280
00:48:04,670 --> 00:48:02,850
Patton school of organizational

1281
00:48:06,710 --> 00:48:04,680
psychology which is never tell people

1282
00:48:08,840 --> 00:48:06,720
how to do something just tell me what

1283
00:48:11,480 --> 00:48:08,850
you need done and they'll surprise you

1284
00:48:12,590 --> 00:48:11,490
with their ingenuity right but I would

1285
00:48:14,540 --> 00:48:12,600
like to take a few minutes if there's

1286
00:48:18,980 --> 00:48:14,550
anything you guys would like to comment

1287
00:48:24,650 --> 00:48:18,990
on about each other's presentations this

1288
00:48:26,870 --> 00:48:24,660

would be the time to do it and then at

1289
00:48:35,480 --> 00:48:26,880
that then let's move on to to audience

1290
00:48:40,560 --> 00:48:38,220
all right I'm gonna I'm gonna make a

1291
00:48:44,300 --> 00:48:40,570
point then so this question of

1292
00:48:47,070 --> 00:48:44,310
sub-aerial hot springs seems that very

1293
00:48:48,660 --> 00:48:47,080
it would rule out most of the other

1294
00:48:52,620 --> 00:48:48,670
places in our solar system that we're

1295
00:49:03,000 --> 00:48:52,630
looking for life right how strongly do

1296
00:49:05,520 --> 00:49:03,010
you feel about that listen as I said I

1297
00:49:08,940 --> 00:49:05,530
come to it from a point of view of

1298
00:49:11,160 --> 00:49:08,950
developing complexity and I think we

1299
00:49:13,830 --> 00:49:11,170
have to be aware of the fact that you

1300
00:49:15,750 --> 00:49:13,840
know some ideas are are testable and and

1301
00:49:18,030 --> 00:49:15,760
I think as as Eric was saying you know

1302
00:49:19,530 --> 00:49:18,040
it takes such a huge community to

1303
00:49:21,030 --> 00:49:19,540
develop the resources and that's what

1304
00:49:23,910 --> 00:49:21,040
we're doing here to really investigate

1305
00:49:25,590 --> 00:49:23,920
these systems and it's the evolution of

1306
00:49:27,480 --> 00:49:25,600
systems and I think at some point you

1307
00:49:29,730 --> 00:49:27,490
have to start to try and understand

1308
00:49:34,320 --> 00:49:29,740
where the breaking points are like how

1309
00:49:35,550 --> 00:49:34,330
far can a system go and you can do and

1310
00:49:38,310 --> 00:49:35,560
we've heard you know there's some

1311
00:49:40,860 --> 00:49:38,320
beautiful examples of we can go so far

1312
00:49:42,720 --> 00:49:40,870
and get product ABCD in the system but

1313
00:49:45,870 --> 00:49:42,730

maybe a system is limited to those

1314
00:49:47,790 --> 00:49:45,880
products and I think one thing we need

1315
00:49:50,040 --> 00:49:47,800
to start thinking about and of course

1316
00:49:51,930 --> 00:49:50,050
many people are already but you know is

1317
00:49:54,450 --> 00:49:51,940
are there systems or do we have to

1318
00:49:58,050 --> 00:49:54,460
transfer systems or do we have to think

1319
00:50:00,090 --> 00:49:58,060
about mixing systems and I guess from my

1320
00:50:02,580 --> 00:50:00,100
point of view that the beauty of Hot

1321
00:50:04,590 --> 00:50:02,590
Springs is that you know there are 100

1322
00:50:08,210 --> 00:50:04,600
different systems and they change hourly

1323
00:50:10,590 --> 00:50:08,220
you know seasonally daily whatever and

1324
00:50:12,750 --> 00:50:10,600
so for me and just in terms of thinking

1325
00:50:15,090 --> 00:50:12,760
about complexity and mixing components

1326
00:50:17,520 --> 00:50:15,100
and generating you know compound a over

1327
00:50:20,640 --> 00:50:17,530
here and lipid membrane B over there and

1328
00:50:23,430 --> 00:50:20,650
it's just it's just from that point of

1329
00:50:26,460 --> 00:50:23,440
view I didn't want to get into the idea

1330
00:50:28,860 --> 00:50:26,470
of what that means for astrobiology and

1331
00:50:31,620 --> 00:50:28,870
exploring other planets but you know it

1332
00:50:33,120 --> 00:50:31,630
does have some profound consequences but

1333
00:50:35,310 --> 00:50:33,130
we have to be certain that that's

1334
00:50:37,170 --> 00:50:35,320
correct and of course we're not so I

1335
00:50:40,050 --> 00:50:37,180
don't think we're at the stage where you

1336
00:50:41,670 --> 00:50:40,060
can say yes or no to any exploration any

1337
00:50:44,460 --> 00:50:41,680
exploration is good and as we heard

1338
00:50:47,270 --> 00:50:44,470

we'll learn more about parts of those

1339
00:50:48,380 --> 00:50:47,280
systems if we go to anywhere because

1340
00:50:50,270 --> 00:50:48,390
every time we go somewhere new we

1341
00:50:52,520 --> 00:50:50,280
learned something so you know there's

1342
00:50:54,950 --> 00:50:52,530
incredible value in exploring systems

1343
00:50:57,440 --> 00:50:54,960
whether we think they're our preferred

1344
00:50:58,850 --> 00:50:57,450
one or not our preferred one because

1345
00:51:01,940 --> 00:50:58,860
we're gonna keep learning and that's

1346
00:51:04,070 --> 00:51:01,950
what this business is all about so yeah

1347
00:51:06,500 --> 00:51:04,080
I've got my preferences and you know I'm

1348
00:51:08,480 --> 00:51:06,510
interested to get feedback from from the

1349
00:51:10,010 --> 00:51:08,490
community and and put those ideas up

1350
00:51:13,010 --> 00:51:10,020
there because they're testable and

1351
00:51:14,810 --> 00:51:13,020
that's what we need to do so it's just

1352
00:51:16,640 --> 00:51:14,820
another step along the way of providing

1353
00:51:20,120 --> 00:51:16,650
some ideas for people to follow up on

1354
00:51:22,040 --> 00:51:20,130
and and generate new interactions and

1355
00:51:23,960 --> 00:51:22,050
working with people in different fields

1356
00:51:27,580 --> 00:51:23,970
and so you know I think what what Boz

1357
00:51:31,010 --> 00:51:27,590
was saying is with the abcdes

1358
00:51:32,960 --> 00:51:31,020
part of it is that embracing experiments

1359
00:51:36,200 --> 00:51:32,970
and then looking outside your particular

1360
00:51:38,210 --> 00:51:36,210
discipline and getting ideas and taking

1361
00:51:51,440 --> 00:51:38,220
those and yeah all the time we're making

1362
00:51:56,030 --> 00:51:53,330
Vladimir Putin NASA Goddard Space Flight

1363
00:51:58,430 --> 00:51:56,040

Center so I want to share my perspective

1364
00:52:00,590 --> 00:51:58,440
and an astrophysicist and Helio

1365
00:52:03,200 --> 00:52:00,600
physicist an astrobiologist on the

1366
00:52:06,590 --> 00:52:03,210
origin of life so I want to comment on a

1367
00:52:09,160 --> 00:52:06,600
and B an astrobiology normally when we

1368
00:52:12,830 --> 00:52:09,170
say astrobiology we mean that the

1369
00:52:14,510 --> 00:52:12,840
biology the distribution original

1370
00:52:16,820 --> 00:52:14,520
distribution life of the universe and

1371
00:52:18,980 --> 00:52:16,830
the Astro means universe but actually I

1372
00:52:21,680 --> 00:52:18,990
think that the Astro means Astra from

1373
00:52:23,900 --> 00:52:21,690
stellar it's basically maybe reflecting

1374
00:52:27,830 --> 00:52:23,910
the intimate relation between the our

1375
00:52:30,380 --> 00:52:27,840
Sun and the planet so the stellar

1376
00:52:32,570 --> 00:52:30,390
evolution as we learned goes you know

1377
00:52:35,390 --> 00:52:32,580
shoulder-to-shoulder with the planetary

1378
00:52:37,700 --> 00:52:35,400
evolution so the question and and and

1379
00:52:40,430 --> 00:52:37,710
that the we will learn over the last few

1380
00:52:41,450 --> 00:52:40,440
years that the Stars provide a huge

1381
00:52:45,590 --> 00:52:41,460
amount of energy

1382
00:52:48,290 --> 00:52:45,600
ionizing radiation that may provoke the

1383
00:52:51,140 --> 00:52:48,300
formation of the you know building

1384
00:52:54,200 --> 00:52:51,150
blocks of provider chemistry and I

1385
00:52:57,290 --> 00:52:54,210
didn't see actually the Sun and the

1386
00:53:01,250 --> 00:52:57,300
solar radiation on this picture

1387
00:53:07,700 --> 00:53:01,260
andhe's chemical evolution which

1388
00:53:09,170 --> 00:53:07,710

probably a missing link yeah I mean

1389
00:53:11,750 --> 00:53:09,180
that's definitely an important part of

1390
00:53:12,470 --> 00:53:11,760
it and the the picture is just to get us

1391
00:53:14,270 --> 00:53:12,480
thinking about all the different

1392
00:53:16,640 --> 00:53:14,280
environment it's not totally inclusive

1393
00:53:19,430 --> 00:53:16,650
but yeah it's really important to think

1394
00:53:21,440 --> 00:53:19,440
about that interplay between their sign

1395
00:53:26,050 --> 00:53:21,450
and now their environments where they're

1396
00:53:32,090 --> 00:53:28,970
Carl Pilcher Blue Marble space institute

1397
00:53:34,540 --> 00:53:32,100
of science this is a great topic and a

1398
00:53:36,560 --> 00:53:34,550
great panel to address the topic I've

1399
00:53:39,080 --> 00:53:36,570
heard it said that there were three

1400
00:53:42,020 --> 00:53:39,090
great questions that confront us as

1401
00:53:44,360 --> 00:53:42,030
inquiring beings and that is the origin

1402
00:53:47,960 --> 00:53:44,370
of the universe the origin of life and

1403
00:53:50,140 --> 00:53:47,970
the origin of consciousness and looking

1404
00:53:54,350 --> 00:53:50,150
at this question of the origin of life

1405
00:53:56,600 --> 00:53:54,360
in that context the question comes up

1406
00:53:59,570 --> 00:53:56,610
not only did how did life arise on earth

1407
00:54:02,330 --> 00:53:59,580
but why did life arise on earth and Eric

1408
00:54:05,030 --> 00:54:02,340
alluded to that in his comments when he

1409
00:54:08,480 --> 00:54:05,040
quoted Sarah Walker quoting David

1410
00:54:11,150 --> 00:54:08,490
Grinspoon that life happens to a planet

1411
00:54:14,960 --> 00:54:11,160
rather than on a planet and Eric was too

1412
00:54:17,330 --> 00:54:14,970
modest to note that Sarah quoted David

1413
00:54:19,970 --> 00:54:17,340

in a review of Eric and Harald Mara with

1414
00:54:21,590 --> 00:54:19,980
his marvelous book which anybody in this

1415
00:54:23,690 --> 00:54:21,600
audience who doesn't have a copy of it

1416
00:54:27,650 --> 00:54:23,700
really ought to get one and spend some

1417
00:54:30,800 --> 00:54:27,660
time with him so my question to you is

1418
00:54:33,950 --> 00:54:30,810
if if in with that is a sort of context

1419
00:54:38,480 --> 00:54:33,960
if this were an Oxford style debate and

1420
00:54:41,860 --> 00:54:38,490
the question on the table was life is an

1421
00:54:44,120 --> 00:54:41,870
natural organizational state of matter

1422
00:54:48,810 --> 00:54:44,130
what would be your positions in the

1423
00:54:57,540 --> 00:54:55,890
I mean I'm gonna say something small

1424
00:54:58,980 --> 00:54:57,550
because I we've had the beginnings of

1425
00:55:00,480 --> 00:54:58,990
this conversation before and I know

1426
00:55:02,610 --> 00:55:00,490
there are several people who sort of

1427
00:55:04,140 --> 00:55:02,620
independently have arrived at the same

1428
00:55:07,740 --> 00:55:04,150
point of view and are looking for how to

1429
00:55:09,930 --> 00:55:07,750
push it forward we we are two state

1430
00:55:12,900 --> 00:55:09,940
dominated in our thinking and we are not

1431
00:55:15,330 --> 00:55:12,910
process oriented enough and one of the

1432
00:55:18,000 --> 00:55:15,340
things that for a theoretician makes the

1433
00:55:20,940 --> 00:55:18,010
living state interesting is that the

1434
00:55:24,030 --> 00:55:20,950
problem is not only and maybe not

1435
00:55:25,950 --> 00:55:24,040
principally a problem of understanding

1436
00:55:28,830 --> 00:55:25,960
the organization of matter in States

1437
00:55:32,730 --> 00:55:28,840
rather it's a problem of understanding

1438
00:55:38,160 --> 00:55:32,740

the organization of events in regularity

1439
00:55:40,470 --> 00:55:38,170
of processes and that's an area where we

1440
00:55:41,850 --> 00:55:40,480
can make enough analogies to things that

1441
00:55:45,150 --> 00:55:41,860
are well understood that we're not

1442
00:55:47,100 --> 00:55:45,160
without tools but I expect that in this

1443
00:55:48,900 --> 00:55:47,110
new menagerie there's gonna be a lot

1444
00:55:51,000 --> 00:55:48,910
that we have never seen before in our

1445
00:55:53,130 --> 00:55:51,010
understanding of States so it's both

1446
00:55:56,040 --> 00:55:53,140
empirically and also theoretically a

1447
00:55:59,760 --> 00:55:56,050
really appealing direction to go into

1448
00:56:05,810 --> 00:55:59,770
and I would just you know I've spoken to

1449
00:56:08,640 --> 00:56:05,820
Alexis about this in the past sort of a

1450
00:56:11,670 --> 00:56:08,650
theory of the organization of processes

1451
00:56:14,310 --> 00:56:11,680
as the mindset for thinking about origin

1452
00:56:19,380 --> 00:56:14,320
of life it's just a nice direction to go

1453
00:56:27,840 --> 00:56:19,390
from a lot of perspectives yeah this is

1454
00:56:30,260 --> 00:56:27,850
multi gree party JBL what we know by the

1455
00:56:34,740 --> 00:56:30,270
way there was a tremendous amount of

1456
00:56:38,070 --> 00:56:34,750
advancement of our understanding of how

1457
00:56:39,600 --> 00:56:38,080
life could have evolved I want to

1458
00:56:42,420 --> 00:56:39,610
congratulate the whole community for

1459
00:56:46,410 --> 00:56:42,430
that before I go into my comments so

1460
00:56:48,900 --> 00:56:46,420
what we know today is the precursors of

1461
00:56:52,260 --> 00:56:48,910
life they're everywhere they're as jamie

1462
00:56:55,290 --> 00:56:52,270
pointed out and what we know is that

1463
00:56:58,890 --> 00:56:55,300

there is life on earth we all know that

1464
00:57:02,370 --> 00:56:58,900
and what we don't know is where there is

1465
00:57:05,280 --> 00:57:02,380
life elsewhere and what we don't know

1466
00:57:08,840 --> 00:57:05,290
is how the precursors of precursors of

1467
00:57:12,570 --> 00:57:08,850
life have evolved to life on this planet

1468
00:57:15,690 --> 00:57:12,580
keeping these points in mind it reminds

1469
00:57:19,950 --> 00:57:15,700
me that we are in a situation like gold

1470
00:57:23,670 --> 00:57:19,960
rush some time ago the king with limited

1471
00:57:27,960 --> 00:57:23,680
tools from trying to find out whether we

1472
00:57:32,310 --> 00:57:27,970
can hit the gold or not and so what we

1473
00:57:35,220 --> 00:57:32,320
should do is adapt a policy of pluralism

1474
00:57:38,250 --> 00:57:35,230
in other words let everyone take in

1475
00:57:41,790 --> 00:57:38,260
every place rather than to say that my

1476
00:57:45,180 --> 00:57:41,800
religion is the religion and my way is

1477
00:57:47,160 --> 00:57:45,190
the way and by the way people who who

1478
00:57:49,500 --> 00:57:47,170
were digging gold became actually

1479
00:57:53,480 --> 00:57:49,510
lunatics sometimes because they didn't

1480
00:57:57,060 --> 00:57:53,490
get and unfortunately I have also seen

1481
00:58:00,000 --> 00:57:57,070
my beloved Co you know scientists

1482
00:58:03,770 --> 00:58:00,010
becoming so engrossed in their belief

1483
00:58:07,290 --> 00:58:03,780
system so what I wanted to say here is

1484
00:58:09,750 --> 00:58:07,300
the path forward to understand the

1485
00:58:12,420 --> 00:58:09,760
origin of life on Earth and probably

1486
00:58:15,510 --> 00:58:12,430
potentially life elsewhere is to adapt

1487
00:58:18,240 --> 00:58:15,520
the pluralism and let us move forward

1488
00:58:20,010 --> 00:58:18,250

and try to understand we may not be able

1489
00:58:22,350 --> 00:58:20,020
to answer these questions in several

1490
00:58:32,880 --> 00:58:22,360
lifetimes to come but let's not give it

1491
00:58:35,430 --> 00:58:32,890
up thank you oh hi I'm Stuart Bala from

1492
00:58:36,840 --> 00:58:35,440
Caltech and I just wanted to ask a

1493
00:58:40,380 --> 00:58:36,850
couple of questions about our

1494
00:58:42,360 --> 00:58:40,390
philosophical approach and about a an

1495
00:58:44,910 --> 00:58:42,370
example sort of paradigm shift that

1496
00:58:46,350 --> 00:58:44,920
happened in machine learning so for a

1497
00:58:50,820 --> 00:58:46,360
little I mean I'm not a machine learning

1498
00:58:53,910 --> 00:58:50,830
expert but for a while machine learning

1499
00:58:55,710 --> 00:58:53,920
algorithms were evolved mostly by a kind

1500
00:58:58,440 --> 00:58:55,720
of hill climbing algorithm so you have

1501
00:59:00,720 --> 00:58:58,450
some target function and and you have

1502
00:59:02,190 --> 00:59:00,730
your system at once day and you can't

1503
00:59:04,980 --> 00:59:02,200
you change things and whenever you

1504
00:59:07,020 --> 00:59:04,990
change things with a slight improvement

1505
00:59:11,010 --> 00:59:07,030
in function you adopt that and you sort

1506
00:59:14,340 --> 00:59:11,020
of you know move up a hill in some in

1507
00:59:16,140 --> 00:59:14,350
some kind of landscape and this this

1508
00:59:18,360 --> 00:59:16,150
kind of worked ok but not but

1509
00:59:20,480 --> 00:59:18,370
not always particularly well and more

1510
00:59:24,240 --> 00:59:20,490
recently in the last or 10 years or so

1511
00:59:26,400 --> 00:59:24,250
this technique called novelty search has

1512
00:59:29,760 --> 00:59:26,410
enjoyed a lot of success where when

1513
00:59:32,880 --> 00:59:29,770

you're modifying your your network or

1514
00:59:37,580 --> 00:59:32,890
your system instead of optimizing for

1515
00:59:40,680 --> 00:59:37,590
increases in function you optimize for

1516
00:59:42,750 --> 00:59:40,690
increases in novelty and the problem

1517
00:59:44,910 --> 00:59:42,760
with the objective based approach is

1518
00:59:47,310 --> 00:59:44,920
that often you end up in in dead ends

1519
00:59:50,040 --> 00:59:47,320
whereas with novelty search you you

1520
00:59:52,680 --> 00:59:50,050
explore the space and and and you do a

1521
00:59:54,840 --> 00:59:52,690
lot more discovery and in the community

1522
00:59:57,030 --> 00:59:54,850
they found that novelty search can be

1523
00:59:59,400 --> 00:59:57,040
much much more effective at finding

1524
01:00:03,480 --> 00:59:59,410
solutions to complex problems than

1525
01:00:06,660 --> 01:00:03,490
simple hill climbing techniques so it

1526
01:00:08,790 --> 01:00:06,670
strikes me that this might apply to the

1527
01:00:10,460 --> 01:00:08,800
origin of life because often you know

1528
01:00:14,490 --> 01:00:10,470
whether it's our lab systems or our

1529
01:00:15,450 --> 01:00:14,500
model systems when we see when we see

1530
01:00:19,440 --> 01:00:15,460
some change

1531
01:00:21,690 --> 01:00:19,450
that's incrementally more like life as

1532
01:00:23,010 --> 01:00:21,700
we recognize it we think oh that's good

1533
01:00:25,710 --> 01:00:23,020
and we sort of keep moving in that

1534
01:00:28,650 --> 01:00:25,720
direction but we have no guarantee that

1535
01:00:31,560 --> 01:00:28,660
when when life is complexified that it

1536
01:00:34,880 --> 01:00:31,570
actually works like that and so my

1537
01:00:38,280 --> 01:00:34,890
question is whether we should also

1538
01:00:40,500 --> 01:00:38,290

accept sort of a novelty search

1539
01:00:44,610 --> 01:00:40,510
philosophy when we're exploring our

1540
01:00:47,280 --> 01:00:44,620
systems so so we just allow the system

1541
01:00:50,910 --> 01:00:47,290
to do things which are different rather

1542
01:00:52,860 --> 01:00:50,920
than just more like what we're expecting

1543
01:00:56,390 --> 01:00:52,870
because what we're expecting might be

1544
01:01:02,520 --> 01:00:56,400
wrong and in another sense I also wonder

1545
01:01:04,430 --> 01:01:02,530
whether in the sense of getting ideas

1546
01:01:06,420 --> 01:01:04,440
from different disciplines whether

1547
01:01:10,050 --> 01:01:06,430
understanding the origin of life we

1548
01:01:13,770 --> 01:01:10,060
might have to work or study in different

1549
01:01:19,760 --> 01:01:13,780
disciplines completely yeah I just

1550
01:01:26,150 --> 01:01:23,660
I feel like Lee Cronin is probably the

1551
01:01:28,520 --> 01:01:26,160
most energetic spokesman for that point

1552
01:01:30,380 --> 01:01:28,530
of view that I know of in the room and I

1553
01:01:33,020 --> 01:01:30,390
think he would say that there are

1554
01:01:35,210 --> 01:01:33,030
versions of that that are good to do and

1555
01:01:37,040 --> 01:01:35,220
that are being pursued right now very

1556
01:01:44,800 --> 01:01:37,050
much in the spirit of what you suggest

1557
01:01:51,350 --> 01:01:47,660
hi Sara Mauer Central Connecticut State

1558
01:01:54,280 --> 01:01:51,360
University I heard some of you use the

1559
01:01:58,190 --> 01:01:54,290
term complexity to describe diverse

1560
01:02:00,740 --> 01:01:58,200
molecular chemistry and I guess I'm kind

1561
01:02:04,700 --> 01:02:00,750
of curious as to whether this is a just

1562
01:02:07,450 --> 01:02:04,710
a definitional issue but is a mixture of

1563
01:02:10,820 --> 01:02:07,460

chemicals that has a large diversity

1564
01:02:13,010 --> 01:02:10,830
actually complex or is complexity

1565
01:02:15,890 --> 01:02:13,020
something more like life where we limit

1566
01:02:18,530 --> 01:02:15,900
molecular diversity and we have more

1567
01:02:20,840 --> 01:02:18,540
complex reactions going on or something

1568
01:02:23,750 --> 01:02:20,850
that's different than actual diversity

1569
01:02:26,900 --> 01:02:23,760
and so when we're using the term

1570
01:02:29,510 --> 01:02:26,910
complexity does that include all diverse

1571
01:02:33,200 --> 01:02:29,520
systems or is it a specific subset of

1572
01:02:35,540 --> 01:02:33,210
those systems I think that's a really

1573
01:02:37,070 --> 01:02:35,550
interesting point to think about because

1574
01:02:38,750 --> 01:02:37,080
I think people do use complexity in

1575
01:02:40,940 --> 01:02:38,760
different ways here you know I tend to

1576
01:02:44,060 --> 01:02:40,950
be looking at the organic inventory of

1577
01:02:46,160 --> 01:02:44,070
prebiotic chemistry and I when I talk

1578
01:02:48,380 --> 01:02:46,170
about a complex meteorite extract I mean

1579
01:02:50,690 --> 01:02:48,390
it has millions of compounds in it and

1580
01:02:52,670 --> 01:02:50,700
trying to understand the interplay of

1581
01:02:55,070 --> 01:02:52,680
reactions that led to that is a complex

1582
01:02:56,359 --> 01:02:55,080
system but then there's other ways of

1583
01:02:58,220 --> 01:02:56,369
looking at complexity that means you're

1584
01:03:00,740 --> 01:02:58,230
getting to more and more complex

1585
01:03:02,540 --> 01:03:00,750
molecules complex systems things that

1586
01:03:04,400 --> 01:03:02,550
you know that are more biologically

1587
01:03:06,320 --> 01:03:04,410
complex and so I think it's being used

1588
01:03:08,960 --> 01:03:06,330

both ways in the community right now and

1589
01:03:09,950 --> 01:03:08,970
that's a really good point that it that

1590
01:03:11,990 --> 01:03:09,960
that's a word that means different

1591
01:03:13,790 --> 01:03:12,000
things in different contexts different

1592
01:03:17,750 --> 01:03:13,800
conversations and it's good to be aware

1593
01:03:19,550 --> 01:03:17,760
of that I'll comment on that too so it

1594
01:03:21,440 --> 01:03:19,560
you're right that you can get a huge

1595
01:03:23,330 --> 01:03:21,450
diversity of compounds it's pretty easy

1596
01:03:25,280 --> 01:03:23,340
in a mineral organic experiment to get

1597
01:03:26,990 --> 01:03:25,290
all sorts of products and the issue is

1598
01:03:28,820 --> 01:03:27,000
actually trying to pare down the side

1599
01:03:30,620 --> 01:03:28,830
reactions and so you don't want to you

1600
01:03:32,450 --> 01:03:30,630
know always focus on the thing you're

1601
01:03:33,170 --> 01:03:32,460
trying to make because that also can be

1602
01:03:35,569 --> 01:03:33,180
wrong if you're not

1603
01:03:37,520 --> 01:03:35,579
to make the right thing but it just

1604
01:03:38,690 --> 01:03:37,530
having a whole bunch of products doesn't

1605
01:03:40,040 --> 01:03:38,700
mean that you're gonna get to life you

1606
01:03:42,109 --> 01:03:40,050
need to be able to direct the reaction

1607
01:03:43,760 --> 01:03:42,119
towards something and an enzyme can do

1608
01:03:45,410 --> 01:03:43,770
that and life does this very well and

1609
01:03:46,640 --> 01:03:45,420
you need to be able to connect these you

1610
01:03:48,530 --> 01:03:46,650
know connect these dots of different

1611
01:03:50,569 --> 01:03:48,540
reactions and so part of what we do in

1612
01:03:52,400 --> 01:03:50,579
experiments is trying to find a biotic

1613
01:03:53,870 --> 01:03:52,410

versions of this but you do have to cut

1614
01:03:54,890 --> 01:03:53,880
down on side products otherwise that's

1615
01:04:03,260 --> 01:03:54,900
kicking it can be very hard to go

1616
01:04:05,329 --> 01:04:03,270
forward there's a very nice paper

1617
01:04:07,280 --> 01:04:05,339
written by Bob Hazen and Jack szostak

1618
01:04:09,200 --> 01:04:07,290
Patrick Griffin I forget who the fourth

1619
01:04:12,079 --> 01:04:09,210
author was but on the concept of

1620
01:04:13,819 --> 01:04:12,089
functional complexity where the

1621
01:04:15,650 --> 01:04:13,829
components of a system can be very

1622
01:04:20,990 --> 01:04:15,660
simple but the function of the system

1623
01:04:23,150 --> 01:04:21,000
can be very complex so it matters he'll

1624
01:04:26,359 --> 01:04:23,160
enhance bus Santa Barbara and I want to

1625
01:04:29,329 --> 01:04:26,369
ask Martin how do to remind us how we

1626
01:04:35,180 --> 01:04:29,339
know that the pill the dresser formation

1627
01:04:37,190 --> 01:04:35,190
started out above sea level so it didn't

1628
01:04:39,230 --> 01:04:37,200
start out above sea level it's actually

1629
01:04:41,480 --> 01:04:39,240
quite a lovely story if you look at the

1630
01:04:44,030 --> 01:04:41,490
sequence it's all pillow basalts

1631
01:04:47,059 --> 01:04:44,040
submarine below and you can see it shows

1632
01:04:49,130 --> 01:04:47,069
a slow shallowing that's hard to say in

1633
01:04:51,289 --> 01:04:49,140
the morning that's slow shallowing of

1634
01:04:53,870 --> 01:04:51,299
the stir ticker fee until you get to

1635
01:04:56,299 --> 01:04:53,880
these very distinctive hot spring

1636
01:04:58,460 --> 01:04:56,309
deposits this guy's right which is well

1637
01:05:01,130 --> 01:04:58,470
known from modern environments and does

1638
01:05:02,930 --> 01:05:01,140

not form in submarine and we've got

1639
01:05:05,599 --> 01:05:02,940
desiccation cracks we've got ripples

1640
01:05:08,089 --> 01:05:05,609
there's a whole variety of information

1641
01:05:10,789 --> 01:05:08,099
in the sedimentary sequence that it

1642
01:05:13,130 --> 01:05:10,799
actually becomes emergent and then it

1643
01:05:14,750 --> 01:05:13,140
subsides again so we're working on a

1644
01:05:16,460 --> 01:05:14,760
paper that we want to call the rise and

1645
01:05:18,530 --> 01:05:16,470
fall of early life because it looks like

1646
01:05:21,490 --> 01:05:18,540
it's actually driven by pulses of

1647
01:05:24,559 --> 01:05:21,500
magmatic inflation and deflation that

1648
01:05:26,780 --> 01:05:24,569
brings the surface up to an exposed

1649
01:05:29,660 --> 01:05:26,790
condition and so that's of course our

1650
01:05:31,250 --> 01:05:29,670
3.5 that's already way past you know the

1651
01:05:32,450 --> 01:05:31,260
starting point when the crustal

1652
01:05:35,120 --> 01:05:32,460
configuration may have been much

1653
01:05:38,180 --> 01:05:35,130
different so ours is really just a

1654
01:05:39,980 --> 01:05:38,190
snapshot of this ancient environment and

1655
01:05:46,190 --> 01:05:39,990
we have to then project again further

1656
01:05:48,680 --> 01:05:46,200
back so that's our challenge both legs

1657
01:05:51,829 --> 01:05:48,690
from McMaster the genetic code came up

1658
01:05:53,930 --> 01:05:51,839
in Eric's talk and the genetic code is

1659
01:05:55,880 --> 01:05:53,940
important in earth life because we've

1660
01:05:59,000 --> 01:05:55,890
separated the roles of proteins and

1661
01:06:00,440 --> 01:05:59,010
nucleic acids and we have to chemically

1662
01:06:03,770 --> 01:06:00,450
different ways of storing information

1663
01:06:05,390 --> 01:06:03,780

and aspera no means obvious that life

1664
01:06:07,549 --> 01:06:05,400
elsewhere would need two kinds of

1665
01:06:09,680 --> 01:06:07,559
informational polymers we can imagine

1666
01:06:12,950 --> 01:06:09,690
something like an RNA world when there's

1667
01:06:15,170 --> 01:06:12,960
one kind of polymer and in an RNA world

1668
01:06:17,180 --> 01:06:15,180
and RNA is its own thing it's not coding

1669
01:06:19,690 --> 01:06:17,190
for something else so that would be one

1670
01:06:22,849 --> 01:06:19,700
kind of polymer but it's also maybe not

1671
01:06:24,710 --> 01:06:22,859
obvious that we even need one current we

1672
01:06:26,960 --> 01:06:24,720
might be out to envisage life without

1673
01:06:29,569 --> 01:06:26,970
informational polymers so so would

1674
01:06:31,250 --> 01:06:29,579
anybody like to speculate on when we

1675
01:06:33,260 --> 01:06:31,260
find life elsewhere will it have two

1676
01:06:44,359 --> 01:06:33,270
kinds of polymers will it have one kind

1677
01:06:47,690 --> 01:06:44,369
or no kinds okay so if nobody else wants

1678
01:06:49,900 --> 01:06:47,700
to spit you might my feeling is my

1679
01:06:52,880 --> 01:06:49,910
feeling is

1680
01:06:54,289 --> 01:06:52,890
polymers are pretty important so my I

1681
01:06:56,030 --> 01:06:54,299
would put some money on finding

1682
01:06:58,160 --> 01:06:56,040
informational polymers in life elsewhere

1683
01:07:01,819 --> 01:06:58,170
maybe not the same ones but some kind

1684
01:07:05,089 --> 01:07:01,829
and and also I guess I would I would say

1685
01:07:06,680 --> 01:07:05,099
the separating genes from catalysts is

1686
01:07:08,210 --> 01:07:06,690
also important but that doesn't mean

1687
01:07:10,640 --> 01:07:08,220
they need to be chemically different I

1688
01:07:13,640 --> 01:07:10,650

mean you can have the same kind of

1689
01:07:15,440 --> 01:07:13,650
molecule to get the same chemistry which

1690
01:07:18,109 --> 01:07:15,450
makes a catalyst and the same chemistry

1691
01:07:21,140 --> 01:07:18,119
that makes a gene without necessarily

1692
01:07:22,700 --> 01:07:21,150
needing to make the chemistry of the

1693
01:07:27,079 --> 01:07:22,710
catalyst different from the genes thus

1694
01:07:28,609 --> 01:07:27,089
that's where I'm heading with us I want

1695
01:07:29,990 --> 01:07:28,619
to not take too much time and I want to

1696
01:07:35,089 --> 01:07:30,000
give you an answer that will probably be

1697
01:07:41,870 --> 01:07:38,359
I think there's an idea of typicality

1698
01:07:45,410 --> 01:07:41,880
that has played a big role in creating a

1699
01:07:47,809 --> 01:07:45,420
theory of information and what's typical

1700
01:07:50,269 --> 01:07:47,819
in the world of small molecule chemistry

1701
01:07:54,769 --> 01:07:50,279
is different from what's typical in the

1702
01:07:59,029 --> 01:07:54,779
polymer domain and the idea that some

1703
01:08:02,930 --> 01:07:59,039
things that life relies on depend on the

1704
01:08:05,630 --> 01:08:02,940
constraints that there's not typicality

1705
01:08:07,609 --> 01:08:05,640
of structures kind of following laws as

1706
01:08:11,809 --> 01:08:07,619
point and there are other things that

1707
01:08:14,569 --> 01:08:11,819
life depends on that entirely require

1708
01:08:17,959 --> 01:08:14,579
extensibility to be a typical property

1709
01:08:21,499 --> 01:08:17,969
is the way I would look for the relative

1710
01:08:29,329 --> 01:08:21,509
roles of polymers versus the non horror

1711
01:08:31,430 --> 01:08:29,339
aspects of organizing this is Mike

1712
01:08:33,620 --> 01:08:31,440
travisano University of Minnesota so

1713
01:08:36,349 --> 01:08:33,630

like bars I'm really from outside this

1714
01:08:38,510 --> 01:08:36,359
community um I do experimental Ellucian

1715
01:08:42,050 --> 01:08:38,520
and try and investigate the origins of

1716
01:08:43,550 --> 01:08:42,060
innovation and when one does that when

1717
01:08:45,260 --> 01:08:43,560
one looks at the origins of innovation

1718
01:08:46,729 --> 01:08:45,270
quite often one finds that the first

1719
01:08:49,039 --> 01:08:46,739
steps in the origins have been some

1720
01:08:51,129 --> 01:08:49,049
innovative thing that's changed biology

1721
01:08:52,849 --> 01:08:51,139
as we know it that it's almost

1722
01:08:55,189 --> 01:08:52,859
unrecognizable from the things that

1723
01:08:57,050 --> 01:08:55,199
motivated the study itself so like the

1724
01:08:58,760 --> 01:08:57,060
innovation of multicellularity the first

1725
01:09:01,669 --> 01:08:58,770
steps of multicellularity first

1726
01:09:04,039 --> 01:09:01,679
multicellular organisms are quite you

1727
01:09:06,200 --> 01:09:04,049
know pathetic as multicellular organisms

1728
01:09:08,120 --> 01:09:06,210
are and so when I think about the

1729
01:09:10,069 --> 01:09:08,130
challenge of origin of life I think of

1730
01:09:12,379 --> 01:09:10,079
as a transition from a nonliving state

1731
01:09:16,490 --> 01:09:12,389
to a living State maybe a biotic

1732
01:09:19,039 --> 01:09:16,500
prebiotic biological and it seems to me

1733
01:09:21,800 --> 01:09:19,049
at the challenge for that is recognizing

1734
01:09:23,660 --> 01:09:21,810
this group's success already that the

1735
01:09:25,729 --> 01:09:23,670
very first steps in the origins of life

1736
01:09:28,099 --> 01:09:25,739
are hardly going to be recognizable

1737
01:09:30,439 --> 01:09:28,109
they're gonna be pathetic they're barely

1738
01:09:33,499 --> 01:09:30,449

gonna be operating as a biological

1739
01:09:36,319 --> 01:09:33,509
system and I kind of wonder if we

1740
01:09:37,729 --> 01:09:36,329
actually could find the very first steps

1741
01:09:40,459 --> 01:09:37,739
for the origin of life that happened on

1742
01:09:42,319 --> 01:09:40,469
is that on this earth at what step would

1743
01:09:46,420 --> 01:09:42,329
we find it that it's recognizable to us

1744
01:09:48,910 --> 01:09:46,430
as the origin of life

1745
01:09:51,070 --> 01:09:48,920
this life wet how much complexity would

1746
01:09:56,740 --> 01:09:51,080
it have that we would be able to say aha

1747
01:10:00,820 --> 01:09:56,750
that's the one I have a paper you can

1748
01:10:07,990 --> 01:10:00,830
read on that well that's why I've said I

1749
01:10:10,060 --> 01:10:08,000
outside of the community it's a question

1750
01:10:17,230 --> 01:10:10,070
for you guys I mean although some have

1751
01:10:24,010 --> 01:10:17,240
answered it apparently yeah coming from

1752
01:10:25,330 --> 01:10:24,020
you later yeah I have a question for the

1753
01:10:26,740 --> 01:10:25,340
panel I mean I could ask lots of

1754
01:10:28,870 --> 01:10:26,750
questions but I really think the panel's

1755
01:10:32,020 --> 01:10:28,880
done an excellent job to really show how

1756
01:10:34,780 --> 01:10:32,030
this community uniquely I think can

1757
01:10:36,490 --> 01:10:34,790
really great the search for life and the

1758
01:10:39,940 --> 01:10:36,500
origin of life because we want to search

1759
01:10:42,610 --> 01:10:39,950
for life so my question is we're going

1760
01:10:44,710 --> 01:10:42,620
beyond to historical contingency and

1761
01:10:46,690 --> 01:10:44,720
coming up with our own pet projects or

1762
01:10:49,030 --> 01:10:46,700
what are gonna make us famous in our

1763
01:10:51,850 --> 01:10:49,040

isolated Phil field for whatever thing

1764
01:10:53,380 --> 01:10:51,860
we think is interesting and what we

1765
01:10:54,730 --> 01:10:53,390
probably need to do given there's so

1766
01:10:56,620 --> 01:10:54,740
much money going to be spent on search

1767
01:10:59,500 --> 01:10:56,630
for exoplanets and analyzing their

1768
01:11:01,090 --> 01:10:59,510
atmospheres is how can we create a new

1769
01:11:02,580 --> 01:11:01,100
type of way of collaborating what

1770
01:11:04,960 --> 01:11:02,590
problems can we agree on this community

1771
01:11:06,790 --> 01:11:04,970
that we can give the younger people to

1772
01:11:09,040 --> 01:11:06,800
say oh I'm gonna work on that one work

1773
01:11:10,510 --> 01:11:09,050
on that one and I advocate for the kind

1774
01:11:12,880 --> 01:11:10,520
of particle physics type of

1775
01:11:14,920 --> 01:11:12,890
collaboration physicists are just as

1776
01:11:16,930 --> 01:11:14,930
grumpy as chemists particularly particle

1777
01:11:19,180 --> 01:11:16,940
physicists don't let the nice

1778
01:11:21,250 --> 01:11:19,190
collaboration for you there's a lot of

1779
01:11:22,750 --> 01:11:21,260
money invested in a big machine and we

1780
01:11:25,150 --> 01:11:22,760
don't have that yet but we do have big

1781
01:11:27,670 --> 01:11:25,160
machines big telescopes and that data is

1782
01:11:30,100 --> 01:11:27,680
very costly so my question is can we

1783
01:11:31,810 --> 01:11:30,110
come up beyond the life ladder and these

1784
01:11:33,850 --> 01:11:31,820
other things with a way of collaborating

1785
01:11:35,320 --> 01:11:33,860
together to inspire the younger people

1786
01:11:37,960 --> 01:11:35,330
that they don't feel they're coming in

1787
01:11:40,450 --> 01:11:37,970
an adversarial way an absolute on being

1788
01:11:41,590 --> 01:11:40,460

so inclusive and really pushing things

1789
01:11:43,930 --> 01:11:41,600
forward I think is a really nice

1790
01:11:46,840 --> 01:11:43,940
platform to ask those questions together

1791
01:11:48,670 --> 01:11:46,850
so I pause my own selfishness to talk

1792
01:11:50,920 --> 01:11:48,680
about my question but really to ask the

1793
01:11:52,390 --> 01:11:50,930
panel question about how we can develop

1794
01:11:56,970 --> 01:11:52,400
that collaboration and inspire other

1795
01:11:59,760 --> 01:11:58,380
let me say that you know while you were

1796
01:12:01,470 --> 01:11:59,770
saying that I think it's absolutely true

1797
01:12:03,750 --> 01:12:01,480
and AB saikhan is a great way to start

1798
01:12:05,760 --> 01:12:03,760
bringing people together and to build

1799
01:12:07,320 --> 01:12:05,770
these collaborations and hopefully the

1800
01:12:09,630 --> 01:12:07,330
new RC ends will help with that as well

1801
01:12:11,720 --> 01:12:09,640
by bringing together people that those

1802
01:12:15,180 --> 01:12:11,730
are still kind of focused on individual

1803
01:12:17,189 --> 01:12:15,190
themed areas it can help to bring people

1804
01:12:18,840 --> 01:12:17,199
bring the younger scientists in and

1805
01:12:20,490 --> 01:12:18,850
people who are looking at the same

1806
01:12:22,200 --> 01:12:20,500
question from different perspectives and

1807
01:12:23,700 --> 01:12:22,210
so that that's something to keep an eye

1808
01:12:25,770 --> 01:12:23,710
on I think I mean maybe maybe

1809
01:12:28,050 --> 01:12:25,780
competition categories like who has the

1810
01:12:31,229 --> 01:12:28,060
most pathetic know the last question

1811
01:12:33,930 --> 01:12:31,239
almost life today or who has the best

1812
01:12:37,110 --> 01:12:33,940
new kind of pre building soup reactor or

1813
01:12:38,700 --> 01:12:37,120

you know atmosphere analyzer these

1814
01:12:40,740 --> 01:12:38,710
little competitions in little areas

1815
01:12:43,140 --> 01:12:40,750
where people would dial in and we bring

1816
01:12:45,510 --> 01:12:43,150
in people we develop their skills be in

1817
01:12:47,250 --> 01:12:45,520
chemistry physics machine learning or

1818
01:12:48,500 --> 01:12:47,260
whatever else would be quite good so

1819
01:12:50,160 --> 01:12:48,510
maybe we should think about some

1820
01:12:55,229 --> 01:12:50,170
competitions that we could give each

1821
01:12:56,700 --> 01:12:55,239
other some reality TV I don't want to be

1822
01:12:59,700 --> 01:12:56,710
that famous but maybe just some

1823
01:13:00,750 --> 01:12:59,710
competitions maybe with some maybe with

1824
01:13:02,459 --> 01:13:00,760
some money maybe we could get a

1825
01:13:04,320 --> 01:13:02,469
billionaire or two to give some money

1826
01:13:07,970 --> 01:13:04,330
some big competitions in the field I

1827
01:13:10,080 --> 01:13:07,980
don't know just a suggestion thank you

1828
01:13:11,820 --> 01:13:10,090
it's really good to bring up the physics

1829
01:13:14,100 --> 01:13:11,830
community and that always comes up and I

1830
01:13:17,070 --> 01:13:14,110
guess one thing they're able to do very

1831
01:13:19,919 --> 01:13:17,080
well is decide what experiment they want

1832
01:13:22,320 --> 01:13:19,929
to put their resources into us as a

1833
01:13:23,850 --> 01:13:22,330
community to say oh at this stage this

1834
01:13:26,070 --> 01:13:23,860
is the most important thing it's gonna

1835
01:13:27,720 --> 01:13:26,080
cost X billion dollars and we'll get

1836
01:13:29,939 --> 01:13:27,730
everybody and we'll agree to put in this

1837
01:13:32,130 --> 01:13:29,949
massive you know grant application

1838
01:13:33,330 --> 01:13:32,140

before you know multinational things so

1839
01:13:34,890 --> 01:13:33,340
I guess if you're talking about

1840
01:13:37,590 --> 01:13:34,900
competitions you might think about

1841
01:13:39,209 --> 01:13:37,600
setting up a set of selections of

1842
01:13:42,209 --> 01:13:39,219
questions like the some of the big

1843
01:13:44,640 --> 01:13:42,219
questions and and what are approaches

1844
01:13:46,800 --> 01:13:44,650
that are so big that we can't do it in

1845
01:13:49,530 --> 01:13:46,810
an individual lab it would have to take

1846
01:13:51,330 --> 01:13:49,540
a multinational you know group and say

1847
01:13:53,820 --> 01:13:51,340
okay let's locate in a lovely location

1848
01:13:55,950 --> 01:13:53,830
and build a huge set of hot springs that

1849
01:13:56,650 --> 01:13:55,960
we can you know whatever you could have

1850
01:13:58,090 --> 01:13:56,660
you could have

1851
01:13:59,440 --> 01:13:58,100
questions and then you know any group

1852
01:14:01,270 --> 01:13:59,450
like this you could sort of break them

1853
01:14:03,760 --> 01:14:01,280
and then maybe that's where then you can

1854
01:14:05,290 --> 01:14:03,770
get consensus towards what's a really

1855
01:14:14,140 --> 01:14:05,300
important set of experiments that we

1856
01:14:17,830 --> 01:14:14,150
can't do individual my my phone says we

1857
01:14:21,310 --> 01:14:17,840
are supposed to end at 9:45 so I'm gonna

1858
01:14:23,620 --> 01:14:21,320
say one more question from Steve you see

1859
01:14:26,110 --> 01:14:23,630
this is bad because I was finding this

1860
01:14:27,820 --> 01:14:26,120
meeting to self congratulatory so I was

1861
01:14:30,250 --> 01:14:27,830
gonna mix it up and get myself into

1862
01:14:32,080 --> 01:14:30,260
trouble and the reason I was gonna do

1863
01:14:34,870 --> 01:14:32,090

this is because I was serving as an

1864
01:14:36,490 --> 01:14:34,880
advisor for a panel of federal powers

1865
01:14:39,100 --> 01:14:36,500
and whose name I not I'm not allowed to

1866
01:14:41,290 --> 01:14:39,110
mention to reviewing origins of life

1867
01:14:43,660 --> 01:14:41,300
grant applications there was a person in

1868
01:14:47,560 --> 01:14:43,670
the room a new investigator a callow

1869
01:14:49,270 --> 01:14:47,570
youth who said hey you realize if all of

1870
01:14:51,730 --> 01:14:49,280
these proposals were funded and all

1871
01:14:54,400 --> 01:14:51,740
turned out perfectly

1872
01:14:57,430 --> 01:14:54,410
as expected we would not make a dent at

1873
01:14:59,260 --> 01:14:57,440
all in the origins of life problem and

1874
01:15:01,090 --> 01:14:59,270
the reason for that has actually already

1875
01:15:03,070 --> 01:15:01,100
been mentioned by Lee is that people

1876
01:15:06,190 --> 01:15:03,080
tend to do what they have done before

1877
01:15:09,280 --> 01:15:06,200
and all of us very interesting but the

1878
01:15:11,620 --> 01:15:09,290
facts are there are paradoxes and in

1879
01:15:13,810 --> 01:15:11,630
fact this we're coming off of a 3-year

1880
01:15:16,120 --> 01:15:13,820
templeton program now we raise five and

1881
01:15:18,040 --> 01:15:16,130
a half million dollars to give out to

1882
01:15:20,500 --> 01:15:18,050
people many of them in this room to

1883
01:15:22,690 --> 01:15:20,510
where we were not asking for proposals

1884
01:15:25,800 --> 01:15:22,700
to desk go further with whatever we were

1885
01:15:28,540 --> 01:15:25,810
interested in but rather to identify a

1886
01:15:30,130 --> 01:15:28,550
step in the formation of RNAi for

1887
01:15:33,490 --> 01:15:30,140
example in the RNA world first

1888
01:15:36,160 --> 01:15:33,500

hypothesis which if it could not be

1889
01:15:39,220 --> 01:15:36,170
solved the origin of life was impossible

1890
01:15:41,440 --> 01:15:39,230
and I've got a lot of criticism people

1891
01:15:42,910 --> 01:15:41,450
attacked me personally some quite

1892
01:15:45,040 --> 01:15:42,920
bitterly some in the room saying well

1893
01:15:46,750 --> 01:15:45,050
you took money from this creationist

1894
01:15:49,360 --> 01:15:46,760
organization the Templeton Foundation

1895
01:15:51,070 --> 01:15:49,370
and it didn't help that I said ok if you

1896
01:15:53,590 --> 01:15:51,080
want to go look where the paradoxes are

1897
01:15:55,360 --> 01:15:53,600
just go to a good creationist web page

1898
01:15:55,680 --> 01:15:55,370
and they will tell you why life could

1899
01:15:57,030 --> 01:15:55,690
not

1900
01:15:59,340 --> 01:15:57,040
originate without the intervention of

1901
01:16:01,530 --> 01:15:59,350
God and solve one of those problems and

1902
01:16:04,200 --> 01:16:01,540
so by focusing that I've actually been

1903
01:16:05,729 --> 01:16:04,210
quite surprised at how well the people

1904
01:16:08,250 --> 01:16:05,739
who were funded in this program have

1905
01:16:10,830 --> 01:16:08,260
solved these paradoxes so Jim and your

1906
01:16:12,870 --> 01:16:10,840
title for this session I came here

1907
01:16:14,880 --> 01:16:12,880
expecting to have me do exactly what

1908
01:16:17,760 --> 01:16:14,890
Martin just said which was to come up

1909
01:16:19,680 --> 01:16:17,770
with a list of the next set of paradoxes

1910
01:16:22,260 --> 01:16:19,690
because because one of the central

1911
01:16:24,720 --> 01:16:22,270
paradox is is if you take organic matter

1912
01:16:27,450 --> 01:16:24,730
put energy into it without the benefit

1913
01:16:29,610 --> 01:16:27,460

of Darwinism it doesn't create Darwinism

1914
01:16:32,580 --> 01:16:29,620
it devolves to create asphalt and that's

1915
01:16:34,439 --> 01:16:32,590
the so called tar paradox but you know

1916
01:16:36,990 --> 01:16:34,449
I'm surprised after three years of

1917
01:16:38,820 --> 01:16:37,000
people focusing on this problem and

1918
01:16:41,550 --> 01:16:38,830
remember your chances of solving a

1919
01:16:44,189 --> 01:16:41,560
problem to drop to zero if you don't

1920
01:16:46,920 --> 01:16:44,199
work on the problem right but one of the

1921
01:16:49,680 --> 01:16:46,930
problems is have say you made RNA how

1922
01:16:51,630 --> 01:16:49,690
would you preserve it because RNA is

1923
01:16:53,580 --> 01:16:51,640
well known for forming as well well you

1924
01:16:55,979 --> 01:16:53,590
know ELISA Biondi who's here in the room

1925
01:16:57,689 --> 01:16:55,989
someplace will has come up with a

1926
01:16:59,010 --> 01:16:57,699
solution to that problem it may not be

1927
01:17:02,580 --> 01:16:59,020
the solution but it's no longer a

1928
01:17:05,209 --> 01:17:02,590
paradox or how do you make you know

1929
01:17:07,890 --> 01:17:05,219
activated nucleoside phosphates

1930
01:17:09,959 --> 01:17:07,900
everybody is still back in on the Orgel

1931
01:17:12,810 --> 01:17:09,969
problem right where they are going and

1932
01:17:14,459 --> 01:17:12,820
making methyl imidazole lives as their

1933
01:17:16,680 --> 01:17:14,469
activation well it turns out that

1934
01:17:19,620 --> 01:17:16,690
magnesium baro phosphate minerals make

1935
01:17:21,120 --> 01:17:19,630
diphosphates of nucleotides and speaking

1936
01:17:23,490 --> 01:17:21,130
of Orgel they're these problems which we

1937
01:17:25,050 --> 01:17:23,500
call or go hard there's a paradox right

1938
01:17:27,810 --> 01:17:25,060

but less the article try something and

1939
01:17:29,820 --> 01:17:27,820
it failed it can't be done but you know

1940
01:17:31,800 --> 01:17:29,830
hyo-jin Kim is in the room now showing

1941
01:17:34,110 --> 01:17:31,810
that Orgel sold you couldn't make cited

1942
01:17:36,150 --> 01:17:34,120
Dean out of cytosine in rabaa said you

1943
01:17:38,280 --> 01:17:36,160
can as long as you do something that

1944
01:17:39,990 --> 01:17:38,290
Rama Krishna Murthy told you about 20

1945
01:17:41,760 --> 01:17:40,000
years ago and so you can go back through

1946
01:17:44,250 --> 01:17:41,770
these paradoxes and you say well what's

1947
01:17:46,080 --> 01:17:44,260
remaining now now in the RNA world first

1948
01:17:48,870 --> 01:17:46,090
it's quite clear there's some things

1949
01:17:51,270 --> 01:17:48,880
chirality is a big problem for us we

1950
01:17:54,600 --> 01:17:51,280
don't know and maybe a little molar will

1951
01:17:56,430 --> 01:17:54,610
tell me why what are and I can do after

1952
01:17:59,490 --> 01:17:56,440
you make it there's a big problem there

1953
01:18:01,290 --> 01:17:59,500
but keep in mind that if you focus on

1954
01:18:03,120 --> 01:18:01,300
what you like to work on you're not

1955
01:18:05,310 --> 01:18:03,130
necessarily going to solve a problem

1956
01:18:06,670 --> 01:18:05,320
that is actually critical to solving the

1957
01:18:09,160 --> 01:18:06,680
big problem so I'm

1958
01:18:11,110 --> 01:18:09,170
the community would recognize and so not

1959
01:18:13,000 --> 01:18:11,120
to contradict Carl too strongly but one

1960
01:18:15,310 --> 01:18:13,010
of the problems with alternative models

1961
01:18:17,650 --> 01:18:15,320
like metabolism first is that the way

1962
01:18:20,020 --> 01:18:17,660
those models are formulated are their

1963
01:18:22,180 --> 01:18:20,030

questions are asked in a non actionable

1964
01:18:23,740 --> 01:18:22,190
way and that meaning that there's no way

1965
01:18:25,780 --> 01:18:23,750
you can go in and actually do something

1966
01:18:28,030 --> 01:18:25,790
so that's the second thing first make

1967
01:18:30,580 --> 01:18:28,040
your research focus on a problem that if

1968
01:18:32,770 --> 01:18:30,590
you solve it you actually solve part of

1969
01:18:34,450 --> 01:18:32,780
the bigger problem and many people don't

1970
01:18:36,340 --> 01:18:34,460
do that and the second if you're going

1971
01:18:38,380 --> 01:18:36,350
to ask a question make it

1972
01:18:40,780 --> 01:18:38,390
philosophically constructive so that

1973
01:18:42,400 --> 01:18:40,790
there's actually an answer that might

1974
01:18:46,890 --> 01:18:42,410
actually be something other than the

1975
01:18:50,200 --> 01:18:46,900
number 42 so now I'm prepared to die

1976
01:18:50,770 --> 01:18:50,210
thank you we're gonna take one last

1977
01:18:52,990 --> 01:18:50,780
question

1978
01:18:55,300 --> 01:18:53,000
I actually just like requests I'm a

1979
01:18:58,210 --> 01:18:55,310
professor of physics at the University

1980
01:19:00,460 --> 01:18:58,220
of Pennsylvania and we have astronomers

1981
01:19:03,370 --> 01:19:00,470
who do dark matter we have someone who

1982
01:19:05,440 --> 01:19:03,380
is studying squid and vision and they

1983
01:19:08,820 --> 01:19:05,450
always fight about hiring and these guys

1984
01:19:11,370 --> 01:19:08,830
want Astro these guys want soft matter

1985
01:19:14,680 --> 01:19:11,380
so I said oh but like there's this

1986
01:19:18,340 --> 01:19:14,690
astrobiology field and then everybody

1987
01:19:21,130 --> 01:19:18,350
was so negative so what I want you to

1988
01:19:22,840 --> 01:19:21,140

send me some email how I can pitch this

1989
01:19:25,080 --> 01:19:22,850
to a faculty meeting so that in a

1990
01:19:27,610 --> 01:19:25,090
physics department we can hire an

1991
01:19:28,820 --> 01:19:27,620
astrobiologists I see a lot of value but

1992
01:19:35,180 --> 01:19:28,830
they don't see it

1993
01:19:41,190 --> 01:19:35,190
[Applause]

1994
01:19:43,290 --> 01:19:41,200
yeah I have a super big comment please

1995
01:19:45,630 --> 01:19:43,300
do the same also in regards to

1996
01:19:51,720 --> 01:19:45,640
University of Texas at Arlington we have

1997
01:19:54,840 --> 01:19:51,970
[Applause]