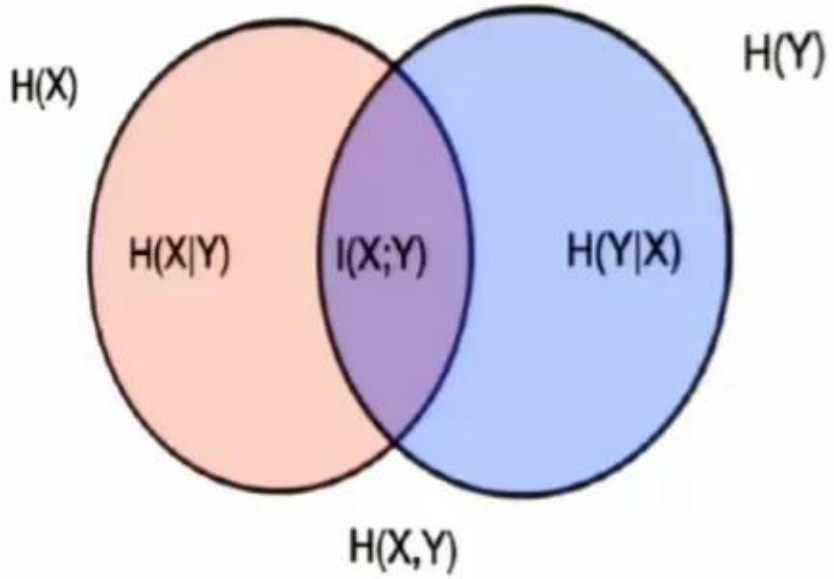
Information Theory Interlude



$$I(X;Y) = \sum_{y \in Y} \sum_{x \in X} p(x,y) \log \left(\frac{p(x,y)}{p(x)\,p(y)} \right)$$

1
00:00:11,020 --> 00:00:08,560
so if you haven't met me yet my name is

2
00:00:12,690 --> 00:00:11,030
Cole Mathis and this is a project that

3
00:00:17,380 --> 00:00:12,700
I've been working on for a couple years

4
00:00:22,179 --> 00:00:17,390
this is not ABS I con sorry that's

5
00:00:24,249 --> 00:00:22,189
reducing so yeah emergence of life is a

6
00:00:25,929 --> 00:00:24,259
first order phase transition so to

7
00:00:27,130 --> 00:00:25,939
preface this a little bit I give you

8
00:00:28,330 --> 00:00:27,140
guys a bit of an explanation what's

9
00:00:29,589 --> 00:00:28,340
going on here this is completely

10
00:00:32,830 --> 00:00:29,599
different than everything else I've seen

11
00:00:34,210 --> 00:00:32,840
here so in evolutionary biology and

12
00:00:35,830 --> 00:00:34,220
mathematical biology you see these

13
00:00:38,590 --> 00:00:35,840

replicator models every once in a while

14
00:00:41,050 --> 00:00:38,600
and these are a sort of abstraction to

15
00:00:43,210 --> 00:00:41,060
help understand biological evolution in

16
00:00:45,940 --> 00:00:43,220
terms of variation and selection and

17
00:00:48,070 --> 00:00:45,950
replication and so these models are

18
00:00:49,780 --> 00:00:48,080
really interesting but I'm more

19
00:00:52,900 --> 00:00:49,790
interested in how what we call chemical

20
00:00:54,880 --> 00:00:52,910
evolution eventually became a biological

21
00:00:57,640 --> 00:00:54,890
evolution and so for this particular

22
00:00:59,050 --> 00:00:57,650
project I focused in on one function

23
00:01:01,510 --> 00:00:59,060
that seems to be really important to

24
00:01:03,010 --> 00:01:01,520
biology and that's replication and if

25
00:01:06,370 --> 00:01:03,020
you think replication isn't necessary

26
00:01:07,810 --> 00:01:06,380
for biology or evolution I might agree

27
00:01:09,429 --> 00:01:07,820
with you depends on the day and I'd love

28
00:01:12,399 --> 00:01:09,439
to have that conversation so I'm find me

29
00:01:14,860 --> 00:01:12,409
after but what I became interested in is

30
00:01:17,530 --> 00:01:14,870
in normal replicator models they sort of

31
00:01:20,200 --> 00:01:17,540
have you know replicators exist as a

32
00:01:21,730 --> 00:01:20,210
given and so what I wanted to say is

33
00:01:24,010 --> 00:01:21,740
okay what if they just don't exist as a

34
00:01:26,080 --> 00:01:24,020
given they have to be made sort of from

35
00:01:29,469 --> 00:01:26,090
some underlying chemistry that

36
00:01:32,170 --> 00:01:29,479
ultimately constraints their ability to

37
00:01:33,969 --> 00:01:32,180
replicate and evolve so I'm going to

38
00:01:37,899 --> 00:01:33,979

describe a model and some results that I

39
00:01:39,969 --> 00:01:37,909
have so cool so the chemistry that I

40
00:01:42,160 --> 00:01:39,979
described it's really simple it's not

41
00:01:45,399 --> 00:01:42,170
even really chemistry but there's these

42
00:01:47,050 --> 00:01:45,409
two elements here they're purple and

43
00:01:48,550 --> 00:01:47,060
blue one or zero however you want to

44
00:01:51,280 --> 00:01:48,560
think of them these can come together

45
00:01:53,620 --> 00:01:51,290
and add one to the end to form sequences

46
00:01:55,899 --> 00:01:53,630
through polymerization and any sequence

47
00:01:57,670 --> 00:01:55,909
can degrade at any point and break into

48
00:01:59,740 --> 00:01:57,680
smaller pieces and if you get above a

49
00:02:02,080 --> 00:01:59,750
certain length in this case I said

50
00:02:04,210 --> 00:02:02,090
length 7 you can make a copy of yourself

51
00:02:06,310 --> 00:02:04,220
and you're constrained by what resources

52
00:02:08,139 --> 00:02:06,320
are available it's a closed mass system

53
00:02:10,899 --> 00:02:08,149
so there's always the same number of

54
00:02:12,610 --> 00:02:10,909
blue and purple squares it's not closed

55
00:02:15,550 --> 00:02:12,620
energy if you're into rate equations I

56
00:02:16,929 --> 00:02:15,560
can show you why afterwards but it's

57
00:02:17,680 --> 00:02:16,939
there's definitely an energy flux going

58
00:02:25,600 --> 00:02:17,690
on

59
00:02:29,050 --> 00:02:25,610
novelty is through polymerizing new

60
00:02:30,730 --> 00:02:29,060
sequences and this might look a little

61
00:02:34,300 --> 00:02:30,740
bit like a replication first RNA world

62
00:02:36,460 --> 00:02:34,310
type scenario and it is definitely

63
00:02:38,440 --> 00:02:36,470

replication first but the actual

64
00:02:42,070 --> 00:02:38,450
chemistry I'm pretty agnostic this could

65
00:02:43,360 --> 00:02:42,080
be anything you really like so all right

66
00:02:44,710 --> 00:02:43,370
so there's replicators so there's two

67
00:02:47,110 --> 00:02:44,720
different kinds of fitness there's

68
00:02:48,220 --> 00:02:47,120
static fitness which is associated with

69
00:02:51,490 --> 00:02:48,230
function and there's environmental

70
00:02:52,690 --> 00:02:51,500
fitness so the static fitness is

71
00:02:54,600 --> 00:02:52,700
associated with a fundamental trade-off

72
00:02:57,190 --> 00:02:54,610
in chemical systems and that is

73
00:03:00,100 --> 00:02:57,200
molecules that are very functional they

74
00:03:01,540 --> 00:03:00,110
fold well are hard to copy and molecules

75
00:03:04,210 --> 00:03:01,550
that are easy to copy tend to not fold

76
00:03:05,800 --> 00:03:04,220
very well and are not very stable so in

77
00:03:08,140 --> 00:03:05,810
this system there's two ways to be very

78
00:03:10,750 --> 00:03:08,150
fit you can either be very stable by

79
00:03:13,420 --> 00:03:10,760
being all blues or you can be very easy

80
00:03:15,010 --> 00:03:13,430
to copy by being all purple the fact

81
00:03:17,740 --> 00:03:15,020
that it's all one and all the other is

82
00:03:19,600 --> 00:03:17,750
to one show that trade-off and two to be

83
00:03:21,520 --> 00:03:19,610
very rare in the system you expect that

84
00:03:23,770 --> 00:03:21,530
functionally fit sequences are rare and

85
00:03:25,570 --> 00:03:23,780
the scheme of all possible sequences and

86
00:03:27,220 --> 00:03:25,580
then there's all these other ones that

87
00:03:29,020 --> 00:03:27,230
are pretty much easy to make and they

88
00:03:31,090 --> 00:03:29,030

are a little bit stable and they get a

89
00:03:33,220 --> 00:03:31,100
little bit of a replication enhancement

90
00:03:35,949 --> 00:03:33,230
but they're not very good at neither all

91
00:03:38,229 --> 00:03:35,959
right oh and then the dynamic aspect is

92
00:03:39,640 --> 00:03:38,239
your replication rate is coupled to the

93
00:03:41,710 --> 00:03:39,650
resources available in the environment

94
00:03:43,600 --> 00:03:41,720
so for example if you're this blue one

95
00:03:45,160 --> 00:03:43,610
and there's just a bunch of purples out

96
00:03:48,490 --> 00:03:45,170
in the environment you your replication

97
00:03:51,670 --> 00:03:48,500
rate is suppressed and the purple ones

98
00:03:53,830 --> 00:03:51,680
replication rate is enhanced all right

99
00:03:56,650 --> 00:03:53,840
and so we do this we run it all together

100
00:03:58,300 --> 00:03:56,660
and we get sort of two stable

101
00:04:00,940 --> 00:03:58,310
equilibrium that I've arbitrarily

102
00:04:03,460 --> 00:04:00,950
decided to call non-life in life and

103
00:04:05,740 --> 00:04:03,470
they have these properties I don't think

104
00:04:08,620 --> 00:04:05,750
replication defines life as i said

105
00:04:11,890 --> 00:04:08,630
earlier but it's not just replication

106
00:04:14,170 --> 00:04:11,900
it's a selection on functional fitness

107
00:04:16,390 --> 00:04:14,180
that I really think is the motivating

108
00:04:17,409 --> 00:04:16,400
factor behind behind calling it life so

109
00:04:19,330 --> 00:04:17,419
I'm just going to talk about these two

110
00:04:20,680 --> 00:04:19,340
different phases really fast so if you

111
00:04:23,560 --> 00:04:20,690
just look at all the different lengths

112
00:04:24,690 --> 00:04:23,570
sequences and the non life sequence

113
00:04:26,770 --> 00:04:24,700

production is dominated by

114
00:04:28,890 --> 00:04:26,780
polymerization so you get this

115
00:04:31,740 --> 00:04:28,900
exponential decay with a little bit of a

116
00:04:34,930 --> 00:04:31,750
modification here because it's

117
00:04:38,260 --> 00:04:34,940
constrained by resources so this is the

118
00:04:40,030 --> 00:04:38,270
length so like during non life we say

119
00:04:42,490 --> 00:04:40,040
okay length three what fraction of the

120
00:04:44,380 --> 00:04:42,500
system ass is like three and it's this

121
00:04:45,940 --> 00:04:44,390
and then for non-life we do the exact

122
00:04:47,830 --> 00:04:45,950
same thing you see a very different

123
00:04:50,140 --> 00:04:47,840
story because everything's tied up in

124
00:04:52,360 --> 00:04:50,150
replicators right so the like seven was

125
00:04:54,400 --> 00:04:52,370
the minimum length to replicate and all

126
00:04:56,620 --> 00:04:54,410
the mass is shifted their your resource

127
00:04:58,210 --> 00:04:56,630
limited there's very little mass left to

128
00:05:00,040 --> 00:04:58,220
continue replication because it's all

129
00:05:01,630 --> 00:05:00,050
tied up here and then you get the

130
00:05:06,160 --> 00:05:01,640
exponential exponential decay from

131
00:05:08,230 --> 00:05:06,170
dimers again okay so then I said

132
00:05:10,390 --> 00:05:08,240
functional selection takes hold in the

133
00:05:12,160 --> 00:05:10,400
life phase so this is a slightly

134
00:05:13,840 --> 00:05:12,170
different plot if anybody was at my talk

135
00:05:15,910 --> 00:05:13,850
a tabs icon and this a little bit

136
00:05:17,170 --> 00:05:15,920
different so what I did here is again

137
00:05:20,860 --> 00:05:17,180
you have all the different length scales

138
00:05:24,640 --> 00:05:20,870

one through seven and on top is non life

139
00:05:27,790 --> 00:05:24,650
and on bottom is life so the solid

140
00:05:29,860 --> 00:05:27,800
purple is the pure purple sequins and

141
00:05:32,560 --> 00:05:29,870
the solid blue is the pure blue sequins

142
00:05:34,540 --> 00:05:32,570
right and so as you see in non life as

143
00:05:36,760 --> 00:05:34,550
you go up you get these mixed sequences

144
00:05:38,440 --> 00:05:36,770
dominating stone like seven sequences

145
00:05:41,830 --> 00:05:38,450
there's replicators there in non life

146
00:05:43,450 --> 00:05:41,840
but they're these sort of heterogeneous

147
00:05:44,830 --> 00:05:43,460
mixtures are not very good anything

148
00:05:47,920 --> 00:05:44,840
there were just what was easy to make

149
00:05:50,160 --> 00:05:47,930
okay but then in life you see a very

150
00:05:53,080 --> 00:05:50,170
different story the entire system has

151
00:05:55,450 --> 00:05:53,090
restructured because you get selection

152
00:06:00,220 --> 00:05:55,460
on these homogeneous sequences so length

153
00:06:02,440 --> 00:06:00,230
7 it's about seventy percent of the

154
00:06:04,090 --> 00:06:02,450
length 7 sequences are the very stable

155
00:06:06,190 --> 00:06:04,100
ones so they just sit there they're

156
00:06:10,030 --> 00:06:06,200
stable the replicating and they're using

157
00:06:13,810 --> 00:06:10,040
up all of the ones or the blues in the

158
00:06:15,550 --> 00:06:13,820
the system and then the rest are mostly

159
00:06:17,320 --> 00:06:15,560
these homogeneous zeros that replicate

160
00:06:20,290 --> 00:06:17,330
very fast but they also break apart

161
00:06:23,020 --> 00:06:20,300
really easily and then the entire system

162
00:06:25,060 --> 00:06:23,030
is just being made by breaking these

163
00:06:26,740 --> 00:06:25,070

lengths seven sequences so you see these

164
00:06:29,050 --> 00:06:26,750
same patterns being sort of copied

165
00:06:30,670 --> 00:06:29,060
throughout the entire thing if you're

166
00:06:32,560 --> 00:06:30,680
interested why it switches from mostly

167
00:06:33,940 --> 00:06:32,570
blue to mostly purple right here we can

168
00:06:36,760 --> 00:06:33,950
talk about that after you can ask me

169
00:06:38,500 --> 00:06:36,770
it's kind of interesting all right so

170
00:06:41,170 --> 00:06:38,510
then another key distinguishing feature

171
00:06:43,150 --> 00:06:41,180
between life and non-life I measure with

172
00:06:44,350 --> 00:06:43,160
an information measure is anybody here

173
00:06:46,629 --> 00:06:44,360
ever studied any

174
00:06:50,439 --> 00:06:46,639
in theory even a little bit no presents

175
00:06:52,510 --> 00:06:50,449
one person cool okay so if you read

176
00:06:53,529 --> 00:06:52,520
anything on information theory the first

177
00:06:55,390 --> 00:06:53,539
thing they introduce the stranded

178
00:06:57,429 --> 00:06:55,400
information which is largely useless and

179
00:06:59,709 --> 00:06:57,439
then the second thing they introduce is

180
00:07:02,559 --> 00:06:59,719
mutual information which is a little bit

181
00:07:03,969 --> 00:07:02,569
more useful so mutual information if you

182
00:07:05,980 --> 00:07:03,979
like math that's right here if you're

183
00:07:07,689 --> 00:07:05,990
good with pictures this kind of makes

184
00:07:09,790 --> 00:07:07,699
sense but the way to think about it is

185
00:07:12,339 --> 00:07:09,800
if I have two random variables x and y

186
00:07:15,249 --> 00:07:12,349
the mutual information between x and y

187
00:07:17,439 --> 00:07:15,259
is what do I learn about x given that I

188
00:07:19,089 --> 00:07:17,449

fixed why right so it's a way to make

189
00:07:21,040 --> 00:07:19,099
measure arbitrary correlations between

190
00:07:22,570 --> 00:07:21,050
two different variables you don't have

191
00:07:24,640 --> 00:07:22,580
to specify a functional dependence you

192
00:07:25,570 --> 00:07:24,650
don't have to specify anything you just

193
00:07:27,459 --> 00:07:25,580
have to have the probability

194
00:07:29,920 --> 00:07:27,469
distributions and you say given that I

195
00:07:34,570 --> 00:07:29,930
know X was in this state what do I know

196
00:07:36,879 --> 00:07:34,580
about the state of why make sense so one

197
00:07:39,339 --> 00:07:36,889
way to distinguish non life and life in

198
00:07:41,860 --> 00:07:39,349
this model was that if you look at the

199
00:07:43,540 --> 00:07:41,870
composition of the Replicators and the

200
00:07:45,999 --> 00:07:43,550
composition of the free resources in the

201
00:07:47,740 --> 00:07:46,009
environment you can say what is the

202
00:07:50,050 --> 00:07:47,750
mutual information between these two so

203
00:07:51,790 --> 00:07:50,060
what do I know about the Replicators

204
00:07:55,240 --> 00:07:51,800
given that I fixed the environment and

205
00:07:58,420 --> 00:07:55,250
in the non-life phase you see a hut high

206
00:07:59,740 --> 00:07:58,430
positive value around three depends on

207
00:08:02,019 --> 00:07:59,750
how you set the parameters a model it

208
00:08:03,579 --> 00:08:02,029
changes a little bit and then in the the

209
00:08:06,670 --> 00:08:03,589
life phase you see that they're largely

210
00:08:09,279 --> 00:08:06,680
uncorrelated it tends to 0 so this means

211
00:08:11,800 --> 00:08:09,289
that the Replicators that exist in the

212
00:08:13,390 --> 00:08:11,810
non-life phase are completely determined

213
00:08:14,740 --> 00:08:13,400

by their environment that if you fix the

214
00:08:16,059 --> 00:08:14,750
environment you know a lot about the

215
00:08:17,740 --> 00:08:16,069
Replicators that exist and you know

216
00:08:19,360 --> 00:08:17,750
about their composition whereas in the

217
00:08:20,559 --> 00:08:19,370
life phase just because you know the

218
00:08:22,269 --> 00:08:20,569
environment doesn't mean you necessarily

219
00:08:24,610 --> 00:08:22,279
know much about the composition of the

220
00:08:26,860 --> 00:08:24,620
Replicators i think is i'm pretty

221
00:08:28,860 --> 00:08:26,870
interesting sort of effect that's been

222
00:08:32,949 --> 00:08:28,870
caused by this selection on function

223
00:08:34,600 --> 00:08:32,959
alright so as I said there's a first

224
00:08:36,870 --> 00:08:34,610
order phase transition and you might

225
00:08:38,740 --> 00:08:36,880
have predicted it if you do any

226
00:08:40,810 --> 00:08:38,750
statistical physics or thermodynamics

227
00:08:43,149 --> 00:08:40,820
you see these sharp discontinuities and

228
00:08:46,480 --> 00:08:43,159
state state variables that's the first

229
00:08:48,430 --> 00:08:46,490
order phase transition so why does this

230
00:08:50,620 --> 00:08:48,440
happen well the Trent and how does it

231
00:08:53,019 --> 00:08:50,630
happen so the transition happens when

232
00:08:54,340 --> 00:08:53,029
the environments available or the

233
00:08:57,280 --> 00:08:54,350
resources available in the environment

234
00:08:57,970 --> 00:08:57,290
match the composition of replicators so

235
00:08:59,560 --> 00:08:57,980
what this

236
00:09:00,850 --> 00:08:59,570
plot is showing is the relative

237
00:09:02,290 --> 00:09:00,860
difference between the composition of

238
00:09:04,840 --> 00:09:02,300

the environment and the free resources

239
00:09:07,990 --> 00:09:04,850
and it's the frequency of the transition

240
00:09:10,030 --> 00:09:08,000
actually happening so this is for 256

241
00:09:12,310 --> 00:09:10,040
different runs and I said okay when the

242
00:09:14,050 --> 00:09:12,320
transition happens what was the relative

243
00:09:17,200 --> 00:09:14,060
difference between the number of ones

244
00:09:18,610 --> 00:09:17,210
over the total mass in replicators and

245
00:09:20,860 --> 00:09:18,620
the number of ones over the total mass

246
00:09:22,660 --> 00:09:20,870
in the environment and you see that

247
00:09:24,280 --> 00:09:22,670
almost sixty percent of them happen when

248
00:09:26,080 --> 00:09:24,290
they exactly match and then it's a

249
00:09:28,510 --> 00:09:26,090
pretty nice Gaussian centered around

250
00:09:31,780 --> 00:09:28,520
there so one thing that's interesting

251
00:09:33,820 --> 00:09:31,790
about this transition is that you might

252
00:09:36,190 --> 00:09:33,830
expect that the very fast replicators

253
00:09:37,750 --> 00:09:36,200
would drive the system into into this

254
00:09:39,160 --> 00:09:37,760
sort of new state where replications

255
00:09:40,780 --> 00:09:39,170
dominating everything or that the very

256
00:09:42,100 --> 00:09:40,790
stable ones would get formed and then

257
00:09:44,320 --> 00:09:42,110
eventually those would build up enough

258
00:09:45,910 --> 00:09:44,330
of them to drive the transition but what

259
00:09:48,100 --> 00:09:45,920
actually happens is because you have to

260
00:09:50,380 --> 00:09:48,110
match the environment it's the very

261
00:09:52,870 --> 00:09:50,390
unfit the easy to make replicators that

262
00:09:56,920 --> 00:09:52,880
end up causing it so here these are like

263
00:10:01,480 --> 00:09:56,930

34 43 even splits between purple and

264
00:10:04,300 --> 00:10:01,490
blue and then here is 5 to 25 and then

265
00:10:06,100 --> 00:10:04,310
there's a brief 6116 and then eventually

266
00:10:08,470 --> 00:10:06,110
at the end you get the very stable once

267
00:10:10,540 --> 00:10:08,480
selected so this means that if you were

268
00:10:12,370 --> 00:10:10,550
to observe a transition from non-life to

269
00:10:14,800 --> 00:10:12,380
life if you like alternative you know

270
00:10:16,900 --> 00:10:14,810
prebiotic chemistry this is exactly that

271
00:10:18,520 --> 00:10:16,910
this is saying that the things which

272
00:10:20,080 --> 00:10:18,530
nucleate the transition into a living

273
00:10:23,230 --> 00:10:20,090
state are not going to be those that are

274
00:10:24,940 --> 00:10:23,240
ultimately selected at the end the

275
00:10:27,190 --> 00:10:24,950
transition is associated with a massive

276
00:10:28,690 --> 00:10:27,200
explosion of diversity so here I've

277
00:10:31,480 --> 00:10:28,700
plotted the total number of explored

278
00:10:33,790 --> 00:10:31,490
sequences on top as a function of time

279
00:10:35,020 --> 00:10:33,800
and the transition happens right here as

280
00:10:37,720 --> 00:10:35,030
you can see there's this huge

281
00:10:39,400 --> 00:10:37,730
discontinuity the exploration rate for

282
00:10:41,830 --> 00:10:39,410
exploring new sequences this would be

283
00:10:43,390 --> 00:10:41,840
like speciation rate goes up by two

284
00:10:45,280 --> 00:10:43,400
orders of magnitude during the

285
00:10:49,150 --> 00:10:45,290
transition and it's higher after the

286
00:10:51,190 --> 00:10:49,160
transition than before all right but

287
00:10:53,800 --> 00:10:51,200
also associated with this transition is

288
00:10:56,140 --> 00:10:53,810

a mass extinction event because the

289
00:10:58,510 --> 00:10:56,150
entire system gets restructured so if we

290
00:11:00,430 --> 00:10:58,520
start here so here I've plotted the

291
00:11:02,140 --> 00:11:00,440
formation versus degradation rate in the

292
00:11:05,650 --> 00:11:02,150
total system and the mutual information

293
00:11:07,210 --> 00:11:05,660
right so if we start stable formation

294
00:11:09,040 --> 00:11:07,220
degradation here with high mutual

295
00:11:10,220 --> 00:11:09,050
information this is the non life state

296
00:11:12,590 --> 00:11:10,230
at steady state

297
00:11:15,230 --> 00:11:12,600
right up here and then it's going to

298
00:11:17,330 --> 00:11:15,240
eventually end up over here with the one

299
00:11:18,860 --> 00:11:17,340
value formation to degradation if you

300
00:11:21,040 --> 00:11:18,870
have anything other than one the system

301
00:11:23,090 --> 00:11:21,050
is unstable so it has to end there and

302
00:11:25,370 --> 00:11:23,100
so as you see the mutual information

303
00:11:27,140 --> 00:11:25,380
starts going down everything's getting

304
00:11:29,060 --> 00:11:27,150
ripped apart faster than its being made

305
00:11:30,830 --> 00:11:29,070
anything below one means for everything

306
00:11:33,920 --> 00:11:30,840
you're making you're destroying more

307
00:11:35,570 --> 00:11:33,930
than that thing hits this bottom and

308
00:11:39,410 --> 00:11:35,580
then eventually stabilizes by finding

309
00:11:42,020 --> 00:11:39,420
the functionally fit sequences so yeah

310
00:11:44,060 --> 00:11:42,030
in summary a functional selection leads

311
00:11:46,060 --> 00:11:44,070
to an observable decoupling from of

312
00:11:48,800 --> 00:11:46,070
replicators from their environment and

313
00:11:51,500 --> 00:11:48,810

this by driving a restructuring of that

314
00:11:53,150 --> 00:11:51,510
environment this restructuring would

315
00:11:56,090 --> 00:11:53,160
have been associated with an explosion

316
00:11:58,190 --> 00:11:56,100
of diversity and a mass extinction event

317
00:11:59,510 --> 00:11:58,200
and the Replicators which came out of

318
00:12:02,180 --> 00:11:59,520
that would not have been the ones that

319
00:12:04,340 --> 00:12:02,190
nucleated the transition and for the

320
00:12:06,050 --> 00:12:04,350
sake of time I'll just skip these future

321
00:12:07,970 --> 00:12:06,060
directions if you're interested in why

322
00:12:10,730 --> 00:12:07,980
simple replicators are not the right

323
00:12:12,380 --> 00:12:10,740
logical architecture for life you can

324
00:12:15,650 --> 00:12:12,390
ask me about that later it's pretty cool

325
00:12:18,050 --> 00:12:15,660
and yeah that's it thanks to all these

326
00:12:20,600 --> 00:12:18,060
people especially my advisor Sarah

327
00:12:22,460 --> 00:12:20,610
Walker she's super rad and she's been

328
00:12:29,540 --> 00:12:22,470
very helpful in all this and that's it

329
00:12:38,360 --> 00:12:29,550
take any questions okay we have time for

330
00:12:41,720 --> 00:12:38,370
one quick question you already so can

331
00:12:44,600 --> 00:12:41,730
you say anything about the species that

332
00:12:48,260 --> 00:12:44,610
nucleate the emergence of life from the

333
00:12:51,740 --> 00:12:48,270
context of the things that our life so

334
00:12:53,300 --> 00:12:51,750
they I mean in this model they would

335
00:12:55,030 --> 00:12:53,310
have been made out of the same basic

336
00:12:57,200 --> 00:12:55,040
building blocks is all it really says

337
00:12:59,510 --> 00:12:57,210
but they would have been structured

338
00:13:01,730 --> 00:12:59,520

completely differently so the sequence

339
00:13:03,320 --> 00:13:01,740
composition and the actual sequence

340
00:13:05,600 --> 00:13:03,330
played two different roles in the way

341
00:13:07,370 --> 00:13:05,610
the fitness landscape is instantiated so

342
00:13:09,080 --> 00:13:07,380
depending on how you want to interpret

343
00:13:11,870 --> 00:13:09,090
the chemistry or magic to some kind of

344
00:13:13,460 --> 00:13:11,880
toy system there are some things you

345
00:13:16,940 --> 00:13:13,470
might be able to say but it's really

346
00:13:18,950 --> 00:13:16,950
sort of touchy but they would have been

347
00:13:20,600 --> 00:13:18,960
reflective of the initial composition of

348
00:13:23,440 --> 00:13:20,610
the system so they wouldn't have been

349
00:13:27,280 --> 00:13:23,450
outliers in the scheme of all possible

350
00:13:28,960 --> 00:13:27,290
sort of compositions as super chair I'm

351
00:13:33,040 --> 00:13:28,970
granting myself extra time to ask a

352
00:13:34,300 --> 00:13:33,050
question ah this was super cool so I

353
00:13:36,580 --> 00:13:34,310
want to know what the future direction

354
00:13:39,250 --> 00:13:36,590
is just a 30 second yeah where you going

355
00:13:41,320 --> 00:13:39,260
next yeah so when I made these slides

356
00:13:44,920 --> 00:13:41,330
actually I had a different idea the this

357
00:13:46,600 --> 00:13:44,930
project came out of some other ideas

358
00:13:48,400 --> 00:13:46,610
that I I thought this was going to be

359
00:13:49,750 --> 00:13:48,410
like the easy step and then like okay

360
00:13:51,790 --> 00:13:49,760
cool what will actually be able to ask a

361
00:13:53,020 --> 00:13:51,800
question and then all this phase

362
00:13:54,310 --> 00:13:53,030
transitions to have happened and I was

363
00:13:58,210 --> 00:13:54,320

like whoa I didn't understand that I

364
00:13:59,590 --> 00:13:58,220
respect that so the future direction is

365
00:14:02,710 --> 00:13:59,600
I'm looking at different evolvable life

366
00:14:04,720 --> 00:14:02,720
histories or sort of ya life histories

367
00:14:06,610 --> 00:14:04,730
so you know if you just if you're

368
00:14:08,710 --> 00:14:06,620
prebiotic chemistry discovers a Palmer

369
00:14:11,710 --> 00:14:08,720
raised before discovers like something

370
00:14:13,150 --> 00:14:11,720
that can recycle things or you know a

371
00:14:14,890 --> 00:14:13,160
synthase or something that makes

372
00:14:17,380 --> 00:14:14,900
components that you need how does that

373
00:14:21,190 --> 00:14:17,390
enhance or slow down the evolvability

374
00:14:23,050 --> 00:14:21,200
and sort of how does that change how

375
00:14:25,450 --> 00:14:23,060
constrained your rate constants

376
00:14:28,300 --> 00:14:25,460
basically need to be in that system but

377
00:14:30,820 --> 00:14:28,310
I'm also interested in so Von Neumanns

378
00:14:31,960 --> 00:14:30,830
got this great idea about what what

379
00:14:34,180 --> 00:14:31,970
things need to do to be able to make

380
00:14:36,550 --> 00:14:34,190
copies themselves and it needs a

381
00:14:37,750 --> 00:14:36,560
specific logical architecture and I can

382
00:14:39,130 --> 00:14:37,760
point you to some references but

383
00:14:41,650 --> 00:14:39,140
basically you need a replicator and a

384
00:14:43,720 --> 00:14:41,660
vehicle and all of these replicator

385
00:14:46,000 --> 00:14:43,730
models that have ever been made ignore

386
00:14:47,560 --> 00:14:46,010
that and they just say oh well we just

387
00:14:51,340 --> 00:14:47,570
have a replicator but you can press a

388
00:14:54,550 --> 00:14:51,350

lot of biological function and you

389
00:14:55,870 --> 00:14:54,560
introduce a lot of logical paradoxes if

390
00:14:59,560 --> 00:14:55,880
you try to do it that way so I'm