
AbSciCon
2019

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

2
00:00:11,450 --> 00:00:09,070
[Applause]

3
00:00:12,440 --> 00:00:11,460
this ain't a thank you everybody for

4
00:00:14,480 --> 00:00:12,450
being here today

5
00:00:17,000 --> 00:00:14,490
I thought the title would be better if I

6
00:00:18,200 --> 00:00:17,010
wrote this way what I'm going to talk

7
00:00:22,280 --> 00:00:18,210
about today what I would like to

8
00:00:24,109 --> 00:00:22,290
compress my 15 minutes is the results of

9
00:00:26,510 --> 00:00:24,119
some ideas that we've been developing

10
00:00:28,880 --> 00:00:26,520
trying to understand why we have life in

11
00:00:31,460 --> 00:00:28,890
the universe and all and in particular

12
00:00:35,000 --> 00:00:31,470
in the earth and what we attack we've

13
00:00:36,920 --> 00:00:35,010

taken is trying to actually mimic what

14
00:00:39,740 --> 00:00:36,930
we see in life some of the features that

15
00:00:42,799 --> 00:00:39,750
we see in life maybe mimic them without

16
00:00:45,649 --> 00:00:42,809
actually looking without actually using

17
00:00:50,060 --> 00:00:45,659
biochemistry so I see that I have that

18
00:00:52,100 --> 00:00:50,070
there I can so let's look at the

19
00:00:53,840 --> 00:00:52,110
enormous complexity that we do see in

20
00:00:56,390 --> 00:00:53,850
life this is a humbling experience for

21
00:00:58,520 --> 00:00:56,400
anybody who looks at it but we can get

22
00:01:00,979 --> 00:00:58,530
out of it a few lessons one of them is

23
00:01:04,009 --> 00:01:00,989
that of course all life is based on and

24
00:01:06,500 --> 00:01:04,019
is and uses standard physical chemical

25
00:01:08,060 --> 00:01:06,510
processes but when we look at the

26
00:01:11,570 --> 00:01:08,070
previous transparency we see that there

27
00:01:14,959 --> 00:01:11,580
is a huge a jumping complexity from in

28
00:01:17,240 --> 00:01:14,969
in life itself but even more since life

29
00:01:19,550 --> 00:01:17,250
is based on chemistry there is a huge

30
00:01:21,200 --> 00:01:19,560
jump from regular chemistry or inorganic

31
00:01:24,289 --> 00:01:21,210
chemistry for example to biochemistry

32
00:01:26,120 --> 00:01:24,299
and even on to life so we asked

33
00:01:27,980 --> 00:01:26,130
ourselves the question a few years ago

34
00:01:30,499 --> 00:01:27,990
we asked ourself the question could we

35
00:01:32,419 --> 00:01:30,509
build chemical functional complexity in

36
00:01:34,459 --> 00:01:32,429
the laboratory from simple chemical

37
00:01:38,660 --> 00:01:34,469
systems who are from simple chemical

38
00:01:40,940 --> 00:01:38,670

parts and we decided my training is that

39
00:01:43,099 --> 00:01:40,950
of a physicist and the thinking that

40
00:01:45,410 --> 00:01:43,109
underlies a lot of what I do is it's got

41
00:01:47,359 --> 00:01:45,420
to do with that training and I am not

42
00:01:51,739 --> 00:01:47,369
apologizing but I'm saying I'm not a

43
00:01:53,809 --> 00:01:51,749
chemist then a the track the track that

44
00:01:58,069 --> 00:01:53,819
we decided to take would be attack where

45
00:02:00,889 --> 00:01:58,079
we actually go from the top down or from

46
00:02:04,399 --> 00:02:00,899
outside in there is a confusion on the

47
00:02:06,739 --> 00:02:04,409
use of those terms so and first try to

48
00:02:10,999 --> 00:02:06,749
see what the metric would be that we

49
00:02:12,530 --> 00:02:11,009
would understand for life so a chemical

50
00:02:15,110 --> 00:02:12,540
system which is capable of handling

51
00:02:17,000 --> 00:02:15,120
information which is kept capable of

52
00:02:19,850 --> 00:02:17,010
metabolizing that is to say in this

53
00:02:22,670 --> 00:02:19,860
context making its own parts and it's

54
00:02:25,370 --> 00:02:22,680
capable of executing programming program

55
00:02:27,340 --> 00:02:25,380
self-replication and evolving we would

56
00:02:30,020 --> 00:02:27,350
call that if it is based in chemistry

57
00:02:32,150 --> 00:02:30,030
something like a mimic of life if it is

58
00:02:34,820 --> 00:02:32,160
not basing biochemistry as we know it

59
00:02:37,190 --> 00:02:34,830
here so we went ahead and we studied a

60
00:02:38,870 --> 00:02:37,200
asking ourselves a question which is the

61
00:02:42,650 --> 00:02:38,880
typical question a physicist would ask

62
00:02:45,050 --> 00:02:42,660
is how do we represent those four

63
00:02:47,840 --> 00:02:45,060

properties and how we would represent

64
00:02:50,180 --> 00:02:47,850
them with equations this is a attack

65
00:02:52,850 --> 00:02:50,190
which is often used in hospitals

66
00:02:56,840 --> 00:02:52,860
throughout history in in physics

67
00:02:58,730 --> 00:02:56,850
Maxwell's equations a many other type of

68
00:03:00,650 --> 00:02:58,740
considerations having to do with the

69
00:03:02,270 --> 00:03:00,660
description of gravitation of phenomena

70
00:03:04,310 --> 00:03:02,280
or elementary particles and so on and so

71
00:03:06,790 --> 00:03:04,320
forth so we are worth trying to actually

72
00:03:09,230 --> 00:03:06,800
write down some sets of equations

73
00:03:11,900 --> 00:03:09,240
preferably simple equations with simple

74
00:03:13,580 --> 00:03:11,910
hypothesis minimum in all senses that

75
00:03:16,130 --> 00:03:13,590
are actually that would actually be able

76
00:03:17,600 --> 00:03:16,140
to represent those properties those

77
00:03:23,870 --> 00:03:17,610
properties can be associated with a

78
00:03:26,540 --> 00:03:23,880
number of each of behaviors that can be

79
00:03:30,410 --> 00:03:26,550
encapsulated in terms of a couple of a

80
00:03:32,900 --> 00:03:30,420
couple of two metal functions one for

81
00:03:34,580 --> 00:03:32,910
example in which we call V which would

82
00:03:37,910 --> 00:03:34,590
represent the living cell is this would

83
00:03:39,860 --> 00:03:37,920
be the simplest a conception and then

84
00:03:42,350 --> 00:03:39,870
another another variable which we would

85
00:03:45,080 --> 00:03:42,360
represent us the food u in this case if

86
00:03:47,600 --> 00:03:45,090
that was the case I mean U and V would

87
00:03:50,020 --> 00:03:47,610
have to represent the properties that we

88
00:03:52,520 --> 00:03:50,030

just mentioned those four properties

89
00:03:54,500 --> 00:03:52,530
then when we need to have them interact

90
00:03:56,870 --> 00:03:54,510
in different ways we would have in order

91
00:03:59,030 --> 00:03:56,880
for them to handle information they

92
00:04:01,130 --> 00:03:59,040
would have to interact linearly and

93
00:04:03,620 --> 00:04:01,140
quadratically in order for them to do a

94
00:04:05,720 --> 00:04:03,630
metabolism they would have to be a

95
00:04:08,210 --> 00:04:05,730
quadratically interacting as you see

96
00:04:10,009 --> 00:04:08,220
there in the in their kinetics in order

97
00:04:12,110 --> 00:04:10,019
to have self replication or generating

98
00:04:13,880 --> 00:04:12,120
which is in some sense equivalent to

99
00:04:16,130 --> 00:04:13,890
generate internal patterns they would

100
00:04:17,960 --> 00:04:16,140
have to be cubic in the ways you see

101
00:04:20,420 --> 00:04:17,970
there for example and in order to have

102
00:04:23,540 --> 00:04:20,430
evolution as for example pointed out by

103
00:04:25,159 --> 00:04:23,550
Viggo and eigen and you would need to

104
00:04:26,990 --> 00:04:25,169
have two feedback books in order to have

105
00:04:28,589 --> 00:04:27,000
adaptive behavior in a random

106
00:04:32,909 --> 00:04:28,599
environment so we're gonna head

107
00:04:34,529 --> 00:04:32,919
and back in 2003 we wrote a set of

108
00:04:35,969 --> 00:04:34,539
equations so let me see if I can make

109
00:04:38,010 --> 00:04:35,979
this thing work I don't know if I will

110
00:04:41,779 --> 00:04:38,020
be able to but it would be what I'm

111
00:04:46,529 --> 00:04:41,789
trying to do is to nope bummer

112
00:04:48,570 --> 00:04:46,539
how do I get the movie going there is a

113
00:04:52,709 --> 00:04:48,580

movement here do you have it in a

114
00:04:54,749 --> 00:04:52,719
computer somewhere click on it where

115
00:04:58,739 --> 00:04:54,759
there it goes he's got it now thank you

116
00:05:01,290 --> 00:04:58,749
oh yeah thank you there are a few more

117
00:05:02,760 --> 00:05:01,300
movies coming so this is to put the

118
00:05:04,199 --> 00:05:02,770
solutions to those equations in

119
00:05:06,600 --> 00:05:04,209
particular with a particular set of

120
00:05:10,199 --> 00:05:06,610
parameters do and you can see that there

121
00:05:15,629 --> 00:05:10,209
is the create the generation of a series

122
00:05:19,260 --> 00:05:15,639
of a generation of it can you click

123
00:05:21,540 --> 00:05:19,270
again if you don't mind a general out of

124
00:05:23,309 --> 00:05:21,550
the food that general you begin to

125
00:05:26,459 --> 00:05:23,319
generate systems which actually

126
00:05:28,169 --> 00:05:26,469
replicate sometimes they die and for

127
00:05:29,969 --> 00:05:28,179
this particular set of parameters there

128
00:05:31,799 --> 00:05:29,979
is noise in the system for this

129
00:05:36,029 --> 00:05:31,809
particular set of parameters then there

130
00:05:37,829 --> 00:05:36,039
is a but a noise value or a property of

131
00:05:39,659 --> 00:05:37,839
the noise which actually generates an

132
00:05:42,299 --> 00:05:39,669
optimum number of spots which actually

133
00:05:45,029 --> 00:05:42,309
are in homeostatic equilibrium with the

134
00:05:47,779 --> 00:05:45,039
environment in which they are so we said

135
00:05:51,119 --> 00:05:47,789
hmm this is interesting how do we

136
00:05:53,040 --> 00:05:51,129
actually general what how do we

137
00:05:56,790 --> 00:05:53,050
generalize those equations to also

138
00:05:59,489 --> 00:05:56,800

include something like waste so we added

139
00:06:03,449 --> 00:05:59,499
a waste and from two equations we went

140
00:06:05,579 --> 00:06:03,459
to three and then we began to in a can

141
00:06:09,629 --> 00:06:05,589
you click on this movie also sorry to

142
00:06:13,199 --> 00:06:09,639
keep you busy and there is no change in

143
00:06:14,879 --> 00:06:13,209
the general behavior so we then said can

144
00:06:16,049 --> 00:06:14,889
we click again so that we stopped it

145
00:06:19,439 --> 00:06:16,059
thank you

146
00:06:21,869 --> 00:06:19,449
then we said what can we do with this if

147
00:06:23,850 --> 00:06:21,879
can we use chemistry some sort some

148
00:06:26,459 --> 00:06:23,860
chemistry to actually somehow generate

149
00:06:28,439 --> 00:06:26,469
this type of behaviors that is to say

150
00:06:31,589 --> 00:06:28,449
how do we interpret those equations we

151
00:06:34,319 --> 00:06:31,599
just wrote down so we went ahead with

152
00:06:35,399 --> 00:06:34,329
that and going fast by the way if

153
00:06:37,529 --> 00:06:35,409
anybody wants to have this

154
00:06:39,540 --> 00:06:37,539
transparencies just send me an email and

155
00:06:41,080 --> 00:06:39,550
I'll be happy to send it to you in the

156
00:06:43,210 --> 00:06:41,090
movies or whatever you want

157
00:06:45,310 --> 00:06:43,220
so then we took a cue this is just to

158
00:06:48,700 --> 00:06:45,320
break a little bit the the Train of the

159
00:06:50,860 --> 00:06:48,710
of the talk a cue from another for from

160
00:06:52,240 --> 00:06:50,870
a Spaniard who said that everything you

161
00:06:54,220 --> 00:06:52,250
can imagine is real I don't know how

162
00:06:55,750 --> 00:06:54,230
many bottles of wine he drank but when

163
00:06:58,450 --> 00:06:55,760

he said that but I would say with the

164
00:07:01,510 --> 00:06:58,460
help of the Civic method and that then I

165
00:07:03,129 --> 00:07:01,520
would even almost agree with him and of

166
00:07:04,659 --> 00:07:03,139
course you can imagine you can write a

167
00:07:06,159 --> 00:07:04,669
questions you can imagine many things

168
00:07:08,710 --> 00:07:06,169
but for example even if you have mass

169
00:07:10,780 --> 00:07:08,720
Wells equations they do not contain the

170
00:07:13,240 --> 00:07:10,790
radio or the microwave oven you have to

171
00:07:15,129 --> 00:07:13,250
do much more than just equations so in

172
00:07:18,310 --> 00:07:15,139
this quest to try and represent this

173
00:07:20,469 --> 00:07:18,320
system with a non chemistry we

174
00:07:22,150 --> 00:07:20,479
discovered that our equations are very

175
00:07:25,060 --> 00:07:22,160
similar to the brew so later the oregano

176
00:07:26,379 --> 00:07:25,070
boost later or regular model of the sila

177
00:07:28,330 --> 00:07:26,389
Tory builds of several things clear

178
00:07:30,490 --> 00:07:28,340
reaction and we say ah so that's what we

179
00:07:32,830 --> 00:07:30,500
need to study the first thing that we

180
00:07:35,140 --> 00:07:32,840
would need to study is to see if you

181
00:07:36,969 --> 00:07:35,150
could actually handle information using

182
00:07:39,159 --> 00:07:36,979
the values of salt in scale reaction and

183
00:07:41,469 --> 00:07:39,169
the answer is yes I'm going to use two

184
00:07:44,920 --> 00:07:41,479
transparencies very quickly and the less

185
00:07:49,150 --> 00:07:44,930
the less a idea is to show you very

186
00:07:50,740 --> 00:07:49,160
quickly how a chemical to new machine

187
00:07:51,250 --> 00:07:50,750
would look like you would have a reactor

188
00:07:56,909 --> 00:07:51,260

like this

189
00:08:04,659 --> 00:08:00,130
sorry so you would have a reactor like

190
00:08:08,820 --> 00:08:04,669
this here can you start it again at the

191
00:08:14,290 --> 00:08:08,830
bottom and you would AK you would add

192
00:08:16,629 --> 00:08:14,300
letters just ask you a CT or G and then

193
00:08:19,750 --> 00:08:16,639
the letters will change the state of the

194
00:08:22,290 --> 00:08:19,760
reaction you saw a pipette and then the

195
00:08:24,820 --> 00:08:22,300
reaction is a nonlinear reaction and

196
00:08:27,040 --> 00:08:24,830
when you add another type another

197
00:08:30,940 --> 00:08:27,050
reactant in this case B which is malonic

198
00:08:35,589 --> 00:08:30,950
acid to a reaction with a the vessel

199
00:08:37,029 --> 00:08:35,599
already contained a bromate and then you

200
00:08:38,500 --> 00:08:37,039
see you begin to see how there are

201
00:08:40,240 --> 00:08:38,510
oscillations this is typical of

202
00:08:42,070 --> 00:08:40,250
nonlinear chemistry relaxation

203
00:08:43,990 --> 00:08:42,080
oscillations the amplitude changes as

204
00:08:46,630 --> 00:08:44,000
you change this the amplitude changes

205
00:08:48,730 --> 00:08:46,640
etc and then what you end up finding is

206
00:08:50,560 --> 00:08:48,740
that depending on the order of the

207
00:08:53,020 --> 00:08:50,570
letters and the amount of the letters

208
00:08:54,120 --> 00:08:53,030
that you put you do get an acceptance or

209
00:08:56,190 --> 00:08:54,130
rejection of

210
00:08:58,680 --> 00:08:56,200
sequence that is precisely where the

211
00:09:02,160 --> 00:08:58,690
Turing machine Dasom if your machine is

212
00:09:03,990 --> 00:09:02,170
capable of recognizing a sequence in a

213
00:09:06,750 --> 00:09:04,000

particular language and the language the

214
00:09:08,310 --> 00:09:06,760
complexity of the language is such that

215
00:09:09,690 --> 00:09:08,320
it has to belong to a certain class in

216
00:09:11,430 --> 00:09:09,700
that case you say you have a Turing

217
00:09:12,870 --> 00:09:11,440
machine the machine of course that

218
00:09:15,570 --> 00:09:12,880
theoretical Turing machine has an

219
00:09:18,480 --> 00:09:15,580
infinite tape that's not possible to

220
00:09:20,640 --> 00:09:18,490
make but a real physical tuned machine

221
00:09:22,590 --> 00:09:20,650
like this you can build so with this the

222
00:09:25,110 --> 00:09:22,600
lesson a we take from this is that you

223
00:09:26,520 --> 00:09:25,120
can actually use chemistry a to a

224
00:09:29,580 --> 00:09:26,530
process information in the form of

225
00:09:31,320 --> 00:09:29,590
nonlinear chemistry so then we and we

226
00:09:33,240 --> 00:09:31,330
put together because to process

227
00:09:35,610 --> 00:09:33,250
information you would need to have some

228
00:09:37,680 --> 00:09:35,620
a free energy gradient in such a way

229
00:09:39,450 --> 00:09:37,690
that the entropy in the system and the

230
00:09:41,220 --> 00:09:39,460
and the information can be exchanged and

231
00:09:43,140 --> 00:09:41,230
for that you you would need to have a

232
00:09:46,710 --> 00:09:43,150
gradient of free energy I just said can

233
00:09:48,120 --> 00:09:46,720
you make a membrane that from a system

234
00:09:51,050 --> 00:09:48,130
where there were no memories can you

235
00:09:54,020 --> 00:09:51,060
make a membrane and have the system self

236
00:09:57,690 --> 00:09:54,030
encapsulated itself and we did that we

237
00:10:00,030 --> 00:09:57,700
learned about it a field which is

238
00:10:01,920 --> 00:10:00,040

copolymerization use service Emily

239
00:10:03,680 --> 00:10:01,930
techniques which cost per unit session

240
00:10:07,380 --> 00:10:03,690
your service and Bullock where you start

241
00:10:10,290 --> 00:10:07,390
with a hydrophilic polymer with a small

242
00:10:13,160 --> 00:10:10,300
molecule attached here and then in under

243
00:10:16,140 --> 00:10:13,170
certain conditions and certain a a

244
00:10:18,360 --> 00:10:16,150
catalyst including ruthenium which is

245
00:10:20,610 --> 00:10:18,370
also the catalyst for the BC reaction

246
00:10:23,610 --> 00:10:20,620
you can actually begin to add monomers

247
00:10:27,660 --> 00:10:23,620
and again you can make a you can start

248
00:10:30,870 --> 00:10:27,670
with a hydrophilic block and add a

249
00:10:32,970 --> 00:10:30,880
hydrophobic block and then a what

250
00:10:35,970 --> 00:10:32,980
happens is that as the hydrophobic block

251
00:10:39,960 --> 00:10:35,980
changes the structures that are stable

252
00:10:42,510 --> 00:10:39,970
or metastable a ground states change

253
00:10:44,780 --> 00:10:42,520
from his fears to so-called worms to

254
00:10:49,260 --> 00:10:44,790
vesicles so we did that we done that and

255
00:10:51,390 --> 00:10:49,270
then we added a little bit of a photo

256
00:10:54,000 --> 00:10:51,400
chemistry to it and we discovered that

257
00:10:55,950 --> 00:10:54,010
you could have in a small cuvette you

258
00:10:58,980 --> 00:10:55,960
could have this mixture of chemicals

259
00:11:01,530 --> 00:10:58,990
process them for a few hours and you

260
00:11:04,110 --> 00:11:01,540
start a until you begin the reaction

261
00:11:06,240 --> 00:11:04,120
begins to occur at the beginning the

262
00:11:07,500 --> 00:11:06,250
liquid looks transparent after three or

263
00:11:09,750 --> 00:11:07,510

four hours the liquid

264
00:11:12,780 --> 00:11:09,760
a little it's less transparent after six

265
00:11:14,700 --> 00:11:12,790
hours the liquid begins to show phase

266
00:11:18,120 --> 00:11:14,710
separation and then you begin when you

267
00:11:19,440 --> 00:11:18,130
put this in a slide in a microscope then

268
00:11:22,130 --> 00:11:19,450
you begin to see the formation of

269
00:11:26,220 --> 00:11:22,140
vesicles and it's much more than that

270
00:11:29,910 --> 00:11:26,230
the vesicles can you a fiction that that

271
00:11:32,610 --> 00:11:29,920
movie the vesicles you see the sky which

272
00:11:36,330 --> 00:11:32,620
is coming from the northwest he's

273
00:11:38,490 --> 00:11:36,340
growing the reaction is making him then

274
00:11:43,170 --> 00:11:38,500
he will collapse when he gets to the

275
00:11:44,970 --> 00:11:43,180
center and then he starts again so you

276
00:11:47,490 --> 00:11:44,980
have cycles of this kind now we do this

277
00:11:50,190 --> 00:11:47,500
in a CSTR and we're able to we have

278
00:11:53,790 --> 00:11:50,200
being able to make something like 70 70

279
00:11:57,060 --> 00:11:53,800
cycles so we in this case we said okay

280
00:11:58,950 --> 00:11:57,070
so we studied a that what's going on we

281
00:12:00,210 --> 00:11:58,960
found out at first we found out and this

282
00:12:03,420 --> 00:12:00,220
is what I'm showing you today this is

283
00:12:06,930 --> 00:12:03,430
couple of years old it we found out that

284
00:12:09,120 --> 00:12:06,940
this transition from a droplet my cell

285
00:12:10,620 --> 00:12:09,130
dominated to vesicle dominated and today

286
00:12:13,230 --> 00:12:10,630
we do know that this transition is not

287
00:12:15,030 --> 00:12:13,240
as sharp as this but sigmoid and it

288
00:12:19,170 --> 00:12:15,040

follows everything the simple relation

289
00:12:21,090 --> 00:12:19,180
law and we also have have seen that this

290
00:12:22,380 --> 00:12:21,100
system becomes it likes to be where

291
00:12:24,060 --> 00:12:22,390
there is light so there is some

292
00:12:28,950 --> 00:12:24,070
principle of selection based on

293
00:12:31,380 --> 00:12:28,960
phototaxis and we understand then you

294
00:12:33,630 --> 00:12:31,390
start this again we understand a lot of

295
00:12:36,300 --> 00:12:33,640
this a lot about this system and what

296
00:12:37,710 --> 00:12:36,310
we've done is gone from this very simple

297
00:12:40,410 --> 00:12:37,720
system that you see here what you see

298
00:12:42,780 --> 00:12:40,420
when this guy's a implode

299
00:12:45,600 --> 00:12:42,790
we call this Phoenix because they grow

300
00:12:48,240 --> 00:12:45,610
they die and then they rise again from

301
00:12:49,920 --> 00:12:48,250
their own ashes so to speak so you see

302
00:12:51,540 --> 00:12:49,930
that there is self-replication the

303
00:12:54,090 --> 00:12:51,550
system actually self replicates we have

304
00:12:55,710 --> 00:12:54,100
studied this in lots of detail and we do

305
00:12:57,480 --> 00:12:55,720
know that the system is actually

306
00:13:00,270 --> 00:12:57,490
self-replicating because there are some

307
00:13:01,620 --> 00:13:00,280
spores or some material not really

308
00:13:03,750 --> 00:13:01,630
spores but some molecules that are

309
00:13:08,250 --> 00:13:03,760
released and then the PCR reaction

310
00:13:12,150 --> 00:13:08,260
starts again so we have a motivate we

311
00:13:15,120 --> 00:13:12,160
have done the same thing with a but

312
00:13:18,240 --> 00:13:15,130
powered by the values of solute in scale

313
00:13:20,070 --> 00:13:18,250

reaction we can and we when we put the

314
00:13:21,160 --> 00:13:20,080
values of solute insuk reaction you have

315
00:13:23,470 --> 00:13:21,170
also and

316
00:13:25,509 --> 00:13:23,480
type of a behavior in the vesicles which

317
00:13:27,759 --> 00:13:25,519
are formed by Pisa which is that the

318
00:13:30,519 --> 00:13:27,769
vesicles divide so we have come up with

319
00:13:32,800 --> 00:13:30,529
a way of mimicking some of the basic

320
00:13:34,150 --> 00:13:32,810
features of linear systems and we are

321
00:13:36,519 --> 00:13:34,160
now finding out that you could start

322
00:13:39,189 --> 00:13:36,529
with a mix where the system begins to

323
00:13:42,540 --> 00:13:39,199
operate under its own control it

324
00:13:45,699 --> 00:13:42,550
self-assembles and then eventually a

325
00:13:48,910 --> 00:13:45,709
this of course is not like a Latorre

326
00:13:50,860 --> 00:13:48,920
chemical reaction this is taken from a

327
00:13:53,110 --> 00:13:50,870
pulse in the heart but anyway it

328
00:13:54,759 --> 00:13:53,120
represents oscillations if you have

329
00:13:57,250 --> 00:13:54,769
oscillatory chemistry inside which can

330
00:13:59,500 --> 00:13:57,260
actually do a complex computations you

331
00:14:01,540 --> 00:13:59,510
have at least two routes for server

332
00:14:05,620 --> 00:14:01,550
application this mitotic and this other

333
00:14:07,840 --> 00:14:05,630
in terms of Phoenix style things and of

334
00:14:09,579 --> 00:14:07,850
course we don't think that anything like

335
00:14:12,129 --> 00:14:09,589
that happened in the origin of life on

336
00:14:17,590 --> 00:14:12,139
earth but it to me as a physicist I am

337
00:14:20,980 --> 00:14:17,600
aware thank you to me as a physicist it

338
00:14:23,079 --> 00:14:20,990

gives me pleasure to see that or it adds

339
00:14:24,750 --> 00:14:23,089
it gives me understanding to see that

340
00:14:28,480 --> 00:14:24,760
something like this may have happened

341
00:14:31,900 --> 00:14:28,490
before life evolved into 40 days so here

342
00:14:33,670 --> 00:14:31,910
are some conclusions that I am offering

343
00:14:35,410 --> 00:14:33,680
to you what this is service is summing

344
00:14:38,079 --> 00:14:35,420
up - this one is a summary of what I've

345
00:14:41,290 --> 00:14:38,089
said so far but I would also like to say

346
00:14:42,759 --> 00:14:41,300
that we have now two a varieties one

347
00:14:44,889 --> 00:14:42,769
with ruthenium another one with the

348
00:14:47,199 --> 00:14:44,899
iridium in the laboratory you put them

349
00:14:50,139 --> 00:14:47,209
to compete in the same beaker and guess

350
00:14:54,970 --> 00:14:50,149
what if the light benefits one of them

351
00:14:59,620 --> 00:14:54,980
say ruthenium the ruthenium eats the

352
00:15:01,600 --> 00:14:59,630
ones which are iridium and vice versa so

353
00:15:03,220 --> 00:15:01,610
we are very excited and of course I'm

354
00:15:06,400 --> 00:15:03,230
gonna end with a joke and a little bit

355
00:15:07,750 --> 00:15:06,410
of a scared thank you very much for your

356
00:15:08,890 --> 00:15:07,760
attention and I hope you enjoyed the

357
00:15:10,530 --> 00:15:08,900
talk thank you

358
00:15:11,330 --> 00:15:10,540
[Applause]