Exo-Evo? An Organismal Approach to Evolutionary Dynamics

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1
00:00:00,820 --> 00:00:09,430
[Music]

2
00:00:17,090 --> 00:00:13,430
hello so after all these great talks

3
00:00:21,410 --> 00:00:17,100
about the chemistry of life or the

4
00:00:23,689 --> 00:00:21,420
chemistry before life I'm not I feel

5
00:00:24,320 --> 00:00:23,699
kind of out of fit like a fish out of

6
00:00:25,939 --> 00:00:24,330
the water

7
00:00:29,089 --> 00:00:25,949
because I'm gonna talk about

8
00:00:31,970 --> 00:00:29,099
evolutionary dynamics from an organismal

9
00:00:35,620 --> 00:00:31,980
approach and what an organismal approach

10
00:00:38,869 --> 00:00:35,630
is is kind of the main point of my talk

11
00:00:42,770 --> 00:00:38,879
and the reason is that we understand a

12
00:00:46,430 --> 00:00:42,780
lot of the material basis of life what

13
00:00:49,670 --> 00:00:46,440

we even look for biosignatures as the

14
00:00:52,250 --> 00:00:49,680
detection of oxygen or methane or many

15
00:00:55,340 --> 00:00:52,260
other molecules but then these all these

16
00:00:59,590 --> 00:00:55,350
ingredients of life should be arranged

17
00:01:03,830 --> 00:00:59,600
in a specific manner in order to have

18
00:01:07,190 --> 00:01:03,840
life in a system point of view and we

19
00:01:10,340 --> 00:01:07,200
don't have a theory for that but it is

20
00:01:13,100 --> 00:01:10,350
important because when we study life or

21
00:01:16,399 --> 00:01:13,110
evolution we are referring to organisms

22
00:01:19,730 --> 00:01:16,409
we're referring to specific entities and

23
00:01:22,240 --> 00:01:19,740
this is quite nicely related to what

24
00:01:26,179 --> 00:01:22,250
happened in math with Corey Vidal

25
00:01:28,880 --> 00:01:26,189
who basically solve the debate with a

26
00:01:30,679 --> 00:01:28,890
table over by saying that we cannot

27
00:01:33,800 --> 00:01:30,689
forget that number theory is about

28
00:01:36,100 --> 00:01:33,810
numbers and then in biology more or less

29
00:01:40,429 --> 00:01:36,110
we have the same equivalence with

30
00:01:43,249 --> 00:01:40,439
Nicolas reshef ski and Rosen who said

31
00:01:45,950 --> 00:01:43,259
biology is about organisms so the

32
00:01:49,429 --> 00:01:45,960
problem was that back then and we still

33
00:01:52,910 --> 00:01:49,439
I don't know what an organism is but we

34
00:01:55,940 --> 00:01:52,920
practice biology a counting organisms

35
00:01:59,690 --> 00:01:55,950
counting genes in organisms in cells in

36
00:02:02,030 --> 00:01:59,700
bacterium exist like we do in Orla but

37
00:02:06,319 --> 00:02:02,040
we don't yet know what is an organism

38
00:02:09,169 --> 00:02:06,329

and if we go somewhere outside in

39
00:02:12,080 --> 00:02:09,179
including earth and try to to describe

40
00:02:13,460 --> 00:02:12,090
life or living systems we're faced with

41
00:02:16,310 --> 00:02:13,470
a lot of problems

42
00:02:19,700 --> 00:02:16,320
and we need a set of tools that we still

43
00:02:21,680 --> 00:02:19,710
lack or are very primitive irreversible

44
00:02:23,510 --> 00:02:21,690
thermodynamics information theories of

45
00:02:25,990 --> 00:02:23,520
organization american emergence

46
00:02:29,750 --> 00:02:26,000
historical contingency what is a novelty

47
00:02:32,960 --> 00:02:29,760
non-ironic systems autonomy what is a

48
00:02:36,350 --> 00:02:32,970
function and then a theory of organisms

49
00:02:39,530 --> 00:02:36,360
that we don't have and that's a point of

50
00:02:41,780 --> 00:02:39,540
the talk this is more or less what

51
00:02:44,510 --> 00:02:41,790
Schrodinger was thinking when he said we

52
00:02:50,720 --> 00:02:44,520
need new physics but we still don't have

53
00:02:53,360 --> 00:02:50,730
it as a generally accepted theory so if

54
00:02:55,460 --> 00:02:53,370
we go and search for life we might find

55
00:02:57,800 --> 00:02:55,470
three cases three general cases I would

56
00:03:00,140 --> 00:02:57,810
say there was a final with no life

57
00:03:03,440 --> 00:03:00,150
there's a planet with life and there's a

58
00:03:05,420 --> 00:03:03,450
planet with post life I'll call it so

59
00:03:08,300 --> 00:03:05,430
then a problem is the origins how did

60
00:03:09,980 --> 00:03:08,310
emerge then extinction that we're not as

61
00:03:12,500 --> 00:03:09,990
interested but it might be a fundamental

62
00:03:16,280 --> 00:03:12,510
process as well and certainly is

63
00:03:18,949 --> 00:03:16,290

happening in earth at some level but if

64
00:03:21,650 --> 00:03:18,959
we do find life then our best approach

65
00:03:25,190 --> 00:03:21,660
to study life is evolution evolutionary

66
00:03:28,250 --> 00:03:25,200
dynamics and we all know that if we have

67
00:03:30,770 --> 00:03:28,260
this dictum in our brain and so nothing

68
00:03:33,320 --> 00:03:30,780
biology makes sense even it's not in the

69
00:03:35,870 --> 00:03:33,330
light of evolution but evolutionary

70
00:03:40,840 --> 00:03:35,880
theory itself has its own history and it

71
00:03:43,850 --> 00:03:40,850
is quite detailed but there some major

72
00:03:47,990 --> 00:03:43,860
advances in this theory that are exactly

73
00:03:50,270 --> 00:03:48,000
100 years old since Ronald Fisher who

74
00:03:53,270 --> 00:03:50,280
was the first who formally mathematize

75
00:03:57,500 --> 00:03:53,280
most of what we think of as population

76
00:03:59,840 --> 00:03:57,510
genetics so one of our main arguments is

77
00:04:02,620 --> 00:03:59,850
that all of these equations and

78
00:04:05,750 --> 00:04:02,630
everything is it is not that they're bad

79
00:04:09,560 --> 00:04:05,760
math or it is just that they're not

80
00:04:11,540 --> 00:04:09,570
referred to organisms yet so the theory

81
00:04:13,160 --> 00:04:11,550
of evolution is more or less like 100

82
00:04:16,580 --> 00:04:13,170
years of so it is not just because the

83
00:04:19,130 --> 00:04:16,590
100 is but because they're two people at

84
00:04:21,440 --> 00:04:19,140
the top who have so much effect in all

85
00:04:23,990 --> 00:04:21,450
of our community as as a group of

86
00:04:26,090 --> 00:04:24,000
scientists and this two people in

87
00:04:29,790 --> 00:04:26,100
science will be Newton and our

88
00:04:32,850 --> 00:04:29,800

so well this two people wanted to give

89
00:04:34,770 --> 00:04:32,860
us is scientific happiness because happy

90
00:04:37,890 --> 00:04:34,780
is who is able to know the causes of

91
00:04:40,830 --> 00:04:37,900
things and it is someone said this 2,000

92
00:04:43,409 --> 00:04:40,840
years ago so how do we know the causes

93
00:04:46,379 --> 00:04:43,419
of things where you have a system a

94
00:04:48,330 --> 00:04:46,389
natural system then you build a formal

95
00:04:51,210 --> 00:04:48,340
system that has some assumptions

96
00:04:53,969 --> 00:04:51,220
internal assumptions and then you decode

97
00:04:56,850 --> 00:04:53,979
back to the natural systems and they say

98
00:05:00,180 --> 00:04:56,860
ok my formal system is giving me

99
00:05:03,450 --> 00:05:00,190
predictions or useful knowledge about

100
00:05:05,940 --> 00:05:03,460
the natural system so the main framework

101
00:05:08,460 --> 00:05:05,950
currently is just that you have given

102
00:05:11,280 --> 00:05:08,470
some initial conditions and then you

103
00:05:13,020 --> 00:05:11,290
have some below and then you have

104
00:05:15,480 --> 00:05:13,030
boundary conditions and then that law

105
00:05:17,730 --> 00:05:15,490
will predict what's gonna happen and

106
00:05:21,719 --> 00:05:17,740
that's the contemporary view of physics

107
00:05:23,279 --> 00:05:21,729
in very general terms so if you know

108
00:05:25,050 --> 00:05:23,289
what's gonna happen here at this level

109
00:05:27,600 --> 00:05:25,060
out Adams then you know what's gonna

110
00:05:30,270 --> 00:05:27,610
happen in molecules and so on and so

111
00:05:33,930 --> 00:05:30,280
forth until you can explain a social

112
00:05:36,779 --> 00:05:33,940
cultural systems so that's a very gross

113
00:05:39,330 --> 00:05:36,789

simplification but it is a huge debate

114
00:05:42,510 --> 00:05:39,340
currently in physics and this is what is

115
00:05:44,790 --> 00:05:42,520
called awkward conversation you have

116
00:05:47,219 --> 00:05:44,800
subatomic particles that have some

117
00:05:49,560 --> 00:05:47,229
causal effects on atomic level and then

118
00:05:53,370 --> 00:05:49,570
if you see all of the arrows or pointing

119
00:05:55,800 --> 00:05:53,380
upwards but then very recently and it is

120
00:05:59,219 --> 00:05:55,810
not a couple of years busy base has been

121
00:06:02,490 --> 00:05:59,229
going for decades we have George Ellis

122
00:06:05,909 --> 00:06:02,500
that says construction can happen at at

123
00:06:08,400 --> 00:06:05,919
both directions of this tree and we have

124
00:06:14,100 --> 00:06:08,410
evidence of this and we have everything

125
00:06:17,150 --> 00:06:14,110
in biology about this they grow my great

126
00:06:21,420 --> 00:06:17,160
book called from matter to life this

127
00:06:22,740 --> 00:06:21,430
this problem so one example in this many

128
00:06:25,170 --> 00:06:22,750
examples but the one example is that

129
00:06:27,659 --> 00:06:25,180
structure dictates function in many

130
00:06:29,879 --> 00:06:27,669
biological systems and natural selection

131
00:06:32,820 --> 00:06:29,889
adds at this level and therefore it

132
00:06:36,690 --> 00:06:32,830
selects out some molecular components

133
00:06:39,060 --> 00:06:36,700
that are not as good or as fit and there

134
00:06:42,360 --> 00:06:39,070
are historical components in bio

135
00:06:44,880 --> 00:06:42,370
a historical contingency and there's so

136
00:06:47,010 --> 00:06:44,890
much evidence about this in experimental

137
00:06:50,310 --> 00:06:47,020
populations experimental evolution and

138
00:06:52,700 --> 00:06:50,320

that's why how old model which said that

139
00:06:56,130 --> 00:06:52,710
biology is between history and physics

140
00:06:58,020 --> 00:06:56,140
and that's why we cannot really

141
00:06:59,790 --> 00:06:58,030
understand very well so we are

142
00:07:02,490 --> 00:06:59,800
privileged but also we're in trouble

143
00:07:04,920 --> 00:07:02,500
because historical processes are very

144
00:07:09,150 --> 00:07:04,930
hard to just explain with entailing Laos

145
00:07:10,680 --> 00:07:09,160
and physics alone so biologists

146
00:07:13,080 --> 00:07:10,690
somewhere there in the middle this a

147
00:07:16,950 --> 00:07:13,090
figure modified but from Mora wits

148
00:07:18,620 --> 00:07:16,960
original paper and the only framework

149
00:07:21,380 --> 00:07:18,630
that we have to explain order or

150
00:07:23,940 --> 00:07:21,390
emergent properties one of the main

151
00:07:26,670 --> 00:07:23,950
frameworks is used statistical mechanics

152
00:07:29,370 --> 00:07:26,680
that reduces order to a single scalar

153
00:07:31,740 --> 00:07:29,380
value but we as biologists have the

154
00:07:33,660 --> 00:07:31,750
intuition that you cannot just reduce an

155
00:07:37,500 --> 00:07:33,670
organization at a higher level to a

156
00:07:39,780 --> 00:07:37,510
scalar value so and the constants of

157
00:07:42,840 --> 00:07:39,790
things can be explained basically in a

158
00:07:45,090 --> 00:07:42,850
simple framework that's thousands of

159
00:07:46,800 --> 00:07:45,100
years old if you have a material cause

160
00:07:48,510 --> 00:07:46,810
an efficient cause in the formal cost

161
00:07:50,450 --> 00:07:48,520
the material cost is just kind of the

162
00:07:52,620 --> 00:07:50,460
ingredients if you want to make a cake

163
00:07:54,270 --> 00:07:52,630

the efficient cause will be the process

164
00:07:55,920 --> 00:07:54,280
of transforming these ingredients and

165
00:07:59,070 --> 00:07:55,930
the cake will be a formal cause or the

166
00:08:01,620 --> 00:07:59,080
outcome of this process for example this

167
00:08:04,980 --> 00:08:01,630
is a simple example but in evolution we

168
00:08:07,470 --> 00:08:04,990
know that it be we can also frame the

169
00:08:10,980 --> 00:08:07,480
problem in these three causes by saying

170
00:08:12,990 --> 00:08:10,990
that the material cause is individuals

171
00:08:16,020 --> 00:08:13,000
in a population and diffusion costs are

172
00:08:18,150 --> 00:08:16,030
the actual changes of rates of survival

173
00:08:19,890 --> 00:08:18,160
differential fitness and then the

174
00:08:21,390 --> 00:08:19,900
optimum is a new generation of

175
00:08:21,750 --> 00:08:21,400
individuals then you can start over

176
00:08:25,110 --> 00:08:21,760
again

177
00:08:27,690 --> 00:08:25,120
and so forth so what's the evolution

178
00:08:30,570 --> 00:08:27,700
about that's again the question is about

179
00:08:34,230 --> 00:08:30,580
individuals but individuals are not just

180
00:08:36,840 --> 00:08:34,240
single particles or care scalars

181
00:08:40,469 --> 00:08:36,850
individuals are organisms and I guess

182
00:08:42,450 --> 00:08:40,479
that's a problem that we put a with the

183
00:08:46,410 --> 00:08:42,460
physicists are not to blame that the car

184
00:08:50,100 --> 00:08:46,420
is around it because we do make cause or

185
00:08:52,470 --> 00:08:50,110
on our own way we have these particles

186
00:08:54,300 --> 00:08:52,480
that are going to a bottleneck and they

187
00:08:56,430 --> 00:08:54,310
we can these particles as either genes

188
00:08:59,069 --> 00:08:56,440

phenotypic traits or any other

189
00:09:01,199 --> 00:08:59,079
particulate that we can identify and

190
00:09:03,180 --> 00:09:01,209
then from these particles that are

191
00:09:07,110 --> 00:09:03,190
abstracted from the organism we make

192
00:09:09,480 --> 00:09:07,120
predictions but we know that that's

193
00:09:12,569 --> 00:09:09,490
problematic because if the fitness of

194
00:09:15,180 --> 00:09:12,579
traded tokens is not independent of the

195
00:09:17,160 --> 00:09:15,190
organism where these tokens are so

196
00:09:19,350 --> 00:09:17,170
that's why many other people have been

197
00:09:21,720 --> 00:09:19,360
debating that is organism is Fitness

198
00:09:25,139 --> 00:09:21,730
what is important and not just the trait

199
00:09:27,449 --> 00:09:25,149
fitness and we know this if you have

200
00:09:29,670 --> 00:09:27,459
different mutations in different genetic

201
00:09:31,920 --> 00:09:29,680
backgrounds then the phenotype will be

202
00:09:35,550 --> 00:09:31,930
different not as the world type that is

203
00:09:36,930 --> 00:09:35,560
context dependent so the same happens

204
00:09:39,090 --> 00:09:36,940
with game theory and many other

205
00:09:40,860 --> 00:09:39,100
approaches in evolutionary biology that

206
00:09:42,480 --> 00:09:40,870
you have particles that are competing or

207
00:09:44,129 --> 00:09:42,490
doing something you have a payoff matrix

208
00:09:45,870 --> 00:09:44,139
and then you solve the equations and

209
00:09:50,100 --> 00:09:45,880
then you get the dynamics but you're

210
00:09:52,050 --> 00:09:50,110
again abstracting the organism and this

211
00:09:54,300 --> 00:09:52,060
is the practice the current practice we

212
00:09:57,629 --> 00:09:54,310
have these tokens and they interact some

213
00:10:00,900 --> 00:09:57,639

way then we get the dynamics so a

214
00:10:03,389 --> 00:10:00,910
proposal is just very simple and really

215
00:10:06,120 --> 00:10:03,399
not really revolutionary but it sounds

216
00:10:09,660 --> 00:10:06,130
strange for some people if we're not

217
00:10:12,180 --> 00:10:09,670
together this all the time is that we

218
00:10:15,139 --> 00:10:12,190
need to take in acted on the organisms

219
00:10:19,410 --> 00:10:15,149
and the environment is a simple proposal

220
00:10:22,500 --> 00:10:19,420
so our proposal is having a system Oh II

221
00:10:24,930 --> 00:10:22,510
all being the focal organism even the

222
00:10:26,939 --> 00:10:24,940
environmental field which is using all

223
00:10:30,870 --> 00:10:26,949
the things that are not organisms and

224
00:10:33,300 --> 00:10:30,880
the other organisms and do we need a

225
00:10:35,129 --> 00:10:33,310
concept for organisms I think we do and

226
00:10:38,009 --> 00:10:35,139
this is a great review about Matt Farah

227
00:10:39,439 --> 00:10:38,019
where he basically concludes that we do

228
00:10:42,389 --> 00:10:39,449
need

229
00:10:44,939 --> 00:10:42,399
organisms and then other papers have

230
00:10:46,860 --> 00:10:44,949
been trying to explain what an organism

231
00:10:49,379 --> 00:10:46,870
is including this that is not very

232
00:10:51,269 --> 00:10:49,389
sophisticated and physicists will

233
00:10:55,280 --> 00:10:51,279
criticize because the axes have no

234
00:10:57,750 --> 00:10:55,290
values all no but there are recent and

235
00:11:00,900 --> 00:10:57,760
also the environment is not considered

236
00:11:03,420 --> 00:11:00,910
as I mentioned even so we are trying to

237
00:11:06,000 --> 00:11:03,430
design minimum bacterial genomes but I

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00:11:07,530 --> 00:11:06,010

will ask this in this studies what is

239
00:11:09,780 --> 00:11:07,540
the environment so are you providing

240
00:11:11,940 --> 00:11:09,790
with everything that this bacteria needs

241
00:11:15,660 --> 00:11:11,950
is a minimum media blah blah blah was

242
00:11:17,670 --> 00:11:15,670
temperature so then the synthesis is

243
00:11:19,830 --> 00:11:17,680
very simple we have the organism we have

244
00:11:22,050 --> 00:11:19,840
the environment in their environment can

245
00:11:24,000 --> 00:11:22,060
be another other organisms but this

246
00:11:27,360 --> 00:11:24,010
still the question was what is an

247
00:11:30,690 --> 00:11:27,370
organism well there's this paper in 2015

248
00:11:33,360 --> 00:11:30,700
that is promising to be a very good

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00:11:36,360 --> 00:11:33,370
definition of organism and it's very

250
00:11:38,520 --> 00:11:36,370
simple you just take in your organism of

251
00:11:41,040 --> 00:11:38,530
preference all the constraints that are

252
00:11:43,530 --> 00:11:41,050
present for instance and enzyme is

253
00:11:46,650 --> 00:11:43,540
constraining a reaction and you can

254
00:11:48,750 --> 00:11:46,660
represent this in a formal way and then

255
00:11:51,330 --> 00:11:48,760
you can change different if different

256
00:11:54,210 --> 00:11:51,340
processes that have constraints on each

257
00:11:57,780 --> 00:11:54,220
other process but then you still have

258
00:12:00,510 --> 00:11:57,790
kind of loose ends so the the problem is

259
00:12:04,200 --> 00:12:00,520
then to close it and this happens

260
00:12:06,210 --> 00:12:04,210
spontaneously in many systems it's an

261
00:12:07,980 --> 00:12:06,220
emergent property that sometimes a

262
00:12:11,340 --> 00:12:07,990
constraint will close the system and

263
00:12:13,950 --> 00:12:11,350

then just to not draw all the rows and

264
00:12:16,290 --> 00:12:13,960
all of these symbols we can just

265
00:12:18,810 --> 00:12:16,300
represent this as a graph that is a

266
00:12:22,500 --> 00:12:18,820
closed graph you can reach any other

267
00:12:24,450 --> 00:12:22,510
node from n for any any node so then

268
00:12:26,340 --> 00:12:24,460
there are other organisms that are also

269
00:12:28,650 --> 00:12:26,350
interacting and even though this looks

270
00:12:31,320 --> 00:12:28,660
complicated is the same principle so

271
00:12:34,770 --> 00:12:31,330
organisms can have constraints in other

272
00:12:38,340 --> 00:12:34,780
organisms and what we're proposing also

273
00:12:40,440 --> 00:12:38,350
is that we need to map the Fitness we is

274
00:12:42,920 --> 00:12:40,450
not sufficient to just design the

275
00:12:48,420 --> 00:12:42,930
organism but to map the Fitness into

276
00:12:51,270 --> 00:12:48,430
functional by Darwinian individual so

277
00:12:55,020 --> 00:12:51,280
how do we do that is just we as we

278
00:12:56,790 --> 00:12:55,030
assign some parts some constraints just

279
00:12:59,460 --> 00:12:56,800
metabolic constraints some other

280
00:13:02,550 --> 00:12:59,470
constraints are involved in reproduction

281
00:13:04,140 --> 00:13:02,560
and the whole system is the organism if

282
00:13:06,870 --> 00:13:04,150
you don't have reproduction but you can

283
00:13:09,750 --> 00:13:06,880
you have organization then you are not

284
00:13:13,430 --> 00:13:09,760
Darwinian organism reproduction also has

285
00:13:15,960 --> 00:13:13,440
to be a heritable variation as we know

286
00:13:18,540 --> 00:13:15,970
and different organisms can cooperate

287
00:13:20,130 --> 00:13:18,550
and for new entities so that

288
00:13:24,750 --> 00:13:20,140

the entire system of these two organisms

289
00:13:26,970 --> 00:13:24,760
is what is closed and then what is the

290
00:13:29,100 --> 00:13:26,980
function here a function is just each of

291
00:13:32,250 --> 00:13:29,110
the constraints that participate in the

292
00:13:34,949 --> 00:13:32,260
system so now this is purely theoretical

293
00:13:37,380 --> 00:13:34,959
but we can model this because there are

294
00:13:40,199 --> 00:13:37,390
many frameworks that we can use from

295
00:13:42,810 --> 00:13:40,209
network theory and from individual based

296
00:13:45,030 --> 00:13:42,820
models and before we didn't have the

297
00:13:47,940 --> 00:13:45,040
concept of organisms but now we do now

298
00:13:51,750 --> 00:13:47,950
we have it so that's what we are going

299
00:13:54,960 --> 00:13:51,760
to show that are just preliminary

300
00:13:57,300 --> 00:13:54,970
results and what we are going to have is

301
00:13:59,639 --> 00:13:57,310
in the individual base model where the

302
00:14:03,180 --> 00:13:59,649
individual is an organism defined as a

303
00:14:06,030 --> 00:14:03,190
closure of constraints and we're going

304
00:14:08,370 --> 00:14:06,040
to call individual processes H processes

305
00:14:10,440 --> 00:14:08,380
you have an organism that interacts with

306
00:14:15,810 --> 00:14:10,450
the environment you have three or Step

307
00:14:18,500 --> 00:14:15,820
alien classes and after you have the

308
00:14:21,600 --> 00:14:18,510
outcome of this process you can have

309
00:14:23,819 --> 00:14:21,610
path and this path if you have a

310
00:14:25,949 --> 00:14:23,829
population that every individual has its

311
00:14:28,440 --> 00:14:25,959
own path and the entire population will

312
00:14:30,480 --> 00:14:28,450
have a path scape not olanski because we

313
00:14:31,680 --> 00:14:30,490

don't know the entire space we don't

314
00:14:36,329 --> 00:14:31,690
know what's going to happen we don't

315
00:14:38,730 --> 00:14:36,339
know what will happen so just this is a

316
00:14:41,790 --> 00:14:38,740
diagram to show the synthesis of the

317
00:14:44,480 --> 00:14:41,800
framework that we have the tools already

318
00:14:47,130 --> 00:14:44,490
well developed by many other people

319
00:14:49,710 --> 00:14:47,140
individual based models spatial models

320
00:14:53,069 --> 00:14:49,720
or Fitness mapping is something that we

321
00:14:54,960 --> 00:14:53,079
can also may put in the computer running

322
00:14:57,449 --> 00:14:54,970
the computer run populations in the

323
00:14:59,639 --> 00:14:57,459
computer and do again as I said

324
00:15:01,319 --> 00:14:59,649
individual based models but each

325
00:15:08,010 --> 00:15:01,329
individual now is an algorithm that

326
00:15:10,199 --> 00:15:08,020
interacts with the environment so that's

327
00:15:15,270 --> 00:15:10,209
it I'm just going to take thank all

328
00:15:20,560 --> 00:15:18,720
[Applause]

329
00:15:29,940 --> 00:15:20,570
take any questions

330
00:15:35,620 --> 00:15:33,430
momentum that biologists intent they

331
00:15:37,780 --> 00:15:35,630
would the mindset would be to rebel

332
00:15:41,590 --> 00:15:37,790
against the idea of trying to represent

333
00:15:44,530 --> 00:15:41,600
like a network of creatures as as a

334
00:15:46,450 --> 00:15:44,540
scalar quantity but in a way isn't that

335
00:15:48,820 --> 00:15:46,460
what the like representation of an

336
00:15:52,360 --> 00:15:48,830
organism is it's it's just a scalar

337
00:15:55,300 --> 00:15:52,370
quantity in the vast web of life is it

338
00:15:57,460 --> 00:15:55,310

work I mean you could possibly encode a

339
00:16:00,730 --> 00:15:57,470
network structure in the states of the

340
00:16:03,070 --> 00:16:00,740
of the network in a scalar value but

341
00:16:05,020 --> 00:16:03,080
that's not what we usually do in

342
00:16:06,790 --> 00:16:05,030
statistical mechanics you just have

343
00:16:10,120 --> 00:16:06,800
different arrangements of a system

344
00:16:11,530 --> 00:16:10,130
probably you can encode it but that's

345
00:16:12,820 --> 00:16:11,540
not the fundamental thing the

346
00:16:16,320 --> 00:16:12,830
fundamental thing is the description

347
00:16:19,090 --> 00:16:16,330
itself of the organism not being

348
00:16:21,510 --> 00:16:19,100
described as a particle but as the

349
00:16:24,040 --> 00:16:21,520
system because life is a system proper

350
00:16:25,930 --> 00:16:24,050
so you think that statistical modeling

351
00:16:28,240 --> 00:16:25,940
is like the sorry that's okay I

352
00:16:30,670 --> 00:16:28,250
apologize we do need to take this

353
00:16:31,990 --> 00:16:30,680
offline it can we thank our speaker