
AbSciCon
2017
MESA, ARIZONA

1
00:00:06,160 --> 00:00:12,250
you

2
00:00:17,430 --> 00:00:14,549
[Music]

3
00:00:19,660 --> 00:00:17,440
for this morning

4
00:00:22,420 --> 00:00:19,670
we actually are going to be talking

5
00:00:24,100 --> 00:00:22,430
about origins of life and you'll note

6
00:00:26,230 --> 00:00:24,110
the title of the session is new

7
00:00:27,730 --> 00:00:26,240
approaches to origins and I think that

8
00:00:29,680 --> 00:00:27,740
all three of our speakers this morning

9
00:00:31,330 --> 00:00:29,690
really epitomized very innovative and

10
00:00:33,520 --> 00:00:31,340
cutting-edge approaches so it should be

11
00:00:35,530 --> 00:00:33,530
a really exciting session we're gonna

12
00:00:38,530 --> 00:00:35,540
have the juice to Kjar speaking first

13
00:00:42,220 --> 00:00:38,540

and then Irina manage Ahmad and Leroy

14
00:00:43,509 --> 00:00:42,230
Cronin so to set this stage for sort of

15
00:00:44,920 --> 00:00:43,519
to get you in the right mindset for

16
00:00:47,709 --> 00:00:44,930
thinking about origins kind of from new

17
00:00:49,299 --> 00:00:47,719
perspectives I'm going to just do a sort

18
00:00:51,310 --> 00:00:49,309
of brief introduction this morning and

19
00:00:55,990 --> 00:00:51,320
then I'm going to pass it off to the two

20
00:00:58,060 --> 00:00:56,000
to get us kicked off so on new

21
00:01:01,990 --> 00:00:58,070
approaches origins one of the things

22
00:01:02,979 --> 00:01:02,000
that you might you know think about what

23
00:01:04,630 --> 00:01:02,989
the origin of life is what are the

24
00:01:06,700 --> 00:01:04,640
relevant questions and it's been a

25
00:01:08,290 --> 00:01:06,710
really exciting time to work in origin

26
00:01:10,749 --> 00:01:08,300
'life fields because there have been a

27
00:01:12,430 --> 00:01:10,759
lot of really new ideas just in the last

28
00:01:14,980 --> 00:01:12,440
few years generated through a lot of

29
00:01:16,810 --> 00:01:14,990
centers that have formed recently which

30
00:01:17,950 --> 00:01:16,820
probably a lot of you know about like

31
00:01:20,260 --> 00:01:17,960
the Center for chemical evolution at

32
00:01:22,330 --> 00:01:20,270
Georgia Tech LLC in Japan there's a

33
00:01:23,590 --> 00:01:22,340
Harvard origins initiative and it's

34
00:01:26,469 --> 00:01:23,600
bringing a lot of new perspectives into

35
00:01:29,289 --> 00:01:26,479
the field so with this idea of new

36
00:01:30,789 --> 00:01:29,299
approaches there's been a kind of

37
00:01:32,140 --> 00:01:30,799
emphasis on recontextualizing the

38
00:01:34,480 --> 00:01:32,150

origins of life when we've had a meeting

39
00:01:37,600 --> 00:01:34,490
at Carnegie Institution about a year and

40
00:01:42,370 --> 00:01:37,610
a half ago now with that that name and

41
00:01:44,170 --> 00:01:42,380
so the idea is not just a focus on the

42
00:01:45,969 --> 00:01:44,180
chemical pathways to origins but also

43
00:01:47,950 --> 00:01:45,979
the networks and information properties

44
00:01:49,359 --> 00:01:47,960
and really bring in some deep insights

45
00:01:51,460 --> 00:01:49,369
from the knowledge we've gained about

46
00:01:52,749 --> 00:01:51,470
evolutionary biology and synthetic

47
00:01:54,640 --> 00:01:52,759
approaches to understanding living

48
00:01:55,539 --> 00:01:54,650
systems so those are the kind of things

49
00:01:58,420 --> 00:01:55,549
that we're going to be hearing about

50
00:02:00,249 --> 00:01:58,430
today and the idea is really to try to

51
00:02:02,889 --> 00:02:00,259
drive at a universal understanding of

52
00:02:04,719 --> 00:02:02,899
living systems and to use origins of the

53
00:02:06,010 --> 00:02:04,729
platform for doing that so for any of

54
00:02:07,749 --> 00:02:06,020
you guys in this room that have worked

55
00:02:09,490 --> 00:02:07,759
on origins of life I think one of the

56
00:02:11,050 --> 00:02:09,500
things that's really compelling about

57
00:02:12,699 --> 00:02:11,060
that problem is it forces you to think

58
00:02:16,330 --> 00:02:12,709
about biology in totally different ways

59
00:02:17,830 --> 00:02:16,340
and we're really seeing that inform not

60
00:02:19,840 --> 00:02:17,840
only our understanding of origins that

61
00:02:23,020 --> 00:02:19,850
our understanding of living systems more

62
00:02:24,790 --> 00:02:23,030
broadly and so I hope that you all get a

63
00:02:26,620 --> 00:02:24,800

lot out of this session as far as

64
00:02:29,640 --> 00:02:26,630
about biology differently in addition to

65
00:02:32,770 --> 00:02:29,650
thinking about the origins problem and

66
00:02:35,650 --> 00:02:32,780
so when we were coming up with who to

67
00:02:37,120 --> 00:02:35,660
include in this session some people in

68
00:02:40,750 --> 00:02:37,130
this room probably were involved in the

69
00:02:42,610 --> 00:02:40,760
strategy guy that came out of LC almost

70
00:02:45,040 --> 00:02:42,620
two years ago now but I think this makes

71
00:02:46,480 --> 00:02:45,050
me captures kind of the merger of all of

72
00:02:47,470 --> 00:02:46,490
these different approaches to origins

73
00:02:49,030 --> 00:02:47,480
that we're seeing now

74
00:02:50,500 --> 00:02:49,040
so traditionally in the field we may

75
00:02:52,270 --> 00:02:50,510
have had more of a historical approach

76
00:02:54,040 --> 00:02:52,280
but there's increasing interest in

77
00:02:56,140 --> 00:02:54,050
synthetic and universal approaches and

78
00:02:57,940 --> 00:02:56,150
so the original idea for the session was

79
00:03:00,400 --> 00:02:57,950
why don't we get a speaker from each one

80
00:03:01,900 --> 00:03:00,410
of these different areas and so that's

81
00:03:03,550 --> 00:03:01,910
kind of cool to try to see the merger in

82
00:03:05,080 --> 00:03:03,560
the origins of life but what I really

83
00:03:07,000 --> 00:03:05,090
like about all three of our speakers

84
00:03:09,100 --> 00:03:07,010
that we have is they are all squarely in

85
00:03:11,920 --> 00:03:09,110
the middle already so this is going to

86
00:03:15,640 --> 00:03:11,930
be really fun and with that I'm going to

87
00:03:21,730 --> 00:03:15,650
now have the to come up and talk to us

88
00:03:27,970 --> 00:03:21,740

about synthetic biology and then first

89
00:03:31,540 --> 00:03:27,980
pass and you are off that timeline oh is

90
00:03:34,660 --> 00:03:31,550
it okay great perfect well good morning

91
00:03:36,490 --> 00:03:34,670
everyone and thanks for joining us this

92
00:03:38,530 --> 00:03:36,500
morning for a discussion on origins of

93
00:03:41,410 --> 00:03:38,540
life and I am an evolutionary biologist

94
00:03:43,990 --> 00:03:41,420
and today I want to talk to you about

95
00:03:45,580 --> 00:03:44,000
what biology can do in order to answer

96
00:03:48,400 --> 00:03:45,590
the questions in origins of life and

97
00:03:50,740 --> 00:03:48,410
also what biology has been doing in a

98
00:03:52,510 --> 00:03:50,750
part of the astrobiology field this is

99
00:03:55,060 --> 00:03:52,520
the last slide that I have can we go to

100
00:04:00,040 --> 00:03:55,070
the beginning and with that thank you

101
00:04:01,690 --> 00:04:00,050
very much yeah all right that was a

102
00:04:10,780 --> 00:04:01,700
great talk yeah thanks for all the great

103
00:04:15,400 --> 00:04:10,790
questions all right like I was harder

104
00:04:17,500 --> 00:04:15,410
right I did obtain this slide from John

105
00:04:19,659 --> 00:04:17,510
burrows that beautifully I think

106
00:04:21,220 --> 00:04:19,669
summarizes the approaches that we have

107
00:04:23,890 --> 00:04:21,230
in order to answer your questions

108
00:04:25,930 --> 00:04:23,900
related surgeons of life and biology in

109
00:04:28,450 --> 00:04:25,940
particular falls into the category of

110
00:04:30,730 --> 00:04:28,460
the top-down approach that we can use

111
00:04:32,830 --> 00:04:30,740
the organisms today or sequences of

112
00:04:35,620 --> 00:04:32,840
genetic information that is available to

113
00:04:36,909 --> 00:04:35,630

us today and extrapolate information

114
00:04:38,560 --> 00:04:36,919
about the past

115
00:04:40,600 --> 00:04:38,570
biological States

116
00:04:44,200 --> 00:04:40,610
and of course for the origin of life you

117
00:04:45,790 --> 00:04:44,210
can imagine life has already for biology

118
00:04:47,650 --> 00:04:45,800
to study origins of life it's a bit of

119
00:04:49,510 --> 00:04:47,660
an interesting problem because we do

120
00:04:52,480 --> 00:04:49,520
deal with life itself the life should

121
00:04:55,150 --> 00:04:52,490
originate for us to study it but as

122
00:04:57,430 --> 00:04:55,160
biologists we also have room in place

123
00:04:58,780 --> 00:04:57,440
for questions about astrobiology origins

124
00:05:02,850 --> 00:04:58,790
of life and I'm going to be reviewing

125
00:05:06,760 --> 00:05:02,860
what those are and and one of the main

126
00:05:09,510 --> 00:05:06,770
approach that it has been commonly used

127
00:05:11,950 --> 00:05:09,520
today is developed by environmental

128
00:05:14,470 --> 00:05:11,960
microbiologist and geo biologists and

129
00:05:16,870 --> 00:05:14,480
that builds on using modern microbes

130
00:05:19,600 --> 00:05:16,880
today that are obtained by the ratio of

131
00:05:21,970 --> 00:05:19,610
extreme or not extreme environments and

132
00:05:24,580 --> 00:05:21,980
then using these microbes as a proxy to

133
00:05:27,490 --> 00:05:24,590
understand the ancient environments or

134
00:05:29,890 --> 00:05:27,500
early environments that that could

135
00:05:32,140 --> 00:05:29,900
possibly give rise to the evolution and

136
00:05:35,110 --> 00:05:32,150
emergence perhaps of life itself also

137
00:05:36,630 --> 00:05:35,120
and my observation is though is that

138
00:05:38,890 --> 00:05:36,640

recently there has been other

139
00:05:41,980 --> 00:05:38,900
development I have in other developments

140
00:05:44,710 --> 00:05:41,990
that aim to target biological organisms

141
00:05:47,260 --> 00:05:44,720
at the molecular scale and then modify

142
00:05:49,180 --> 00:05:47,270
these organisms at the cell or molecular

143
00:05:51,070 --> 00:05:49,190
to genetic level and then try to

144
00:05:52,750 --> 00:05:51,080
extrapolate not only extrapolate

145
00:05:55,060 --> 00:05:52,760
information but to see if we can

146
00:05:56,830 --> 00:05:55,070
reconstruct biology that would give us

147
00:05:59,620 --> 00:05:56,840
information about the origins of life

148
00:06:02,260 --> 00:05:59,630
and that's I mean that's a challenging

149
00:06:04,180 --> 00:06:02,270
question because in one hand we do have

150
00:06:06,430 --> 00:06:04,190
genetic information that we have today

151
00:06:09,030 --> 00:06:06,440
but the genetics today is a result of

152
00:06:12,010 --> 00:06:09,040
about at least 3.5 billion years of

153
00:06:13,810 --> 00:06:12,020
evolutionary accumulation so in one hand

154
00:06:15,640 --> 00:06:13,820
we have the genetics that we have today

155
00:06:17,530 --> 00:06:15,650
on the other hand this genetic

156
00:06:20,140 --> 00:06:17,540
information has been overwritten and

157
00:06:21,880 --> 00:06:20,150
that is on the other hand the only

158
00:06:24,310 --> 00:06:21,890
fossil that you can think of for

159
00:06:27,100 --> 00:06:24,320
biologists to extrapolate information

160
00:06:29,470 --> 00:06:27,110
about the past itself so how do we then

161
00:06:31,720 --> 00:06:29,480
use the genetics that we have today in

162
00:06:34,690 --> 00:06:31,730
order to understand the ancient genetic

163
00:06:37,570 --> 00:06:34,700

conditions especially knowing that whole

164
00:06:40,240 --> 00:06:37,580
life we know built on this central

165
00:06:42,940 --> 00:06:40,250
mechanism that drives from the DNA and

166
00:06:45,730 --> 00:06:42,950
the RNA and the protein information so

167
00:06:48,760 --> 00:06:45,740
what you have today all life today uses

168
00:06:51,119 --> 00:06:48,770
this basic system so to replicate but

169
00:06:53,579 --> 00:06:51,129
generate variation in response

170
00:06:56,249 --> 00:06:53,589
environment and early life also built on

171
00:06:57,749 --> 00:06:56,259
this very core system so in this case

172
00:06:59,309 --> 00:06:57,759
this could help us right so we have

173
00:07:01,589 --> 00:06:59,319
genetics today and we have the core

174
00:07:04,169 --> 00:07:01,599
genetics today and we think that this

175
00:07:06,149 --> 00:07:04,179
also was the same in the ancient life so

176
00:07:10,109 --> 00:07:06,159
how do we then use today's genetics and

177
00:07:12,449 --> 00:07:10,119
then infer the ancient genetics and well

178
00:07:14,429 --> 00:07:12,459
lucky for us there have been lot of

179
00:07:16,559 --> 00:07:14,439
senior people also in this room that

180
00:07:18,570 --> 00:07:16,569
told hard about this question and then

181
00:07:20,549 --> 00:07:18,580
that developed techniques also that

182
00:07:23,429 --> 00:07:20,559
thrive by research that was funded by

183
00:07:25,350 --> 00:07:23,439
NASA but additionally so in the biology

184
00:07:27,209 --> 00:07:25,360
field today there have been techniques

185
00:07:29,939 --> 00:07:27,219
and methods that are developed that are

186
00:07:32,129 --> 00:07:29,949
outside of our field but also could

187
00:07:34,859 --> 00:07:32,139
potentially benefit origins of life in

188
00:07:36,779 --> 00:07:34,869

astrobiology biology research and during

189
00:07:40,159 --> 00:07:36,789
the next few slides I'm going to review

190
00:07:42,389 --> 00:07:40,169
a multiple techniques that I think is

191
00:07:44,339 --> 00:07:42,399
origins of life and also by all the

192
00:07:45,929 --> 00:07:44,349
researchers we could use and we've been

193
00:07:49,559 --> 00:07:45,939
using some of these things increasingly

194
00:07:51,239 --> 00:07:49,569
so and and it is top level when you look

195
00:07:53,040 --> 00:07:51,249
at this you can see that these are not

196
00:07:54,719 --> 00:07:53,050
the questions that origins of life in

197
00:07:57,089 --> 00:07:54,729
astrobiology community is interested

198
00:08:00,149 --> 00:07:57,099
these are questions that are interesting

199
00:08:02,279 --> 00:08:00,159
to perhaps DARPA through NIH to for

200
00:08:04,559 --> 00:08:02,289
example with the outbreak response and

201
00:08:07,350 --> 00:08:04,569
how come a technique that is developed

202
00:08:09,749 --> 00:08:07,360
for rapid outbreak response can be used

203
00:08:12,179 --> 00:08:09,759
for us in astrobiology origins of life

204
00:08:14,489 --> 00:08:12,189
research but well if you think about it

205
00:08:16,649 --> 00:08:14,499
at the core all these tools that are

206
00:08:19,049 --> 00:08:16,659
developed for a rapid response to a

207
00:08:21,629 --> 00:08:19,059
human or environmental need to rely on

208
00:08:23,399 --> 00:08:21,639
connecting genetics and environments if

209
00:08:25,619 --> 00:08:23,409
you were to understand an outbreak

210
00:08:27,689 --> 00:08:25,629
response you need to understand it's the

211
00:08:29,879 --> 00:08:27,699
genetic level or at the stable level or

212
00:08:32,159 --> 00:08:29,889
at the community level what the response

213
00:08:34,079 --> 00:08:32,169

is in a changing environment and of

214
00:08:36,659 --> 00:08:34,089
course for an outbreak response the

215
00:08:39,120 --> 00:08:36,669
environment is not going to be in hot

216
00:08:41,519 --> 00:08:39,130
acidic environments like we think Asian

217
00:08:43,230 --> 00:08:41,529
environment was but the environment will

218
00:08:45,210 --> 00:08:43,240
be perhaps a contamination the

219
00:08:47,879 --> 00:08:45,220
contaminated water that the human

220
00:08:50,220 --> 00:08:47,889
population is exposed to but it doesn't

221
00:08:53,009 --> 00:08:50,230
matter the tools are still developed to

222
00:08:54,689 --> 00:08:53,019
connect the cell and the genetics to the

223
00:08:56,579 --> 00:08:54,699
environment and we can benefit from

224
00:08:58,920 --> 00:08:56,589
these tools in origins of life in

225
00:09:01,470 --> 00:08:58,930
astrobiology research and NASA has been

226
00:09:03,750 --> 00:09:01,480
working differently than all these great

227
00:09:06,540 --> 00:09:03,760
foundations that support our research

228
00:09:08,730 --> 00:09:06,550
and also has been encouraging us to

229
00:09:10,230 --> 00:09:08,740
develop not only develop tools that will

230
00:09:12,720 --> 00:09:10,240
have an immediate answer to these

231
00:09:14,910 --> 00:09:12,730
questions but extract and benefit from

232
00:09:16,889 --> 00:09:14,920
these tools and combine them in a very

233
00:09:19,259 --> 00:09:16,899
interdisciplinary and cross-disciplinary

234
00:09:23,250 --> 00:09:19,269
way and apply it to the questions that

235
00:09:26,879 --> 00:09:23,260
involve deep fundamental are questions

236
00:09:30,569 --> 00:09:26,889
about life so how do we apply these

237
00:09:35,699 --> 00:09:30,579
techniques to questions of astrobiology

238
00:09:38,430 --> 00:09:35,709

and origins of life significance I will

239
00:09:40,889 --> 00:09:38,440
walk you through a multiple of these

240
00:09:44,160 --> 00:09:40,899
techniques and and how do we use them

241
00:09:46,230 --> 00:09:44,170
today in astrobiology research and what

242
00:09:48,600 --> 00:09:46,240
I think also can be done moving forward

243
00:09:51,629 --> 00:09:48,610
so at the DNA level we are rested

244
00:09:53,189 --> 00:09:51,639
perhaps at the revolution maybe I'll

245
00:09:55,230 --> 00:09:53,199
have already passed that we all benefit

246
00:09:58,829 --> 00:09:55,240
from the whole genome sequencing the

247
00:10:01,170 --> 00:09:58,839
ability to identify all the changes of a

248
00:10:03,329 --> 00:10:01,180
biological organism genetic components

249
00:10:05,160 --> 00:10:03,339
and this organism can be as simple as

250
00:10:07,079 --> 00:10:05,170
bacterial or more complicated than a

251
00:10:10,350 --> 00:10:07,089
bacteria and here you're looking at the

252
00:10:12,829 --> 00:10:10,360
data that was published in 2010 by rich

253
00:10:15,960 --> 00:10:12,839
Lansky's group that revealed the whole

254
00:10:18,090 --> 00:10:15,970
genome and the mutation that has

255
00:10:21,000 --> 00:10:18,100
accumulated on this genome throughout

256
00:10:23,069 --> 00:10:21,010
the evolution of this ecoli bacteria in

257
00:10:25,230 --> 00:10:23,079
the laboratory and this was quite

258
00:10:27,210 --> 00:10:25,240
revolutionary we can map the mutations

259
00:10:29,879 --> 00:10:27,220
in the genome and understand what these

260
00:10:31,769 --> 00:10:29,889
mutations perhaps can even do and in

261
00:10:33,960 --> 00:10:31,779
terms of impacting the behavior of this

262
00:10:37,980 --> 00:10:33,970
organism in which these mutations are

263
00:10:42,240 --> 00:10:37,990

accumulated in and and and and I do

264
00:10:44,460 --> 00:10:42,250
benefit from this methodology in in my

265
00:10:46,199 --> 00:10:44,470
lab and I'm not the only one in the

266
00:10:48,689 --> 00:10:46,209
Astro biology community NASA has been

267
00:10:50,730 --> 00:10:48,699
investing a lot of resources and time in

268
00:10:52,650 --> 00:10:50,740
order to use these tools that are

269
00:10:55,259 --> 00:10:52,660
significant for us and they're actually

270
00:10:57,870 --> 00:10:55,269
as in there is an astrobiology node

271
00:11:00,090 --> 00:10:57,880
right now that is only targeted on

272
00:11:01,680 --> 00:11:00,100
evolving organisms and studying the

273
00:11:05,009 --> 00:11:01,690
behavior of these organisms using

274
00:11:06,930 --> 00:11:05,019
variety of genomic techniques and in my

275
00:11:09,150 --> 00:11:06,940
research I do start with an initial

276
00:11:11,790 --> 00:11:09,160
population in initial bacteria and

277
00:11:13,470 --> 00:11:11,800
subject this population for evolution in

278
00:11:16,319 --> 00:11:13,480
the lab under a controlled environment

279
00:11:17,260 --> 00:11:16,329
that may or may not replicate an ancient

280
00:11:19,390 --> 00:11:17,270
earth in why

281
00:11:21,700 --> 00:11:19,400
and then I study the changes on this

282
00:11:24,040 --> 00:11:21,710
population by subjecting this population

283
00:11:25,810 --> 00:11:24,050
to whole genome sequencing and mapping

284
00:11:28,120 --> 00:11:25,820
the changes in the DNA of this

285
00:11:33,900 --> 00:11:28,130
population through a periodic need at

286
00:11:37,000 --> 00:11:33,910
any given time that I desire next

287
00:11:40,240 --> 00:11:37,010
innovative's the the hot tool that we

288
00:11:42,700 --> 00:11:40,250

have is CRISPR CRISPR can be imagined as

289
00:11:45,280 --> 00:11:42,710
a molecular scissor it is it is now

290
00:11:48,190 --> 00:11:45,290
being thought as one of the most I would

291
00:11:51,010 --> 00:11:48,200
say useful tools that we have in biology

292
00:11:53,590 --> 00:11:51,020
that of course we could engineer genomic

293
00:11:56,350 --> 00:11:53,600
content DNA of an organism in different

294
00:11:58,990 --> 00:11:56,360
ways before by relying on of perhaps

295
00:12:01,240 --> 00:11:59,000
recombinator for example that are given

296
00:12:03,490 --> 00:12:01,250
to us wiser that we extract from viruses

297
00:12:05,380 --> 00:12:03,500
for example by stealing from nature we

298
00:12:07,630 --> 00:12:05,390
could modify genome but the premise of

299
00:12:10,360 --> 00:12:07,640
CRISPR is that now we are able to

300
00:12:12,790 --> 00:12:10,370
perhaps we will be able to modify any

301
00:12:16,570 --> 00:12:12,800
organism that we want at the precise

302
00:12:18,970 --> 00:12:16,580
genomic location and a very rapid in a

303
00:12:20,530 --> 00:12:18,980
very rapid way and given that the

304
00:12:23,290 --> 00:12:20,540
premise is that we can use this system

305
00:12:24,760 --> 00:12:23,300
in any organism Hollywood wasn't you

306
00:12:27,360 --> 00:12:24,770
know didn't miss this opportunity and if

307
00:12:30,460 --> 00:12:27,370
you watch the last x-files in the last

308
00:12:33,280 --> 00:12:30,470
last at the end of X Files a new one is

309
00:12:35,590 --> 00:12:33,290
coming at the end of this X Files Scully

310
00:12:37,660 --> 00:12:35,600
was saved because her genome and not

311
00:12:39,670 --> 00:12:37,670
only Scully but the whole human race was

312
00:12:42,310 --> 00:12:39,680
saved because the genome content of

313
00:12:47,050 --> 00:12:42,320

humans were engineered with alien DNA

314
00:12:51,430 --> 00:12:47,060
using CRISPR cash system so that was

315
00:12:55,120 --> 00:12:51,440
great and and and we do rely on this

316
00:12:58,090 --> 00:12:55,130
CRISPR system in my group right now in

317
00:13:01,030 --> 00:12:58,100
order to engineer cyanobacteria with the

318
00:13:04,240 --> 00:13:01,040
synthetic artificial genes in order to

319
00:13:07,180 --> 00:13:04,250
reboot the behavior of cyanobacteria to

320
00:13:09,490 --> 00:13:07,190
perhaps see if we can reconstruct the

321
00:13:11,590 --> 00:13:09,500
bacteria spiral bacteria that behaves

322
00:13:12,940 --> 00:13:11,600
like it did in the past even that we

323
00:13:14,890 --> 00:13:12,950
think that the innovation of

324
00:13:18,400 --> 00:13:14,900
evolutionary innovation of cyanobacteria

325
00:13:20,260 --> 00:13:18,410
itself has contributed to the even

326
00:13:23,170 --> 00:13:20,270
oxygen that we have in doubt most fear

327
00:13:25,930 --> 00:13:23,180
today and and and what we do is that the

328
00:13:27,940 --> 00:13:25,940
growth sign of bacteria that we obtain

329
00:13:29,590 --> 00:13:27,950
from variety of environments and then

330
00:13:32,020 --> 00:13:29,600
after culturing this party

331
00:13:34,180 --> 00:13:32,030
the engineer the cyanobacterial Gino

332
00:13:36,010 --> 00:13:34,190
which was also needing information to

333
00:13:38,500 --> 00:13:36,020
redesign of oxidase three genomes this

334
00:13:41,350 --> 00:13:38,510
is the new system for me and we can use

335
00:13:43,120 --> 00:13:41,360
you by using CRISPR we can target the

336
00:13:45,310 --> 00:13:43,130
specific regions in the side of

337
00:13:49,180 --> 00:13:45,320
bacterial genome and think with the

338
00:13:52,000 --> 00:13:49,190

cyanobacterial of circadian cicle in or

339
00:13:54,370 --> 00:13:52,010
in a way that our gene will be active

340
00:13:55,870 --> 00:13:54,380
whenever we want in terms of decided in

341
00:14:01,090 --> 00:13:55,880
sync with the side of bacterial growth

342
00:14:03,220 --> 00:14:01,100
itself and tail your genetics and the

343
00:14:07,260 --> 00:14:03,230
pioneer of the field is I think with us

344
00:14:10,950 --> 00:14:07,270
here today Steve Benner and he he in

345
00:14:14,200 --> 00:14:10,960
1990 show that by reconstructing and

346
00:14:16,800 --> 00:14:14,210
inferring an intestinal sequence that

347
00:14:21,370 --> 00:14:16,810
builds on generating a phylogenetic tree

348
00:14:23,920 --> 00:14:21,380
we can extract information about the

349
00:14:26,710 --> 00:14:23,930
past by just looking at the behavior of

350
00:14:28,570 --> 00:14:26,720
a protein and of course the paleo

351
00:14:30,970 --> 00:14:28,580
genetics itself is shown here deals on

352
00:14:32,560 --> 00:14:30,980
generating sequences and by looking at a

353
00:14:36,670 --> 00:14:32,570
sequence itself we cannot really

354
00:14:39,250 --> 00:14:36,680
understand what the protein outputs can

355
00:14:41,140 --> 00:14:39,260
do what the function can be by by only

356
00:14:43,330 --> 00:14:41,150
looking at the sequence and this very

357
00:14:45,820 --> 00:14:43,340
point remains to be one of the biggest

358
00:14:48,400 --> 00:14:45,830
challenges in biology today can we

359
00:14:50,950 --> 00:14:48,410
extract information about the behavior

360
00:14:52,990 --> 00:14:50,960
about the function by looking at the way

361
00:14:56,050 --> 00:14:53,000
these letters of DNA or amino acid

362
00:14:59,170 --> 00:14:56,060
letters are written and but yes paleo

363
00:15:01,600 --> 00:14:59,180

genetics has been increasingly Seoul

364
00:15:03,760 --> 00:15:01,610
used also recently and even if the paper

365
00:15:06,010 --> 00:15:03,770
came out and I believe like last week on

366
00:15:08,980 --> 00:15:06,020
ancient Chinese and how this can be used

367
00:15:11,950 --> 00:15:08,990
also to benchmark ancestral environments

368
00:15:13,840 --> 00:15:11,960
but also what was not shown is that we

369
00:15:15,640 --> 00:15:13,850
do generate all these ancient proteins

370
00:15:18,370 --> 00:15:15,650
and make inferences about the ancient

371
00:15:20,920 --> 00:15:18,380
earth but can we see that whether these

372
00:15:24,130 --> 00:15:20,930
proteins would function inside the cell

373
00:15:26,440 --> 00:15:24,140
environment and that's that's what I've

374
00:15:29,080 --> 00:15:26,450
done previously with the support of NASA

375
00:15:31,320 --> 00:15:29,090
postdoctoral program where I engineered

376
00:15:33,730 --> 00:15:31,330
a modern microbe with an ancient

377
00:15:36,400 --> 00:15:33,740
inferred ancestral sequence of the

378
00:15:38,530 --> 00:15:36,410
ribosomal protein and and today we are

379
00:15:40,720 --> 00:15:38,540
engineering cyanobacteria with the

380
00:15:43,410 --> 00:15:40,730
ancient versions of the Rubisco protein

381
00:15:45,840 --> 00:15:43,420
and Rubisco itself is first of all

382
00:15:48,180 --> 00:15:45,850
the most abundant protein that we have

383
00:15:50,700 --> 00:15:48,190
today and and one significance about

384
00:15:53,010 --> 00:15:50,710
Rubisco for the poor geologists in

385
00:15:54,870 --> 00:15:53,020
geobiologist in the room is that it is

386
00:15:57,090 --> 00:15:54,880
thought to the function is supposed to

387
00:15:59,670 --> 00:15:57,100
be significantly coupled to a

388
00:16:02,430 --> 00:15:59,680

significant bio signature which in this

389
00:16:04,140 --> 00:16:02,440
case is the carbon isotope so if the

390
00:16:06,780 --> 00:16:04,150
function of this protein is directly

391
00:16:09,030 --> 00:16:06,790
coupled to a bio signature that we use

392
00:16:11,670 --> 00:16:09,040
the inferred ancient environments by

393
00:16:14,040 --> 00:16:11,680
reconstructing an ancient protein can be

394
00:16:16,170 --> 00:16:14,050
delicate situate or resurrect an ancient

395
00:16:20,280 --> 00:16:16,180
bio signature in the lab solely by

396
00:16:22,050 --> 00:16:20,290
building on biological components and in

397
00:16:24,510 --> 00:16:22,060
order to answer this question is a first

398
00:16:26,880 --> 00:16:24,520
step we reconstructed the phylogenetic

399
00:16:28,500 --> 00:16:26,890
tree of ancient Rubisco and and there

400
00:16:30,180 --> 00:16:28,510
have been several attempts to create

401
00:16:33,840 --> 00:16:30,190
trees about Rubisco in the literature

402
00:16:36,300 --> 00:16:33,850
but for our tree we used all the Rubisco

403
00:16:38,340 --> 00:16:36,310
sequences that are available to us today

404
00:16:40,320 --> 00:16:38,350
and that included the ancestor of

405
00:16:43,800 --> 00:16:40,330
cyanobacteria for example here you have

406
00:16:45,810 --> 00:16:43,810
the group 8 2 C and D the whole group B

407
00:16:48,360 --> 00:16:45,820
and we have the incest or cyanobacteria

408
00:16:50,940 --> 00:16:48,370
and going backwards all the way back

409
00:16:53,310 --> 00:16:50,950
into the ancestral Rubisco that

410
00:16:56,130 --> 00:16:53,320
supposedly the ancestor of all currently

411
00:16:57,990 --> 00:16:56,140
existing risco proteins and then we

412
00:17:00,660 --> 00:16:58,000
inferred the structure of these ancient

413
00:17:03,060 --> 00:17:00,670

proteins and try to understand very the

414
00:17:05,939 --> 00:17:03,070
changes if any throughout time are

415
00:17:08,130 --> 00:17:05,949
located on the protein itself and are

416
00:17:10,590 --> 00:17:08,140
these changes important for the protein

417
00:17:12,660 --> 00:17:10,600
function or not and currently we are

418
00:17:15,270 --> 00:17:12,670
engineering the cyanobacteria with these

419
00:17:17,069 --> 00:17:15,280
very ancient Rubisco proteins with the

420
00:17:19,170 --> 00:17:17,079
goal of measuring this but the bio

421
00:17:21,360 --> 00:17:19,180
signature that's going to be generated

422
00:17:23,220 --> 00:17:21,370
by this engineered organism and I think

423
00:17:25,500 --> 00:17:23,230
this can be used for a variety of

424
00:17:27,600 --> 00:17:25,510
different isotopes by using variety of

425
00:17:28,920 --> 00:17:27,610
different organisms now that we have so

426
00:17:31,320 --> 00:17:28,930
much information about the bio

427
00:17:33,410 --> 00:17:31,330
signatures and we know so much about the

428
00:17:35,160 --> 00:17:33,420
microbes itself thanks to the work of

429
00:17:39,630 --> 00:17:35,170
environmental microbiology and

430
00:17:41,430 --> 00:17:39,640
geobiologist last but not least I want

431
00:17:44,070 --> 00:17:41,440
to I want to say a few words about the

432
00:17:48,270 --> 00:17:44,080
artificial organisms this then when they

433
00:17:50,460 --> 00:17:48,280
think of its of the original cell itself

434
00:17:52,080 --> 00:17:50,470
also in a way really foreign to us we

435
00:17:54,080 --> 00:17:52,090
don't know by original I mean all the

436
00:17:56,330 --> 00:17:54,090
cells and in this school

437
00:17:58,220 --> 00:17:56,340
relatively recent examples all of them

438
00:18:01,280 --> 00:17:58,230

Debbie's recent cutting came out in

439
00:18:02,870 --> 00:18:01,290
March 10th last month and on the on the

440
00:18:06,620 --> 00:18:02,880
right you're looking at the smallest yet

441
00:18:08,630 --> 00:18:06,630
bacterial cell that contains only 473

442
00:18:10,880 --> 00:18:08,640
genes so for non biologists this may

443
00:18:13,910 --> 00:18:10,890
still seem like a large number but it is

444
00:18:16,670 --> 00:18:13,920
just for us the smallest genome that we

445
00:18:19,730 --> 00:18:16,680
know so far and and it is created

446
00:18:23,570 --> 00:18:19,740
artificially in the lab and and for us

447
00:18:25,160 --> 00:18:23,580
to I'm studying about the House of

448
00:18:27,560 --> 00:18:25,170
Representatives these days and I realize

449
00:18:29,900 --> 00:18:27,570
the house also has about 400 something

450
00:18:32,540 --> 00:18:29,910
members so I was thinking okay if all

451
00:18:34,400 --> 00:18:32,550
the members of the House worked in the

452
00:18:36,890 --> 00:18:34,410
precise way and if they did their

453
00:18:39,010 --> 00:18:36,900
function the best way possible we could

454
00:18:47,090 --> 00:18:39,020
also create a functional organism and

455
00:18:50,420 --> 00:18:47,100
display and on on the on the on the left

456
00:18:53,000 --> 00:18:50,430
is the synthetic yeast that is also

457
00:18:55,220 --> 00:18:53,010
engineered to create artificial genome

458
00:18:57,650 --> 00:18:55,230
and this also will be interesting to the

459
00:19:00,140 --> 00:18:57,660
to the members of astrobiology community

460
00:19:02,540 --> 00:19:00,150
that study our yeast organisms in the

461
00:19:04,790 --> 00:19:02,550
laboratory and also answer questions

462
00:19:05,750 --> 00:19:04,800
related to Australia to the origins of

463
00:19:09,620 --> 00:19:05,760

multicellularity

464
00:19:11,690 --> 00:19:09,630
and I think what could be interesting

465
00:19:14,300 --> 00:19:11,700
and we made the decades away from this

466
00:19:16,670 --> 00:19:14,310
is to engineer the last Universal common

467
00:19:19,340 --> 00:19:16,680
ancestor or an organism that is similar

468
00:19:21,500 --> 00:19:19,350
to that that has no prior perhaps

469
00:19:23,750 --> 00:19:21,510
genetic baggage that we don't deal with

470
00:19:26,690 --> 00:19:23,760
the accumulation of genetic information

471
00:19:28,850 --> 00:19:26,700
and restricted by what the rest of the

472
00:19:30,320 --> 00:19:28,860
cellular machinery will have this pet

473
00:19:32,720 --> 00:19:30,330
rest of the cellular machine will

474
00:19:36,350 --> 00:19:32,730
respond to our ancients or a synthetic

475
00:19:39,290 --> 00:19:36,360
gene but but build a system without any

476
00:19:42,020 --> 00:19:39,300
prior genetic baggage that and that we

477
00:19:45,860 --> 00:19:42,030
can control better than when we do with

478
00:19:48,740 --> 00:19:45,870
a modern organism but definitely has

479
00:19:52,160 --> 00:19:48,750
more than more the high amounts of

480
00:19:55,970 --> 00:19:52,170
genetic information and also history so

481
00:19:58,160 --> 00:19:55,980
with that desire this is what I would

482
00:20:02,030 --> 00:19:58,170
like to do in in my lab it hopefully

483
00:20:04,040 --> 00:20:02,040
however long and good career and there

484
00:20:06,020 --> 00:20:04,050
was this this is was that I was like

485
00:20:07,460 --> 00:20:06,030
peachy by combining synthetic biology

486
00:20:10,610 --> 00:20:07,470
and bacterial evolution

487
00:20:13,009 --> 00:20:10,620
by extracting information from molecular

488
00:20:15,409 --> 00:20:13,019

evolution and experimental evolution and

489
00:20:17,119 --> 00:20:15,419
and studying the the evolved organisms

490
00:20:19,789 --> 00:20:17,129
in the lab assemble a children's

491
00:20:21,649 --> 00:20:19,799
cellular level and by engineering the

492
00:20:23,869 --> 00:20:21,659
systems and networks by learning from

493
00:20:26,299 --> 00:20:23,879
nature and then tying the behavior that

494
00:20:28,100 --> 00:20:26,309
we reconstruct in the lab to the the

495
00:20:32,269 --> 00:20:28,110
environmental level to the information

496
00:20:33,769 --> 00:20:32,279
that we get from the rock record and and

497
00:20:35,899 --> 00:20:33,779
with that I would like to thank all the

498
00:20:38,990 --> 00:20:35,909
funding agencies that supporting us and

499
00:20:41,269 --> 00:20:39,000
NSF and recently NASA once again

500
00:20:44,779 --> 00:20:41,279
supported us through the outcome of the

501
00:20:47,659 --> 00:20:44,789
ideas lab in origins of life and and my

502
00:20:50,210 --> 00:20:47,669
student Anna she has a poster on Rubisco

503
00:20:51,950 --> 00:20:50,220
reconstruction and modeling on Wednesday

504
00:20:53,330 --> 00:20:51,960
and I will talk about experimental

505
00:20:55,999 --> 00:20:53,340
evolution and bio signatures work

506
00:20:58,100 --> 00:20:56,009
through two technical talks on Thursday

507
00:21:00,919 --> 00:20:58,110
if you like to listen more about it and

508
00:21:03,169 --> 00:21:00,929
the last I would like to plug in book

509
00:21:05,060 --> 00:21:03,179
that will that's going to come out we

510
00:21:07,399 --> 00:21:05,070
are working on this book is a biologist

511
00:21:09,259 --> 00:21:07,409
in and a geologist Attilio biologist and

512
00:21:11,659 --> 00:21:09,269
an anthropologist to talk about the

513
00:21:13,850 --> 00:21:11,669

lives otamatone and how we can link

514
00:21:16,430 --> 00:21:13,860
biochemistry and fundamental information

515
00:21:26,430 --> 00:21:16,440
about the lives working through the

516
00:21:30,970 --> 00:21:29,650
we have time for about two questions and

517
00:21:32,380 --> 00:21:30,980
we're also going to have an open

518
00:21:34,900 --> 00:21:32,390
question session for all of our speakers

519
00:21:36,820 --> 00:21:34,910
at the end so few questions if we have

520
00:21:42,460 --> 00:21:36,830
people come up to the mic sir and the

521
00:21:43,720 --> 00:21:42,470
aisles that was such a fascinating talk

522
00:21:49,180 --> 00:21:43,730
come on bag nobody's awake this morning

523
00:21:57,160 --> 00:21:49,190
oh thank you oh good lager I know you

524
00:22:00,520 --> 00:21:57,170
guys need more coffee okay hello that

525
00:22:03,160 --> 00:22:00,530
stood apart from Elsie here thanks for

526
00:22:06,850 --> 00:22:03,170
the great talk it was fascinating do you

527
00:22:10,440 --> 00:22:06,860
have any possible suggestions for how we

528
00:22:13,360 --> 00:22:10,450
might take a top-down approach that goes

529
00:22:16,060 --> 00:22:13,370
goes even further back before the

530
00:22:19,000 --> 00:22:16,070
genetic hero so is there any way that we

531
00:22:21,940 --> 00:22:19,010
might be able to deconstruct an ancient

532
00:22:26,980 --> 00:22:21,950
organism back to kind of pre genome

533
00:22:29,170 --> 00:22:26,990
stays that might be possible so I think

534
00:22:31,120 --> 00:22:29,180
that well I didn't talk about today were

535
00:22:32,530 --> 00:22:31,130
the tools that are developed is an

536
00:22:34,690 --> 00:22:32,540
outcome of structural biology and

537
00:22:37,830 --> 00:22:34,700
origins of life research and one of this

538
00:22:41,860 --> 00:22:37,840

is like the protocells I would say is

539
00:22:44,530 --> 00:22:41,870
one and I think the closest I can think

540
00:22:47,890 --> 00:22:44,540
of would be to start with it it's a

541
00:22:50,500 --> 00:22:47,900
lipid zone and and then see whether we

542
00:22:59,860 --> 00:22:50,510
can create an Evo little system within

543
00:23:01,420 --> 00:22:59,870
this cell like components I had a little

544
00:23:03,190 --> 00:23:01,430
question for the RIP disco system

545
00:23:06,250 --> 00:23:03,200
because if you know you have all those

546
00:23:10,140 --> 00:23:06,260
proteins and you study the mechanism can

547
00:23:13,120 --> 00:23:10,150
you see from the mutations traces of

548
00:23:14,830 --> 00:23:13,130
evolution or is there well what

549
00:23:16,780 --> 00:23:14,840
information do you get out exactly or

550
00:23:18,760 --> 00:23:16,790
what-what are interesting aspects on

551
00:23:21,910 --> 00:23:18,770
those experiments yes thank you for this

552
00:23:23,830 --> 00:23:21,920
question so we do see so what we did

553
00:23:27,070 --> 00:23:23,840
when we when we looked at the structure

554
00:23:29,080 --> 00:23:27,080
of the ancestral proteins is that we try

555
00:23:31,240 --> 00:23:29,090
to understand whether that whether there

556
00:23:33,130 --> 00:23:31,250
are mutations the part of the protein

557
00:23:35,140 --> 00:23:33,140
that impact its function that we know

558
00:23:36,760 --> 00:23:35,150
today which is its interaction with

559
00:23:38,770 --> 00:23:36,770
carbon dioxide and oxygen

560
00:23:41,890 --> 00:23:38,780
and then we want to understand whether

561
00:23:44,320 --> 00:23:41,900
we see any changes in these regions as

562
00:23:46,770 --> 00:23:44,330
we go backwards in time and what we

563
00:23:49,360 --> 00:23:46,780

found is that particularly for the

564
00:23:50,500 --> 00:23:49,370
ancestral note that corresponds to what

565
00:23:53,320 --> 00:23:50,510
we think is the ancestor of

566
00:23:56,740 --> 00:23:53,330
cyanobacteria and the ancestor preceding

567
00:23:59,220 --> 00:23:56,750
that are the two ancestor that we see

568
00:24:02,230 --> 00:23:59,230
differences in a high level of mutation

569
00:24:04,930 --> 00:24:02,240
and so it's kind of interesting it's

570
00:24:06,190 --> 00:24:04,940
almost like protein doesn't experience

571
00:24:08,980 --> 00:24:06,200
much change and then a lot of

572
00:24:10,720 --> 00:24:08,990
differences in the region that is

573
00:24:13,270 --> 00:24:10,730
important for protein function and then

574
00:24:16,570 --> 00:24:13,280
stability again so we think that those

575
00:24:19,510 --> 00:24:16,580
perhaps could represent the riscos that

576
00:24:23,710 --> 00:24:19,520
may coincide with the great oxidation

577
00:24:31,030 --> 00:24:23,720
event so let's thank the two again for

578
00:24:34,270 --> 00:24:31,040
an excellent talk and we're going to

579
00:24:36,310 --> 00:24:34,280
welcome irina manageable from Elsi and

580
00:24:47,210 --> 00:24:36,320
she is going to be talking about messy

581
00:24:56,250 --> 00:24:51,600
okay good morning I got it so it's a

582
00:24:58,140 --> 00:24:56,260
clicker now I need that well good

583
00:25:01,470 --> 00:24:58,150
morning and thank you all for coming and

584
00:25:03,510 --> 00:25:01,480
thank for the invitation and kind

585
00:25:06,510 --> 00:25:03,520
introduction so just been sent a couple

586
00:25:08,159 --> 00:25:06,520
of time I'm from LC and I have to say it

587
00:25:10,230 --> 00:25:08,169
once again we're a wonderful

588
00:25:12,090 --> 00:25:10,240

international quite unit Institute there

589
00:25:13,980 --> 00:25:12,100
is a lot of us here at this conference

590
00:25:16,320 --> 00:25:13,990
and actually in the other building we

591
00:25:19,049 --> 00:25:16,330
have our booth we provide a lot of

592
00:25:20,730 --> 00:25:19,059
opportunities for scientists at

593
00:25:24,780 --> 00:25:20,740
different stages of their career so

594
00:25:27,419 --> 00:25:24,790
please stop by the other building pick

595
00:25:29,580 --> 00:25:27,429
up some information talk to some of LC

596
00:25:31,020 --> 00:25:29,590
people and if you're outside I would

597
00:25:32,909 --> 00:25:31,030
like to encourage you to read this

598
00:25:34,799 --> 00:25:32,919
wonderful article Mark Hofmann wrote

599
00:25:40,289 --> 00:25:34,809
about us last week in astrobiology

600
00:25:44,250 --> 00:25:40,299
magazine so I'm going to be talking

601
00:25:45,870 --> 00:25:44,260
about this new or like an concentrated

602
00:25:49,380 --> 00:25:45,880
approach and it's very much a

603
00:25:53,789 --> 00:25:49,390
concentrated effort for many people from

604
00:25:55,440 --> 00:25:53,799
LC that are working on it so when you're

605
00:25:57,270 --> 00:25:55,450
thinking about origin of life there are

606
00:25:59,520 --> 00:25:57,280
a few chemical approaches you can take

607
00:26:01,799 --> 00:25:59,530
one and this is how we chemists are

608
00:26:03,840 --> 00:26:01,809
trained is to take classical synthetic

609
00:26:06,539 --> 00:26:03,850
chemistry approach take a single

610
00:26:08,730 --> 00:26:06,549
reaction try to maximize yield of the

611
00:26:12,539 --> 00:26:08,740
product however when you're thinking

612
00:26:14,220 --> 00:26:12,549
about prebiotic ly plausible system

613
00:26:16,530 --> 00:26:14,230

you're probably not thinking about those

614
00:26:19,640 --> 00:26:16,540
clean reaction you're thinking about HTN

615
00:26:21,870 --> 00:26:19,650
polymers those are heterogeneous

616
00:26:23,970 --> 00:26:21,880
polymers of incredible complexity

617
00:26:27,150 --> 00:26:23,980
products of many different chemical

618
00:26:30,600 --> 00:26:27,160
processes you might be thinking about

619
00:26:33,480 --> 00:26:30,610
miller-urey system and which produces a

620
00:26:36,690 --> 00:26:33,490
vast system of monomers and polymers

621
00:26:38,549 --> 00:26:36,700
that are relevant to probably to

622
00:26:40,409 --> 00:26:38,559
biologically relevant and if you're

623
00:26:42,539 --> 00:26:40,419
thinking a little more exotic Li you

624
00:26:44,880 --> 00:26:42,549
might be thinking about solids of Titan

625
00:26:48,360 --> 00:26:44,890
another very complex mixture of polymer

626
00:26:50,360 --> 00:26:48,370
and this is picture of tightness in but

627
00:26:53,960 --> 00:26:50,370
cassini-huygens and the polymers are

628
00:26:56,460 --> 00:26:53,970
supposedly in that brownish color and

629
00:27:00,220 --> 00:26:56,470
yet again when you're thinking even

630
00:27:02,830 --> 00:27:00,230
about a biological pathway this is how

631
00:27:04,510 --> 00:27:02,840
with the biochemist define life and when

632
00:27:06,490 --> 00:27:04,520
you're thinking about life like process

633
00:27:08,260 --> 00:27:06,500
you hardly thinking about one single

634
00:27:13,090 --> 00:27:08,270
reaction if you're probably thinking

635
00:27:14,770 --> 00:27:13,100
about some subset of this vast system

636
00:27:18,250 --> 00:27:14,780
and so it doesn't it stand to reason

637
00:27:21,310 --> 00:27:18,260
that in just a study system that are

638
00:27:23,590 --> 00:27:21,320

converted into more orchestrated more

639
00:27:27,330 --> 00:27:23,600
clean biological system rather than

640
00:27:29,970 --> 00:27:27,340
single reaction diversifying into this

641
00:27:33,190 --> 00:27:29,980
biological system

642
00:27:35,440 --> 00:27:33,200
well I'm sorry Stephen I know you're

643
00:27:37,480 --> 00:27:35,450
somewhere here so Steve vinter likes to

644
00:27:41,080 --> 00:27:37,490
say that when organic molecules are

645
00:27:43,030 --> 00:27:41,090
given energy and left to their own

646
00:27:45,100 --> 00:27:43,040
devices they devolve into a complex

647
00:27:47,919 --> 00:27:45,110
mixture more suitable for paving roads

648
00:27:50,230 --> 00:27:47,929
than sustaining their engine evolution

649
00:27:50,830 --> 00:27:50,240
with all due respect we would like to

650
00:27:56,440 --> 00:27:50,840
disagree

651
00:27:58,750 --> 00:27:56,450
so we at LC was slowly studying this

652
00:28:01,060 --> 00:27:58,760
research project and we're in the habit

653
00:28:03,010 --> 00:28:01,070
of calling it messy chemistry and of

654
00:28:06,130 --> 00:28:03,020
course we're borrowing a lot of concept

655
00:28:08,860 --> 00:28:06,140
from system chemistry and complex system

656
00:28:11,500 --> 00:28:08,870
science but just we needed this new term

657
00:28:14,740 --> 00:28:11,510
because for example systems chemistry is

658
00:28:16,950 --> 00:28:14,750
often referred to small and defined

659
00:28:20,380 --> 00:28:16,960
reaction networks is coming from

660
00:28:24,130 --> 00:28:20,390
synthesis world when researchers are

661
00:28:26,860 --> 00:28:24,140
using by inspired methods for new

662
00:28:29,350 --> 00:28:26,870
synthetic approaches so in our mind

663
00:28:32,970 --> 00:28:29,360

messy chemistry is where prebiotic

664
00:28:35,470 --> 00:28:32,980
chemistry meets systems chemistry it's a

665
00:28:38,650 --> 00:28:35,480
system of complex interacting

666
00:28:40,960 --> 00:28:38,660
multi-component reaction network not

667
00:28:43,990 --> 00:28:40,970
necessarily unstructured but structure

668
00:28:46,539 --> 00:28:44,000
of it is not immediately apparent and in

669
00:28:49,570 --> 00:28:46,549
our minds origin of life is transitioned

670
00:28:52,210 --> 00:28:49,580
from meta chemistry to well-defined well

671
00:28:54,700 --> 00:28:52,220
controlled biochemical networks so the

672
00:28:57,370 --> 00:28:54,710
way we're doing it LC we're trying to

673
00:28:59,980 --> 00:28:57,380
study this messy chemistry as one entity

674
00:29:03,070 --> 00:28:59,990
we're not trying to deconstruct and

675
00:29:05,049 --> 00:29:03,080
really identify it every component of

676
00:29:07,750 --> 00:29:05,059
our chemical system and we're using

677
00:29:10,210 --> 00:29:07,760
computer experimental and experimental

678
00:29:12,430 --> 00:29:10,220
modeling to study the structure of this

679
00:29:13,240 --> 00:29:12,440
entity and we're also obviously looking

680
00:29:15,640 --> 00:29:13,250
at organ is

681
00:29:18,430 --> 00:29:15,650
Asian selection and all other emergent

682
00:29:21,790 --> 00:29:18,440
phenomena that are happening in Mesa

683
00:29:23,650 --> 00:29:21,800
chemistry's so let me give you one

684
00:29:26,710 --> 00:29:23,660
example what we're thinking about Mesa

685
00:29:29,530 --> 00:29:26,720
chemistry and this is a tangible messy

686
00:29:32,350 --> 00:29:29,540
chemistry we like to use polyesters and

687
00:29:36,880 --> 00:29:32,360
the reason we like them if they're sort

688
00:29:40,470 --> 00:29:36,890

of resembling peptides however they are

689
00:29:44,140 --> 00:29:40,480
much easier to synthesize and it's been

690
00:29:46,930 --> 00:29:44,150
said few and few different ways that

691
00:29:49,870 --> 00:29:46,940
they could be potential ancestors for

692
00:29:53,230 --> 00:29:49,880
peptides for example from the work of

693
00:29:55,510 --> 00:29:53,240
alex rich at MIT we know that ribosome

694
00:29:58,120 --> 00:29:55,520
catalyzes alpha hydroxy acid polish

695
00:30:01,990 --> 00:29:58,130
purification for not chemists of us

696
00:30:04,750 --> 00:30:02,000
alpha hydroxy acid our Oh H analogs of

697
00:30:07,300 --> 00:30:04,760
alpha amino acid and especially with

698
00:30:09,630 --> 00:30:07,310
lots of work coming from Nakata and

699
00:30:13,950 --> 00:30:09,640
Ramakrishna morsel labs there is a

700
00:30:18,370 --> 00:30:13,960
renewed interest in studying polyesters

701
00:30:21,730 --> 00:30:18,380
potential early polymer is an origin of

702
00:30:24,700 --> 00:30:21,740
life and so this is I want to talk about

703
00:30:27,400 --> 00:30:24,710
work pioneered at LC by Jim Cleveland

704
00:30:29,380 --> 00:30:27,410
kahan Chandra so what they did here it's

705
00:30:32,140 --> 00:30:29,390
a very simple experiment they took five

706
00:30:35,860 --> 00:30:32,150
different alpha hydroxy acid dried them

707
00:30:38,650 --> 00:30:35,870
down at probiotic plausible mild

708
00:30:42,210 --> 00:30:38,660
conditions and they're getting this vast

709
00:30:44,800 --> 00:30:42,220
complex array of components which is not

710
00:30:48,430 --> 00:30:44,810
surprising because if you assume you

711
00:30:51,850 --> 00:30:48,440
have those five alpha hydroxy acid and

712
00:30:53,710 --> 00:30:51,860
assume you only made 20 MERS you will

713
00:30:55,450 --> 00:30:53,720

get five to the twentieth unique

714
00:30:58,060 --> 00:30:55,460
sequences and obviously you're not only

715
00:30:59,620 --> 00:30:58,070
making twenty MERS and imagine this how

716
00:31:02,080 --> 00:30:59,630
this is a message system and this is

717
00:31:04,660 --> 00:31:02,090
only at this point based on one reaction

718
00:31:08,200 --> 00:31:04,670
poorly esterification so what Jim and

719
00:31:10,840 --> 00:31:08,210
kahan right now are doing is trying to

720
00:31:14,350 --> 00:31:10,850
figure out ways how they can bias their

721
00:31:17,700 --> 00:31:14,360
synthesis to produce different

722
00:31:19,990 --> 00:31:17,710
polyesters of some somewhat controlled

723
00:31:22,930 --> 00:31:20,000
properties somewhat cultured sequence

724
00:31:25,480 --> 00:31:22,940
and structure so what I am interesting

725
00:31:26,779 --> 00:31:25,490
is is whether this messy polymers can be

726
00:31:30,919 --> 00:31:26,789
functional

727
00:31:32,629 --> 00:31:30,929
polymers even if it wasn't called that

728
00:31:36,799 --> 00:31:32,639
it's not a new idea

729
00:31:39,889 --> 00:31:36,809
so Sydney Fox spent a huge chunk of his

730
00:31:43,969 --> 00:31:39,899
career working effectively on messy

731
00:31:46,969 --> 00:31:43,979
polymer so what he did he dry down like

732
00:31:49,269 --> 00:31:46,979
certain mixture of amino acid and he was

733
00:31:53,089 --> 00:31:49,279
able to synthesize those interesting

734
00:31:56,269 --> 00:31:53,099
microsphere structures and he studied

735
00:31:58,779 --> 00:31:56,279
them a lot so and there are a few good

736
00:32:01,879 --> 00:31:58,789
things that came out of his research

737
00:32:02,959 --> 00:32:01,889
some of his papers show that these

738
00:32:07,789 --> 00:32:02,969

microspheres

739
00:32:10,399 --> 00:32:07,799
are capable of catalysis mostly towards

740
00:32:12,199 --> 00:32:10,409
hydrolysis but nevertheless and I just

741
00:32:15,259 --> 00:32:12,209
went unfortunately when the good thing

742
00:32:17,719 --> 00:32:15,269
stopped so that the Economist

743
00:32:20,629 --> 00:32:17,729
always claimed that this catalytic

744
00:32:25,509 --> 00:32:20,639
activity is low with marginal and Sydney

745
00:32:28,339 --> 00:32:25,519
folks never even tried to explain any

746
00:32:30,319 --> 00:32:28,349
mechanism vive is why this catalysis is

747
00:32:32,809 --> 00:32:30,329
working and towards the end of his

748
00:32:36,559 --> 00:32:32,819
career unfortunately the ugly has

749
00:32:38,869 --> 00:32:36,569
started so she claimed that he's making

750
00:32:40,849 --> 00:32:38,879
proteins basically that the corporation

751
00:32:43,009 --> 00:32:40,859
of amino acids is not random and there

752
00:32:46,269 --> 00:32:43,019
was never evidence to that that the

753
00:32:48,619 --> 00:32:46,279
polymers is forming a linear and this is

754
00:32:51,769 --> 00:32:48,629
particularly funny because it seemed to

755
00:32:54,289 --> 00:32:51,779
be working only we have when he loaded

756
00:32:56,329 --> 00:32:54,299
his system with glutamic acid and you

757
00:32:58,689 --> 00:32:56,339
can see varied by functional so you're

758
00:33:02,059 --> 00:32:58,699
probably making some sort of branched

759
00:33:04,609 --> 00:33:02,069
polymers and quite outrageously he

760
00:33:08,689 --> 00:33:04,619
claims that his microspheres have

761
00:33:11,239 --> 00:33:08,699
lifelike behavior of consciousness and

762
00:33:14,509 --> 00:33:11,249
you know what it just really soured a

763
00:33:15,949 --> 00:33:14,519

lot of people nobody worked on this

764
00:33:18,889 --> 00:33:15,959
research for years

765
00:33:21,169 --> 00:33:18,899
so we at LC we decided to take a

766
00:33:26,539 --> 00:33:21,179
different more structured approach of

767
00:33:28,729 --> 00:33:26,549
making a proto enzyme and what is an

768
00:33:31,669 --> 00:33:28,739
enzyme when you think of an enzyme it

769
00:33:34,189 --> 00:33:31,679
consists of catalytic site which is

770
00:33:39,510 --> 00:33:34,199
careful did by intricately folded

771
00:33:43,610 --> 00:33:39,520
protein or sometimes RNA polymer

772
00:33:46,920 --> 00:33:43,620
and the function of this careful is is

773
00:33:51,720 --> 00:33:46,930
important because well for once it's

774
00:33:55,500 --> 00:33:51,730
protect the active sites from hydrolysis

775
00:33:59,570 --> 00:33:55,510
it helps to bind and orientate very

776
00:34:03,900 --> 00:33:59,580
specifically well needed substrate and

777
00:34:05,460 --> 00:34:03,910
more importantly it can create micro

778
00:34:08,580 --> 00:34:05,470
environments that are different from

779
00:34:11,820 --> 00:34:08,590
surrounding water helping to promote

780
00:34:16,500 --> 00:34:11,830
very earth specific reaction and in the

781
00:34:20,550 --> 00:34:16,510
work pioneered by Doron Breslow dental

782
00:34:23,820 --> 00:34:20,560
resins enzymes that are using this

783
00:34:26,130 --> 00:34:23,830
regular branched polymers are widely

784
00:34:30,330 --> 00:34:26,140
used and in some cases they work almost

785
00:34:32,220 --> 00:34:30,340
as good as biological enzymes so what is

786
00:34:34,970 --> 00:34:32,230
a dental is I'm you see in the middle of

787
00:34:38,669 --> 00:34:34,980
that fractal molecule you have your a

788
00:34:40,500 --> 00:34:38,679

catalytic site and then you can just use

789
00:34:45,540 --> 00:34:40,510
all sorts of synthetic methods to

790
00:34:48,000 --> 00:34:45,550
generate a generation story of branch

791
00:34:52,320 --> 00:34:48,010
parlament surrounding and you can cut

792
00:34:54,960 --> 00:34:52,330
control properties like interior of the

793
00:34:58,440 --> 00:34:54,970
dendrimer solubility of coarse-grained

794
00:35:00,210 --> 00:34:58,450
resins are very synthetic very

795
00:35:03,180 --> 00:35:00,220
engineered systems which are hardly

796
00:35:07,290 --> 00:35:03,190
probiotic so we were thinking what if we

797
00:35:09,030 --> 00:35:07,300
took irregular hype branched polymer

798
00:35:11,670 --> 00:35:09,040
irregular denture science called hyper

799
00:35:16,970 --> 00:35:11,680
branched polymers so it turns out these

800
00:35:20,160 --> 00:35:16,980
are also globular molecules that are

801
00:35:22,200 --> 00:35:20,170
retaining a lot of properties of

802
00:35:27,570 --> 00:35:22,210
dendrimers of course in less control way

803
00:35:30,150 --> 00:35:27,580
and here what we try to do and our first

804
00:35:32,640 --> 00:35:30,160
attempt to evaluate the catalytic

805
00:35:35,970 --> 00:35:32,650
ability so that the first question i

806
00:35:38,420 --> 00:35:35,980
asked whether this hyper branched

807
00:35:40,800 --> 00:35:38,430
polymers is capable of providing

808
00:35:43,050 --> 00:35:40,810
modulated environment within the

809
00:35:46,110 --> 00:35:43,060
structure that helps promote reaction so

810
00:35:48,260 --> 00:35:46,120
we chose this reaction called camp

811
00:35:53,070 --> 00:35:48,270
elimination it's not of any particular

812
00:35:55,110 --> 00:35:53,080
interest to grab IOT chemistry but

813
00:35:59,000 --> 00:35:55,120

it's interesting about this reaction it

814
00:36:01,920 --> 00:35:59,010
is very sensitive to a solvent

815
00:36:04,170 --> 00:36:01,930
environment so the reaction proceeded

816
00:36:07,470 --> 00:36:04,180
quite sluggishly in water and that the

817
00:36:10,890 --> 00:36:07,480
polarity of the solvent is is dropping

818
00:36:12,600 --> 00:36:10,900
the rate of the reaction is amplified so

819
00:36:15,360 --> 00:36:12,610
what I'm thinking is actually build

820
00:36:18,330 --> 00:36:15,370
hyper branched polymers based crotteau

821
00:36:22,050 --> 00:36:18,340
enzyme and just force the reaction to

822
00:36:24,870 --> 00:36:22,060
happen inside the polymer maybe I can

823
00:36:28,020 --> 00:36:24,880
actually show that you know the rate of

824
00:36:29,880 --> 00:36:28,030
this reaction is amplified so what I

825
00:36:32,720 --> 00:36:29,890
wanted I did and it's just been very

826
00:36:36,060 --> 00:36:32,730
simple just simple drying down process I

827
00:36:39,150 --> 00:36:36,070
synthesized this polymer based on citric

828
00:36:41,820 --> 00:36:39,160
acid glycerol it's a polyester I threw

829
00:36:43,770 --> 00:36:41,830
in triathlon I mean if I forgot to

830
00:36:46,230 --> 00:36:43,780
mention at camp elimination is base

831
00:36:49,620 --> 00:36:46,240
catalyzed as well so if I attend all I

832
00:36:55,740 --> 00:36:49,630
mean in this case as the catalytic core

833
00:36:58,080 --> 00:36:55,750
and if you see from that mass spec you

834
00:37:01,700 --> 00:36:58,090
get a very massive polymer there are a

835
00:37:04,080 --> 00:37:01,710
lot of a lot of different structures a

836
00:37:07,470 --> 00:37:04,090
lot of different species with different

837
00:37:10,140 --> 00:37:07,480
components in them but what's

838
00:37:12,690 --> 00:37:10,150

interesting they're all rather short so

839
00:37:15,300 --> 00:37:12,700
I'm not getting any species that are

840
00:37:18,690 --> 00:37:15,310
higher than thousand Dalton's so we're

841
00:37:22,200 --> 00:37:18,700
probably talking only seven seven MERS

842
00:37:26,960 --> 00:37:22,210
and eight MERS so sounds like short but

843
00:37:31,470 --> 00:37:26,970
I nevertheless went and conducted

844
00:37:34,110 --> 00:37:31,480
experiments with trying to essay this

845
00:37:37,050 --> 00:37:34,120
proteins I am using camp elimination and

846
00:37:39,690 --> 00:37:37,060
so I tried few systems so one of them is

847
00:37:42,650 --> 00:37:39,700
citric acid go through try as an element

848
00:37:45,270 --> 00:37:42,660
quite polar another one is adipic acid

849
00:37:47,520 --> 00:37:45,280
glycerol triethylamine somewhat less

850
00:37:50,310 --> 00:37:47,530
polar and the same is true for methyl

851
00:37:53,910 --> 00:37:50,320
methyl sexy nick acid glycerol triathlon

852
00:37:57,420 --> 00:37:53,920
amine and if you see like in that line

853
00:37:59,880 --> 00:37:57,430
in red that is the reaction happening

854
00:38:02,460 --> 00:37:59,890
with unpolymerized triathlon mean and

855
00:38:04,680 --> 00:38:02,470
when you try to use citric acid polymer

856
00:38:05,820 --> 00:38:04,690
it works a little bit better and when

857
00:38:07,980 --> 00:38:05,830
using

858
00:38:10,110 --> 00:38:07,990
methyl succeeding acid polymers so

859
00:38:13,230 --> 00:38:10,120
reaction proceeds like five times better

860
00:38:15,840 --> 00:38:13,240
and of course when talking about

861
00:38:17,820 --> 00:38:15,850
enzymatic amplification and just

862
00:38:20,490 --> 00:38:17,830
amplification of fire sounds like

863
00:38:23,520 --> 00:38:20,500

nothing but just remember this polymers

864
00:38:26,160 --> 00:38:23,530
are messy this polymers are only seven

865
00:38:29,130 --> 00:38:26,170
or eight more long this is an just we're

866
00:38:31,470 --> 00:38:29,140
quite excited and we're actually I'm not

867
00:38:35,330 --> 00:38:31,480
ready to talk about it we are working on

868
00:38:40,200 --> 00:38:35,340
scaffolding more biologically relevant

869
00:38:42,450 --> 00:38:40,210
active site so please stay tuned and so

870
00:38:45,060 --> 00:38:42,460
right now I want to switch gears and

871
00:38:48,870 --> 00:38:45,070
talk a little bit about the artificial

872
00:38:53,090 --> 00:38:48,880
chemistry effort we're doing in our lab

873
00:38:57,210 --> 00:38:53,100
and this work is pioneered by Nicolas

874
00:39:00,450 --> 00:38:57,220
Guttenberg nathaniel verver and Norman

875
00:39:03,120 --> 00:39:00,460
Packard and so first I want to talk

876
00:39:05,520 --> 00:39:03,130
about this auto catalysis threshold for

877
00:39:07,740 --> 00:39:05,530
dominance and so in general what we

878
00:39:10,770 --> 00:39:07,750
trying to achieve here how do we

879
00:39:13,980 --> 00:39:10,780
introduce partners into those messy

880
00:39:16,650 --> 00:39:13,990
chemistry okay you start with vast array

881
00:39:18,930 --> 00:39:16,660
of components how do you get to clean up

882
00:39:22,500 --> 00:39:18,940
the system and produce some sort of

883
00:39:25,260 --> 00:39:22,510
order some sort of function so Nathaniel

884
00:39:27,780 --> 00:39:25,270
there is looking at the system which is

885
00:39:29,820 --> 00:39:27,790
messy which is reversible and it's

886
00:39:33,750 --> 00:39:29,830
competing for the same resources and

887
00:39:36,810 --> 00:39:33,760
then he allows for some replicators to

888
00:39:39,420 --> 00:39:36,820

form in that particular system and it

889
00:39:42,030 --> 00:39:39,430
turns out maybe not surprisingly so that

890
00:39:45,630 --> 00:39:42,040
when this replicator reaches their

891
00:39:48,870 --> 00:39:45,640
certain threshold rate of auto catalysis

892
00:39:51,390 --> 00:39:48,880
it takes over the whole system so this

893
00:39:55,230 --> 00:39:51,400
is one way to transition to sparseness

894
00:39:58,980 --> 00:39:55,240
and this other system is how do you use

895
00:40:01,050 --> 00:39:58,990
a super molecular interaction to

896
00:40:02,940 --> 00:40:01,060
transition to sparseness and i just kind

897
00:40:06,270 --> 00:40:02,950
of want to advertise here a little bit a

898
00:40:09,630 --> 00:40:06,280
norman packard will be giving more

899
00:40:12,630 --> 00:40:09,640
detailed talk on this project on friday

900
00:40:15,330 --> 00:40:12,640
morning so please come and see him talk

901
00:40:18,180 --> 00:40:15,340
so in this system they have a solution

902
00:40:20,820 --> 00:40:18,190
of the non basic components

903
00:40:22,620 --> 00:40:20,830
and through some introduced a pro

904
00:40:25,260 --> 00:40:22,630
molecular interactions they're allowed

905
00:40:27,960 --> 00:40:25,270
to precipitate and you know you can only

906
00:40:30,870 --> 00:40:27,970
crash out of solution if you co

907
00:40:34,380 --> 00:40:30,880
precipitating with something else and in

908
00:40:39,030 --> 00:40:34,390
this system the the solution undergoes

909
00:40:42,390 --> 00:40:39,040
like multiple washings and what you end

910
00:40:45,360 --> 00:40:42,400
up here is with here so in red you have

911
00:40:47,730 --> 00:40:45,370
a system which is completely messy has a

912
00:40:49,440 --> 00:40:47,740
lot of states but allowing this

913
00:40:53,040 --> 00:40:49,450

supramolecular instruction you

914
00:40:59,640 --> 00:40:53,050
eventually transition into this kind of

915
00:41:01,230 --> 00:40:59,650
sparse or blue system so and just when

916
00:41:04,370 --> 00:41:01,240
they started talking about that it's

917
00:41:07,530 --> 00:41:04,380
just actually brought one of the other

918
00:41:10,380 --> 00:41:07,540
hyper branch polymer system I've been

919
00:41:13,920 --> 00:41:10,390
doing when I was and joke Cody's love

920
00:41:15,870 --> 00:41:13,930
and so in this particular system we were

921
00:41:17,730 --> 00:41:15,880
synthesizing citric acid reversal of

922
00:41:21,000 --> 00:41:17,740
polymer and let's just take some

923
00:41:24,600 --> 00:41:21,010
learning and just to make hyper branched

924
00:41:27,120 --> 00:41:24,610
polymer rather than cross-linked ones

925
00:41:30,120 --> 00:41:27,130
you actually need to use excess of one

926
00:41:31,800 --> 00:41:30,130
of the ingredients and so that's what we

927
00:41:34,800 --> 00:41:31,810
did will work the loved with the system

928
00:41:37,230 --> 00:41:34,810
that that consists of two parts literal

929
00:41:40,050 --> 00:41:37,240
one part citric acid and so when you

930
00:41:44,040 --> 00:41:40,060
synthesize this polymer by simple dry

931
00:41:46,350 --> 00:41:44,050
down analyze it by mass spec what

932
00:41:49,440 --> 00:41:46,360
happens you get a species that I reach

933
00:41:51,570 --> 00:41:49,450
in go 0 which is not surprising however

934
00:41:54,870 --> 00:41:51,580
when you throw in like basically any

935
00:41:57,290 --> 00:41:54,880
devil and cation your system because

936
00:42:01,860 --> 00:41:57,300
starts getting rich in species that are

937
00:42:03,570 --> 00:42:01,870
actually enriched in citric acid and I

938
00:42:05,700 --> 00:42:03,580

think the reason it's happening it's

939
00:42:08,580 --> 00:42:05,710
once again supramolecular introduction

940
00:42:11,580 --> 00:42:08,590
so citric acid is a fantastic you later

941
00:42:17,340 --> 00:42:11,590
for this devlins and so when teacher

942
00:42:20,550 --> 00:42:17,350
guess it participates in a in chelate it

943
00:42:25,020 --> 00:42:20,560
becomes less reactive towards

944
00:42:26,700 --> 00:42:25,030
polyesterification and therefore you

945
00:42:28,860 --> 00:42:26,710
know in order to make polymer you just

946
00:42:29,520 --> 00:42:28,870
need a lot more of them so I'm hoping at

947
00:42:32,220 --> 00:42:29,530
some point

948
00:42:34,140 --> 00:42:32,230
Norman Parker and Nick Guttenberg

949
00:42:36,480 --> 00:42:34,150
we'll actually tweak this previous

950
00:42:40,440 --> 00:42:36,490
system to actually help me explain what

951
00:42:44,160 --> 00:42:40,450
happens with mine and this is like the

952
00:42:45,930 --> 00:42:44,170
last completely last experiment I want

953
00:42:48,720 --> 00:42:45,940
to talk about and it's pioneered but

954
00:42:50,910 --> 00:42:48,730
Nathaniel Virgo in her lab so here what

955
00:42:53,099 --> 00:42:50,920
he is looking to study she is studying

956
00:42:56,220 --> 00:42:53,109
at the catalysis in this polymerization

957
00:42:59,609 --> 00:42:56,230
system there is one monomer and in this

958
00:43:01,500 --> 00:42:59,619
system you can now have two mala

959
00:43:03,690 --> 00:43:01,510
monomers react with each other

960
00:43:05,640 --> 00:43:03,700
oligomers can react with each other

961
00:43:07,230 --> 00:43:05,650
oligomers can react with monomers and

962
00:43:09,599 --> 00:43:07,240
then just everything is reversible and

963
00:43:12,630 --> 00:43:09,609

this is a simple system where you're

964
00:43:14,640 --> 00:43:12,640
just not completely difficult to figure

965
00:43:17,070 --> 00:43:14,650
out what would be the kinetics what

966
00:43:19,260 --> 00:43:17,080
would be the inter distribution but then

967
00:43:23,670 --> 00:43:19,270
she's doing interesting system for this

968
00:43:27,359 --> 00:43:23,680
is if for in this particular system so

969
00:43:30,599 --> 00:43:27,369
he disallowing the step of two monomers

970
00:43:32,430 --> 00:43:30,609
reacting with each other or diminution

971
00:43:34,680 --> 00:43:32,440
probability of that happening and in

972
00:43:36,480 --> 00:43:34,690
that case you see over there when you're

973
00:43:38,910 --> 00:43:36,490
analyzing the kinetic you have this

974
00:43:41,040 --> 00:43:38,920
characteristic lag you're getting your

975
00:43:42,990 --> 00:43:41,050
first order auto catalysis

976
00:43:44,849 --> 00:43:43,000
well this reaction might be not

977
00:43:49,200 --> 00:43:44,859
particularly interesting it's probably

978
00:43:51,060 --> 00:43:49,210
resembling for most reaction in foremost

979
00:43:52,650 --> 00:43:51,070
just to bring to formaldehydes together

980
00:43:54,270 --> 00:43:52,660
it's a difficult step but if you want

981
00:43:57,660 --> 00:43:54,280
once you're done that the reaction takes

982
00:44:01,020 --> 00:43:57,670
off but then asagna went and did things

983
00:44:03,690 --> 00:44:01,030
that are completely crazy he you know to

984
00:44:06,180 --> 00:44:03,700
say let's disallow a seven monomer and

985
00:44:08,750 --> 00:44:06,190
what's interesting here was starting to

986
00:44:13,050 --> 00:44:08,760
happening you need you start making

987
00:44:17,280 --> 00:44:13,060
cycles to access synthetically all of

988
00:44:20,550 --> 00:44:17,290

your oligomers in there and so in this

989
00:44:25,770 --> 00:44:20,560
particular sample his christy disallowed

990
00:44:27,320 --> 00:44:25,780
any ligament full of threes and what's

991
00:44:30,320 --> 00:44:27,330
happening he created those

992
00:44:32,700 --> 00:44:30,330
interconnected cycles that are quite

993
00:44:38,210 --> 00:44:32,710
interesting who had entered connected

994
00:44:40,859 --> 00:44:38,220
and once again you have this very

995
00:44:43,290 --> 00:44:40,869
characteristic leg of auto catalysis

996
00:44:45,400 --> 00:44:43,300
however the kinetics of this reaction

997
00:44:48,340 --> 00:44:45,410
becomes much more calm

998
00:44:50,650 --> 00:44:48,350
located so what's the main point that

999
00:44:52,930 --> 00:44:50,660
Nathaniel said to drive over so in order

1000
00:44:55,540 --> 00:44:52,940
to get interesting system interesting

1001
00:44:59,230 --> 00:44:55,550
outer catalysis you need to have large

1002
00:45:02,080 --> 00:44:59,240
messy interesting complicated system and

1003
00:45:03,850 --> 00:45:02,090
with that this is my life slide that

1004
00:45:06,070 --> 00:45:03,860
probably you can read my conclusions

1005
00:45:08,290 --> 00:45:06,080
because I'm over my time and thank you

1006
00:45:16,450 --> 00:45:08,300
very much for your attention I'll take

1007
00:45:18,700 --> 00:45:16,460
any questions then we have time for one

1008
00:45:20,950 --> 00:45:18,710
question over here hi Mike long from

1009
00:45:23,860 --> 00:45:20,960
Caltech I'm wondering in what planetary

1010
00:45:26,380 --> 00:45:23,870
environments do you envision this messy

1011
00:45:27,880 --> 00:45:26,390
chemistry taking places we're on early

1012
00:45:31,720 --> 00:45:27,890
Earth is it applicable is it applicable

1013
00:45:34,150 --> 00:45:31,730

to ocean worlds to Titan just your

1014
00:45:35,500 --> 00:45:34,160
thoughts on that our justice is messy I

1015
00:45:37,180 --> 00:45:35,510
know I don't know what particular

1016
00:45:40,110 --> 00:45:37,190
chemists were talking about I think

1017
00:45:42,490 --> 00:45:40,120
you'll get messy in whatever environment

1018
00:45:45,000 --> 00:45:42,500
right you know if you don't you don't

1019
00:45:47,680 --> 00:45:45,010
have a urine somatic reaction to you

1020
00:45:49,480 --> 00:45:47,690
eventually you'll get some complicated

1021
00:45:51,760 --> 00:45:49,490
messy environment that's how chemistry

1022
00:45:53,110 --> 00:45:51,770
works so I guess maybe I can rephrase

1023
00:45:55,930 --> 00:45:53,120
you you started off with a quote by

1024
00:45:57,760 --> 00:45:55,940
Steve Benner about adding energy into

1025
00:45:59,800 --> 00:45:57,770
chemistry and then and then you said we

1026
00:46:03,700 --> 00:45:59,810
disagree so what what is your energy

1027
00:46:05,950 --> 00:46:03,710
source in there oh yeah well whatever I

1028
00:46:07,900 --> 00:46:05,960
described here energy source is just

1029
00:46:09,610 --> 00:46:07,910
heat from the Sun but I think of

1030
00:46:16,270 --> 00:46:09,620
anything else

1031
00:46:18,400 --> 00:46:16,280
all right let's thank Irene again and

1032
00:46:24,150 --> 00:46:18,410
our last speaker this morning is Lee

1033
00:46:30,440 --> 00:46:28,100
yeah I'm just starting my stopwatch

1034
00:46:33,020 --> 00:46:30,450
so morning everybody so I'm going to

1035
00:46:36,440 --> 00:46:33,030
kind of change gear a bit and try and

1036
00:46:38,140 --> 00:46:36,450
think about how you might reimagine life

1037
00:46:41,210 --> 00:46:38,150
and the completely different

1038
00:46:43,670 --> 00:46:41,220

circumstances to try and see how we

1039
00:46:46,970 --> 00:46:43,680
might imagine life might occur on say

1040
00:46:48,950 --> 00:46:46,980
Titan or elsewhere and to do that the

1041
00:46:51,410 --> 00:46:48,960
message I want to kind of start with is

1042
00:46:53,060 --> 00:46:51,420
thinking what did life look like before

1043
00:46:54,260 --> 00:46:53,070
there was life well that's a clearly a

1044
00:46:56,810 --> 00:46:54,270
crazy question you just had an

1045
00:46:59,150 --> 00:46:56,820
environment but really the emergence of

1046
00:47:00,740 --> 00:46:59,160
biology has something to do with taking

1047
00:47:03,380 --> 00:47:00,750
the environment and putting it into a

1048
00:47:05,330 --> 00:47:03,390
container so you have kind of increasing

1049
00:47:06,530 --> 00:47:05,340
evolution and this is kind of an

1050
00:47:08,870 --> 00:47:06,540
interesting idea because of the

1051
00:47:11,080 --> 00:47:08,880
beginning there was no biology there

1052
00:47:14,210 --> 00:47:11,090
were no cells so how do we suddenly

1053
00:47:15,920 --> 00:47:14,220
shake the environment and out pops some

1054
00:47:18,380 --> 00:47:15,930
biology and that's what we're going to

1055
00:47:22,430 --> 00:47:18,390
try and talk about today in the next 10

1056
00:47:25,850 --> 00:47:22,440
or 15 minutes now in my group at Glasgow

1057
00:47:28,430 --> 00:47:25,860
we are fairly interested in redefining

1058
00:47:32,060 --> 00:47:28,440
not just the search for biology but how

1059
00:47:33,440 --> 00:47:32,070
we might make one and when we're looking

1060
00:47:35,060 --> 00:47:33,450
at the origin of life that's a very

1061
00:47:37,040 --> 00:47:35,070
interesting question but it's quite a

1062
00:47:39,980 --> 00:47:37,050
historical question and quite a hard one

1063
00:47:42,290 --> 00:47:39,990

so how can we circumnavigate get round

1064
00:47:44,180 --> 00:47:42,300
that problem by imagining a slightly

1065
00:47:46,550 --> 00:47:44,190
different problem to try and make a life

1066
00:47:49,070 --> 00:47:46,560
form to do that I think we need a new

1067
00:47:51,800 --> 00:47:49,080
theory for biology and evolution and I

1068
00:47:54,440 --> 00:47:51,810
think this is if we have that maybe we

1069
00:47:56,120 --> 00:47:54,450
can use that to develop a model to

1070
00:47:58,370 --> 00:47:56,130
simulate the emergence of biology and

1071
00:48:00,530 --> 00:47:58,380
then if we have a model then maybe we

1072
00:48:02,660 --> 00:48:00,540
can use that to build a machine to

1073
00:48:05,120 --> 00:48:02,670
actually make that biology and then by

1074
00:48:06,620 --> 00:48:05,130
doing that what we've also tried to do

1075
00:48:09,380 --> 00:48:06,630
in the group has come up with a metric

1076
00:48:12,710 --> 00:48:09,390
to identify bio signatures this will not

1077
00:48:14,480 --> 00:48:12,720
only help find life elsewhere but if we

1078
00:48:15,800 --> 00:48:14,490
actually make it in the lab wouldn't it

1079
00:48:17,540 --> 00:48:15,810
be terrible if we make a life form in

1080
00:48:20,060 --> 00:48:17,550
the lab we convinces it's plausible that

1081
00:48:23,450 --> 00:48:20,070
is not a robot making a robot and

1082
00:48:24,830 --> 00:48:23,460
suddenly we spend 30 years arguing about

1083
00:48:26,840 --> 00:48:24,840
whether it's really a life form or not

1084
00:48:28,840 --> 00:48:26,850
that's kind of that would be kind of sad

1085
00:48:31,340 --> 00:48:28,850
but what I'm going to do today is really

1086
00:48:33,410 --> 00:48:31,350
focus on this idea of making a machine

1087
00:48:36,470 --> 00:48:33,420
to emerge new biology's now I'm an

1088
00:48:38,330 --> 00:48:36,480

inorganic chemist so I would love to

1089
00:48:40,460 --> 00:48:38,340
blind you with fancy molecules and and

1090
00:48:41,900 --> 00:48:40,470
messy chemistry but the last speakers

1091
00:48:43,130 --> 00:48:41,910
done that really elegantly

1092
00:48:47,029 --> 00:48:43,140
I'm going to do something completely

1093
00:48:50,150 --> 00:48:47,039
different but let's think about what

1094
00:48:50,839 --> 00:48:50,160
life is is life about chemistry I don't

1095
00:48:52,279 --> 00:48:50,849
think so

1096
00:48:53,779 --> 00:48:52,289
I'm a chemist I'd love to make

1097
00:48:55,849 --> 00:48:53,789
everything I'd like to make myself the

1098
00:48:57,230 --> 00:48:55,859
center of the universe and I'll let

1099
00:49:03,620 --> 00:48:57,240
Steve Benner do that I don't agree

1100
00:49:06,740 --> 00:49:03,630
siting here sorry Steve but a serious

1101
00:49:08,900 --> 00:49:06,750
point is can we how can we turn blobs

1102
00:49:12,079 --> 00:49:08,910
into life forms so let's just think

1103
00:49:13,880 --> 00:49:12,089
about the blob the living blob the blob

1104
00:49:15,109 --> 00:49:13,890
that survives the environment the blob

1105
00:49:17,720 --> 00:49:15,119
that goes through the environment is

1106
00:49:19,490 --> 00:49:17,730
able to propagate itself is that what

1107
00:49:21,289 --> 00:49:19,500
life is is as simple as that well I

1108
00:49:23,569 --> 00:49:21,299
don't want to really start worrying too

1109
00:49:26,029 --> 00:49:23,579
much but my group really interested in

1110
00:49:28,339 --> 00:49:26,039
taking a morphology first approach so

1111
00:49:31,370 --> 00:49:28,349
you can imagine growing things from a

1112
00:49:33,020 --> 00:49:31,380
seed okay well that's what biology does

1113
00:49:34,670 --> 00:49:33,030

biology you've got the machinery to do

1114
00:49:37,279 --> 00:49:34,680
that but where does the machinery come

1115
00:49:40,309 --> 00:49:37,289
from we go around in circles so could we

1116
00:49:42,620 --> 00:49:40,319
just allow the environment to generate

1117
00:49:45,650 --> 00:49:42,630
objects that persist for a long time and

1118
00:49:47,329 --> 00:49:45,660
can start to copy themselves and we

1119
00:49:48,620 --> 00:49:47,339
think that a mechanism given rise for

1120
00:49:51,559 --> 00:49:48,630
the things are more important than the

1121
00:49:53,660 --> 00:49:51,569
things themselves and then look growing

1122
00:49:55,910 --> 00:49:53,670
the objects on multiple scales will

1123
00:49:57,500 --> 00:49:55,920
we'll introduce all sorts of ideas when

1124
00:50:00,529 --> 00:49:57,510
it comes to exploring collective

1125
00:50:02,210 --> 00:50:00,539
organization again the origin of life

1126
00:50:04,309 --> 00:50:02,220
problem or the creation of life problem

1127
00:50:06,140 --> 00:50:04,319
is simply how do we take hydrogen a'ti

1128
00:50:08,329 --> 00:50:06,150
from the environment and put it into a

1129
00:50:10,329 --> 00:50:08,339
boundary and allow that boundary to be

1130
00:50:13,130 --> 00:50:10,339
autonomous ish within that environment

1131
00:50:14,990 --> 00:50:13,140
you have that white house with that

1132
00:50:16,400 --> 00:50:15,000
strange blob in the white house playing

1133
00:50:19,370 --> 00:50:16,410
with the autonomy I didn't mention his

1134
00:50:21,220 --> 00:50:19,380
name I sure don't but it's a serious

1135
00:50:24,200 --> 00:50:21,230
question about how the environment

1136
00:50:25,789 --> 00:50:24,210
compartmentalizes itself so what we

1137
00:50:27,589 --> 00:50:25,799
envisage a few years ago in blog at

1138
00:50:29,690 --> 00:50:27,599

Glasgow was to try and make an

1139
00:50:31,400 --> 00:50:29,700
evolutionary engine and what we wanted

1140
00:50:34,819 --> 00:50:31,410
to do is start with simple chemistry

1141
00:50:36,710 --> 00:50:34,829
that almost all of you would would

1142
00:50:38,599 --> 00:50:36,720
recognize like salad dressing and

1143
00:50:41,240 --> 00:50:38,609
literally it is salad dressing and say

1144
00:50:42,980 --> 00:50:41,250
can we turn something as simple as salad

1145
00:50:47,650 --> 00:50:42,990
dressing into an object the

1146
00:50:51,680 --> 00:50:49,910
so what we envisage is having touched

1147
00:50:53,630 --> 00:50:51,690
some kind of mixer mix up our salad

1148
00:50:55,880 --> 00:50:53,640
dressing and then we'd have an entity

1149
00:50:57,140 --> 00:50:55,890
generator that could be a piece of rock

1150
00:50:59,509 --> 00:50:57,150
the hole in it and out would come the

1151
00:51:01,819 --> 00:50:59,519
blobs the blobs would be put in the

1152
00:51:05,599 --> 00:51:01,829
arena and the environment would be

1153
00:51:08,720 --> 00:51:05,609
changed they would have a selector we

1154
00:51:12,019 --> 00:51:08,730
can play God are you going to live are

1155
00:51:14,210 --> 00:51:12,029
you going to die and then you could then

1156
00:51:16,370 --> 00:51:14,220
and the living in the dying part which

1157
00:51:18,109 --> 00:51:16,380
is really orchestrated here but you just

1158
00:51:21,910 --> 00:51:18,119
decide then at the end that you would

1159
00:51:24,769 --> 00:51:21,920
recycle the ones that you want to live

1160
00:51:27,349 --> 00:51:24,779
so now this is very contrived it's a

1161
00:51:29,960 --> 00:51:27,359
formulaic system but you could imagine

1162
00:51:33,259 --> 00:51:29,970
that the recirculate er if you wanted to

1163
00:51:34,609 --> 00:51:33,269

observe a particular property see like

1164
00:51:38,690 --> 00:51:34,619
there's no death in our system we're

1165
00:51:41,809 --> 00:51:38,700
very elegant areum's so but the point is

1166
00:51:43,430 --> 00:51:41,819
to generate some entities here and then

1167
00:51:45,920 --> 00:51:43,440
to then by selecting them as a function

1168
00:51:48,230 --> 00:51:45,930
in the environment will the objects as

1169
00:51:51,109 --> 00:51:48,240
you recycle them take that environment

1170
00:51:54,170 --> 00:51:51,119
that baggage and use that to create

1171
00:51:56,539 --> 00:51:54,180
function to become more lifelike we are

1172
00:51:58,759 --> 00:51:56,549
all evolutionary baggage and the third

1173
00:52:00,049 --> 00:51:58,769
speaker said you know in a way resetting

1174
00:52:02,089 --> 00:52:00,059
that evolutionary baggage is really

1175
00:52:05,839 --> 00:52:02,099
interesting because we'll get more

1176
00:52:07,730 --> 00:52:05,849
information of mechanism okay so what we

1177
00:52:09,920 --> 00:52:07,740
wanted to do is start really simple

1178
00:52:12,559 --> 00:52:09,930
systems like these oil droplets these

1179
00:52:14,749 --> 00:52:12,569
are just oil in water with a stable

1180
00:52:16,430 --> 00:52:14,759
series of stabilizers and the other one

1181
00:52:17,420 --> 00:52:16,440
on the bottom left side I wouldn't

1182
00:52:21,079 --> 00:52:17,430
really want to be whoops

1183
00:52:23,990 --> 00:52:21,089
we'll go back getting used to this now

1184
00:52:26,059 --> 00:52:24,000
reset it there we go so if you look at

1185
00:52:27,620 --> 00:52:26,069
the blue droplets there I mean they look

1186
00:52:30,230 --> 00:52:27,630
quite of lifelike right there did

1187
00:52:33,140 --> 00:52:30,240
chasing this poor geezer and you know

1188
00:52:35,749 --> 00:52:33,150

until Eve is it gone dead no longer

1189
00:52:37,970 --> 00:52:35,759
existing whereas this one here this

1190
00:52:39,890 --> 00:52:37,980
spiky droplet is moving around feeling

1191
00:52:41,450 --> 00:52:39,900
the environment it looks lifelike it

1192
00:52:44,660 --> 00:52:41,460
kind of mysterious but it's not of

1193
00:52:47,509 --> 00:52:44,670
course it's just an unstable oil and

1194
00:52:49,789 --> 00:52:47,519
water emotion and it loses its form as

1195
00:52:51,579 --> 00:52:49,799
the as the stabilizers and the alcohols

1196
00:52:53,779 --> 00:52:51,589
inside it dissolving the aqueous phase

1197
00:52:55,339 --> 00:52:53,789
so we want to take something which I

1198
00:52:57,049 --> 00:52:55,349
think we all agree is it may be

1199
00:52:58,940 --> 00:52:57,059
interesting from a physical chemistry

1200
00:53:00,799 --> 00:52:58,950
point of view but quite clearly dead

1201
00:53:02,859 --> 00:53:00,809
you don't expect your salad dressing to

1202
00:53:05,569 --> 00:53:02,869
start self-replicating in front of you

1203
00:53:07,999 --> 00:53:05,579
so what we wanted to do is build a robot

1204
00:53:09,570 --> 00:53:08,009
which would basically orchestrate what

1205
00:53:11,850 --> 00:53:09,580
would happen on a planet Earth

1206
00:53:12,990 --> 00:53:11,860
day/night cycle if you like so to do

1207
00:53:15,180 --> 00:53:13,000
this we've got our solutions our

1208
00:53:19,170 --> 00:53:15,190
chemical inputs and pumps we then put

1209
00:53:21,390 --> 00:53:19,180
the pumps into a robot using some

1210
00:53:23,070 --> 00:53:21,400
syringes and mixing up the ingredients

1211
00:53:25,860 --> 00:53:23,080
almost randomly and then in our

1212
00:53:30,480 --> 00:53:25,870
Orwellian arena we will then video what

1213
00:53:32,040 --> 00:53:30,490

the droplets do and this is a highly

1214
00:53:33,180 --> 00:53:32,050
sped up version because I've only got a

1215
00:53:34,590 --> 00:53:33,190
few minutes they could have spent 20

1216
00:53:36,300 --> 00:53:34,600
minutes is showing you how this works

1217
00:53:39,960 --> 00:53:36,310
but I'll go back again once you've

1218
00:53:41,490 --> 00:53:39,970
overcome the the kind of there's quite a

1219
00:53:44,580 --> 00:53:41,500
lot in this nine seconds so I'll play it

1220
00:53:46,380 --> 00:53:44,590
again but what you can see is that the

1221
00:53:49,350 --> 00:53:46,390
formulation is made up here the salad

1222
00:53:51,120 --> 00:53:49,360
dressing and then it's prepared and put

1223
00:53:53,550 --> 00:53:51,130
in this dish and then rotate it under in

1224
00:53:55,530 --> 00:53:53,560
a webcam and so basically what we can do

1225
00:53:57,240 --> 00:53:55,540
on the left-hand side at the top is we

1226
00:53:58,950 --> 00:53:57,250
randomly take some salad dressings all

1227
00:54:00,960 --> 00:53:58,960
the different formulations you could

1228
00:54:02,880 --> 00:54:00,970
call them the genome if you like you

1229
00:54:04,740 --> 00:54:02,890
then take them and put the droplets in

1230
00:54:06,570 --> 00:54:04,750
the arena and you embody them it's

1231
00:54:08,400 --> 00:54:06,580
almost like the genotype-phenotype

1232
00:54:10,110 --> 00:54:08,410
transition you take that code and make

1233
00:54:12,270 --> 00:54:10,120
material and you then evaluate that

1234
00:54:14,520 --> 00:54:12,280
material with a webcam and then the rot

1235
00:54:18,570 --> 00:54:14,530
and then the image recognition makes a

1236
00:54:20,190 --> 00:54:18,580
decision about life or death so

1237
00:54:22,430 --> 00:54:20,200
basically what we've been doing in the

1238
00:54:24,330 --> 00:54:22,440

lab is using robotic exploration and

1239
00:54:26,730 --> 00:54:24,340
using machine learning and

1240
00:54:30,270 --> 00:54:26,740
physicochemical analysis to look for

1241
00:54:33,270 --> 00:54:30,280
interesting morphologies interesting

1242
00:54:34,890 --> 00:54:33,280
behaviors the way we've been doing this

1243
00:54:36,480 --> 00:54:34,900
is we've used image recognition now this

1244
00:54:38,010 --> 00:54:36,490
is very contrived before you get up and

1245
00:54:42,570 --> 00:54:38,020
say that's not a life-form it's a robot

1246
00:54:45,300 --> 00:54:42,580
making salad dressing yeah it is but the

1247
00:54:48,240 --> 00:54:45,310
point is to see if we can show that

1248
00:54:50,580 --> 00:54:48,250
through selection and propagation we can

1249
00:54:53,340 --> 00:54:50,590
do some kind of evolutionary experiment

1250
00:54:54,930 --> 00:54:53,350
to do that we have a workflow where we

1251
00:54:57,090 --> 00:54:54,940
can take the droplets and do image

1252
00:54:59,640 --> 00:54:57,100
recognition on the droplets and then

1253
00:55:02,730 --> 00:54:59,650
decide whether that formulation is a

1254
00:55:05,250 --> 00:55:02,740
favored formulation and so we go through

1255
00:55:06,720 --> 00:55:05,260
a very complex workflow which is what

1256
00:55:08,190 --> 00:55:06,730
it's like complex is relatively simple

1257
00:55:09,480 --> 00:55:08,200
but it's quite laborious and the

1258
00:55:11,610 --> 00:55:09,490
computer does a lot of the job for us

1259
00:55:13,380 --> 00:55:11,620
much have done the initial programming

1260
00:55:15,960 --> 00:55:13,390
so the workflow is really we have this

1261
00:55:17,820 --> 00:55:15,970
robot controller handles the chemistry

1262
00:55:19,740 --> 00:55:17,830
in the robot the camera does the image

1263
00:55:21,750 --> 00:55:19,750

tracking then the pumps are then

1264
00:55:22,680 --> 00:55:21,760
selected again at random to start with

1265
00:55:28,440 --> 00:55:22,690
to put in before

1266
00:55:31,109 --> 00:55:28,450
emulation so to start with we just did

1267
00:55:35,750 --> 00:55:31,119
random stuff so what could what do these

1268
00:55:46,430 --> 00:55:45,450
they divide they divide at the wall they

1269
00:55:50,569 --> 00:55:46,440
explode

1270
00:55:53,280 --> 00:55:50,579
it's kind of cool and they wobble and

1271
00:55:55,910 --> 00:55:53,290
these are the same thought there's only

1272
00:55:58,170 --> 00:55:55,920
four or five chemicals in these droplets

1273
00:56:00,140 --> 00:55:58,180
only four or five chemicals and they're

1274
00:56:04,829 --> 00:56:00,150
selected at random we found these

1275
00:56:06,300 --> 00:56:04,839
behaviors by searching the space so this

1276
00:56:07,500 --> 00:56:06,310
is like Lazarus right you get kind of

1277
00:56:11,220 --> 00:56:07,510
some kind of reform elation there's a

1278
00:56:14,160 --> 00:56:11,230
lot of interesting physical chemistry

1279
00:56:16,290 --> 00:56:14,170
here so okay so we've done our random if

1280
00:56:18,780 --> 00:56:16,300
you like messy screen a bit like we

1281
00:56:21,329 --> 00:56:18,790
could imagine doing in protein space or

1282
00:56:24,480 --> 00:56:21,339
chemical space what we then wanted to do

1283
00:56:25,589 --> 00:56:24,490
is then take those droplets and see if

1284
00:56:27,809 --> 00:56:25,599
we could put them through an

1285
00:56:29,220 --> 00:56:27,819
evolutionary experience now for those

1286
00:56:30,569 --> 00:56:29,230
who want to know what's going on with

1287
00:56:32,339 --> 00:56:30,579
the drop that's why early interesting

1288
00:56:34,079 --> 00:56:32,349

where as an emotion coming from well

1289
00:56:35,220 --> 00:56:34,089
they all droplet has a number of

1290
00:56:38,309 --> 00:56:35,230
components in them

1291
00:56:41,390 --> 00:56:38,319
DEP is a stabilizer Penton all auxin all

1292
00:56:44,339 --> 00:56:41,400
oakland oeq acid and there's sea tab

1293
00:56:46,200 --> 00:56:44,349
outside and basically the movement of

1294
00:56:47,670 --> 00:56:46,210
the alcohol to the aqueous phase gives

1295
00:56:51,300 --> 00:56:47,680
it all that energy so you have a

1296
00:56:53,069 --> 00:56:51,310
metabolism so that metabolism is really

1297
00:56:56,609 --> 00:56:53,079
quite important you have these different

1298
00:56:58,349 --> 00:56:56,619
behaviors so what we then did is we took

1299
00:57:00,300 --> 00:56:58,359
the division part and we put it through

1300
00:57:01,620 --> 00:57:00,310
an evolutionary algorithm and we

1301
00:57:03,300 --> 00:57:01,630
embodied the evolution and basically

1302
00:57:05,490 --> 00:57:03,310
what we did is we generate a population

1303
00:57:07,620 --> 00:57:05,500
of dividers and we optimized for

1304
00:57:09,809 --> 00:57:07,630
population for devote division and by

1305
00:57:12,390 --> 00:57:09,819
the end of 15 generations we got very

1306
00:57:15,569 --> 00:57:12,400
good division we also did this some

1307
00:57:17,490 --> 00:57:15,579
motion and okay this is arbitrary this

1308
00:57:21,180 --> 00:57:17,500
is us adding a fitness functional but

1309
00:57:24,030 --> 00:57:21,190
you could imagine the Preta dish being

1310
00:57:27,000 --> 00:57:24,040
the world and the world selects the

1311
00:57:28,890 --> 00:57:27,010
droplets from being alive and dead so

1312
00:57:30,809 --> 00:57:28,900
what we've been able to do in these

1313
00:57:32,790 --> 00:57:30,819

experiments is not only randomly make

1314
00:57:36,280 --> 00:57:32,800
droplets I have really rich behaviors

1315
00:57:38,470 --> 00:57:36,290
with very simple chemical inputs we star

1316
00:57:39,700 --> 00:57:38,480
to evolve them and this is really quite

1317
00:57:42,310 --> 00:57:39,710
important because if you imagine going

1318
00:57:43,990 --> 00:57:42,320
to Titan Titan has got really simple

1319
00:57:45,880 --> 00:57:44,000
organic chemistry has a lot the type of

1320
00:57:49,030 --> 00:57:45,890
chemistry we would normally imagine

1321
00:57:51,280 --> 00:57:49,040
would be associated with life but I

1322
00:57:54,430 --> 00:57:51,290
reckon that the you can probably make

1323
00:57:57,700 --> 00:57:54,440
lifelike things in oils okay and get

1324
00:57:59,230 --> 00:57:57,710
evolutionary behavior to emerge now and

1325
00:58:00,340 --> 00:57:59,240
then last five minutes of the talk I'm

1326
00:58:03,160 --> 00:58:00,350
going to try and convince you of this a

1327
00:58:04,720 --> 00:58:03,170
bit more dramatically so in this system

1328
00:58:06,580 --> 00:58:04,730
we were quite excited when we did this

1329
00:58:08,800 --> 00:58:06,590
because this is the first time that

1330
00:58:10,480 --> 00:58:08,810
evolutionary genetic algorithms have

1331
00:58:13,240 --> 00:58:10,490
been embodied in a interacting

1332
00:58:15,880 --> 00:58:13,250
population so we actually have a genome

1333
00:58:18,040 --> 00:58:15,890
we have Fitness landscapes and it looks

1334
00:58:19,810 --> 00:58:18,050
like biology get epistasis Pleader drop

1335
00:58:21,580 --> 00:58:19,820
it all these things you associate with

1336
00:58:26,170 --> 00:58:21,590
biological evolution we were getting in

1337
00:58:28,240 --> 00:58:26,180
salad dressing how could this be and on

1338
00:58:30,430 --> 00:58:28,250

the one you can see here the function of

1339
00:58:33,220 --> 00:58:30,440
generation the Fitness function

1340
00:58:36,160 --> 00:58:33,230
the number of droplets for the offspring

1341
00:58:38,020 --> 00:58:36,170
goes up the ability to move goes up and

1342
00:58:41,470 --> 00:58:38,030
the vibration goes up and we show the

1343
00:58:43,900 --> 00:58:41,480
different error limits there so what we

1344
00:58:45,730 --> 00:58:43,910
wanted to do now is say okay we have

1345
00:58:47,830 --> 00:58:45,740
shown that we can use a genetic

1346
00:58:50,590 --> 00:58:47,840
algorithm to put droplets into a glass

1347
00:58:52,030 --> 00:58:50,600
dish and optimize them that's like if

1348
00:58:53,860 --> 00:58:52,040
you are really the worst critic that's

1349
00:58:55,240 --> 00:58:53,870
what you'd say so what you optimize

1350
00:58:58,240 --> 00:58:55,250
salad dressing I already know how to

1351
00:58:59,560 --> 00:58:58,250
make salad dressing so what I wanted to

1352
00:59:01,510 --> 00:58:59,570
then try and do is to say well can we

1353
00:59:03,190 --> 00:59:01,520
then show how changes in the environment

1354
00:59:05,140 --> 00:59:03,200
show the evolutionary trajectory changes

1355
00:59:07,930 --> 00:59:05,150
so we had to make a new robot and we

1356
00:59:09,790 --> 00:59:07,940
call this flow bot so again pumps for

1357
00:59:12,100 --> 00:59:09,800
chemical inputs and we now 3d print a

1358
00:59:14,020 --> 00:59:12,110
microfluidic device and a chamber and

1359
00:59:16,480 --> 00:59:14,030
because we're 3d printing the chamber

1360
00:59:19,180 --> 00:59:16,490
guess what we can do we are god of the

1361
00:59:21,190 --> 00:59:19,190
world because we can reach Ange the the

1362
00:59:25,510 --> 00:59:21,200
digital landscape we just change the

1363
00:59:26,800 --> 00:59:25,520

code and that's what we did so to start

1364
00:59:28,230 --> 00:59:26,810
with before we did that we just

1365
00:59:30,040 --> 00:59:28,240
demonstrated we can again evolve

1366
00:59:33,310 --> 00:59:30,050
division because the division is

1367
00:59:34,960 --> 00:59:33,320
probably a good good measure for making

1368
00:59:36,820 --> 00:59:34,970
proto cells which we're now going to

1369
00:59:40,600 --> 00:59:36,830
call them not salad dressing to make

1370
00:59:42,730 --> 00:59:40,610
life forms so you can see down the

1371
00:59:46,240 --> 00:59:42,740
bottom here the number of the population

1372
00:59:48,100 --> 00:59:46,250
going up and this is how the the

1373
00:59:49,030 --> 00:59:48,110
droplets look in our 3d printed petri

1374
00:59:51,700 --> 00:59:49,040
dish

1375
00:59:53,290 --> 00:59:51,710
in the empty arena so this is the empty

1376
00:59:55,210 --> 00:59:53,300
world this is the easy world of the

1377
00:59:56,470 --> 00:59:55,220
droplet and you can see some of the

1378
01:00:00,010 --> 00:59:56,480
droplets a change in color because the

1379
01:00:01,630 --> 01:00:00,020
pH is changing over time so what we then

1380
01:00:03,040 --> 01:00:01,640
did is they right we are now going to 3d

1381
01:00:06,400 --> 01:00:03,050
print environments here are the caves

1382
01:00:08,080 --> 01:00:06,410
and we use a really simple procedures to

1383
01:00:09,880 --> 01:00:08,090
generate algorithmically different

1384
01:00:13,210 --> 01:00:09,890
environments and the idea is now to say

1385
01:00:14,620 --> 01:00:13,220
let's take random stuff and change the

1386
01:00:16,630 --> 01:00:14,630
environment and seeing how the

1387
01:00:21,400 --> 01:00:16,640
environment if you like digitally

1388
01:00:24,730 --> 01:00:21,410

changes the the outcome so do we go from

1389
01:00:27,250 --> 01:00:24,740
the genotype to the phenotype virally

1390
01:00:29,320 --> 01:00:27,260
enviro type now if you don't like those

1391
01:00:31,750 --> 01:00:29,330
words it's fine just say can we change

1392
01:00:33,100 --> 01:00:31,760
the starting conditions by changing

1393
01:00:35,650 --> 01:00:33,110
getting the environment to help us out

1394
01:00:37,540 --> 01:00:35,660
so we then started to say okay if we 3d

1395
01:00:39,850 --> 01:00:37,550
printed pillars how would that change

1396
01:00:41,260 --> 01:00:39,860
the division of the droplets and you can

1397
01:00:43,240 --> 01:00:41,270
see the function of generation we've got

1398
01:00:45,190 --> 01:00:43,250
all sorts of interesting behaviors that

1399
01:00:48,400 --> 01:00:45,200
you did get division you were able to

1400
01:00:49,720 --> 01:00:48,410
optimize after a drop off this is what

1401
01:00:51,310 --> 01:00:49,730
the droplets look like in the in the

1402
01:00:55,270 --> 01:00:51,320
pilot arena in fact the pill is in some

1403
01:00:59,010 --> 01:00:55,280
cases assist division here's some

1404
01:01:04,150 --> 01:01:02,650
and what we didn't understand what we

1405
01:01:06,700 --> 01:01:04,160
didn't anticipate is actually the

1406
01:01:09,040 --> 01:01:06,710
surfactant coats the plastic pillars and

1407
01:01:10,690 --> 01:01:09,050
make some slippery at some point and

1408
01:01:14,710 --> 01:01:10,700
then the droplets get released now this

1409
01:01:16,930 --> 01:01:14,720
isn't it now an ecosystem the the actual

1410
01:01:18,970 --> 01:01:16,940
entities the artificial living entities

1411
01:01:22,240 --> 01:01:18,980
are now affecting the dead environment

1412
01:01:24,480 --> 01:01:22,250
and and changing it to suit its

1413
01:01:29,190 --> 01:01:24,490

evolutionary trajectory

1414
01:01:30,970 --> 01:01:29,200
now this core time over time now as now

1415
01:01:32,710 --> 01:01:30,980
but I've only got a couple of slides

1416
01:01:34,870 --> 01:01:32,720
left so well what point am i trying to

1417
01:01:37,120 --> 01:01:34,880
make well now we've done environmentally

1418
01:01:38,530 --> 01:01:37,130
coupled evolution I'll take you back to

1419
01:01:40,720 --> 01:01:38,540
the beginning where we were doing

1420
01:01:42,280 --> 01:01:40,730
evolution in empty petri dish we then

1421
01:01:43,780 --> 01:01:42,290
put some features into the pet position

1422
01:01:45,400 --> 01:01:43,790
as you can see on the left hand side

1423
01:01:46,690 --> 01:01:45,410
you've got the empty dish then you've

1424
01:01:48,760 --> 01:01:46,700
got the different pillared arrays and

1425
01:01:52,690 --> 01:01:48,770
the caves and you could see if you look

1426
01:01:57,490 --> 01:01:52,700
up at the graph how we have the change

1427
01:01:59,740 --> 01:01:57,500
of the the number of droplets in the

1428
01:02:01,930 --> 01:01:59,750
arena you can see goes up as it's been

1429
01:02:02,830 --> 01:02:01,940
optimized all the way there so we've got

1430
01:02:05,080 --> 01:02:02,840
evolution so we can

1431
01:02:07,270 --> 01:02:05,090
increase the population then when you go

1432
01:02:09,310 --> 01:02:07,280
from the empty arena to the pillar it

1433
01:02:11,410 --> 01:02:09,320
filters the population and it drops off

1434
01:02:13,690 --> 01:02:11,420
dramatically and the evolution starts

1435
01:02:16,120 --> 01:02:13,700
again and when you go to the caves it

1436
01:02:18,280 --> 01:02:16,130
continues really interesting thing is

1437
01:02:19,980 --> 01:02:18,290
the foot this is the life form if you

1438
01:02:22,780 --> 01:02:19,990

like the best formulation from the caves

1439
01:02:24,700 --> 01:02:22,790
survives in the empty arena but the

1440
01:02:26,620 --> 01:02:24,710
formulation for the empty arena doesn't

1441
01:02:28,950 --> 01:02:26,630
survive in the caves and it's shown in

1442
01:02:32,110 --> 01:02:28,960
this Fitness map down here where this

1443
01:02:33,190 --> 01:02:32,120
species starts to decrease over time and

1444
01:02:35,740 --> 01:02:33,200
what you get here

1445
01:02:39,130 --> 01:02:35,750
on the fitness landscape is a new peak

1446
01:02:40,750 --> 01:02:39,140
which we wish if you are a geneticist

1447
01:02:42,490 --> 01:02:40,760
looking at populated looking at

1448
01:02:46,120 --> 01:02:42,500
populations of objects that were living

1449
01:02:47,890 --> 01:02:46,130
you'd call that new species and and and

1450
01:02:49,600 --> 01:02:47,900
so what we show here is we took the heat

1451
01:02:51,100 --> 01:02:49,610
we basically took the formulation and

1452
01:02:53,500 --> 01:02:51,110
generate a heat map and made a letter

1453
01:02:55,990 --> 01:02:53,510
code a kind of genome and you can see

1454
01:02:58,630 --> 01:02:56,000
how from the app the best genome for the

1455
01:03:00,550 --> 01:02:58,640
empty arena to the pill arena to the

1456
01:03:04,660 --> 01:03:00,560
caves for the best one at the caves you

1457
01:03:07,380 --> 01:03:04,670
can see how we get this g2 e2f mutation

1458
01:03:09,640 --> 01:03:07,390
that either kept the C mutates the

1459
01:03:11,530 --> 01:03:09,650
e-beam mutates the B and you can see

1460
01:03:14,350 --> 01:03:11,540
from this species to this specie or this

1461
01:03:16,030 --> 01:03:14,360
this generation this arena to this arena

1462
01:03:18,760 --> 01:03:16,040
the mutation and this arena to this

1463
01:03:21,970 --> 01:03:18,770

arena so what does this all mean well it

1464
01:03:23,890 --> 01:03:21,980
means that in a robotic environment if

1465
01:03:26,530 --> 01:03:23,900
you use the robot is almost like a

1466
01:03:28,510 --> 01:03:26,540
custodian that you can start to do

1467
01:03:30,280 --> 01:03:28,520
evolution in very simple systems and

1468
01:03:31,900 --> 01:03:30,290
they interact with the environment and

1469
01:03:34,120 --> 01:03:31,910
the environment influences the

1470
01:03:36,880 --> 01:03:34,130
trajectory of the optimization or the

1471
01:03:39,760 --> 01:03:36,890
evolution so this means that evolution

1472
01:03:41,680 --> 01:03:39,770
can work outside of biology so the next

1473
01:03:43,990 --> 01:03:41,690
step for us is really to put in messy

1474
01:03:46,180 --> 01:03:44,000
chemistry and get these oil droplets to

1475
01:03:50,260 --> 01:03:46,190
select the chemistry to actually start

1476
01:03:51,730 --> 01:03:50,270
to behave so I'm going to stop here and

1477
01:03:53,290 --> 01:03:51,740
thank my research group have done all

1478
01:03:55,390 --> 01:03:53,300
this work particularly the robots team

1479
01:03:57,400 --> 01:03:55,400
and I have to because I think I have two

1480
01:03:58,960 --> 01:03:57,410
young boys at home and Glasgow watching

1481
01:04:07,630 --> 01:03:58,970
let's say hello to them thank you very

1482
01:04:11,809 --> 01:04:09,859
so we have time for one or two questions

1483
01:04:13,700 --> 01:04:11,819
for Li and then I'm going to invite the

1484
01:04:14,779 --> 01:04:13,710
two and Irina to join me on stage and

1485
01:04:23,289 --> 01:04:14,789
we'll have sort of a general question

1486
01:04:32,089 --> 01:04:25,910
now one wants out addressing on Titan

1487
01:04:34,940 --> 01:04:32,099
I know speechless I highly highly hi I'm

1488
01:04:37,789 --> 01:04:34,950

in the the question which comes up is

1489
01:04:39,829 --> 01:04:37,799
the auto word so how much can you make

1490
01:04:42,079 --> 01:04:39,839
this autonomously you know that they

1491
01:04:44,900 --> 01:04:42,089
refill really themselves I mean they're

1492
01:04:47,180 --> 01:04:44,910
beside the forwards reaction it's quite

1493
01:04:51,789 --> 01:04:47,190
difficult to make things as concentrated

1494
01:04:54,470 --> 01:04:51,799
or as you know so refilling or no I so I

1495
01:04:56,029 --> 01:04:54,480
agree and disagree I think actually the

1496
01:04:58,099 --> 01:04:56,039
robot does a bit too much and on the

1497
01:04:59,569 --> 01:04:58,109
next mission is to not put in the

1498
01:05:01,700 --> 01:04:59,579
fitness function just to say

1499
01:05:04,400 --> 01:05:01,710
survivability is the only criterion and

1500
01:05:06,289 --> 01:05:04,410
then what we need to do is work out what

1501
01:05:08,420 --> 01:05:06,299
is the simplest input so we can use it

1502
01:05:09,920 --> 01:05:08,430
get concentrated if you imagine so you

1503
01:05:11,329 --> 01:05:09,930
can imagine a lot of the models of the

1504
01:05:14,210 --> 01:05:11,339
origin of life where you have day/night

1505
01:05:16,730 --> 01:05:14,220
cycles so it is pioneered by by Nick and

1506
01:05:19,160 --> 01:05:16,740
Bruce and so on that they then dry down

1507
01:05:20,779 --> 01:05:19,170
so you can imagine the Pope the process

1508
01:05:23,210 --> 01:05:20,789
of selecting the formulation would be

1509
01:05:26,480 --> 01:05:23,220
random accumulation of chemicals in a

1510
01:05:29,180 --> 01:05:26,490
puddle that puddle gets dried down and

1511
01:05:31,910 --> 01:05:29,190
then gets hydrated a little bit and then

1512
01:05:33,319 --> 01:05:31,920
you get some behavior and the objects

1513
01:05:34,660 --> 01:05:33,329

that make it out of that puddle into

1514
01:05:36,440 --> 01:05:34,670
another puddle with a bit of

1515
01:05:38,779 --> 01:05:36,450
environmental information from that

1516
01:05:40,279 --> 01:05:38,789
puzzle basically migrates from puddle to

1517
01:05:43,670 --> 01:05:40,289
puddle to puddle now how this translates

1518
01:05:45,710 --> 01:05:43,680
the puddles on Titan I'm not there but

1519
01:05:47,569 --> 01:05:45,720
what I think your point is very good and

1520
01:05:50,230 --> 01:05:47,579
what we're trying to do is automate that

1521
01:05:54,079 --> 01:05:50,240
robot so it looks as much like a

1522
01:05:56,210 --> 01:05:54,089
day/night cycle an oscillation of some

1523
01:05:58,819 --> 01:05:56,220
description and then I think we can then

1524
01:06:01,670 --> 01:05:58,829
say we're a bit more plausible with with

1525
01:06:04,039 --> 01:06:01,680
you know if a creation so I should not

1526
01:06:06,440 --> 01:06:04,049
use the word if somebody designs a robot

1527
01:06:07,999 --> 01:06:06,450
that makes an artificial life form that

1528
01:06:09,499 --> 01:06:08,009
doesn't really help you unless you can

1529
01:06:10,670 --> 01:06:09,509
show the robot is doing something that

1530
01:06:14,029 --> 01:06:10,680
could happen in the natural environment

1531
01:06:16,370 --> 01:06:14,039
I mean just to understand I'm a right

1532
01:06:18,050 --> 01:06:16,380
now the droplet I lose it I mean I'm

1533
01:06:19,310 --> 01:06:18,060
sorry you can have more

1534
01:06:21,860 --> 01:06:19,320
I want to make sure we have enough time

1535
01:06:23,540 --> 01:06:21,870
for everyone ask questions so John last

1536
01:06:24,680 --> 01:06:23,550
question specifically for Li and then

1537
01:06:26,870 --> 01:06:24,690
I'm going to open up to the piano

1538
01:06:31,790 --> 01:06:26,880

awesome so Li that was great that Donald

1539
01:06:33,980 --> 01:06:31,800
Burke universe Missouri so I what is a

1540
01:06:37,100 --> 01:06:33,990
generation in your in your formulation

1541
01:06:38,840 --> 01:06:37,110
is it is it a a tweak of the algorithm

1542
01:06:41,120 --> 01:06:38,850
when you come back and make the droplets

1543
01:06:43,940 --> 01:06:41,130
again or is it a simple physical

1544
01:06:46,070 --> 01:06:43,950
transfer of droplets again through the

1545
01:06:49,160 --> 01:06:46,080
exact same outrageously so a generations

1546
01:06:51,200 --> 01:06:49,170
we start off with a fixed kind of matrix

1547
01:06:54,650 --> 01:06:51,210
of experiments to do at the beginning

1548
01:06:56,390 --> 01:06:54,660
its random and we then do those and then

1549
01:06:58,850 --> 01:06:56,400
we assess their fitness according to the

1550
01:07:01,610 --> 01:06:58,860
algorithm do they divide and so on and

1551
01:07:04,340 --> 01:07:01,620
we we then then use that information to

1552
01:07:05,510 --> 01:07:04,350
then see the genetic algorithm so that

1553
01:07:10,940 --> 01:07:05,520
that's what how you and then you do it

1554
01:07:18,200 --> 01:07:10,950
in cycles its algorithmic correct so

1555
01:07:19,880 --> 01:07:18,210
let's thank Lee again so we have a

1556
01:07:21,500 --> 01:07:19,890
little less than ten minutes left in our

1557
01:07:23,240 --> 01:07:21,510
session and so what I'm going to do now

1558
01:07:25,130 --> 01:07:23,250
is open up for questions for all of our

1559
01:07:27,320 --> 01:07:25,140
panelists and I just want to encourage

1560
01:07:28,370 --> 01:07:27,330
everyone we have people three people

1561
01:07:29,780 --> 01:07:28,380
here that have given us sort of

1562
01:07:31,280 --> 01:07:29,790
radically different perspectives on the

1563
01:07:33,770 --> 01:07:31,290

origins of life so if you can have

1564
01:07:36,110 --> 01:07:33,780
questions that are geared at sort of how

1565
01:07:38,450 --> 01:07:36,120
can we push the field forward would be

1566
01:07:40,010 --> 01:07:38,460
really nice to have in a session um and

1567
01:07:42,740 --> 01:07:40,020
so we're going to start over here and go

1568
01:07:45,620 --> 01:07:42,750
yeah hi my name is Marcos returned from

1569
01:07:48,650 --> 01:07:45,630
Paris France and I'm a computational

1570
01:07:51,470 --> 01:07:48,660
physicist and I have a question

1571
01:07:53,960 --> 01:07:51,480
especially for the second speaker about

1572
01:07:56,090 --> 01:07:53,970
Mexico history I'm very impressed about

1573
01:07:58,670 --> 01:07:56,100
the kind of experiments that that you

1574
01:08:01,910 --> 01:07:58,680
can do to get out find some way out of

1575
01:08:04,960 --> 01:08:01,920
this chemical networks I'm just a bit

1576
01:08:07,370 --> 01:08:04,970
surprised that something is not used

1577
01:08:09,230 --> 01:08:07,380
above and on top of that which is

1578
01:08:12,080 --> 01:08:09,240
computational power computational

1579
01:08:14,300 --> 01:08:12,090
exploration of the chemical space so

1580
01:08:17,270 --> 01:08:14,310
there are computer simulations are very

1581
01:08:21,290 --> 01:08:17,280
advanced and they are very can be very

1582
01:08:24,349 --> 01:08:21,300
very useful to get a hold of this messy

1583
01:08:30,109 --> 01:08:24,359
chemist so you have a comment on that

1584
01:08:32,419 --> 01:08:30,119
gave me 16 minutes yes I'm certainly

1585
01:08:35,570 --> 01:08:32,429
thinking and doing it's another effort

1586
01:08:38,840 --> 01:08:35,580
that happened in LC and maybe next time

1587
01:08:41,149 --> 01:08:38,850
I can talk about it all right

1588
01:08:43,640 --> 01:08:41,159

hi yeah I'm Lauren from Georgia Tech and

1589
01:08:45,140 --> 01:08:43,650
I want to talk about a messy chemistry a

1590
01:08:46,490 --> 01:08:45,150
little bit because I was really struck

1591
01:08:48,950 --> 01:08:46,500
by that because what we've been thinking

1592
01:08:51,590 --> 01:08:48,960
about the ribosome which we believe is

1593
01:08:54,070 --> 01:08:51,600
the oldest existing enzyme in biology is

1594
01:08:56,390 --> 01:08:54,080
that it's a terrifically nonspecific

1595
01:08:58,340 --> 01:08:56,400
catalytic Center which looks to be

1596
01:09:00,970 --> 01:08:58,350
designed for messy chemistry you can

1597
01:09:04,399 --> 01:09:00,980
it's kind of a nonspecific condensation

1598
01:09:06,289 --> 01:09:04,409
machine and so I was thinking that

1599
01:09:08,780 --> 01:09:06,299
basically there's a lot of broad support

1600
01:09:10,669 --> 01:09:08,790
for your idea I have kind of a

1601
01:09:12,680 --> 01:09:10,679
sociological question I guess really if

1602
01:09:16,340 --> 01:09:12,690
you look back at Gilbert's seminal paper

1603
01:09:20,419 --> 01:09:16,350
on the RNA world it describes this kind

1604
01:09:23,180 --> 01:09:20,429
of pure simple RNA world that had some

1605
01:09:25,309 --> 01:09:23,190
kind of ability to captures people's

1606
01:09:28,490 --> 01:09:25,319
imagination and I think it just set us

1607
01:09:30,649 --> 01:09:28,500
all in the wrong direction it was sort

1608
01:09:32,990 --> 01:09:30,659
of the opposite of messy chemistry and I

1609
01:09:35,749 --> 01:09:33,000
think it kind of set the field back a

1610
01:09:39,320 --> 01:09:35,759
little bit by directing us sort of

1611
01:09:42,079 --> 01:09:39,330
towards pure pure chemistry thank you

1612
01:09:44,149 --> 01:09:42,089
for that cause you guys have anything to

1613
01:09:45,740 --> 01:09:44,159

say to that I mean I have a comment to

1614
01:09:48,169 --> 01:09:45,750
make on the messy chemistry then I think

1615
01:09:50,990 --> 01:09:48,179
the second speaker put it absolutely

1616
01:09:53,720 --> 01:09:51,000
correctly that that people have been

1617
01:09:55,040 --> 01:09:53,730
avoiding messy chemistry and messy

1618
01:09:56,600 --> 01:09:55,050
chemistry is the only way forward it

1619
01:09:58,040 --> 01:09:56,610
might be dilute it might not be very

1620
01:10:01,100 --> 01:09:58,050
interesting to start with but the

1621
01:10:02,840 --> 01:10:01,110
transition and my group and the LC group

1622
01:10:05,060 --> 01:10:02,850
are you know talking about and working

1623
01:10:08,270 --> 01:10:05,070
on this type of process to basically

1624
01:10:10,939 --> 01:10:08,280
what is the messiest mixture that can

1625
01:10:12,830 --> 01:10:10,949
give us genuine complexity so I used

1626
01:10:14,270 --> 01:10:12,840
those two words deliberately and that's

1627
01:10:18,530 --> 01:10:14,280
an outstanding question that I think a

1628
01:10:20,510 --> 01:10:18,540
lot of us want to answer right yeah

1629
01:10:21,200 --> 01:10:20,520
Charlie lineweaver from the Australian

1630
01:10:23,060 --> 01:10:21,210
National University

1631
01:10:25,010 --> 01:10:23,070
the question for leave at the end of

1632
01:10:26,780 --> 01:10:25,020
your talk you you said something about

1633
01:10:28,910 --> 01:10:26,790
what you plan on doing and I was

1634
01:10:30,680 --> 01:10:28,920
wondering if it as I was watching your

1635
01:10:32,839 --> 01:10:30,690
blobs move around I thought wouldn't it

1636
01:10:34,729 --> 01:10:32,849
be nice if those blobs could control the

1637
01:10:37,150 --> 01:10:34,739
amount of chemicals and the free energy

1638
01:10:38,350 --> 01:10:37,160

that they had access to absolutely

1639
01:10:40,360 --> 01:10:38,360
is that what you plan on doing is so

1640
01:10:41,410 --> 01:10:40,370
I'll - I'll give you a snippet and what

1641
01:10:44,350 --> 01:10:41,420
we're going to do is we're going to make

1642
01:10:46,120 --> 01:10:44,360
mazes as like with them you can imagine

1643
01:10:48,190 --> 01:10:46,130
the assault that the environment for me

1644
01:10:50,020 --> 01:10:48,200
is like a military assault course not

1645
01:10:52,030 --> 01:10:50,030
everyone gets out of right so the

1646
01:10:53,830 --> 01:10:52,040
droplets go down the assault course and

1647
01:10:56,590 --> 01:10:53,840
Odin what only the ones that get to the

1648
01:10:57,970 --> 01:10:56,600
end get fed on and in the end they can

1649
01:11:00,010 --> 01:10:57,980
select from different pit stops

1650
01:11:01,810 --> 01:11:00,020
different types of fuels so then

1651
01:11:03,820 --> 01:11:01,820
Jennifer developed strategies to go to

1652
01:11:05,800 --> 01:11:03,830
the next maze and what we're going to

1653
01:11:08,470 --> 01:11:05,810
see is if we can get droplets in the end

1654
01:11:10,960 --> 01:11:08,480
become autonomous and can start to

1655
01:11:14,110 --> 01:11:10,970
replicate we've just had a paper

1656
01:11:17,740 --> 01:11:14,120
accepted I think I can say where we've

1657
01:11:20,590 --> 01:11:17,750
got a replicating chemical reaction that

1658
01:11:23,020 --> 01:11:20,600
replicates droplets on the macro scale

1659
01:11:26,770 --> 01:11:23,030
so if we could get those droplets to go

1660
01:11:29,350 --> 01:11:26,780
and feed off the replicant but fuel they

1661
01:11:31,390 --> 01:11:29,360
can then overtake the droplet universe

1662
01:11:36,600 --> 01:11:31,400
if you know what I'm here it's a great

1663
01:11:41,320 --> 01:11:38,440

reoccurring themes that I noticed

1664
01:11:43,390 --> 01:11:41,330
throughout all the taxes you all seem to

1665
01:11:44,950 --> 01:11:43,400
have identified specific biases and the

1666
01:11:47,110 --> 01:11:44,960
way we think about the origin of life so

1667
01:11:48,490 --> 01:11:47,120
with messy chemistry the bias that you

1668
01:11:50,650 --> 01:11:48,500
sort of addressed was that chemistry

1669
01:11:53,590 --> 01:11:50,660
should be specific and it should be one

1670
01:11:54,670 --> 01:11:53,600
reaction and with evolution you said

1671
01:11:57,130 --> 01:11:54,680
there's all this evolutionary baggage

1672
01:11:59,380 --> 01:11:57,140
that sort of top-down approaches come

1673
01:12:01,030 --> 01:11:59,390
with and you've been identifying ways to

1674
01:12:02,860 --> 01:12:01,040
get rid of that and study hypotheses

1675
01:12:04,900 --> 01:12:02,870
directly and we you sort of got around

1676
01:12:07,330 --> 01:12:04,910
the bias of what to select for by

1677
01:12:09,520 --> 01:12:07,340
selecting for lots of things do you

1678
01:12:11,260 --> 01:12:09,530
think there's any other biases in the

1679
01:12:13,150 --> 01:12:11,270
way we think about the process of the

1680
01:12:14,980 --> 01:12:13,160
origin of life or the experiments that

1681
01:12:16,930 --> 01:12:14,990
we do that we haven't really identified

1682
01:12:19,120 --> 01:12:16,940
or that are not we're not keenly aware

1683
01:12:22,060 --> 01:12:19,130
of in the field yet so questioners to

1684
01:12:27,010 --> 01:12:22,070
say their name - oh I'm calm a touch for

1685
01:12:28,900 --> 01:12:27,020
me with you I would say that there's

1686
01:12:31,630 --> 01:12:28,910
bias everywhere but I think that that

1687
01:12:32,920 --> 01:12:31,640
bias isn't necessarily bad bias helps us

1688
01:12:35,110 --> 01:12:32,930

come up with a hypothesis and then

1689
01:12:37,360 --> 01:12:35,120
destroy it what I find what I find

1690
01:12:39,160 --> 01:12:37,370
exciting about the origin of life let me

1691
01:12:42,220 --> 01:12:39,170
call it exciting rather than depressing

1692
01:12:44,890 --> 01:12:42,230
is that that bias does go into

1693
01:12:47,140 --> 01:12:44,900
hypotheses but the timescale for that

1694
01:12:49,480 --> 01:12:47,150
has been slow and it's now speeding up

1695
01:12:50,800 --> 01:12:49,490
so I'm really excited by that so I think

1696
01:12:52,390 --> 01:12:50,810
to answer your question

1697
01:12:54,700 --> 01:12:52,400
more directly I think there's a really

1698
01:12:56,650 --> 01:12:54,710
interesting bias the kind of what life

1699
01:13:00,010 --> 01:12:56,660
is I think life is a continuum of

1700
01:13:01,840 --> 01:13:00,020
process and so in my lab what we try and

1701
01:13:04,000 --> 01:13:01,850
do is make a metric and then work with

1702
01:13:06,100 --> 01:13:04,010
you guys and whoever else wants to get

1703
01:13:08,080 --> 01:13:06,110
on board is to look for a metric that

1704
01:13:10,510 --> 01:13:08,090
basically life tends to make complicated

1705
01:13:13,000 --> 01:13:10,520
stuff so if we can just look for

1706
01:13:15,250 --> 01:13:13,010
complicated stuff in the universe and

1707
01:13:16,750 --> 01:13:15,260
also try and make us a complicated the

1708
01:13:19,420 --> 01:13:16,760
problem as we can in our lab without

1709
01:13:20,920 --> 01:13:19,430
actually coding it look at the emergence

1710
01:13:22,810 --> 01:13:20,930
of complexity that might be a way of

1711
01:13:25,330 --> 01:13:22,820
removing a lot of bias because we just

1712
01:13:28,290 --> 01:13:25,340
go for complex stuff first rather than

1713
01:13:31,870 --> 01:13:28,300

worrying about the precise a kind of

1714
01:13:37,390 --> 01:13:31,880
Archaeology 4-bit pre luca because it's

1715
01:13:39,910 --> 01:13:37,400
hard i say that for for biology i think

1716
01:13:41,770 --> 01:13:39,920
the the view of biology as a complex

1717
01:13:44,620 --> 01:13:41,780
system can also be challenged and

1718
01:13:48,100 --> 01:13:44,630
perhaps we can also strip biology into

1719
01:13:50,410 --> 01:13:48,110
systems that are not as complex and

1720
01:13:52,780 --> 01:13:50,420
maybe these systems are embedded within

1721
01:13:54,520 --> 01:13:52,790
the biology that we know today and what

1722
01:13:56,440 --> 01:13:54,530
i mean is that that we have a layer of

1723
01:13:58,720 --> 01:13:56,450
complexity that we need to deal with but

1724
01:14:00,790 --> 01:13:58,730
perhaps by creating simpler systems and

1725
01:14:03,250 --> 01:14:00,800
i gave the example of protocells here

1726
01:14:05,950 --> 01:14:03,260
and or maybe making artificial organism

1727
01:14:08,620 --> 01:14:05,960
ourselves we can reach to a degree of

1728
01:14:10,660 --> 01:14:08,630
biology that is more controllable for

1729
01:14:12,100 --> 01:14:10,670
example in at least in laboratory

1730
01:14:14,350 --> 01:14:12,110
evolution experiments that and again

1731
01:14:17,500 --> 01:14:14,360
these are building on the organisms that

1732
01:14:20,920 --> 01:14:17,510
are complex and that are adapted to life

1733
01:14:23,530 --> 01:14:20,930
today we do realize that and what we see

1734
01:14:25,990 --> 01:14:23,540
is that initial mutations do determine

1735
01:14:27,970 --> 01:14:26,000
the trajectory of the evolution

1736
01:14:30,430 --> 01:14:27,980
evolution a trajectory that is going to

1737
01:14:33,160 --> 01:14:30,440
be taken by the organism and if this can

1738
01:14:35,050 --> 01:14:33,170

apply to life itself and early life

1739
01:14:37,120 --> 01:14:35,060
itself and if the initial mutations that

1740
01:14:40,360 --> 01:14:37,130
determine the complexity of biology I

1741
01:14:42,880 --> 01:14:40,370
think we could challenge biologists also

1742
01:14:44,560 --> 01:14:42,890
to reach to that variant step and then

1743
01:14:48,280 --> 01:14:44,570
think about the biology that maybe is

1744
01:14:51,970 --> 01:14:48,290
not as complex as we think it is great

1745
01:14:53,710 --> 01:14:51,980
so we are officially out of time so I

1746
01:14:56,680 --> 01:14:53,720
want to thank all three of our speakers

1747
01:14:57,919 --> 01:14:56,690
again for excellent talk and really

1748
01:14:59,900 --> 01:14:57,929
challenging