
AbSciCon
2019

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

2
00:00:11,999 --> 00:00:08,669
[Applause]

3
00:00:14,220 --> 00:00:12,009
I think a core problem for many of us in

4
00:00:17,159 --> 00:00:14,230
origin of life science is figuring out

5
00:00:19,650 --> 00:00:17,169
what were the first entities capable of

6
00:00:21,330 --> 00:00:19,660
displaying key lifelike properties such

7
00:00:23,429 --> 00:00:21,340
as self propagation and adaptive

8
00:00:25,499 --> 00:00:23,439
evolution but are also simple enough

9
00:00:27,540 --> 00:00:25,509
that we can imagine them spontaneously

10
00:00:30,540 --> 00:00:27,550
arising in the absence of a prior

11
00:00:32,130 --> 00:00:30,550
adaptive process so there are many

12
00:00:34,740 --> 00:00:32,140
models out there but the one that we

13
00:00:37,410 --> 00:00:34,750

tend to rally behind is this notion that

14
00:00:40,110 --> 00:00:37,420
the first entities capable of self

15
00:00:42,030 --> 00:00:40,120
propagation were cooperating sets of

16
00:00:44,310 --> 00:00:42,040
chemical species that were spatially

17
00:00:46,950 --> 00:00:44,320
localized on a mineral surface and could

18
00:00:48,899 --> 00:00:46,960
grow laterally otto catalytically using

19
00:00:51,420 --> 00:00:48,909
fluxes of food and energy present in the

20
00:00:54,119 --> 00:00:51,430
environment and in addition to being a

21
00:00:56,549 --> 00:00:54,129
being able to self propagate it turns

22
00:00:58,170 --> 00:00:56,559
out that these slimes as we like to

23
00:01:00,570 --> 00:00:58,180
refer to them for surface limited

24
00:01:03,359 --> 00:01:00,580
metabolisms could also be evolvable if

25
00:01:06,030 --> 00:01:03,369
rare side reactions either alter or

26
00:01:08,490 --> 00:01:06,040
expand the existing catalytic core and

27
00:01:11,039 --> 00:01:08,500
add new reaction modules or cores as

28
00:01:12,840 --> 00:01:11,049
they're referred to and in the context

29
00:01:16,290 --> 00:01:12,850
of a natural environment where we have

30
00:01:18,240 --> 00:01:16,300
mineral surfaces bathed in for example

31
00:01:20,700 --> 00:01:18,250
sea water that's rich in organics and

32
00:01:23,220 --> 00:01:20,710
other compounds building up by various

33
00:01:25,260 --> 00:01:23,230
prebiotic synthesis pathways we imagine

34
00:01:27,210 --> 00:01:25,270
that the burial and continual exposure

35
00:01:29,070 --> 00:01:27,220
of new mineral surface would tend to

36
00:01:30,990 --> 00:01:29,080
enrich for systems that are better at

37
00:01:34,470 --> 00:01:31,000
getting from grain to grain or at least

38
00:01:37,260 --> 00:01:34,480

can self propagate faster so the goal of

39
00:01:39,240 --> 00:01:37,270
our research is to test the slime model

40
00:01:41,010 --> 00:01:39,250
for the origin of life by essentially

41
00:01:43,050 --> 00:01:41,020
recreating that little seascape I just

42
00:01:44,940 --> 00:01:43,060
showed you and asking if we can enrich

43
00:01:46,260 --> 00:01:44,950
for these systems using a protocol that

44
00:01:48,570 --> 00:01:46,270
we've developed called chemical

45
00:01:50,580 --> 00:01:48,580
ecosystem selection and the protocol is

46
00:01:54,000 --> 00:01:50,590
very simple it essentially involves

47
00:01:55,680 --> 00:01:54,010
combining prebiotic soups containing

48
00:01:57,780 --> 00:01:55,690
many dissolved organics and other

49
00:02:00,660 --> 00:01:57,790
compounds in the presence of mineral

50
00:02:02,160 --> 00:02:00,670
grains allowing for putative slimes to

51
00:02:04,110 --> 00:02:02,170
emerge and in this figure I've depicted

52
00:02:05,820 --> 00:02:04,120
several kinds of slimes that maybe

53
00:02:08,190 --> 00:02:05,830
differ in their colonizing abilities

54
00:02:10,800 --> 00:02:08,200
denoted by different colors and at the

55
00:02:13,380 --> 00:02:10,810
end of an incubation period we transfer

56
00:02:15,210 --> 00:02:13,390
a small subset of colonized grains to

57
00:02:17,309 --> 00:02:15,220
new reaction vessels containing fresh

58
00:02:19,830 --> 00:02:17,319
compounds so fresh food and fresh

59
00:02:20,590 --> 00:02:19,840
uncolonized mineral surface and we do

60
00:02:23,320 --> 00:02:20,600
this over many

61
00:02:24,700 --> 00:02:23,330
with the hopes that we would enrich for

62
00:02:26,860 --> 00:02:24,710
systems that are better at getting from

63
00:02:28,570 --> 00:02:26,870

grain to grain now the nice thing about

64
00:02:30,670 --> 00:02:28,580
this framework is that it's chemically

65
00:02:32,170 --> 00:02:30,680
agnostic meaning that you can test many

66
00:02:34,630 --> 00:02:32,180
different scenarios based on your

67
00:02:36,610 --> 00:02:34,640
preference but for the purposes of this

68
00:02:38,260 --> 00:02:36,620
talk I'm going to give you an example of

69
00:02:40,030 --> 00:02:38,270
a recipe we've been using extensively

70
00:02:43,450 --> 00:02:40,040
and have been getting some cool results

71
00:02:45,460 --> 00:02:43,460
with so the soup that we use is what we

72
00:02:46,960 --> 00:02:45,470
call an enriched miliary soup so it's

73
00:02:48,400 --> 00:02:46,970
actually a synthetic soup that we build

74
00:02:50,920 --> 00:02:48,410
that we make using off-the-shelf

75
00:02:53,050 --> 00:02:50,930
reagents and we make a number of

76
00:02:54,760 --> 00:02:53,060
additions to reflect for example what

77
00:02:57,400 --> 00:02:54,770
you might find in an ocean so salts

78
00:02:59,710 --> 00:02:57,410
transition metals and we also add

79
00:03:01,240 --> 00:02:59,720
potential sources of chemical energy and

80
00:03:03,760 --> 00:03:01,250
the one I'm going to highlight here is

81
00:03:05,890 --> 00:03:03,770
ATP but I'm also going to say and

82
00:03:07,450 --> 00:03:05,900
acknowledge that ATP is probably not a

83
00:03:09,460 --> 00:03:07,460
very pretty but eclis plausible

84
00:03:11,980 --> 00:03:09,470
phosphate source but we used it anyway

85
00:03:13,990 --> 00:03:11,990
so I'm going to show you that data as

86
00:03:15,340 --> 00:03:14,000
for the mineral we've tried a few but

87
00:03:17,500 --> 00:03:15,350
the one again I'm going to focus on is

88
00:03:19,780 --> 00:03:17,510

pyrite this iron sulfide mineral which

89
00:03:21,850 --> 00:03:19,790
we grind up into fine powders and then

90
00:03:23,260 --> 00:03:21,860
use in our experiments and we combine it

91
00:03:26,050 --> 00:03:23,270
with our soup in these little reaction

92
00:03:27,790 --> 00:03:26,060
vessels which are sealed serum vials we

93
00:03:30,370 --> 00:03:27,800
flush the headspace with nitrogen and

94
00:03:31,780 --> 00:03:30,380
then we also autoclave them at the end

95
00:03:36,310 --> 00:03:31,790
of each generation just to ensure

96
00:03:39,760 --> 00:03:36,320
sterility so that's the recipe and of

97
00:03:41,680 --> 00:03:39,770
course being able to deploy this this

98
00:03:44,590 --> 00:03:41,690
protocol implies that would be able to

99
00:03:46,360 --> 00:03:44,600
detect slimes if they were to emerge and

100
00:03:48,250 --> 00:03:46,370
the way we do that is by assuming that

101
00:03:50,020 --> 00:03:48,260
if slimes did emerge and change over

102
00:03:52,690 --> 00:03:50,030
time we'd be able to see that reflected

103
00:03:54,160 --> 00:03:52,700
and changes in a sealed reaction vessel

104
00:03:55,630 --> 00:03:54,170
either in the bulk solution or on the

105
00:03:59,590 --> 00:03:55,640
mineral surface so that's what we look

106
00:04:01,510 --> 00:03:59,600
at so here what we have on the y-axis is

107
00:04:03,580 --> 00:04:01,520
the amount of free phosphate we detect

108
00:04:05,350 --> 00:04:03,590
in our in our soup in our solutions at

109
00:04:07,930 --> 00:04:05,360
the end of an incubation period so if

110
00:04:10,120 --> 00:04:07,940
you remember I mentioned we add ATP so

111
00:04:11,620 --> 00:04:10,130
we can use simple colorimetric assays to

112
00:04:12,940 --> 00:04:11,630
measure the amount of free inorganic

113
00:04:14,740 --> 00:04:12,950

phosphate that's released from the

114
00:04:16,840 --> 00:04:14,750
hydrolysis of that ATP molecule and

115
00:04:19,360 --> 00:04:16,850
track how that changes over times as we

116
00:04:22,600 --> 00:04:19,370
keep selecting so what we see on the y

117
00:04:25,480 --> 00:04:22,610
axis are different lineages so the gray

118
00:04:26,800 --> 00:04:25,490
bars are ten independent lineages that

119
00:04:28,750 --> 00:04:26,810
were set up in the same way with the

120
00:04:30,760 --> 00:04:28,760
same ingredients but propagated

121
00:04:33,370 --> 00:04:30,770
independently of each other and that

122
00:04:34,159 --> 00:04:33,380
orange bar is the average of a control

123
00:04:36,469 --> 00:04:34,169
pool that's

124
00:04:38,959 --> 00:04:36,479
using the same reagents at the same time

125
00:04:41,270 --> 00:04:38,969
but only exposed to one history of

126
00:04:43,580 --> 00:04:41,280
transfers and what you can see from this

127
00:04:46,129 --> 00:04:43,590
plot hopefully pretty clearly is that as

128
00:04:47,659 --> 00:04:46,139
a number of generations increases we

129
00:04:50,689 --> 00:04:47,669
have a progressive decline in the amount

130
00:04:52,070 --> 00:04:50,699
of phosphate we detect and so we infer

131
00:04:55,369 --> 00:04:52,080
that to mean pretty simply that a

132
00:04:57,290 --> 00:04:55,379
history of transfer matters and then

133
00:04:59,269 --> 00:04:57,300
another thing that we that we measure is

134
00:05:00,589 --> 00:04:59,279
basically how much light is absorbed by

135
00:05:03,439 --> 00:05:00,599
that bulk solution at the end of a

136
00:05:05,059 --> 00:05:03,449
generation as a proxy for how many light

137
00:05:06,290 --> 00:05:05,069
absorbing compounds including some of

138
00:05:08,659 --> 00:05:06,300

the organics that we have in our

139
00:05:11,779 --> 00:05:08,669
solution remain after such incubations

140
00:05:13,369 --> 00:05:11,789
and what we find is that vials or

141
00:05:15,469 --> 00:05:13,379
reaction vessels that have a long

142
00:05:17,869 --> 00:05:15,479
history of transferring in this case 18

143
00:05:19,939 --> 00:05:17,879
have significantly lower absorbance than

144
00:05:21,830 --> 00:05:19,949
our control set and we and for that to

145
00:05:23,540 --> 00:05:21,840
mean that some of light absorbing

146
00:05:25,820 --> 00:05:23,550
compounds including the organics have

147
00:05:26,149 --> 00:05:25,830
been depleted from the solution in some

148
00:05:28,610 --> 00:05:26,159
way

149
00:05:30,260 --> 00:05:28,620
so this coincident reduction in both the

150
00:05:32,029 --> 00:05:30,270
amount of free phosphate and light

151
00:05:35,140 --> 00:05:32,039
absorbing compounds and organics and our

152
00:05:38,209 --> 00:05:35,150
bulk solution led us to inspect the

153
00:05:40,040 --> 00:05:38,219
surfaces of our pyrite grains to see if

154
00:05:41,390 --> 00:05:40,050
we could observe any systematic

155
00:05:43,670 --> 00:05:41,400
differences and we used electron

156
00:05:45,379 --> 00:05:43,680
microscopy to do this so here's a

157
00:05:47,929 --> 00:05:45,389
representative micrograph of grains

158
00:05:50,540 --> 00:05:47,939
taken from a control vial so again this

159
00:05:53,420 --> 00:05:50,550
was one that only had one transfer in

160
00:05:55,339 --> 00:05:53,430
its history and this is what we see when

161
00:05:57,409 --> 00:05:55,349
we look at experimental grain so this

162
00:05:59,300 --> 00:05:57,419
one had 18 rounds of transfer in its

163
00:06:01,850 --> 00:05:59,310

history and what you can see hopefully

164
00:06:03,230 --> 00:06:01,860
yes you can see them pretty clearly are

165
00:06:05,300 --> 00:06:03,240
these really distinctive fractal

166
00:06:07,399 --> 00:06:05,310
structures now to make a long story

167
00:06:09,439 --> 00:06:07,409
short about what our best guess as to

168
00:06:12,139 --> 00:06:09,449
what these things are is so we don't

169
00:06:14,029 --> 00:06:12,149
actually think these are the putative

170
00:06:16,519 --> 00:06:14,039
slime or the phosphate or organic

171
00:06:18,469 --> 00:06:16,529
consuming structures we think that there

172
00:06:20,480 --> 00:06:18,479
are salt crystals that are fouled with

173
00:06:22,010 --> 00:06:20,490
organics or growing on a layer of

174
00:06:23,899 --> 00:06:22,020
organics that are on the pyrite surface

175
00:06:27,769 --> 00:06:23,909
and that gives them this distinctive

176
00:06:29,600 --> 00:06:27,779
fractal or seaweed dendrite shape so

177
00:06:31,790 --> 00:06:29,610
what these results in mind we decided to

178
00:06:33,170 --> 00:06:31,800
repeat the experiment this time we

179
00:06:34,429 --> 00:06:33,180
carried it out for longer and we also

180
00:06:36,950 --> 00:06:34,439
took measurements at the end of each

181
00:06:38,860 --> 00:06:36,960
generation this time and this was what

182
00:06:40,700 --> 00:06:38,870
we saw in the free orthophosphate

183
00:06:43,249 --> 00:06:40,710
concentration so this time I've pulled

184
00:06:45,980 --> 00:06:43,259
it to reflect the average of our ten

185
00:06:47,390 --> 00:06:45,990
independent experimental lineages and

186
00:06:49,810 --> 00:06:47,400
you can see pretty clearly this

187
00:06:52,220 --> 00:06:49,820
pretty distinctive oscillatory pattern

188
00:06:54,890 --> 00:06:52,230

where we have an initial what we call a

189
00:06:57,800 --> 00:06:54,900
boom phase that is this linear decline

190
00:07:00,470 --> 00:06:57,810
in the amount of free phosphate and then

191
00:07:02,150 --> 00:07:00,480
a sudden reversal in that trend where we

192
00:07:04,490 --> 00:07:02,160
go back to our initial phosphate levels

193
00:07:07,430 --> 00:07:04,500
if not overshooting it a little bit so

194
00:07:10,160 --> 00:07:07,440
we have a few hypotheses to explain this

195
00:07:12,230 --> 00:07:10,170
behavior one is that that initial

196
00:07:14,930 --> 00:07:12,240
decline in free phosphate which is now a

197
00:07:16,130 --> 00:07:14,940
repeatable instance although you'll

198
00:07:17,360 --> 00:07:16,140
notice the timing is a little bit

199
00:07:18,670 --> 00:07:17,370
different this time and we think that

200
00:07:20,840 --> 00:07:18,680
that's because we use slightly different

201
00:07:24,050 --> 00:07:20,850
batches of our enriched miliary soup

202
00:07:25,400 --> 00:07:24,060
that might vary a little bit we think

203
00:07:28,040 --> 00:07:25,410
that that's reflective of the

204
00:07:30,470 --> 00:07:28,050
self-propagating state taking hold and

205
00:07:32,300 --> 00:07:30,480
growing on the mineral surface now the

206
00:07:34,450 --> 00:07:32,310
bust phase can be explained in a number

207
00:07:36,440 --> 00:07:34,460
of ways the one that we like to to

208
00:07:38,870 --> 00:07:36,450
consider is kind of an ecological

209
00:07:41,600 --> 00:07:38,880
perspective where you essentially have

210
00:07:43,280 --> 00:07:41,610
resource depletion this the system gets

211
00:07:45,290 --> 00:07:43,290
to stay where it consumes its resources

212
00:07:46,070 --> 00:07:45,300
and then collapses and the process

213
00:07:48,800 --> 00:07:46,080

starts all over again

214
00:07:51,200 --> 00:07:48,810
I also want to point out that we've

215
00:07:52,820 --> 00:07:51,210
looked at the fractal coverage at

216
00:07:57,350 --> 00:07:52,830
different points here and we have some

217
00:07:58,850 --> 00:07:57,360
qualitative arm wavy estimates of how

218
00:08:01,040 --> 00:07:58,860
they correlate with the phosphate

219
00:08:03,680 --> 00:08:01,050
pattern so turns out that we get the

220
00:08:06,200 --> 00:08:03,690
highest incidence of fractals when the

221
00:08:07,130 --> 00:08:06,210
phosphate it is also at its minimum so

222
00:08:08,870 --> 00:08:07,140
we think that this provides

223
00:08:11,210 --> 00:08:08,880
circumstantial evidence for what we

224
00:08:13,910 --> 00:08:11,220
think these critters are they're not

225
00:08:17,090 --> 00:08:13,920
actually the slimes they are a proxy for

226
00:08:18,980 --> 00:08:17,100
them essentially but one thing I mean is

227
00:08:21,230 --> 00:08:18,990
pretty clear from from this graph alone

228
00:08:23,420 --> 00:08:21,240
is that it seems like we've enriched for

229
00:08:26,360 --> 00:08:23,430
some kind of nonlinear chemical system

230
00:08:28,100 --> 00:08:26,370
which is good news and that I view long

231
00:08:31,100 --> 00:08:28,110
linearity as being a self a prerequisite

232
00:08:34,220 --> 00:08:31,110
for self propagation and evolution so in

233
00:08:36,290 --> 00:08:34,230
that front were good but I want to get

234
00:08:37,910 --> 00:08:36,300
at the source of this non-linearity a

235
00:08:39,950 --> 00:08:37,920
little bit more specifically and so what

236
00:08:41,750 --> 00:08:39,960
we did for that is we actually looked at

237
00:08:44,180 --> 00:08:41,760
what happened intra generationally so

238
00:08:46,370 --> 00:08:44,190

what happens when you set up your Miller

239
00:08:47,990 --> 00:08:46,380
Urey soup with your pyrite you autoclave

240
00:08:49,870 --> 00:08:48,000
it and then you track how these

241
00:08:52,310 --> 00:08:49,880
different proxy traits change over time

242
00:08:54,590 --> 00:08:52,320
and what we saw in the phosphate at

243
00:08:56,510 --> 00:08:54,600
least is this really again pronounced

244
00:08:58,370 --> 00:08:56,520
oscillatory pattern that looks to be

245
00:09:00,530 --> 00:08:58,380
damped

246
00:09:02,300 --> 00:09:00,540
and notably it also looks like there's a

247
00:09:04,130 --> 00:09:02,310
lot of potential for non-linearity even

248
00:09:05,480 --> 00:09:04,140
after our typical transfer period which

249
00:09:06,590 --> 00:09:05,490
is two days I'm know if I mentioned that

250
00:09:09,830 --> 00:09:06,600
yet

251
00:09:11,210 --> 00:09:09,840
we also looked at the total absorbance

252
00:09:13,490 --> 00:09:11,220
and how that changed over our time

253
00:09:15,050 --> 00:09:13,500
course and you can see that it has its

254
00:09:16,910 --> 00:09:15,060
own dynamics it doesn't necessarily

255
00:09:19,870 --> 00:09:16,920
completely overlap with what we see in

256
00:09:22,520 --> 00:09:19,880
the phosphate but it does seem to

257
00:09:23,960 --> 00:09:22,530
indicate what we would expect to see

258
00:09:25,970 --> 00:09:23,970
with the fractals so again this is very

259
00:09:28,100 --> 00:09:25,980
qualitative we don't really have a good

260
00:09:30,110 --> 00:09:28,110
way to quantify the extent of fractal

261
00:09:32,120 --> 00:09:30,120
coverage yet but what it looks like is

262
00:09:34,490 --> 00:09:32,130
that the fractal frequency increases

263
00:09:37,670 --> 00:09:34,500

over the first 72 hours which is

264
00:09:40,130 --> 00:09:37,680
coincident with this trough in the

265
00:09:41,990 --> 00:09:40,140
uv-vis data after which we no longer

266
00:09:43,700 --> 00:09:42,000
observe them and they never seem to come

267
00:09:47,140 --> 00:09:43,710
back as far as we can tell at least over

268
00:09:50,000 --> 00:09:47,150
the period we looked at so is it a slime

269
00:09:51,800 --> 00:09:50,010
well we're not sure yet but I do think

270
00:09:53,330 --> 00:09:51,810
that these results are really

271
00:09:54,920 --> 00:09:53,340
interesting and I think they kind of

272
00:09:56,450 --> 00:09:54,930
give us an idea of what kinds of

273
00:09:59,200 --> 00:09:56,460
chemistry and what kinds of dynamics we

274
00:10:01,100 --> 00:09:59,210
can expect to find using this protocol

275
00:10:02,570 --> 00:10:01,110
but what we would really need to

276
00:10:04,340 --> 00:10:02,580
convince ourselves that this has the

277
00:10:06,350 --> 00:10:04,350
potential to be a slime as we've defined

278
00:10:08,060 --> 00:10:06,360
it is to demonstrate that it can self

279
00:10:10,070 --> 00:10:08,070
propagate and although we think it's

280
00:10:12,470 --> 00:10:10,080
likely that there is a self propagating

281
00:10:14,270 --> 00:10:12,480
a stage we would really need to

282
00:10:15,770 --> 00:10:14,280
demonstrate that the non-linearity is

283
00:10:19,250 --> 00:10:15,780
actually confined to the mineral surface

284
00:10:20,900 --> 00:10:19,260
and that's part of ongoing work that

285
00:10:22,130 --> 00:10:20,910
also includes clarifying the chemistry

286
00:10:23,900 --> 00:10:22,140
of the slime I'm sure you are dying to

287
00:10:25,070 --> 00:10:23,910
know as much as I am what this thing

288
00:10:26,720 --> 00:10:25,080

looks like what it's made up of

289
00:10:29,090 --> 00:10:26,730
chemically and we just have no idea at

290
00:10:31,310 --> 00:10:29,100
this point and we also to that end want

291
00:10:33,290 --> 00:10:31,320
to test complementary conditions and do

292
00:10:35,780 --> 00:10:33,300
things like swap out ATP for a more

293
00:10:38,150 --> 00:10:35,790
realistic source of phosphate and

294
00:10:40,460 --> 00:10:38,160
finally I just want to end and comment

295
00:10:42,710 --> 00:10:40,470
on this question of is it evolvable I

296
00:10:44,390 --> 00:10:42,720
think that's ultimately what we want to

297
00:10:48,500 --> 00:10:44,400
know and what would make us really

298
00:10:49,880 --> 00:10:48,510
excited to find and so we're moving in

299
00:10:51,560 --> 00:10:49,890
that direction right now and we're

300
00:10:53,720 --> 00:10:51,570
basically looking to see if we can find

301
00:10:56,450 --> 00:10:53,730
changes in the rate of propagation over

302
00:10:57,980 --> 00:10:56,460
time in response to our protocol and

303
00:11:00,050 --> 00:10:57,990
that figure down there it's just

304
00:11:01,370 --> 00:11:00,060
hypothetical data just to show you that

305
00:11:04,220 --> 00:11:01,380
we have some notion of what that should

306
00:11:06,680 --> 00:11:04,230
look like even if we have kind of

307
00:11:08,450 --> 00:11:06,690
different modes of evolution and then

308
00:11:10,789 --> 00:11:08,460
finally I think a long-term goal or kind

309
00:11:12,859 --> 00:11:10,799
of idealistic one would be to create

310
00:11:14,359 --> 00:11:12,869
environment specific strains if you will

311
00:11:17,179 --> 00:11:14,369
that are adapted to slightly different

312
00:11:21,579 --> 00:11:17,189
conditions like pH temperature dissolved

313
00:11:23,449 --> 00:11:21,589

oxygen and have them be fitter or more

314
00:11:26,419 --> 00:11:23,459
efficient in their own respective

315
00:11:28,039 --> 00:11:26,429
environments so with that I just like to

316
00:11:29,569 --> 00:11:28,049
quickly acknowledge the long list of

317
00:11:31,309 --> 00:11:29,579
people that makes us possible and I

318
00:11:33,859 --> 00:11:31,319
actually do these experiments so of

319
00:11:36,949 --> 00:11:33,869
course my PI David Bohm our co-author

320
00:11:40,159 --> 00:11:36,959
and collaborator Jim Cleves our funding

321
00:11:41,659 --> 00:11:40,169
sources that come out of the NASA NSF

322
00:11:43,939 --> 00:11:41,669
ideas labs I'd like to thank our

323
00:11:45,829 --> 00:11:43,949
collaborators as part of that of course

324
00:11:47,209 --> 00:11:45,839
our amazing research group and then

325
00:11:48,919 --> 00:11:47,219
finally just a quick shout out to the

326
00:11:51,139 --> 00:11:48,929
artist of some of the illustrations that

327
00:11:52,999 --> 00:11:51,149
you saw in my talk that actually comes

328
00:11:54,679 --> 00:11:53,009
from a comic we co-wrote about how you

329
00:11:56,539 --> 00:11:54,689
can use science to solve seemingly

330
00:12:05,179 --> 00:11:56,549
intractable questions like the origin of

331
00:12:06,619 --> 00:12:05,189
life so thank you very much we have time

332
00:12:08,629 --> 00:12:06,629
for a couple of questions while our next

333
00:12:14,269 --> 00:12:08,639
speaker comes up here Yeah right there

334
00:12:16,069 --> 00:12:14,279
in the center so I'm very curious you

335
00:12:18,829 --> 00:12:16,079
have these fractals that are interacting

336
00:12:22,159 --> 00:12:18,839
with the the pyrite crystal correct and

337
00:12:24,139 --> 00:12:22,169
they go away with this you know during

338
00:12:25,759 --> 00:12:24,149

the cycling but I'm wondering if at the

339
00:12:27,229 --> 00:12:25,769
end of your experiment if you look very

340
00:12:29,329 --> 00:12:27,239
carefully at the pyrite crystals is

341
00:12:30,589 --> 00:12:29,339
there some evidence that that was there

342
00:12:31,879 --> 00:12:30,599
was some interaction that that was there

343
00:12:34,279 --> 00:12:31,889
are they leaving a record of themselves

344
00:12:36,049 --> 00:12:34,289
if you will so the short answer is we're

345
00:12:39,139 --> 00:12:36,059
not sure yet so we're just getting in

346
00:12:40,789 --> 00:12:39,149
the realm of in-depth surface analysis

347
00:12:42,949 --> 00:12:40,799
that's something that's been quite

348
00:12:45,139 --> 00:12:42,959
difficult to do using the grain format

349
00:12:47,839 --> 00:12:45,149
that we're using so we just don't know

350
00:12:50,149 --> 00:12:47,849
so it's possible that because we don't

351
00:12:50,779 --> 00:12:50,159
see them come back that it's not that

352
00:12:52,699 --> 00:12:50,789
they're gone

353
00:12:53,719 --> 00:12:52,709
per se but they might have diffused to

354
00:12:55,099 --> 00:12:53,729
the point where we don't actually see

355
00:12:56,689 --> 00:12:55,109
them kind of localized and these really

356
00:12:58,969 --> 00:12:56,699
cool fractal structures so that's one

357
00:13:02,299 --> 00:12:58,979
possibility but we just simply don't

358
00:13:04,939 --> 00:13:02,309
know at this point what was your control

359
00:13:08,269 --> 00:13:04,949
with with no pyrite or did you show that

360
00:13:10,699 --> 00:13:08,279
so in the selection experiments we have

361
00:13:13,519 --> 00:13:10,709
controls that are set up strategically

362
00:13:16,279 --> 00:13:13,529
alongside the generations we measure out

363
00:13:18,589 --> 00:13:16,289

so that they only have one generation in

364
00:13:20,820 --> 00:13:18,599
their history so we'll compare samples

365
00:13:23,370 --> 00:13:20,830
that have identical conditions except

366
00:13:25,920 --> 00:13:23,380
that will have say 20 generations of

367
00:13:27,960 --> 00:13:25,930
transfers versus just one but you

368
00:13:30,120 --> 00:13:27,970
haven't done it with no pyrite oh we've

369
00:13:32,610 --> 00:13:30,130
done the time series experiments with no

370
00:13:34,320 --> 00:13:32,620
pyrite and convinced ourselves that the

371
00:13:36,390 --> 00:13:34,330
at least the intergenerational dynamics

372
00:13:39,090 --> 00:13:36,400
we see require the presence of pyrite

373
00:13:41,820 --> 00:13:39,100
but we have not yet done selection

374
00:13:44,460 --> 00:13:41,830
experiments in the absence of pyrite and

375
00:13:49,260 --> 00:13:44,470
we plan on doing that alright one more

376
00:13:52,440 --> 00:13:49,270
over here so you saw fun dynamics with

377
00:13:55,680 --> 00:13:52,450
within a single vial but without

378
00:13:57,600 --> 00:13:55,690
transfers right so I was wondering is

379
00:13:59,130 --> 00:13:57,610
there anything do you know if there's

380
00:14:01,590 --> 00:13:59,140
anything different that happens if you

381
00:14:04,320 --> 00:14:01,600
transfer out of that vial at different

382
00:14:07,530 --> 00:14:04,330
time points like does it starve and stop

383
00:14:09,300 --> 00:14:07,540
being able to propagate or does it

384
00:14:11,700 --> 00:14:09,310
propagate differently if you pull it out

385
00:14:14,460 --> 00:14:11,710
at different moments like that might

386
00:14:16,740 --> 00:14:14,470
tell you if it's depending on non

387
00:14:20,820 --> 00:14:16,750
equilibrium chemistry yes that's a great

388
00:14:23,730 --> 00:14:20,830

question the only real data that I have

389
00:14:24,720 --> 00:14:23,740
to that from experiments like the ones

390
00:14:26,070 --> 00:14:24,730
you've just suggested are very

391
00:14:27,540 --> 00:14:26,080
preliminary we did them just once

392
00:14:29,490 --> 00:14:27,550
actually in parallel with the time

393
00:14:31,290 --> 00:14:29,500
course I just showed you and we found

394
00:14:32,910 --> 00:14:31,300
basically did a one-day transfer and a

395
00:14:34,650 --> 00:14:32,920
two-day transfer and we kept those

396
00:14:36,480 --> 00:14:34,660
lineages separately so basically one had

397
00:14:38,670 --> 00:14:36,490
a two-day generation time the other had

398
00:14:41,880 --> 00:14:38,680
a 1-day generation time and we did find

399
00:14:43,950 --> 00:14:41,890
that the boom-bust patterning that you

400
00:14:45,480 --> 00:14:43,960
got in those two or it was quite

401
00:14:46,920 --> 00:14:45,490
different the timing was quite different

402
00:14:50,300 --> 00:14:46,930
which suggests that when you do that

403
00:14:52,260 --> 00:14:50,310
initial transfer where you are in that

404
00:14:54,150 --> 00:14:52,270
oscillation that you get

405
00:14:57,030 --> 00:14:54,160
intergenerationally matters but that's

406
00:14:58,860 --> 00:14:57,040
all very preliminary and we are going to

407
00:15:00,860 --> 00:14:58,870
do experiments much more extensively and

408
00:15:03,990 --> 00:15:00,870
try to use that intergenerational

409
00:15:06,630 --> 00:15:04,000
dynamic pattern to strategically select

410
00:15:07,830 --> 00:15:06,640
different generation times but yeah

411
00:15:09,920 --> 00:15:07,840
that's a great question we're thinking

412
00:15:12,330 --> 00:15:09,930
along those lines very much so okay and

413
00:15:15,870 --> 00:15:12,340

one more quick question in the center a

414
00:15:17,640 --> 00:15:15,880
quick question it seems to me that one

415
00:15:19,380 --> 00:15:17,650
of the sort of important assumptions

416
00:15:22,350 --> 00:15:19,390
that goes into the slime model is you

417
00:15:24,090 --> 00:15:22,360
have a relatively slow chaos for these

418
00:15:25,770 --> 00:15:24,100
like organics on its surfaces and it

419
00:15:26,940 --> 00:15:25,780
seems like that's actually a pretty like

420
00:15:28,560 --> 00:15:26,950
at least compared to what you've done

421
00:15:30,360 --> 00:15:28,570
like a pretty simple experiment you

422
00:15:31,980 --> 00:15:30,370
could do to sort of limit or constrain

423
00:15:32,620 --> 00:15:31,990
what types of species you're interested

424
00:15:36,670 --> 00:15:32,630
in

425
00:15:39,040 --> 00:15:36,680
yeah yes and I am by note I'm not an

426
00:15:42,340 --> 00:15:39,050
expert in nonlinear dynamics so I am not

427
00:15:43,960 --> 00:15:42,350
I don't know what to say it your to your

428
00:15:45,249 --> 00:15:43,970
point about yes have you guys tried to

429
00:15:47,379 --> 00:15:45,259
do in the experiment you take a single

430
00:15:49,720 --> 00:15:47,389
component add it to pyrite and just see

431
00:15:52,030 --> 00:15:49,730
what's how what's the kinetics of it

432
00:15:54,100 --> 00:15:52,040
sticking on to pyrite we have not but we

433
00:15:56,230 --> 00:15:54,110
plan on doing kind of reduction

434
00:15:57,819 --> 00:15:56,240
experiments where we leave out whole

435
00:15:59,439 --> 00:15:57,829
groups of compounds and maybe I don't